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Ruthanne Cole
cole46@marshall.edu

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TEACHERS' PERCEPTIONS OF THE NASA STEM EPDC DIGITAL BADGING SYSTEM AS A MODEL OF PERSONALIZED PROFESSIONAL DEVELOPMENT

A dissertation submitted to the
Graduate College of
Marshall University
In partial fulfillment of the
requirements for the degree of
Doctor of Education in
Curriculum and Instruction by
Ruthanne Cole
Approved by
Dr. Edna Meisel, Ed.D. Committee Chairperson
Dr. Ronald Childress, Ph.D. Committee Member
Dr. Travis Bradshaw, Ph.D. Committee Member
Dr. Nega Debela, Ph.D. Committee Member

Marshall University
August 2022

APPROVAL OF DISSERTAION

We, the faculty supervising the work of Ruthanne Cole, affirm that the dissertation *Teachers' Perceptions of the NASA STEM EPDC Digital Badging System as a Model of Personalized Professional Development* meets the high academic standards for original scholarship and creative work established by the Curriculum and Instruction program and the College of Education and Professional Development. This work also conforms to the editorial standards of our discipline and the Graduate College of Marshall University. With our signatures, we approve the manuscript for publication.

Edna Meisel
Edna Meisel (Jul 12, 2022 11:50 EDT)

Date: Jul 12, 2022

Dr. Edna Meisel, Department of Curriculum & Instruction
Committee Chairperson

Ronald Childress (Jul 12, 2022 11:59 EDT)

Date: Jul 12, 2022

Dr. Ron Childress, Department of Curriculum & Instruction
Committee Member

Nega Debela

Date: Jul 12, 2022

Dr. Nega Debela, Department of Curriculum & Instruction
Committee Member

Travis Bradshaw
Travis Bradshaw (Jul 12, 2022 12:36 EDT)

Date: Jul 12, 2022

Dr. Travis Bradshaw
External Committee Member

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DEDICATION

This dissertation is dedicated to my wonderful mother, Nannie Hodge Jones. She instilled in me a love of learning and inspired me to achieve my doctorate.

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I thank my committee for their support. My committee chair, Dr. Edna Meisel, deserves a special thanks for her patient guidance and constant support throughout this study.

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I would like to acknowledge my husband Ken Cole for his support and for believing in me throughout this endeavor. I would also like to thank my son Dr. Brent Cole and his wife Leah, and my two granddaughters, Jenna and Isla, for their love and encouragement throughout this study.

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ABSTRACT

Unlike the ineffective generic approach often used for teacher professional development, NASA STEM Educator Professional Development Collaborative (EPDC) Digital Badging offers access to a highly organized system of knowledge and personalized, online professional development (PD) through digital badging. This qualitative case study provided an in-depth view of teacher perspectives of the value of NASA STEM EPDC Digital Badging as a model for personalized STEM professional development. The population for this study consisted of ten K-12 teachers, from a rural Southwest Virginia school system, who participated in the STEM-UP after school program and experienced PD through NASA STEM EPDC Digital Badging. Data from STEM-UP 2019 program evaluations and teacher responses from semi-structured interviews were used to inform this research. This study focused on teacher demographics, educational advantages and motivating factors that caused teachers to persist with the program, their perceptions of the badging for personalized learning and how the training fit into the over-all learning ecosystem. Data shows that teachers perceive the badge training as motivating, useful, personalized and effective as a form of PD that easily transfers learning into the classroom. Results of this study imply that NASA STEM EPDC Digital Badging was useful for the STEM-UP teachers and may be effective PD in other learning situations.

CHAPTER 1

"Momentum is building for micro-credentials to help move educator professional development and advancement away from inefficient, compliance-focused, blanket approaches toward impactful, individualized, empowering systems" (Tooley & Hood, 2020, para. 16). Many of these micro credentialing systems involve digital badging. National Aeronautics and Space Administration (NASA) STEM Engagement and Educator Professional Development Collaborative (EPDC) Digital Badging provides individualized assessment, online mentoring, and personalized professional science, technology, engineering, and math (STEM) learning (Texas State University, n.d.-b). This study focused on teachers' perceived value of the NASA STEM EPDC Digital Badging system through which K-12 educators received online professional development to earn digital badges.

NASA STEM EPDC digital badging has been used for teacher professional development in many Virginia public school districts, including Bland County Public Schools. NASA STEM EPDC Digital Badging allows educators to choose STEM topics and engage, at their own pace, to earn a digital badge. The badge represents a micro-credential that indicates mastery of STEM topics through NASA content (Texas State University, n.d.-a).

NASA EPDC is a national network system grounded in educational theory and best practices (Texas State University, n.d.-a). This badging system was designed collaboratively in 2015 by Pennsylvania State University, NASA, and the National Science Teaching Association (NSTA). As of 2019, Pensar Learning provides the digital learning platform (Pensar Learning, 2019). This collaborative is dedicated to supporting implementation of personalized PD through micro-credentialing. This team came together because of concerns about traditional PD that does

not meet the specific needs of primary and secondary school teachers for personalized PD (Texas State University, n.d.-a). According to Gamrat et al. (2014), expertise in teaching is dependent on flexible access to highly organized systems of knowledge, and effective PD requires personalization. NASA EPDC provides professional learning experiences to educators in K-12, university, and community settings. These learning experiences are delivered through the expert staff of Texas State University education faculty specialists located regionally at NASA's Research and Space Centers (Texas State University, n.d.-a). The NASA STEM Educator Professional Development Collaborative (EPDC) FY 2016 Annual Performance Report (National Aeronautics and Space Administration [NASA], 2016) lists five innovative approaches as foundational principles:

> 1.attention to the educator across the professional continuum, 2) respect for the culture and language of the learner, 3) openness to sharing learning and harnessing the power of scholar/expert partnerships, 4) boldness to leverage the potential of massive online learning and badging systems, and 5) commitment to create an innovative national impact evaluation model that gets to the heart of professional learning and behavior change. (p. 1)

These approaches focus on improving STEM education and workforce readiness. Bland County STEM-UP used the NASA badging system as a pedagogical tool to integrate STEM into their curriculum.

Digital badges are indications of knowledge, skills, abilities and achievements that appear as digital symbols on an online learning site. Digital badges are awarded by groups, or individuals, as indicators of experience (Casilli & Knight, 2012). To implement a badging

program in a school, it should start with the teachers (Grier, 2015). There is increasing interest in badging PD and using digital badges for learning certification tools in higher education (Hart, 2015).

Technological advances have made it possible to have online professional development but it is not in general use. There are few studies on the topic of how personalization through badging can enhance online teacher professional development (Dyjur & Lindstrom, 2017). With badge systems design in its earliest stages research is limited. Muilenburg and Berge (2016) propose a need for a comprehensive research agenda, including such basics as the definition of what a successful, functional badge system entails. According to Diamond and Gonzales (2014), the award of badges is not the main motivating factor that attracts teachers. What teachers find useful is a PD badging system that is more personalized and relevant.

Assessment methods that are aligned with a state or national framework are important for Bland County educators to see the value of badges. When implementing a digital badging system for teacher PD, validation and trust are the most important factors to consider (Finkelstein et al., 2013). Diamond and Gonzales (2014) propose that researchers should investigate whether individual teachers, school districts, and their communities value the activities and objectives of any given badge system. Finkelstein et al. (2013) emphasized the importance of badging validity:

> Current badge standards call for badge instances to be backed up by an assertion, essentially an online certificate offered or endorsed by the issuer, that confirms the veracity of the data that a badge purports to represent. Validation serves all three parties to a badge transaction-the earner, issuer, and observer-by fostering a sense of trust in the process by which badges are awarded and rewarded. The earner can feel comfortable knowing the authenticity of the achievement has been affirmed. Although most learners

will earn their achievements fairly, any perception that a system lacks appropriate validation can call into question the integrity of every achievement the system grants. (p. 13)

The Bland County STEM-UP program chose to use NASA EPDC digital badging because NASA is a credible resource for teaching and learning.

Statement of the Problem

In-service teacher PD is frequently offered without consideration for how effective it may be for teachers or how it fits into the curriculum (Jayaram et al., 2012). Teacher professional development is considered to be ineffective because it doesn't address the actual practices of teaching a diverse group of educators (Jayaram et al., 2012). The NASA STEM EPDC digital badging presents the possibility of offering a sustained program of online professional learning for STEM teaching and learning that is more personalized and indicates teacher achievements in their specialization and classroom setting (Diamond & Gonzales, 2014). There has been limited data available on the effectiveness of NASA STEM EPDC Digital Badging.

An informal evaluation by STEM teachers, that participated in the NASA STEM EPDC badging program, in Bland County, indicates that most STEM-UP teachers have found the badge process valuable for PD and overall STEM learning. Further research on Bland County STEM-UP teachers' perceived value of this method may give light on the effectiveness of these badge programs for teacher PD in other districts and provide a means of personalization and customization of teacher training.

Purpose of the Study

The purpose of this study was to investigate the Bland County STEM program teachers' perceptions of the value of the experiences, with and through the NASA STEM EPDC badging

system. Specific elements of the NASA STEM EPDC system investigated included STEM teacher perceptions of the educational value of the digital badging program for personalized learning, educational advantages that caused them to persist in the program, and how the program learning strategies were used successfully in their own classrooms. Teachers' perceptions of successful strategies and how these methods may be used to improve other STEM professional development was investigated. Teachers were asked about how interacting with components of the digital badging system, that required ongoing practice with STEM concepts and skills, affected the STEM learning community ecosystem in Bland County.

Rationale of the Study

This study sought to determine teacher perspectives of NASA digital badging as a model of personalized STEM PD. Data such as teacher views on personalized learning, effects on the STEM ecosystem within the Bland County learning community, teacher persistence, and motivating factors of the badging PD were studied. This study will benefit STEM educator development at many levels. Although the study focused on STEM teacher PD in a specific 2-8th grade Bland County program, the findings may highlight useful features of the online NASA STEM EPDC digital badging system that could be used successfully in other learning contexts.

Previous STEM-UP Program Internal Evaluation

Prior to this study throughout 2014-2019, student and teacher online post surveys were given at the end of the school years and at the end of the STEM-UP summer camps for continuous internal program evaluation. For the 2019 post survey, the source of the archival data in the study, all questions were open answer. The student responses were intended to inform teacher participants and program directors about student perceptions of program success. The teacher post surveys were aimed at revealing teacher opinions, that were influenced by student

success, and the pros and cons of implementing the concepts and strategies learned from the NASA STEM EPDC digital badging PD in their classrooms. Student and teacher views were considered for program improvements each year.

Over the six-year period, this data showed that most teachers felt they had successfully implemented most of the STEM concepts and teaching strategies into the STEM-UP summer camp. Several mentioned they used many of those lessons in their own regular classrooms with even more success as they were adapted for their own students. The digital badging system was motivating to some of them and most felt they learned from the digital badging lessons. A few teachers described how the lessons helped them differentiate teaching and learning better with their STEM related program activities.

Analyzing the post survey responses from teachers brought up many questions. Exactly how did teachers successfully implement the lessons and skills from the digital badging into their regular classroom? How useful was the NASA digital badging resource for their PD? Why did they persist with the program?

Significance of the Study

More information was needed to understand how teachers valued the NASA digital badging system. Digital badging in education is an emerging technology and there are not many guides to research badging impacts on teacher PD. An important outcome of this study was to consider which aspects of the NASA digital badging learning method teachers viewed as most useful for STEM teaching and learning. Results from the study provided data on the teachers' perceived value of the NASA STEM EPDC badging system model that could aid in the continuation and development of the NASA STEM EPDC Digital Badging system.

Research Questions

1. What are the teachers' differences, if any, based on selected demographic factors such as years of teaching experience, teaching specializations, ability to access online resources, and prior badging experience, in teachers' perceptions of the value of the NASA STEM EPDC digital badging program?

2. What are teachers' perceptions of educational advantages that cause them to persist in the NASA STEM EPDC Digital Badging Program?

3. What are the teachers' perspectives of the educational value of the NASA STEM EPDC Digital Badging Program for personalized learning?

4. What are teachers' perceptions of successful NASA EPDC Digital Badging Program classroom strategies that were useful in their own classroom and how the NASA STEM digital badging system could improve other STEM programs?

5. What are the teachers' perceptions of how interacting with components of the NASA STEM EPDC digital badging program, that required ongoing practice with STEM concepts and skills, affected the STEM learning community ecosystem in Bland County.

Operational Definitions

Teacher Demographics: The statistical characteristics of human populations, such as age or income (Merriam-Webster Dictionary, 2022a). Teachers' demographic information collected for this study includes years of teaching experience, science, technology, engineering, and math (STEM) teaching, teacher specializations, and prior NASA STEM EPDC badging or other micro credentialing.

STEM learning ecosystem: STEM learning ecosystems are a complex system of learning relationships interacting with the surrounding environment. These relationships involve the

family, school, cultural values, laws, and customs (Guy-Evans, 2020). This study focused on the Bland County STEM learning ecosystem, in which the community, teachers, and students were engaged in STEM education with emphasis on matching STEM learning pathways to the changing needs of the workforce.

Years of Teaching Experience: Years of teaching experience is full-time employment, that includes full responsibility for the planning and delivery of instruction and evaluation of student learning (Law Insider, 2022).

STEM Teaching Experience: STEM teaching experience is the time instructors are involved in teaching science, technology, engineering, or math with an interdisciplinary and applied approach.

Teaching Specializations: Teacher specializations include grade level, subject, or other educational areas.

Prior Badging Experience: Prior badging experience is the teacher' experience with digital badging programs before their participation in NASA STEM EPDC digital badging training during the Bland STEM-UP program.

NASA STEM EPDC Digital Badging Methods: NASA STEM EPDC digital badging methods use inquiry and critical thinking. Education specialists award the badge icon upon completion. (Texas State University, n.d.-b).

Teacher Perceptions of the NASA STEM EDPC Digital Badging Program: Teacher perceptions of the NASA EPDC digital badging program are how the teacher views their interactions with components of NASA STEM EPDC digital badging program training.

Teacher Persistence Concerning their Perception of the NASA STEM EPDC Digital Badging Program: Teacher persistence involves teachers' passion to persevere with the badging program

because they developed successful STEM teaching skills and reformed teaching practices (Hill-Jackson et al., 2019). Teacher persistence in this study relates to their continuance in the NASA STEM EPDC digital badging system.

Delimitations of the Study

Only Bland County Public Schools 2017-2019 STEM-UP program K-12 teachers who participated in NASA STEM EPDC digital badging training, and have earned at least one badge, were included in the study. The group of teachers who were eligible for this study were an assortment of demographic differences; years of teaching experience, teaching specializations, STEM teaching experience, and prior badging experiences. Only those subjects that willingly volunteered were able to participate in the interviews. Barriers that were addressed include Covid-19 regulations that prevented close, face-to-face, meetings with the teachers. Therefore, online teacher interviews were conducted via Microsoft Teams.

CHAPTER 2

LITERATURE REVIEW

This chapter will present issues, concepts, and theoretical constructs that relate to teacher perceptions of educator professional development (PD). Issues include the need for more savvy science, technology, engineering and math (STEM) teachers, the national call for more high quality, customized, STEM professional development at all levels (National Science Teaching Association, 2021), and the concept of developing STEM ecosystems as a strategy for improving STEM literacy (Traill et al., 2015). This chapter will illustrate how the sociocultural concepts of authenticity, collaboration, and personalization are important aspects of most teacher PD badging systems, such as NASA STEM Educator Professional Development Collaborative (EPDC) digital badging (Texas State University, n.d.-a). These constructs will illustrate how teacher PD and digital badging program effectiveness is informed by change theory, adult learning theory, and motivation theory. This literature review will address these issues, concepts and theories linked to teacher PD and digital badging as a pedagogical tool for STEM learning ecosystems (Traill et al., 2015).

High Quality Professional Development

The No Child Left Behind Act (NCLB) of 2001, required highly qualified teachers in all grades for every subject, and high-quality professional development to be available for all teachers (U.S. Department of Education, 2001). The Teaching Commission Report, *Teaching at Risk: A Call to Action*, focused on the importance of helping our teachers succeed to enable our children to learn (Cochran-Smith, 2004). To achieve these requirements, high-quality PD, that meets the specific needs of each individual teacher, was established as a priority. Teachers are

held accountable for students' learning at proficiency levels across content and grades (Cochran-Smith, 2004). This requires continuing PD for teachers to maintain essential knowledge and skills for high quality teaching. David J. Cooper (2016) outlined four components of effective PD delivery:

1. Teaching the theory and presenting the research behind the new skill. Only those ideas supported by scientific research as capable of improving student achievement should be included (Armbruster et al., 2001).
2. Demonstrating the new skill so teachers can observe someone teaching the strategy.
3. Practice and immediate feedback for teachers on how well he or she presented the new lesson or skill.
4. Follow up with additional training and coaching when implementing a new strategy.

According to Joyce and Showers (1988), the follow-up step of these four components ensures that the teacher will implement the strategy, skill, or concept and make it a part of their classroom repertoire. Lauro (1995) noted that it can take many years for a conversion to a new program and new teaching practices in a school system to be fully implemented. Therefore, effective PD must be sustained. They need ongoing support as they implement new skills. The need for effective PD became imperative, but change takes time (Lauro,1995).

David J. Cooper (2016) suggests that PD programs should be ongoing and extended over time to be effective. He added that the school districts should provide ongoing support with feedback to teachers through coaching and observations. The teachers should discus new strategies with their colleagues to reinforce learning. Cooper believes that professional development should be collaborative and provide multiple opportunities for learning (Cooper, 2016).

Initiatives for Promoting High Quality Science, Technology, Engineering, and Math (STEM) Education

High quality STEM skills are essential for all students at every educational level to succeed in the 21st century workplace (National Science Teaching Association, 2021). Many federal initiatives were put into place to promote high quality STEM Education.

President Obama's administration was committed to providing students with the skills needed to excel in STEM fields of study. The Obama administration introduced several STEM initiatives. In 2010, President Obama launched *Changing the Equation in STEM Education* (Sabochik, 2010) to improve STEM education, as part of the administration's *"Educate to Innovate"* campaign (The White House, 2009). Under President Obama's administration, the Committee on STEM Education (CoSTEM) of the National Science and Technology Council, put out a Five-Year Federal Science Technology, Engineering, and Mathematics Education Strategic Plan (Committee on STEM Education, 2013).

In January 2016, Obama put into place the *Computer Science for All Initiative* and the *Elementary and Secondary Education Act (ESEA)*, and reauthorized under *Every Student Succeeds Act (ESSA)* (The Understood Team, 2022). This action identifies all four STEM disciplines and includes engineering and computer science as essential STEM educational components for all students. The ESSA builds on specific areas of progress to improve STEM teaching and learning (U.S. Department of Education, 2016).

In 2018, the federal government issued *Charting A Course for Success: America's Strategy for STEM Education.* This plan outlines the Trump White House five-year vision to make the nation a global front-runner in STEM education and calls for enlisting participation of all Americans in STEM ecosystems as a top priority (Committee on STEM Education, 2018). The plan recommends developing STEM ecosystems that unite communities. The STEM

ecosystem pathways would be a means to support diversity, equity, and inclusion (Committee on STEM Education, 2018). The STEM strategy calls for: supporting online distance learning, more STEM internships, preparation of STEM educators, research on best practices, developing partnerships between schools and local business, and helping students learn STEM through real-world problem solving (Klein, 2018).

Professional Development

Historically, seat time and get the talk (sit and get) PD was used to attain new skills and certification. The teacher PD was limited to a locally available workshops offered by school districts, regional centers, and conferences. This method of PD does not give reliable changes in teaching practice that gives meaningful learning for students (Gamrat et al., 2014). Ball and Cohen (1999) add that a lot of money is spent on teacher PD in our school systems yearly, but most is spent on sessions that are often intellectually shallow. These sessions are frequently disorganized and disconnected from the curriculum and are unrelated to what teachers really need for their own classroom instruction. Wilson and Berne (1999) suggest that PD for teachers tends to be half-day or full-day events that are scattered, not well planned or coordinated over time. Therefore, they seem to be disconnected. Penuel et.al. (2007) offers that teachers perform more effectively with collaboration and results-oriented discourse.

According to Darling-Hammond et al. (2017), effective PD is structured professional learning that results in changes in teacher practices and improvements in student learning outcomes. Individual teacher perceptions of the value of PD make all the difference in the success or failure of a program of change (Harootunian &Yargar,1981). Yargar found that regardless of teaching level, teachers define their success in learning new teaching strategies in terms of their pupils' behaviors and activities, rather than in terms of themselves. Guskey (2002)

proposes that significant change in teachers' attitudes and perceptions is clear evidence of improvement in student learning. Teachers are more likely to value professional development that directly supports their instructional practices.

Many significant challenges and barriers exist to successful integration of STEM instruction for our youngest students, including primarily an underdeveloped teacher workforce (National Conference of State Legislators, 2019). Lack of specific content knowledge in STEM areas and how to teach these concepts is commonplace among pre-service and in-service teachers in the specific content areas of STEM, and especially in adapting them to the youngest learners (National Conference of State Legislators, 2019). STEM professional development and pre-service training can address these concerns if it is ongoing, intentional, reflective, goal-oriented, focused on content knowledge and children's thinking, grounded curriculum materials, and situated in the classroom (National Conference of State Legislators, 2019).

A common problem is inadequate funding to have PD providers and facilitators on a regular basis bring all participants together on collaborative sessions. A solution lies in the use of digital technologies which allow for online PD in groups or individually. Digital badging platforms allow easy access to PD (Martinez, et al., 2018).

Digital Badging Professional Development

In 2011, then-U.S. Secretary of Education Arne Duncan acknowledged digital badges as a significant education asset. In his remarks at the fourth annual launch of the MacArthur Foundation Digital Media and Lifelong Learning Competition, Duncan emphasized how all types of learners could benefit from digital badging programs. He discussed how digital badging could help teachers play a stronger role in their own learning and credential what they have learned (Loutfi, 2020).

Digital badging is a form of micro-credentialing that has become popular to motivate learning and tie achievement to observable tasks, activities, and skills. Online PD through digital badging can be personalized with opportunities for decision making and customized to help learners meet professional needs (Gamrat et al., 2014). Digital badges are stored and managed online. They certify learning in conventional and informal learning situations and could help change educators' views of where and how effective learning takes place (Texas Tech University, 2017). A digital badge recognizes, assesses, motivates, and becomes a visual symbol of ones' credentials (Otto & Hickey, 2014). Digital badges are verifiable, stackable, and portable for sharing across social media sites (Open Badges, 2022). Millennials are behind the major push for digital badging, and other forms of micro-credentialing in higher education (Zalaznick, 2016). Digital badges can facilitate an individualized learning pathway. This is crucial for professional learning development in STEM fields that are rapidly changing. Traditional PD may not be able to keep in step with these emerging trends, technologies, and practices (Fields, 2015).

Besides personalization and relevance, digital badges provide opportunities for collaborations and discussions relating to educational best practices that promote professional growth. Digital badges can also credential unique PD learning experiences (Finkelstein et al., 2013). Badges are earned based on learning evidence that shows teacher competencies. Therefore, teachers can collect and display the competencies they have developed for the course of their professional careers (Jennings & Roome, 2017). A barrier associated with digital badge usage is determining how to make them more authentic. They might not seem credible to potential employers who are more familiar with paper credentials, such as a certification from a recognized post-secondary institution (Glover, 2013). Abramovich et al. (2013) says that digital

badges may have a negative effect on learner motivation for some, but Finkelstein et al. (2013) claims that digital badging optimizes the reward pathways of the brain. These concerns are discussed more fully in the motivation theory section of this chapter.

NASA Educator Professional Development Collaborative (EPDC)

NASA EPDC is a transformative, diversity-focused educator professional development system with a national scope led by Texas State University (NASA, 2016). By supporting educators and institutions, NASA EPDC is a critical link in serving diverse audiences of educators with NASA high-impact approaches for STEM PD. It is an innovative, comprehensive, national network system grounded in educational theory and best practices (NASA, 2016). The NASA EPDC works closely with NASA to pilot and subsequently implement innovative PD like digital badging. They provide professional learning experiences and resources to thousands of educators per year (NASA, 2016).

Through NASA STEM EPDC Digital Badging, educators can earn badges as part of their ongoing personal professional development. The badges can be converted into continuing education units (CEU) and teachers can receive recognition from their employers and teacher licensure boards (Texas State University, n.d.-a).

In a pilot study conducted by NASA to determine teachers' perspectives of NASA digital badging professional development, educators reported that the badge program was worth their time and effort as part of their professional development (Colon Robles et al., 2017). The digital badges used for the pilot study required middle school (grades 6-8) educators and students to apply NASA real-world problems to classroom concepts.

Change Theory and Digital Badging

How change occurs in organizations, like schools, isn't often studied (Fullan, 1982). The participation and collaboration of groups of teachers from the same school, subject, or grade is related both to coherence and active learning opportunities. These in turn are related to improvements in teacher knowledge and skill and changes in classroom practice (Garet et al., 2001). All professional development relates to changing practices.

Kearney et al. (2012) offers that effective PD supports participant agency by offering multiple options easily connected to workplace and/or professional goals in a climate where teachers try new things. Professionals respond enthusiastically to exploration of content in collaboration with colleagues and they value shared in-depth study of content and processes relevant to their job assignment and particular interests (Shelley, 2008). Penuel et al. (2007) showed that teachers perform more effectively with results-oriented, collaborative discourse about content and pedagogy within a community of colleagues and experts. When PD is a vehicle for autonomous, professional collegiality grounded in authentic practice, it affords professionals' opportunities to learn new techniques, skills, and content (Penuel et al., 2007). Piaget (1959) described centering the educational experience around meeting the individual student's needs. Expanding technological advances have helped to lay the foundation for student-centered instruction and differentiated learning (Strunk & Willis, 2017). Digital badging programs could become important tools that provide personalized PD.

Motivation Theory and Digital Badging

Being able to display digital badges may induce competition among badge earners (Schenke, 2013). According to Muilenburg and Berge (2016), there is motivation from the instructional technology community to experiment with badges and develop platforms. Badging

is a form of micro-credentialing that has become popular to both reward learning and tie performance to observable tasks. Online PD, like digital badging, can give opportunities for decision making and personalization to help learners meet professional needs (Gamrat et al., 2014).

Stoll et al. (2006) maintains that professional learning is believed to be more effective when it is based on developing oneself and on what they need for their work. To understand the educational potential of badges requires understanding of how badges affect learning motivation. Motivation and assessment are networked with personalization and customization. Personal achievement goals and intrinsic motivation influences learning (Rawsthorne & Elliot, 1999).

According to Schenke (2013), the motivational impacts of badging have yet to be studied in a systematic manner. Abramovich et al. (2013) suggested that more work is needed to understand the motivation factor of badges through varied learning environments. Intrinsic and extrinsic motivation can play into this understanding. Intrinsic motivation originates from within an individual, while extrinsic motivation is characterized by an influence to learn from external sources (Ryan & Deci, 2000).

According to Deci et al. (1999), studies show that some people are less engaged with activities after receiving tangible rewards for performing activities. Much of the criticism surrounding badges is concern over intrinsic motivation being overcome by using badges as a form of extrinsic motivation. If students feel manipulated by the badges offered as rewards, it could create an adverse reaction (Deci et al., 1999). Frey (2012) references the concept of crowding out to describe intrinsic motivation being crowded out by extrinsic motivating factors. The motivation issue may be more complex that just one crowding out the other. Hickey (2012)

notes that the problem lies more in feedback and opportunity for improvement in traditional classrooms rather than just rewards.

According to B.F. Skinner (1950), rewards for a learning activity strengthens behavior, especially if the individual feels like they were rewarded or more accomplished from the incentive. Based upon operant learning theory, the use of rewards as an extrinsic motivation, such as stickers and grades, have been used to encourage students to learn (Skinner, 1950). Rewards may also motivate individuals to pursue more challenging tasks. Sociocultural views consider motivation in the context in which it operates (Goodenow, 1992).

Motivation can also be viewed first in terms of the social and technological context and only secondarily in terms of individual differences learners bring to those situations (Hickey, 2003). Vroom's (1964) expectancy theory of motivation works on perceptions. If an employer thinks they have provided everything applicable to motivate their workers, some workers still may not perceive it as an incentive. Vroom's expectancy theory of motivation is not about the rewards, but about the expected outcomes and the contribution individuals feel they can make. Skeptics of badges worry that students will focus on just accumulating badges rather than making connections with the concepts, skills and materials associated with the badges (Resnick, 2012).

Game Theory and Digital Badging

Game theory is defined as the analysis of a situation involving conflicting interests in terms of gains and losses (Merriam-Webster Dictionary, 2022b). Badges are engaging in part because they employ game mechanics to inspire collaborative competition (Jennings & Roome, 2017). Today's digital badges are web-enabled symbols of accomplishment that contain claims about achievement (O'Byrne et al., 2015). The practice of creating, rewarding, and sharing digital

badges has emerged as a means to motivate and reward student learning. Digital badges can show anytime, anywhere learning as students acquire credentials that actually measure skills, competencies, and achievements obtained in the classroom, workforce, and community (O'Byrne et al., 2015)

Insights from theory and practice suggest that badges do not always support learning from games. These general findings on external rewards in learning may suggest that the impact of badging could depend on the design of the badges. How well they are connected to the learning process is an important factor (Abramovich et al., 2013).

Ecological Theory of Development and Badging

Collaborative models, like the NASA STEM EPDC badging, that support the whole learning ecosystem, have shown to be effective for PD (Feder, 2017). These badging models include agency, networking, and deep knowledge creation. NASA STEM EPDC badging has the components of a learning ecosystem that works collaboratively to create a rich educational world (NASA, 2016).

Currently, in the context of STEM education there is an increased interest in concepts presented in Bronfenbrenner's 1979 ecological theory of development (Traill et al., 2015). As educators consider redesigning learning to become more student-centered, they must draw on our knowledge of how people learn and where people learn to design a system that more fully utilizes community assets, cultural institutions, technological and media resources. The 2012 National Research Council Report determined that out- of-school-programs and other informal learning settings are an important and growing part of the STEM education ecosystem in the United States (Feder, 2017).

Sociocultural Theory and NASA STEM EPDC Digital Badging

Cultural tools from sociocultural theory and three aspects of mobile learning; authenticity, collaboration, and personalization, are useful in viewing digital badging PD (Gamrat & Toomey Zimmerman, 2015). Knowles (1978) suggests that adult learning theory, andragogy, is also of importance to consider because PD is specifically aimed at adult learners. The core assumptions of andragogy are the learner's need to know, self-concept of the learner, prior experience of the learner, readiness to learn, orientation to learning, and motivation to learn (Knowles, 1978).

Authenticity and Digital Badging

Burden and Kearney (2015) describe authenticity as a mobile learning dimension comprised of two subcomponents: contextualization and situatedness. Contextualization is high when a learner is exposed to learning situations that are perceived to be realistic or relevant to their personal or professional life. When focusing on the specific PD badging activities that are relevant to the topics and grade levels that they are teaching, teachers create an authentic context for the badges available through the system. Situatedness is high when a badging learning experience is related to or within a community of practice (Burden & Kearney, 2015). This can be a full participation, such as engaging in activities and conversations with fellow STEM teachers or observing discussions of webinar participants.

Collaboration and Digital Badging

Borko and Putnam (1996) suggest that collaborative, nurturing, learning communities allow teachers to try new ideas, and reflect on outcomes. They can co-construct knowledge about teaching and learning in the context of authentic activity (Butler et al., 2004). This collaborative community of practice is similar to the work of Lave & Wenger (Matusov et al., 1994) that puts

learning as essential within a socially situated context. As noted by Butler et al. (2004) and colleagues, the collaborative model includes common goals within the local school setting.

Vygotsky and Cole (1978;1980) present the view that children learn by interacting with people and the environment in collaboration with their peers. Language is a social experience as they interpret the world and collaboration shapes their ways of thinking and learning. Jaramillo (1996) highlights Vygotsky's views concerning the influence of peers on each other and how important this peer interaction is for learning. Cultural tools can be language, artifacts such as physical objects like computers, or badging icons. Cultural tools are the set of resources available to members of a cultural group to mediate meaning-making (Gamrat & Toomey Zimmerman, 2015). Computers and digital badging platforms could address the prior critiques of ineffective PD and show what is possible through digital badging systems.

With the emphasis of socio-cultural considerations, cooperative, communicative, and collaborative efforts to support meaning-making are included in the Kearney et al. (2012) framework for mobile learning. According to Kearney et al. (2012), collaboration is included in this framework to permit learners multiple opportunities to articulate their understandings as they engage with others. Conversation provides for a valuable ongoing exchange of ideas that could support the development of STEM teaching practices and collaboration is meant to include the exchange of information between the learners and between the learners and mentors

Personalized Learning and Digital Badging

Kearney et al. (2012) refers to personalization as a concept that supports the just enough, just-in-time, aspect of mobile learning. Learners are able to create their own pathway of learning. Agency is high when a learner can make their own decisions about their education, such as what subjects to take and goals to set (Kearney et al., 2012).

Personalized professional development takes the notion of individualized instruction for students and applies it to teachers working within their specific teaching situations (Fuller,1969). In 1969, Frances Fuller implied that certain research findings supported the need for individualized instruction for students and future teachers. This shows the first suggestion of thought toward individualized teacher PD. In considering personalized learning for teachers, Fuller noted the importance of both student and teacher concerns. Fuller's concerns model suggests a need to consider both student and teacher needs, motives, abilities, and emotions at the beginning of instructional planning. Fuller (1969) further explained that teacher PD should be individualized for the concerns for each teacher. NASA STEM EPDC promotes personalized learning through digital badging (Texas State University, n.d.-a)

Bland County Public Schools STEM PD

According to Bland County Public School administrators and many teachers who participated in the Bland 2017-2019 STEM-UP program, the NASA STEM EPDC digital badging system has been a successful PD program for STEM-UP teachers in Bland County (Bland County Public Schools, 2021). Bland County Public Schools' STEM-UP is in its ninth year of the program. STEM-UP focuses on collaboration between school and community and provides students with a greater understanding of career fields related to STEM while enhancing critical thinking skills. The STEM program encourages students to work collaboratively to solve real-world problems while learning from STEM teacher and mentors from the community and enhancing family involvement through outreach programs. Bland County's STEM program, made possible by a local grant from the Wythe-Bland Foundation, is impacting STEM education in Bland County and serves as a STEM program model for many surrounding counties.

Bland STEM-UP program components:

After-School Enrichment: In the spring, students attend after-school STEM lessons twice a week for 90 minutes in a 9-week period. During 2017-2019, the Elementary and Middle School STEM-UP curriculum included lessons from NASA STEM EPDC digital badging in conjunction with other state and national curriculum.

1. Student Leadership Academy: Student leaders from grades 9-12 serve as volunteer student leaders during the After School Enrichment Program. They work one-on-one with STEM teachers to plan, prepare and present enrichment lessons.
2. STEMPOSIUM Night: STEMPOSIUM is an interactive event for parents, students, teachers, and community members to showcase what the students have learned and to learn more about STEM opportunities in Bland /Wythe counties.
3. Community Connection: Mentors from the community attend 75% of the after-school sessions and serve as co-teachers during learning activities. Engineers and other relative staff from a local power grid company assist in the development of STEM lessons for the program with a concentration on the engineering and design component of the program.
4. Summer STEM-UP Enrichment Camp: Students are provided the opportunity to attend a one-week STEM enrichment camp from 8:30 a.m. until 3:00 p.m. daily.
5. Summer Student Leadership Academy: Students in grades 9 through 12 serve as enrichment camp leaders. Students attend a job fair and interview for their desired position on site through a local business partner. Students chosen for summer employment with the STEM summer camp program receive both general

job training as well as paid training relevant to the summer enrichment program. These students will also earn one-hour credit through Wytheville Community College if they complete the NASA STEM EPDC digital badging session and the other components of training (Bland County Public Schools, 2021).

Professional Development

Teachers in Bland County are provided with PD in STEM activities geared at increasing authentic project-based learning activities in the classroom. Professional development is provided both by outside entities, such as NASA STEM EPDC digital badging and teachers within the system. Through embedding PD led by Bland County teachers, internal capacity, collaboration, and increased application of skill sets are delivered. Teachers have the option to take the one-hour college credit course that incorporates the NASA STEM EPDC digital badging system. This high-quality professional development, that includes the NASA STEM EPDC Digital Badging, is important to the overall success of their STEM-UP program.

The teacher training is provided at least two weeks before the June summer camp to teach specific STEM concepts and skills as well as other lessons that will be taught in the summer camp. Each year the student STEM-UP summer camp has a different STEM theme, such as rocketry. Specific STEM concepts that align with the lessons, such as Newton's Laws of Motion, are taught to teachers for implementation in the summer camps. The NASA STEM EPDC Digital Badging program provides online lessons for PD that is designed to teach these specific concepts and skills for specific STEM topics.

Summary

This literature review examined existing literature surrounding teacher perspectives of PD with digital badging as a pedagogical tool for PD, and theoretical constructs for better learning. Bronfenbrenner's (1979) ecological theory organizes the theories and digital badging strategies that were presented in this review, into a broad multilayered contextual view of teacher education.

According to Muilenburg and Berge (2016), there is certainly motivation from the instructional technology community to experiment with badges and develop platforms research at multiple levels, using a range of methodologies. More in-depth research is needed to better understand the conditions and effective practices that undergird robust learning ecosystems (Traill et al., 2015).

CHAPTER 3

METHODS

The main purpose of this study was to investigate and examine the perspectives of Bland County Public School teachers who have participated in NASA STEM Educator Professional Development Collaborative (EPDC) Digital Badging PD. This digital badging was offered through the Bland County Science, Technology, Engineering, and Math Unlocking Potential (STEM-UP) program. The applicability of a qualitative study with a case study approach for this research is discussed in this chapter. The research plan, including methodology, study participants, context of the study, procedures, analysis method, and ethical concerns are also discussed.

Research Design

This qualitative, holistic, case study, focused on investigating and understanding teacher perceptions of the NASA STEM EPDC Digital Badging System by conducting interviews with educators that have participated in the NASA STEM EPDC digital badging through the Bland County Schools STEM-UP program. According to Stake (2006), a qualitative study is appropriate when the research goal is to explain experiences by relying on the perception of a person's experience in each situation.

Educational research has used case study methods for decades to evaluate curriculum design (Merriam & Tisdell, 2015). Case study methods used to study curriculum could be used to investigate participants' perspectives as well as the influence of socio-political factors (Simons, 2009). Case study research in education focused on determining the impact of learning programs and semi structured interviews to provide evidence for educational policy and practice (Simons, 2009).

Constructionists claim that truth is relative and that it is dependent on one's perspective. Yin (2018) provides a constructivist's approach to case study research regarding case study methods, such as gathering multiple sources of evidence with data, and using theoretical propositions to guide data analysis and collection. Yin (2018) also suggests researchers make use of evidentiary sources such as documentation, archival records, interviews, and physical artifacts. These procedures aided the researcher in gathering useful data and understanding data through various perspectives.

Population and Participants

The population for this study consisted of K-12 teachers from Bland County Public Schools, a rural Southwest Virginia school system with two schools: a middle/high school (BCHS) with approximately 383 students, and an elementary school (BCES) with approximately 347 students. For this case study, 18 K-12 teachers and one educational paraprofessional met the study inclusion criteria. Inclusion criteria requires teacher participation in the Bland County Public Schools STEM-UP program, completion of at least one NASA EPDC digital badging training session from 2017-2019, teaching students during a week-long STEM-UP summer camp and earned at least one digital badge through the NASA STEM EPDC Digital Badging System. Participants were recruited through emails and phone calls and were asked to give verbal consent for an interview. Of the 19 eligible participants, 10 volunteered to participate in an interview.

Data Collection

Before data collection, approval from the Institutional Review Board (IRB) was sought from Marshall University. Once approval was given, the researcher contacted possible participants through the contact information forms filled out by participants during the STEM-UP PD sessions throughout the 2014-2019 academic years. The researcher for this study was the

instructor for the Wytheville Community College course that aligned with the NASA STEM EPDC Digital Badging PD and STEM-UP teacher training for 2017-2019.

Two forms of data were used to inform this study: archival data and semi-structured interviews. The first form of data are archived post survey responses from the STEM-UP 2019 program teacher evaluations collected after the summer STEM-UP camp. With permission from the STEM-UP program director, the survey responses were compiled by lead teachers and the researcher, who at the time was a STEM-UP lead teacher and later became the facilitator for the NASA STEM EPDC Digital Badging part of the program. Teachers expressed their opinions in these surveys and STEM-UP instructors and the STEM-UP director reviewed the data to understand how the teachers viewed certain aspects of the overall program, including NASA Digital Badging. STEM-UP program leaders often made improvements on the STEM-UP program with consideration of the teachers' perspectives.

The second form of data was collected through semi-structured interviews. Bernard (1988) believes that semi-structured interviews are best used when you will get more than one chance to interview someone. As described in the Qualitative Research Guidelines Project (Cohen & Crabtree, 2006), semi-structured interviews can give reliable, comparable qualitative data. Interviews took place online using Microsoft Teams. The semi-structured interview method for this research consisted of open-ended questions that yielded in-depth responses about teacher's perceptions, experiences, opinions, feelings, and knowledge as they experienced the NASA STEM EPDC Digital Badging PD. Semi-structured interviews can generate data that gives a view into the participants' experiences, perceptions, or opinions (Peters & Halcomb, 2015). Data included verbatim questions with enough contextual information to be

understandable. All data was transcribed and coded to explore themes that emerged from the research.

The semi-structured interviews were guided through open-ended questions that were written in a predetermined sequence and the questioning method was consistent in each interview. Each participant was asked the same set of questions so the data could be compared. At times, a probing question was asked to obtain additional information. The researcher wrote memos and recorded participant responses throughout the interviews. In The Qualitative Research Guidelines Project (Cohen & Crabtree, 2006), it is suggested that interviews should be recorded and transcribed for later analysis because open-ended questions from semi-structured interviews, and comments or questions from participants, may diverge from the interview guide.

The interview questions began with demographic questions about the participants' years of teaching experience, subject, age groups they have taught, and their previous experience with digital badging. More open-ended questions followed to gather better views of each teacher's individual perceptions. The interviews ended with more open-ended questions, regarding participant views of the NASA EPDC Digital Badging for STEM PD. Open-ended questions require the respondent to elaborate on their response so the interviewer gains a better view from the teachers' perspective. The open-ended questions allowed for flexibility during the interview while the interviewer followed a predetermined interview structure.

See Appendix B for the interview protocol that includes the questions asked during the teacher interviews. Table 1 shows the relationship between the study research questions and the interview questions.

Table 1

Research Questions concerning NASA STEM EPDC Digital Badging and Correlations to Interview Questions

Research Questions	Interview Questions
1. What are the teachers' differences, if any, based on selected demographic factors such as years of teaching experience, teaching specializations, and prior badging experience, in teachers' perceptions of the value of the NASA STEM EPDC digital badging program?	How long have you been teaching? What subject and age groups have you taught? What are your previous experiences with digital badging for professional development? Describe your level of comfort and abilities when using online technology.
2. What are teachers' perceptions of educational advantages that cause them to persist in the NASA STEM EPDC Digital Badging Program?	Describe the badges you have earned and your experiences while earning them. Do you plan to earn more? Describe your experiences with the process of working toward digital badges that you started but didn't complete. Why didn't you finish all required lessons to earn the badge? What could be done to better support your learning through each step to badge completion? The digital badging lessons are aligned with the Virginia Standards of Learning. In your view, how well does the NASA badging content fit into the SOLs that guide your curriculum? Digital badges can document your professional development and provide a pathway for continued professional education. How have you used your NASA STEM EPDC digital badging experience to show your learning path? How has it moved you toward your PD goals?
3. What are the teacher's perspectives of the educational value of the NASA STEM EPDC Digital Badging Program for personalized learning?	How do you view the digital badging as a program for personalized learning? Other than the badge earning, how have you used the digital badging online site as a resource for your classroom? How did the digital badge earning process encourage you to learn more STEM concepts and skills? What part of the badging program was motivating? What part of the program did not inspire you?

Research Questions	Interview Questions
4. What are teachers' perceptions of successful NASA STEM EPDC Digital Badging Program classroom strategies that were useful in their own classroom and how the NASA STEM EPDC digital badging system could improve other STEM programs?	What parts of the digital badging professional development have positively affected your STEM teaching in your own classroom and boosted student learning? In your opinion, what parts of the program could be used to improve less successful STEM PD programs? How would you describe the digital badging experience compared to other professional development experiences? The digital badging program was designed to deepen your STEM subject knowledge and provide successful teaching strategies. After the PD, how prepared were you to implement the hands-on activities and expanded inquiry approaches, compared to your previous abilities? Student achievement is the ultimate goal of any professional development. Due to your participation in the digital badging PD, how well prepared were you to teach the science concepts related to the topics in STEM in your own classroom? How did it affect student learning? Please give an example.
5. What are the teachers' perceptions of how interacting with components of the digital badging program, that required ongoing practice with STEM concepts and skills, affected the STEM learning community ecosystem in Bland County?	How does digital badging PD fit into the Bland STEM-UP learning ecosystem and the unique culture and community of teacher learners in Bland County?

Pilot Study

To understand the feasibility of the processes that are key to the success of the study, the researcher conducted a pilot study. The pilot study focused on; reactions of the respondents, appropriateness of the study type and research tools, format and wording of the interview questions, time needed, feasibility of the sampling procedure, and data processing. For the pilot study, the researcher worked with two education specialists that were familiar with NASA STEM EPDC Digital Badging: the Bland County Public Schools Supervisor of Special Services/STEM-UP director, and an educator professional development specialist at NASA Goddard Space Flight Center. The researcher used their suggestions to adjust interview questions and protocols.

Data Analysis

Lincoln et al. (1985) believes that trustworthiness of a study is important to evaluating its value. The trustworthiness of qualitative data analysis is often presented by using terms such as authenticity or credibility. Patton (1999, p.1190) provided criteria for assuring credibility in qualitative studies:

1. The researcher should use rigorous techniques and methods for gathering high quality data.
2. Data should be carefully analyzed with attention to issues of reliability, validity, and triangulation.
3. Credibility of the researcher's training and experience, track record, status and presentation of self is important.
4. Analysis should be creative, yet methodical.
5. Sufficient detail should be reported to allow others to judge the quality of the resulting product (audit trail).

Interviews

During the interviews with participants, the researcher took notes and digitally recorded the teacher's answers and any other comments. After the interviews, transcriptions were emailed to each teacher participant. Participants were asked to validate and to review transcripts for correctness. The participants were asked to add comments to the interview transcripts, if necessary. This ensured that categories and themes that emerged from the interviews were verified and clarified by the interviewer.

Coding

After the interviews, specific procedures were used to analyze the qualitative data. Transcripts were coded to ensure the collected information was anonymous, organized, and confidential. In qualitative analysis, a code could be a word or phrase that captures a quality or aspect of the data (Saldana, 2021). Deductive coding is recommended when the framework and research questions suggest that certain themes or concepts are most likely to appear in the data (Saldana, 2021). The coding can be reviewed for emerging themes, pattern detection, categorization, and other means of analysis. As described by Saldana (2021), data were coded in the following way:

1. Begin with a predefined general set of codes from the interview questions and determine a hypothesis.
2. Analyze the data from interview responses and archival data.
3. Perform line by line coding of data and pattern detection.
4. Categorize the topics and ideas.
5. Determine the emerging themes and re-organize.
6. Determine if the original hypothesis was supported or not.

Categories were developed and themes appeared from the coded data. Saldana (2021) explained that coding decisions are driven by what the researcher needs to explore, learn, and discover. The researcher would use systematic and creative analysis with codes or themes. Coding systems were considered before data collection began, while new codes were added, and classifications were re-organized throughout the data analysis process (Saldana, 2021).

Limitations of the Study

This case study involved a small population of Bland County Public School teachers who participated in the STEM-UP 2017, 2018, 2019 program training and earned at least one NASA STEM EPDC digital badge. Only 18 teachers and one educational paraprofessional completed at least one digital badge and met all the study criteria. Ten teachers from that group of 19 volunteered to be interviewed and they became the study group. Some of the teachers who received the NASA STEM EPDC Digital Badge program training were more motivated to access resources and other training concerning the digital badging lessons. Therefore, implementation of lessons and understanding of the digital badging program vary greatly from teacher to teacher.

CHAPTER 4

DATA ANALYSIS

This study was designed to explore and examine the experiences of teachers who have experienced NASA STEM Educator Professional Development Collaborative (EPDC) Digital Badging. This initiative was part of the Bland County, VA, public schools' STEM-UP 2017-2019 summer PD. The research focused on teachers' perceptions of the NASA Digital Badging system as a model of personalized professional development. The purpose of this chapter is to describe the participants of the study along with their experiences and perspectives of NASA EPDC Digital Badging. This chapter presents the interview questions and analysis of participant responses along with the analysis of participant responses from the 2019 STEM-UP archival survey data.

Participants

While the STEM-UP teacher summer training began in 2014, the NASA STEM EPDC Digital Badging was fully incorporated into the STEM-UP summer camp professional development in 2017, 2018, and 2019. Over those three years, 19 teachers experienced the NASA digital badge training, earning a total of 41 badges with seven different badge titles.

The criteria for inclusion in the study required teachers who were part of the group of nineteen K-12 teachers who participated in the Bland County Public Schools STEM-UP program, completed at least one 2017-2019 NASA EPDC digital badging training session, taught students during a week-long STEM-UP summer camp, and earned at least one digital badge through NASA STEM EPDC Digital Badging.

The teachers were contacted by email and were asked if they would agree to be part of this research study on NASA digital badging. Those that agreed became the 10 participants for this study.

Instrumentation

The 16 questions on the interview instrument were derived from five research questions developed from the 2017-2019 STEM-UP Teacher Post Surveys. For more in-depth understanding on each research question, the interview questions focused on specific topics of interest. These topics arose from literature on digital badging in education, the questions and discussions of lead Bland STEM-UP teachers, and from the pilot study for this research.

There were five major categories of questions included from the Bland County STEM-UP teacher interview protocol. The first segment comprised questions on demographics related to teaching experience, specializations, previous badging experience, and comfort and ability to access online resources and contains interview questions 1, 2, 3 and 4. The second segment included questions about the educational advantages that cause teachers to persist with the NASA digital badging program and contains interview questions 5, 6, 7, and 8. The third section asked about their views of the program as personalized PD and as a resource for their classroom, and contains interview questions 9,10, and 11. The fourth segment addressed how the teaching strategies were used in the classroom and how they could be used to help less successful STEM programs and contains interview questions 12, 13, 14, and 15. The fifth segment asked about how the digital badging concepts and methods fit into the culture and learning ecosystem of Bland County STEM-UP and contains interview question 16.

The archival data consists of post survey questions and the responses of the STEM-UP teachers on their 2019 summer camp training post surveys. The Bland County Public Schools

superintendent and the county STEM-UP director granted the researcher access to this data, giving the researcher permission for use of these post surveys and teacher responses as part of the research study. To conduct an interview with the STEM-UP teachers, permission was granted to the researcher by the school district superintendent and the STEM-UP director. Questions and responses from the post survey archival data were used to inform this study.

Data Collection

All interviews with the ten participating teachers were conducted in August-December 2021. Due to COVID-19 restrictions, Microsoft Teams (online platform) was used to conduct the interviews as well as to record and transcribe the session. Each interview started with obtaining consent and providing the participants with information about the study, per the IRB protocol. All participants were told they would be recorded. The interviews included predetermined questions (see Appendix B). The archival data was given to the researcher both as paper copies and online through personal email. The 2021 interview responses and the 2019 archival data were organized into themes that emerged from the data.

Data Presentation and Analysis

The presentation of the data and analysis that follows is organized by the interview questions and how they relate to the study's research questions.

Research Question 1. What are the teachers' differences, if any, based on selected demographic factors such as years of teaching experience, teaching specializations, and prior badging experience, in teachers' perceptions of the value of the NASA STEM EPDC Digital Badging program?

Interview Question 1*. How long have you been teaching?*

To understand STEM teacher experience in the classroom on interview question one, participant responses were coded under years of experience. Based on the participant responses, the span of years of experience was from three to 33 years with half of the teachers having more than 10 years of experience.

Interview Question 2. *What subject and age groups have you taught?*

To understand teachers' perceptions concerning subject and age groups on question two, teacher responses were coded under "8-12 science only, K-12 science or math and various other subjects, subjects other than science or math 7-12." Based on participant responses, one teacher taught 8-12 science only, eight teachers taught multiple subjects including science and math K-12, and one teacher taught subjects other than science or math 7-12.

Interview Question 3. *What are your previous experiences with digital badging for professional development?*

To analyze teacher perceptions on question 3, participant responses were coded under "no previous experiences with digital badging for PD" and "had previous experience with digital badging PD." Based on teacher responses, seven teachers had no previous experience with digital badging, game-based learning, or micro-credentialing for PD. Three teachers had some previous experience with digital badging with micro-credentialing through online college courses or game based professional development. Participant 3 described his experience with online game-based learning for a college course as, "Like the game-based learning, it was a game changer" and he added that, "Students would do a lot to earn a badge."

Interview Question 4*. Describe your level of comfort and abilities when using online technology such as digital badging.*

To analyze the teacher perceptions on interview question four, teacher responses were coded under "not comfortable, comfortable, or very comfortable" with online resources. Teacher responses showed that two teachers did not feel comfortable, four teachers felt comfortable and four felt very comfortable with online technologies. Participant 2 described her comfort level and as, "It's better now after Covid than it was before, because I was kind of forced to." Participant 9 said she was limited, "I'm not very tech savvy. It helped me become tech savvy a little bit more. It helped me understand the process better."

Participant 8 said, "Honestly, I didn't grow up with technology, so I'm a little skittish about it. I'm just comfortable with the technology I use in my own classroom because I don't have enough experience. I know the Smart Board that we have will do way more than what I use it for. And I have asked a few times to maybe having training on it. But they have it and it's just one meeting and they zoom through it because they know what they are doing, not realizing that some of us over here don't know the ins and outs of what they are saying, the vocabulary and stuff."

Participant 6 said "I love technology. I use it just about every day in the classroom and doing the digital badging on the computer wasn't too hard for me." Participant 3, who felt very comfortable with technology said, "Well, I think a lot of that is because I started teaching in Bland County and it is volumes ahead of other counties when it comes to using Google and other online platforms."

Research Question 2. What are teachers' perceptions of educational advantages that cause them to persist in the NASA STEM EPDC Digital Badging Program?

Interview Question 5. *Describe the digital badges you have earned and your experiences while earning them. Do you plan to earn more?*

To understand teacher experiences as they earned the digital badges, teacher responses were coded under "useful learning experiences" or "not a useful learning experience" and their plan to earn more was coded under "plans to earn more" or "doesn't plan to earn more." Seven teachers describe their badge earning experience as useful learning experiences. Three teachers did not respond to that part of the question. Participant 8 said, "I mean it was challenging at times. You know, it helped me, and it stretched me as a teacher." Participant 7 said, "Experiences were fine. The only thing problematic was the feedback required from someone else because there would be a lag in feedback from NASA. Other than that, it was pretty easy, with the exception of that."

Eight of the teachers said they plan to earn more badges. Two teachers did not respond to that part of the question. Teachers that planned to earn more badges mentioned recertification points as a motivating factor. Two of those teachers said they did not know they could do more on their own, but they would like to earn more badges if they offer recertification points.

Participant 6 said, "I know with the solar eclipse one, it gave me more insight to teach my students at that time a little bit about the solar eclipse, since it was happening." Participant 6 plans to do the water cycle and the force and motion badges on her own because, "It fit a certain SOL and it would be a local way to teach the students." Participant 3 said," I think it would be great for non-science teachers teaching STEM."

Participant 1 said, "I found it useful because I could use those lessons in my regular classroom. I may not have remembered or may not have completely understood when you told us we could do them (the badges) on our own later or I would have tried to see what else I could do. What other lessons would I have liked to have completed myself. I guess it would be a badge dealing with the current Sci-Tec program, like dealing with drones or robots and how they are

used. Or on space missions, or NASA in general, whether they are here on Earth or on another planet for instance. That would probably be more beneficial so that I can give that info to my students as they learn how to use the drones and the robots in my classroom? What are their badges? I may have missed that originally." Participant 2 said, "I like Mars, studies on Mars. Now that seems to be the new flavor of the week. When I was small child, we studied Mars. What do we know now that we didn't know then? I would be interested in some of the developments and badge possibilities, and I think the thing about Mars is that, it is what's next."

Participant 10 said, "I didn't know you could earn them on your own. I thought it was just through our STEM part. That would be great to earn more badges together as a group. It is nice to be able to have other people whenever you do things like that because you get to collaborate on things. You know it's like in my college course, you get to talk about them and see different points of view."

Participant 2 said, "The thing about badging is that it's kind of like jewelry. It should complement, but maybe it shouldn't dominate. It shouldn't be the only thing, but it should be a piece of the attire, I guess." Later he added, "I tell the kids all the time that you can be anything you want to be nowadays as long as you have a good computer and a good Wi-Fi connection, Now, they have more opportunities with this program than when I was their age."

2019 Archival Data STEM-UP Post Survey Question 5. *What topic of STEM would you like to explore in our program?*

To understand teacher responses to question 5, the topics were categorized into themes. Teacher 1 said, "I think we should continue to implement technology through robotics, coding, etc." Teacher 2 said, "Oceans, fish, marine life, etc." Teacher 3 said, "More about various careers of STEM" Teacher 4 said, "Space exploration" Teacher 5 said, "Math" Teacher 6 said,

"Technology in various forms" Teacher 7 said, "Topics dealing with the ocean" Teacher 8 said, "I feel like we have done a good job covering a lot of topics."

Teacher 9 said, "I greatly enjoyed this summer's theme and last summer's theme. Maybe incorporating drones in our program again." Teacher 10 said, "More science related topics that I can use in my first-grade classroom. I can use them as a way to encourage my students to do summer STEM." Teacher 11 said, "I would like to have students explore the impact and irresponsible practices on our environment and how to improve in simple ways." Teacher 12 said, "Environmentally sustainable farming and preservation of ecosystems in Appalachia"

Interview Question 6*. Describe your experiences with the process of working toward digital badges that you started but didn't complete. Why didn't you finish all required lessons to earn the badge? What could be done to better support your learning through each step to badge completion.*

To understand teacher experiences on question six, teacher responses were coded under "Didn't start any badges that they didn't complete" and "started a badge but didn't complete it." All ten teachers completed the required badges, but Participant 6 completed more than the required badges and said, "It kept me really interested and I always wanted to see how it turned out." Two teachers felt that time was a factor as to why they didn't even start more badging and two other teachers said they didn't know they could do them on their own.

Participant 7 suggested that to better support teacher learning to each step of completion, "NASA needs to possibly improve their response time because some wanted to move quickly but couldn't." Five of the teachers mentioned learning together in a class because it is easier to solve problems when working in teams.

Interview Question 7. *The digital badging lessons are aligned with the National Education Standards and some Virginia State Standards of Learning. In your view, how well does the badging content fit into the SOLs that guide your curriculum?*

To analyze teacher views on interview question 7, teacher responses were coded under "aligned well with my SOLs" or "did not align well with my SOLs." Nine teachers felt it aligned well with the SOLs that guide their curriculum. Participant 4 said, "I think they follow along quite well with what I was doing. In elementary there are different SOLs in different grades, but they do apply to the elementary curriculum across the grade levels."

Participant 10 said "It would have fit in very well because the SOLs are very heavy on the scientific method, carrying out those, making hypothesis, and then being able to actually carry out the experiment plays into the SOLs in an interactive hands-on way." Participant 2 who teaches civics and history, said, "It didn't directly apply. So, there's always crossover if you are asking me how this particular program would be. The eclipse lesson affected my SOLs directly. It did because I teach social studies, but it fit indirectly through critical thinking."

Interview Question 8. *Digital badges can document your professional development and provide a pathway for continued professional education. How have you used your digital badging experience to show your learning path? How has it moved you toward your PD goals?*

To understand how teachers used the experience for their learning path and PD goals on interview question 8, responses were coded under, "provided a pathway for continued PD," and "moved you toward your PD goal for re-certification points." Based on teacher responses, five teachers said it moved them toward their PD goals of earning re-certification points. The other five teachers commented on how it helped with their learning pathway. Participant 9 said, "It gave me new ideas and new ways to teach

information to students. I want to do more. I'm working toward my master's degree, and it pushed me for my own education. The badging made me realize there's more to learn and I wanted to not stop there." Participant 8 said, "It gives me a different perspective on teaching, that teachers should learn, when they are teaching or not teaching."

Research Question 3. What are the teachers' perceptions of the educational value of the NASA STEM EPDC Digital Badging Program for personalized learning?

Interview Question 9. *How do you view the digital badging as a program for personalized learning?*

To understand teacher perceptions of the value of the badges for personalized learning on question 9, teacher responses were coded under "Perspectives of the value of the badges for personalized learning." All ten teachers were very different on their perception of personalized learning, but self-paced learning and being able to pick and choose the lessons were frequently mentioned as important factors. Participant 9 said, "I think it made me think outside the box. How it wasn't a conventional way of teaching." Participant 2 said, "But, what place the learning comes in for me is we do something, I become curious, so I either ask you, or I Google it or research it. So, for me the learning comes from the spillovers."

Teacher 7. said, "So, it is self-paced with the exception of having something that needs a response or feedback from some else. So, if I want to move quickly, I can go through it quickly. If I want to take my time and really pour over it and study it, I can do that as well." Participant 10 said, "I think that particular badge helped with interest-based learning and so it gave me the background knowledge to be able to share information with the kids, but in a really exciting way. It keeps me wanting to actually look more into certain aspects of what it's talking about. And we have, you know, experts communicating directly with us too."

Interview Question 10*. Other than badge earning, how have you used the digital badging online site as a resource for your classroom?*

To analyze teacher perceptions on interview question ten, teacher responses were coded as "Used the badging online site as a resource" or "Did not use the badging online site as a resource." Three teachers went back to the online site as a resource other than digital badge earning. Participant 5 said, "I have used it to get information or instructional videos to show the students in class, or for after school STEM." Participant 4 said, "I have gone back to the site several times looking for resources and activities to use with some of my kids in an academic enrichment gifted program." Participant 7 said, "It works fairly well. Of course, last year our pull-out program was on hold due to COVID and everything, but when I did use it, they were very receptive to the resources and activities that were included." One of the seven participants who did not use the online site as a resource, Participant 7, said, "I haven't used it as an online resource because of the craziness due to COVID during the past year and a half." Two of the participants mentioned that they would go back to the site for resources, if they taught lessons on certain badging topics.

2019 Archival Data STEM-UP Post Survey

Question. *Comments or questions?*

Teacher 6 said, "STEM is a great program and I'm very honored to be part of it. Watching the faces of the students when they "get" the result is so rewarding as a teacher." Teacher 8 said, "I thoroughly enjoy STEM." Teacher 10 said, "Great experience!" Teacher 11 said, "The STEM program implemented in our school is so beneficial for our students and gives them a further understanding of standards taught in the classroom. There are few improvements that I can see and hope this program continues to last."

Interview Question 11. *How did the earning process encourage you to learn more STEM concepts and skills? What part of the badging program was motivating? What part of the program did not inspire you?*

To analyze teacher perceptions on question 11, responses were coded under, "What part was motivating?" or "What part of the program did not inspire you?" According to the participants' responses, the motivating parts of the digital badging program included; getting to choose the activities, it was interesting to them, and made them want to learn more, they gained the knowledge to teach a particular STEM session, they liked the projects and the activities, it gave them a lot of information from a credible source, helped with concepts and skills, and they liked the hands-on and going outside for teaching about the rockets. Participant 10 said. "The part that was most inspiring was probably having the chance to be confident with the materials, because if some of those things were put in front of me, cold turkey, I would be too nervous to use them." Participant 7 said, "The process itself can be motivating, cause you want to get that badge. So, it is kind of nice, kind of a feather in your cap, to say that you have something from NASA. The only thing I would improve with the NASA Digital Badging is what I've said previously, response rate. I hate to say eliminate those components altogether, but that would be an option if the feedback time is not expediated."

A few participants described features of the badging that were not inspiring to them. One teacher said, "The directions, all the directions, could be a little bit clearer. There were a million steps involved in this that we had to put together." Participant 7 said, "Again, the only part that didn't inspire me is the feedback, the delay in the feedback." A few teachers said it was a lot of work. Participant 10 said, "I remember the site that we were on. Well, if I had to navigate that by

myself, I would be discouraged, and to be relatively technology savvy, I just kept getting lost where I was supposed to be, or if I had skipped a step, or something like that."

2019 Archival Data STEM-UP Post Survey Question 2. *In your opinion, of what value are the badges and certificates as motivational tools for student learning and/or teacher training?*

To understand teacher perspectives, teacher responses to question 2 were coded under, "value of badges of badges as motivational tools for teacher training." Teacher 2 said, "For teachers, I don't think they're that motivational. However, I think the students really enjoy collecting them." Teacher 3 said, "Students enjoy working towards something and having something to show for it. The online badging for teachers seems like the time to complete it could be better placed elsewhere."

Research Question 4. What are teachers' perceptions of successful NASA STEM EPDC Digital Badging Program classroom strategies that were useful in their own classroom and how the NASA STEM EPDC digital badging system could improve other STEM programs?

Interview Question 12. *What parts of the digital badging professional development have positively affected your STEM teaching in your own classroom and boosted student learning? In your opinion, what parts of the program could be used to improve less successful STEM PD programs?*

To analyze teacher responses to interview question 12, responses were coded under "Parts of the program that positively affected your STEM teaching and boosted student learning" and "Parts that could be used to improve less successful STEM PD." Participant 4 said, "I've used those (NASA badging sites) within my own classroom to extend their knowledge for the SOL and to provide extension activities for gifted students who might want to take it further. The program could be used for any STEM program and would make that more successful because the

content is so solid and reliable. They have really good resources. And it can give your teachers who may not be as familiar with those subjects or concepts, a lot of information and make them feel like they can come into the classroom and be an expert on it because they have worked with the, again, credible source, NASA."

Participant 2 said, "I don't want to say routine, but there is a stability factor there, that the same teachers are going to do it. It's all there, always going to be there, and they're going to be passionate about it, and they're going to sell it and they're going to teach STEM. It sells itself with that." He added, "They don't make up training with the badges about what we had, it was mandated that we had it beforehand. We had already done it, so we knew which one we were going to be passionate about." He continued to say, "So, we knew that type of children, we knew what their interests were, and we can almost tailor make it to fit Bland County."

Participant 3 said, "It showed me how important the hands-on learning was, and then especially if we could take them outside. If you could do it outside, you'll get a lot better engagement." Participant 10 said. "We did do a lot with the scientific method, and so really breaking it down instead of rushing through it and telling kids to pay attention to you, to predict what is going to happen. It helped me slow down and think about how to do that in the following year, even with the little kindergarteners."

Participant 4 said," I would say STEM programs that have difficulty determining a direction or actually, maybe just a curriculum or activities to do, that would be a good place to start just to get their feet wet. There's tons of resources and the digital badging to help get the teachers some training and knowledge that may not have, you know, and just transfer that into their program and hopefully find a way to be successful." Participant 9 said, "It brought them together and put them on the same page where they were struggling to learn together, as well as

encourage and push each other. If they didn't have the support system, that was in play, our STEM program wouldn't be as big as it is." Participant 6 said, "It promotes the teachers to see what works for adults and communication is important."

Participant 3 said, "There was something another county did that I thought was cool. They had professional development opportunities that were available each month. We did it for free, all through Google Classroom. I'm more likely to do PD online than one I had to attend in person. I have been super busy teaching full time." He added, "I think the successful STEM programs, like with the Bland STEM program, you had the materials in a box. Some teachers are too busy to go out and buy what they need, or there's not the funding there, or they don't want to spend the hour in the evening collecting the leaves. I think if you put it all in a box with your activities, you will get a lot more people to do what they wouldn't do otherwise."

2019 Archival Data STEM-UP Post Survey 3. *In your opinion, what has been the overall impact of our STEM-UP program for students?*

To analyze teacher views for question 3, responses were coded under, "Little impact on students," or "major impact on students." Teacher 1 said, "Students are engaged in not only learning but learning to think and solve problems." Teacher 2 said, "I think it gives them new experiences as well as teaching them new things." Teacher 3 said, "Many students are getting interested in STEM careers who wouldn't have the exposure to those careers without STEM."

Teacher 4 said, "Encouraging you to think outside the box" Teacher 5 said, "A very positive one." Teacher 6 said, "I see great impact for all students, but I also see students finding their talents through STEM. The program is awesome and a great gateway to open doors for students who otherwise would be left out." Teacher 7 said, "Students get excited about science. They get an understanding that science and math can be fun, and they start looking forward to

them." Teacher 8 said, "Students have gained confidence and experience problem solving tasks they may not have participated in otherwise."

Teacher 9 said, "It is an excellent opportunity for students, and I hope it continues year after year. Those that participate in the program look forward to it each year. Many of the younger students said they were excited for next school year or summer so they could do STEM again." Teacher 10 said, "It encourages students to explore the different areas covered in STEM. They tell other students and get them excited." Teacher 11 said, "Students get a small group session with teachers on topics of interest. They also get more individualized attention on tasks which assists them in retaining the main ideas and themes." Teacher 12 said, "It has allowed students to love science, they learn more and even surpass their peer's abilities to go further. I think it also serves well as a public relations tool because the students have fun and thus have positive associations with STEM materials."

Interview Question 13. *How would you describe the digital badging experience compared to other forms of professional development What would improve your digital badging experiences?*

To analyze teacher perceptions on interview question 13, teacher responses were coded under, "Digital badging experiences compared to other forms of PD" and "What would improve your badging experiences?" Teacher descriptions of other forms of PD were often negative, such as: it was like pulling teeth, they dreaded it, you are stuck in a cafeteria somewhere with people talking at you, you are just an active listener for 45 minutes, it was just telling and showing not doing, or it was just posting to a conversation board. Two participants mentioned some features of the badging that they considered to be a problem. Participant 7 mentioned that the response rate from the NASA experts was too slow. Participant 10 said, "I needed the badging process broken down more because I had trouble going from one module to the next."

Overall, the teachers' perceptions of the digital badging PD were positive. Participant 2 said, "It was much more entertaining. It kind of brought the child out of you. You know what I mean, it was cool." Participant 3 said, "It was a self-paced service from a reputable organization and that is an important part of PD." Participant 4 said, "I would say that compared to traditional PD, the badging program is probably exceptional in the fact that you are choosing what you want to learn and at your own pace."

Others said it was more hands-on and rigorous, the teachers get to participate, and there is discussion time and collaboration. Participant 10 said, "It was a bit more engaging. They wanted to know your thought process a little more than some professional developments. You were concentrating on your end thinking."

Interview Question 14. *The digital badging program was designed to deepen your STEM subject knowledge and provide successful teaching strategies. Due to the digital badging, how prepared were you to implement the hands-on activities and expanded inquiry approaches, compared to your previous abilities?*

To understand the teacher experiences in question 14, teacher responses were coded under," Prepared to implement" or "Not prepared to implement." All ten teachers felt they were prepared to implement the hands-on activities and expanded inquiry approaches. Participant 2 said, "Sure, because again I had to go through the program myself and practice it. Yeah, it was almost like I made an assignment for my students and then took this and did the assignment myself to see how it would work. And I think that is a very important process." Participant 9 said, "The training made the difference, I guess is what I felt like. I was very prepared when the students came in. It was helpful because we were talking about like Newton's Laws and things like that, and really simplifying it for the students. I was able to carry out these experiments with

them with confidence. So, the program helped me with feeling confident in how to help them better, to better understand as well as carry out the actual experiment."

Participant 3. said, "Yeah, I had an absolute blast. We were talking about the environmental impact on the Monarch butterflies. I could turn that into a lesson this year with what I am teaching now. As a science teacher, honestly, I was too serious. It kind of helped me step down a level to where I could get engagement from the children with the hands-on and such to make fun stuff and learn."

2019 Archival Data STEM-UP Post Survey Question 1. *Explain how the skills and knowledge gained from our STEM-UP professional development has been or will be implemented in your own classroom.*

To understand teacher perspectives from question 1, responses were coded under: "how skills were implemented" and "how they will be implemented." Teacher 1 said, "I have used many activities and strategies in my classroom from STEM PD." Teacher 2 said, "STEM always reminds me that there are so many different ways to present the material. Different methods of presentation reach individual students. That's what I will implement." Teacher 3 said, "Many of the activities from both summer and afterschool STEM will be used with my science classes to show students fun ways to learn about those concepts."

Teacher 5 said, "More STEM activities will be incorporated into my classroom next year." Teacher 6. said, "I have more resources to show and explain Newton's Laws better to the students." Teacher 7 said, "Many of the hands-on activities will be implemented." Teacher 8 said, "I will have more hands-on activities for my students. I will also have students using higher level thinking skills as they problem solve." Teacher 9 said, "The ideas and activities I developed in the summer STEM-UP program would be useful for me to use at the end of the school year for

after SOL activities. I would love to use them during the school year (if time allows) to help reinforce the lessons I teach." Teacher 10 said, "I plan to use the investigation skills during rocket and kite making. I will bring in Newton's laws when we do our science unit on force." Teacher 11 said, "I will be able to take the skills from the STEM PD and apply them to future knowledge in STEM camps and in being more knowledgeable about topics that are in SOL standards. I have a larger arsenal of interactive lessons to share with students who are eager to learn." Teacher 12 said, "If I had access to the materials used in STEM, I would use the rockets to teach kinetic energy. Allowing students to build their own rockets would serve as a reward and also help them retain the information."

Interview question 15. *Student achievement is the ultimate goal of any professional development. Due to your participation in the digital badging PD, how well prepared were you to teach the science concepts related to the topics in the STEM in your own classroom? How did it affect student learning? Please give an example.*

To understand participant responses in question 15, the responses were coded with, "preparation to teach science concepts" and "effects on student learning?" Participant 3 said, "That summer, I was very well prepared to teach what I had to teach. I did learn some new things that I could incorporate into what I do, like the raw science, but I had plenty enough information." Participant 4 said, "So, the hands-on activities we talked about, of course NASA provides tons of hands-on activities you can use with the students, but it also provides the content knowledge for you to know more about the subject area itself, in order to be able to teach the students those concepts, ideas, and material. I think it excites them and gets their attention and they want to learn more about it. They participate and do the activities and gain that new knowledge about the subject matter. It makes it interesting to them."

Participant 5 said, “I was a lot more prepared that I would have been if I hadn’t had it. I think it was positive overall. You have some though that it is just not their type of learning. They can learn in that environment, but I don’t think it’s an overall tool for every child, because every child learns differently.” Participant 7 said, “Very well prepared, because I could present what I knew, but then extend it and even talk about it further because I’ve had the knowledge that I gained from the digital badging and the resources they had available. I think any time, being a teacher who has to teach to the SOL, if you can get past and above the SOLs, they’re so amazed by the information that’s not included. And I think it excites the students more if you know more than the base knowledge.”

Participant 6 said, “It gave me more perspective into this and made me feel more confident in presenting them to the students.” And then she added, “I mean you could hear the students talking more about the eclipse even after we talked. When we did the discussion in class, you could see them going out and talking to all the others. They would even come into class and then be like, well I told Mom that the eclipse happens because of this, and we would talk about it, they were talking a lot more about it with other people than just in class, so it went outside the classroom. The students got into it better.”

Participant 10 said, “So, the concepts of force and things like that, the students did really well with the understanding. You know, we talked about one of the laws. Then we would carry out whatever the experiment was that went along with that and we broke it down. So, we had deeper discussions about things like that. And you know, sometimes I’m afraid that conversations like that discourage children, because they just want to do things. They were really engaged with it and they enjoyed being able to answer that question. Participant 9 said, “I feel like I was ready when the students came for the week. We were ready to teach those students

based upon the training and what I learned through training, and also my own preparations and study time."

Research Question 5. *What are the teachers' perceptions of how interacting with components of the digital badging program, that required ongoing practice with STEM concepts and skills, affected the STEM learning community ecosystem in Bland County?*

Interview Question 16. *How does digital badging PD fit into the Bland STEM-UP learning ecosystem and the unique culture and community of teacher learners in Bland County?*

To analyze the teacher responses to question 16, teacher responses were coded under, "Fit with learning ecosystem" and "Fit with unique culture and community." Participant 1 said, "Being able to be a STEM-UP teacher, with the badge, I think I added more knowledge to some of the students because I could give them a little bit more information or background about something that maybe an elementary teacher couldn't. I think it has a good positive influence, especially this past summer. I can see how excited people were to be able to do STEM, or maybe just to be part of something."

Participant 3 said, "It fits beautifully into the ecosystem here because you have knowledge hungry children, but you also have children that love their teachers, like children loved teachers fifty years ago, and you have parents that support you. It's one big family. Given how small we are and these children, some of them don't have other opportunities and there's not many of those upper-level courses, like regular AP classes. It is an excellent opportunity for these children to learn more." Participant 3 later added, "What do I think of when I think of an ecosystem? I think of how embedded into the students' minds and abilities when it is so early. Such a strong program. Even teachers that aren't necessarily science teachers incorporate that stuff into other subject matter areas. I feel like you have such an awesome group of teachers that

care about their students and their community much more than any other group of teachers that I've ever encountered. Everybody here really helps, you played a big role in that, the principal, and the school board plays a huge role. You have a unique bunch of people together like that. They build deep, multiyear relationships. It is clear the students didn't get all caught up in all the other trends that society values."

Participant 3 continued, "Again, I also think that the fact that these students are outside so much they're fishing, they're hunting, they're farming, and those are all connections that you can really tie into your science class to make it culturally relevant. I found it much easier to make science culturally relevant in Bland County than any other county. So, I think like in their own way, they are more into science because they see signs every day. There's science involved in their lives more. So, the digital badging works to enhance what the kids already knew some about. So, the teachers, the elementary teachers and the high school teachers, gain some from the digital badging that added to this unique ecosystem of learners. Somehow when we did the teacher training for this, the digital badging fit into it. I think you have a lot more unconditional support of students by teachers, students supporting the teachers and parents that support the teachers in Bland County."

Participant 4 said, "It helps foster togetherness, and eagerness to learn about STEM and to continue doing our STEM program. It has helped us get really grounded in wanting to have that type of learning program in our school system and to develop it further. A lot of kids that started out when we first did STEM in elementary are now teen helpers or have graduated, and were teen helpers, so it is an all-encompassing thing and you know just kind of tied it together from when they're young elementary, all the way through high school. And you know, the majority of the community, whether it is business, the libraries, or the sheriff's office, they're

just as invested in our STEM program as we are and are eager to help. It's a small rural community, where everybody knows everyone and what's important to one group is important to you. We know everybody. I don't know that you would get that kind of buy-in in a larger county and that kind of support."

Participant 5 said, "First, students come first. We have businesses who support the schools, the student, and their programs, especially if it fits their work force, but not necessarily. You know, they still support them even if it doesn't. Maybe there is no separation. Maybe that is a good way to put it. I think one of the key words is small community." Participant 6 said, "So, I really think the digital badging brought people closer together because, if we didn't understand something, we'd ask, how did you do this, or I'm not sure what this is meaning. Can you help me? I think it just binds people communicating together with it."

Participant 7 said, "I think it fits in fairly well. I think it's interesting for our small county to be involved in something like that, and I also think that it's interesting that Bland County actually has a personal connection with a NASA education specialist from Goddard Space Flight Center, a member of our community, working with us. So, for some of the teachers it's a nice credit. I don't know how to word that, but to put that into perspective it's just a nice feeling to know that somebody on the other end is someone that you know, or you know their family. And so, you don't feel maybe as unconfident as you might feel, if you approach something from NASA, when you know that somebody from your area is on the other side and can be there to help you. I think the community is very supportive of the STEM program, even this year to return to it in the middle of a pandemic. I thought we had a very good turn out, and the children were very, very responsive to it, so I think it's something that their community perceives well,

and I think its connection with NASA, when we've done things through that, has just boosted their confidence in our own program."

Participant 8 said, "I think that as far as the teachers, we do collaborate and we teachers get other teachers to sign up for STEM as teachers. I also think that the parents really enjoy seeing what their kids have done when we would have the parent night at the end. Even though they have been in school all day, they stayed after STEM and when they do go home, they're still excited about it. So, that tickled me to know that all of our hard work was getting out there and the students were enjoying it. The parents were seeing the students enjoy it. It is just the people and the community, and the fact that at all the teachers, they just work together and one of our local businesses is a strong supporter as well. The community experts collaborate. Workers come in and see what we're doing so that they can see where their money is going."

Participant 9 said, "I think for me that it was the excitement in the students' eyes as knowing that they will get a badge. They wanted to earn something for their time. They were eager to be there to learn and come together as a community. They lift each other up and complement each other's goals and their rockets. I can't speak for other teachers, but myself, it made me think. I mean it really made me stop and look and pay attention to what the program has to offer. There are many different badges, but there there's so much involved in STEM that people have no clue. There is an enormous amount that I am even unaware of what it offers, so I think that It's a really good program and I wish that when my kids were in school that they would have had this program. It would be an initiative for the children to do their work and to study, to put forth more effort."

Participant 10 said, "It works well because of being in the community that we are. We don't have children that can really travel out of state a lot. We don't have families that have the

opportunity to take their kids to museums and things like that out of state, and they may not even have the background knowledge to be able to describe that to their children. So, we're giving them a unique opportunity to be able to look into subjects that might interest them. They may have seen something on YouTube or TV or whatever and they get to come in and this small group learning environment caters to something that they might be interested in."

Participant 10 continued, "It gives them an opportunity they might not have otherwise. STEM-UP is really well planned. They put a lot of effort into it and when they go into it, it's not just like well this is a possible thing, it is part of our curriculum. It is an opportunity to further these students understanding in certain skills and concepts and things like that. If you are part of it, you are serious about it. They encourage some kids who want to be leaders. I'm thinking about the high school students that come down and work with the teachers. The students, from a young age like 5th, 6th grade, will watch those older students, and aspire to have the opportunity to work with teachers too. It just gives them, a goal to work towards it. It's the whole STEM program that clicks so well together, just all the different parts like student teachers, the teachers, the instruction, and how it's implemented for the kids. It's surprising that it's only been going for eight years. That really surprises me."

CHAPTER 5

CONCLUSIONS AND DISCUSSION

This chapter includes the purpose and methodology used in this study of teacher's perspectives of the NASA STEM EPDC Digital Badging system as a model of personalized professional development. A summary of the data findings is organized around the five research questions. Discussion of the conclusions, implications, and recommendations for further research, end this chapter.

Purpose of the Study

The purpose of this study was to investigate the Bland County STEM program teachers' perceptions of the value of the experiences, with and through the NASA STEM EPDC badging process. Teacher demographics were considered and teacher perspectives of educational advantages that caused them to persist in the program were studied. Teachers' perceptions of successful teaching strategies and how these methods may be used to improve other STEM PD were investigated. This study also examined teachers' views of how interacting with components of the digital badging program, that required ongoing practice with STEM concepts and skills, affected the overall STEM learning ecosystem in Bland County. The main goal of this study was to determine teachers' perspectives of the NASA EPDC STEM Digital Badging system as a model of personalized PD. Data from this study informed the following research questions.

1. What are the teachers' differences, if any, based on selected demographic factors such as years of teaching experience, teaching specializations, ability to access online resources, and prior badging experience, in teachers' perceptions of the value of the NASA STEM EPDC digital badging program?

2. What are teachers' perceptions of educational advantages that cause them to persist in the NASA STEM EPDC Digital Badging Program?

3. What are the teachers' perspectives of the educational value of the NASA STEM EPDC Digital Badging Program for personalized learning?

4. What are teachers' perceptions of successful NASA EPDC Digital Badging Program classroom strategies that were useful in their own classroom and how the NASA STEM digital badging system could improve other STEM programs?

5. What are the teachers' perceptions of how interacting with components of the NASA STEM EPDC digital badging program, that required ongoing practice with STEM concepts and skills, affected the STEM learning community ecosystem in Bland County.

Population and Participants

The population for this study consisted of ten K-12 teachers employed by Bland County Public Schools. Each of the 10 teachers participated in the school's STEM-UP program that included NASA STEM EPDC digital badging for their STEM PD. Participants took part in an online 16 question interview with the interviewer/researcher. The open-ended interview questions consisted of four demographic questions, four questions on educational advantages and persistence, three questions about personalized learning, four questions about successful strategies, and one question concerning STEM learning ecosystems.

Methods

A pilot study was conducted involving two education specialists familiar with NASA STEM EPDC digital badging and qualitative research methods. Research methods and instruments were emailed to them. Modifications were made according to their responses. The pilot study confirmed the feasibility and validity of this research.

This case study was completed using qualitative methods of one-on-one interviews and analysis of 2019 archival data, post survey responses, from the school's STEM-UP program teacher evaluation. This gave the researcher a view into teacher badging practice over time. Participant interviews and the 2019 STEM-UP archival data were the main data sources for this study. Data was reviewed, coded, and analyzed to determine emergent themes. The following are summaries of the data findings organized around the research questions.

RQ 1. Demographics

Overall, while teachers/participants varied across the studied demographics, their perspectives were rather similar in their experiences with the STEM-UP program. The following demographics were examined.

Teaching Experience

The STEM-UP teachers differed in years of teaching experience, subjects and grade levels taught, prior badging experience, and comfort with online technology. The span of years of teaching experience was from three to 33 years with half of the teachers having more than 10 years of experience. One teacher taught 8-12 science only, eight teachers taught multiple subjects including science and math K-12, and one teacher taught history and subjects other than science or math 7-12. The teachers worked together in teams, and the teams collaborated with each other, so the years of teaching experience didn't seem to matter in how they participated in the badging process.

Online PD Experience

Most of the teachers had no previous professional development experience with digital badging, game-based learning, or micro-credentialing. Only a few teachers felt that the online badging was difficult to work through, but they worked with others for help. They felt that it

helped them practice online learning and that made remote teaching, due to COVID-19, easier. Three teachers had some previous experience with digital badging, game based professional development, or micro-credentialing through online college courses. One teacher described their PD experience with online game-based learning as a game changer, and students would do a lot to earn a badge. The teachers described the process of moving through the online badging as motivating as they completed the necessary activities to earn the award, the badge. The more badging, they did, the more skillful they became with using the technology.

Comfort With Online Technology

Most teachers felt comfortable with the technology needed to participate in the online professional development required for earning badges. The digital badging helped participants with their technology skills by giving them more online resources to explore and the incentive to earn badges on their own.

RQ 2. Educational Advantages and Persistence

Badging Professional Development (PD) Was Useful

All STEM-UP teachers/participants in this study described the digital badging as being useful. The badges were useful to teachers/participants for various reasons such as: serving as a learning cross-over to non-STEM lessons, giving participants more insight into science concepts, science teaching, and non-science teaching, and having a focus on current science events. The badging was useful because it gave them new ideas and perspectives, pushed them to continue their own education, and stretched them as a teacher. They also liked having the PD online because they did not have time to attend PD in person. Participants found the badging useful because it was teaching them to use the scientific method through activities that played into their Standards of Learning (SOLs) in an interactive way.

A few participants believed the badging system program was useful for non-science teachers because these participants believed STEM concepts and problem solving should be taught in all disciplines. This way of thinking helps students become good citizens to make good decisions in our technological society. The science teacher participants felt they knew the STEM basic concepts and many teaching methods, but it added to their knowledge and strategies. Badging was also described as giving more opportunities as a piece of the overall STEM-UP program. All teachers/participants found the badging process useful and experiences good overall, but occasional lag time in feedback from NASA was deemed problematic.

Persistence

Teachers/participants wanted to continue with STEM and the badging activities because they found them useful and enjoyable. Participants believed STEM-UP did a good job with lessons for their students and they also suggested topics for future STEM programs and the digital badging PD.

Many of the teachers/participants wanted to earn more badges in subjects in which they were interested, but mostly for recertification points. All 10 teachers completed one required badge, but some participants completed more badges on their own due to their special interests or student interests. Other teachers/participants believed the time factors at school and home caused them not to persist with badging. A few participants didn't remember they could earn more on their own but mentioned that if it is useful to their classes and fits their SOLs, they would do more badges in the future. All the participants wanted to work on more badges as a collaborative group, as they experienced in the STEM-UP training.

Participants wanted to continue to implement technology in multiple forms such as drones and robotics, math, and coding. Teachers/participants want more STEM lessons on

oceans, and marine life, space exploration and various related STEM careers. Other teacher/participants wanted students to explore the impact of irresponsible practices on our environment and to teach the elementary students how to improve the environment in simple ways. It was important that the environmental lessons begin as early as kindergarten to embed the practices in the young minds. A few teachers/participants mentioned that they would like more STEM related lessons that could be used in kindergarten or first-grade classrooms to encourage very young students to participate in summer STEM. How to teach environmentally sustainable farming and preservation of natural ecosystems in Appalachia was a suggestion for future STEM-UP teacher PD, including digital badging that focused on that topic.

RQ 3. Program for Personalized Learning

Exceptional To Other PD

Many teachers/participants felt the badging was exceptional compared to other forms of PD because they were choosing what lesson to use and often learned at their own pace. These aspects of badging are learner-centered and personalized. The learner creates their own way of learning (Kearney et al., 2015).

The participants described most previous involvements with PD as being negative experiences they often dreaded. It didn't fit with what they taught in their classrooms, and they had no choices as to what they had to learn. They were stuck with people talking at them and everyone had to sit and listen. The presenters were telling and showing them, but the teachers were not practicing anything. Most teachers/participants said the badging process was very different than this kind of PD, because it stimulated their interest and motivated them to choose useful activities. They learned STEM concepts and strategies and practiced hands-on activities that frequently included going outside.

Concentrates on the End-Thinking

One technique particular to the STEM UP program that is necessary to build teacher confidence in teaching a science concept is called "end-thinking," or a type of metacognition, where they are aware of the development their own learning processes or ways of thinking (Merriam-Webster, 2022c). End-thinking involves helping teachers recognize when they have mastered a concept and are able to teach it effectively. The participants felt that the badging process was very effective in their learning about how to use end-thinking in their teaching. The participants believed that developing the technique of end-thinking was good for science teachers, as well as for non-science teachers because it helped them with teaching critical thinking and scientific methods.

From a Reputable Organization

The PD gave teachers/participants a lot of information from a reputable organization, NASA, and that was important to them. To get the badge from NASA was a feather in their cap because the information was from a credible source. For many of the participants it was a chance to be confident with the materials before they used them with the students. They had support from fellow teachers and from experts in the community, as well as NASA experts online to help them personally. They felt that being able to pick and choose the lessons, as with badging, was necessary for effective PD.

Learning with the Spill Overs

The teachers/participants described spill overs as information they learned that was intended to be used to teach one subject, that could also be used to teach another seemingly unrelated subject. It is a way of enhancing a topic and integrating the learning. A few of the participants used the NASA digital badging site for online resources such as activities, videos,

and other information. The badging made them think outside the box and it helped with interest-based learning.

Participants believed the badging professional development gave them background information in an exciting way, often with current topics. Learning came in the spillovers because it made them want to learn more and do research on the topic. Digital badging lessons were used by the teachers/participants to teach lessons that are STEM as well as non-STEM related. They felt the badging prepared them to have deeper science discussions and link information that was hard for students to understand. The students were engaged and enjoying answering questions when they connected learning with STEM information.

Non-inspiring Parts of the Program

Overall, most teachers/participants described badging as a good experience, but there were also a few non-inspiring parts of the badging process that were addressed. These non-inspiring parts included the delay in response back from NASA that was necessary for them to move on to another part of the online process. Participants suggested that they eliminate that part of the process or NASA should expedite it.

Some teachers/participants said the online directions needed to be clearer because the digital badging had many steps, and it was a lot of work. A few participants thought the online site was hard to navigate to get to each section so they could move on. They needed it broken down for them to move through the site effectively. Many teachers/participants said they would use more badging if they had time to explore the site. In the years following the digital badge training, COVID restrictions during 2020-2022 interfered with the time they needed to investigate the badging and it caused them to lose some interest.

A few of the participants noted that some of the badges were perceived as non-motivational; in other words, they were not interested in the badge's science topic. It was noted that when a badge topic was not particularly interesting, the time to complete it could be better placed elsewhere.

RQ 4. STEM Teaching and Learning

Practice and Confidence

After the badging PD, all 10 teachers/participants felt ready to implement the lessons in the classroom, because they had to practice seeing if it worked before teaching students. For them, practice and support during training and equally important practice and support after training was a very helpful part of the PD. They believed the badging PD made the difference and they felt very prepared because they were able to discuss and simplify STEM for the students. The program made them more confident and gave them a better understanding of how to carry out experiments.

The teachers/participants all felt well prepared to teach because NASA badging provided lots of choices for hands-on activities and provided the content knowledge that made it interesting. They could understand how it excites students when the teacher knows more than just basic knowledge about a science topic.

Through badge training and their own preparation, many participants modified badging lessons for use in their regular classroom. Teachers/participants learned to step down to the students' grade level to get them engaged with hands-on activities, have fun, and learn. They learned to slow down with the students to give them the necessary time to think critically to solve problems and use the scientific method. The badging process showed them the importance of teaching hands-on activities in different teaching environments, including going outside to get

more meaningful student engagement in their own environment. The participants reported that students were engaged in not only learning but learning to think outside the box. It gave the students experiences as well as confidence and practice with problem solving tasks they may not have participated in otherwise. Students developed an understanding that science and math can be fun, and they started looking forward to learning more STEM.

What Works for Adult Learning

The teachers/participants felt that NASA badging information allows teachers to become experts in their own classroom with a NASA resource. Participants felt that their personal connection with a NASA specialist, who is also a member of our community, was a significant credit to our community and helped build their teacher confidence as effective teachers.

Participants believed that NASA badging encouraged them to see what works for adult learning. Each participant felt they could add something a little different to the idea of the particular badge they were earning, making it personalized PD. Some teachers/participants said they could choose the lessons, work on the lessons at their own speed and customize activities.

Improving Other STEM Programs

The teachers/participants believed that the NASA badging can bring teachers together where they struggle and encourage each other to grow. They felt that the lessons did the same for the students. Therefore, badging could help improve other STEM programs for teacher collaborations.

Participants believed that Bland County STEM-UP was successful because they are a group of passionate teachers who know their children. They believed this program has a stability factor in that the lessons are structured for reliability in the teaching of a science concept. This adds stability to this program and their teaching as they tailor the STEM lessons for their

students. They felt this successful STEM program provided all the materials they needed for the activities. This can help many teachers that don't have the time, money, or experience to gather the needed materials to teach the STEM lessons.

Inspiration for STEM Careers and Individualized Attention

The teachers/participants believed that STEM-UP encouraged their students to explore the different areas covered in STEM and that many students were getting interested in STEM jobs who wouldn't usually have the exposure to those careers. They believe it has a great impact for all students, and they also see students finding their special talents through STEM. Even the badging resources had a STEM career focus for activities. The participants felt that the STEM-UP program is a great gateway to open doors for students who otherwise would be left out.

Participants believed it is important for STEM-UP students to work in small group sessions with teachers on topics of interest. With the STEM-UP activities, the students received more individualized attention on tasks which assisted them in retaining the main ideas and themes. The participants believed it has allowed students to love science and are then primed to learn more when they go back to their regular classroom, because their abilities surpass their peer's abilities due to the STEM learning experiences.

Larger Arsenal of Interactive Lessons

A few participants believed they have more resources from the training with the digital badging to show and explain specific concepts, like Newton's Laws, to the students and implement many of the hands-on activities. They believed they have a larger arsenal of interactive lessons to share with students who are eager to learn. They also believed that their students are taught how to use higher level thinking skills as they problem solve.

Many of the participants felt that the ideas and activities they developed in the summer STEM-UP program would be useful for them to use at the end of the school year for after SOL activities. A few said they would love to use the lessons during the school year (if time allows) to help reinforce the lessons they teach. Participants said they will be able to take the teaching skills from the STEM PD and apply them to future teaching in STEM camps and to be more knowledgeable about topics that are part of the SOL standards. They believed that STEM training with badging gives many ways to present science concepts and other content material. They felt they gained different methods of presentation to reach individual students.

NASA STEM Digital Badging for Kindergarten and First Grade Teachers

Participants expressed a need for badging developed specifically for kindergarten and 1st grade teachers to teach STEM concepts and build the foundation for future STEM success. They felt it is a challenge to modify middle school level lessons, as used in STEM-UP training from the NASA digital badging, for very young students, but it is crucial to get them engaged in STEM at that young age. An early start with STEM education can make all the difference in children's success with STEM learning when they get to high school (Early Childhood STEM Working Group, 2017). Early childhood educators need access to STEM education resources, support to know what makes the STEM resources high quality and training to use the materials successfully (Early Childhood STEM Working Group, 2017).

Participants believed that kindergarten and first grade teachers and students need access to the age-appropriate STEM materials year-round. They also want more training of the proper uses of the materials. For example, they would use the rockets to teach kinetic energy and allow students to build their own rockets, as they did in STEM, if they had more practice and some support using the materials. It would serve as a reward and help students retain the information.

Teachers said they have adapted many activities and strategies from the badging for their early grade level classrooms.

RQ 5. Ongoing Practice and the STEM learning Ecosystem

Embedded in Student Minds So Early

Participants believed the Bland County STEM learning ecosystem embeds STEM learning in the children's minds very early, and that makes it a strong program. STEM Learning ecosystems involve classrooms, schools, the surrounding community, summer programs, and after-school STEM programs. Experiences in various environments are learning opportunities (Bronfenbrenner, 1979).

Teacher PD Plays a Major Role in the Learning Ecosystem

Throughout this study, it was obvious that these Bland County teachers/participants cared about their students, the community, and STEM learning. Participants noted that everyone helps including the principal, the school board, the community; and in this rural area, STEM is an important part of the expanded learning ecosystem. Participants noted the program builds deep multiyear relationships among teachers, students, businesses, and other community members and the students are eager to learn. Teachers/participants believe the badge training made them think and pay more attention to how program offerings of the badges fit into their teaching and the overall curriculum. They saw how all teacher PD, especially the STEM-UP training, played a major role in STEM learning ecosystems.

The Program Clicks Together

Teachers/participants felt that in a small rural school with fewer opportunities, STEM-UP gives students a chance to learn more. Participants emphasized several positive and effective results from the use of this program: The program clicks together the students, the teachers, the

NASA badge training, the instruction, and how it is implemented. It is an initiative for kids to do their work and to study STEM. It works well. The STEM environment caters to special interests of children and STEM is an opportunity to further the students' understanding. The STEM-UP program fosters togetherness and gets them grounded in wanting that type of learning program in their school and to develop it further. The STEM-UP program serves as a good public relations tool when teachers, students and the community learn, create, and have fun through positive associations with STEM materials.

Badging Adds to the Unique Learning Ecosystem of Learners

Teachers/participants understand that the Bland County students experience fishing, hunting, and farming as a part of their daily lives. The teachers noted how they could tie this into science class and make it relevant to students because the children can see how science is involved in their lives. The teachers/participants felt that the digital badging fit well into teacher training that adds to the unique ecosystem of learners. It fosters togetherness, eagerness to learn STEM and to continue the program. It got the teachers/participants grounded in wanting to have that type of learning program in their schools and develop it further.

Personal Connections with Experts

Teachers said that their personal connection with a NASA specialist from Goddard, that works with designing the NASA badges, who is also a member of our community, is a nice credit to our community and builds the teacher’s confidence. It boosts confidence with their own program. The community is supportive of our STEM program and perceives it well, even returns to it with success in the pandemic.

Implications

1. The NASA digital badging was useful STEM professional development for the Bland County teachers, and it could be useful to other educators.

Results of this study imply that the use of badging as a teacher training process in the Bland County Schools STEM-UP was successful and could serve as a model for PD in other STEM programs. The educators in this study emphasized that the badging was useful because it was personalized. They were able to effectively implement the strategies and concepts in the STEM-UP program and in their regular classrooms.

2. Professional development should be more customized for early STEM education.

Results of this study imply that K-1st grade teachers need more customized, personalized, at age level STEM PD. Most of the educators in this study were elementary educators who described being unconfident about modifying the middle school lessons from the badging for elementary level students. Although NASA STEM EPDC offers many valuable resources for elementary teachers, K-1st grade teachers want more training and customized support with badging to effectively implement STEM learning into their classrooms.

3. The NASA badging process could be used as a model to improve other forms of PD.

Results of this study imply that less successful STEM programs could use the badging methods to improve teacher training and it could be used to improve other forms of PD. Teachers want online STEM training, like the badging process, that focuses on teachers understanding of their own thought processes to build new scientific ways of thinking and teaching STEM. The teachers want ongoing, personalized, collaborative PD from a credible source, like NASA. Comparisons of 2019 archival data and 2021interview data showed that the 2021 teachers had a

more positive perception of the digital badging and STEM-UP, possibly due to ongoing successful practice.

4. Timely feedback for teachers in training is important.

Results of this study imply that most teachers found the digital badging to be interesting, useful, and motivating but occasional delays in expert feedback slowed their learning pace. Timely feedback for support during teacher training is important to keep the flow of information moving smoothly from practice to mastery.

5. Teacher PD should fit learning ecosystems.

Results of this study imply that NASA STEM digital badging PD was effective because it fit into the unique culture of learners in Bland County. STEM teaching and learning was embedded into the community learning ecosystem. Brown et al. (1989) refers to situations co-producing knowledge through activity. Other forms of PD could benefit by personalizing their teacher training for the situation in which it occurs; the overall learning ecosystem, the school culture, and the individual teachers' subject and age levels they teach.

Conclusion

This research highlights perceptions of the value of NASA digital badges for personalized professional development. Teachers were successful when given opportunities for decision making and customization to meet their needs (Gamrat et al., 2014). This investigation gives an in-depth view of how the badge training works with teacher collaborations and helps us understand how badging fits in with the conditions and effective practices that undergird robust school learning ecosystems (Traill et al., 2015). This study also brings attention to STEM learning issues such as the need for more STEM training and support for kindergarten and 1st

grade teachers. STEM and future sustainability needs be at the forefront of early childhood education (Campbell & Speldewinde, 2022).

This research adds to a NASA digital badging pilot study (Colon Robles et al., 2017) in which a group of 6-8th grade teachers/participants found NASA digital badges worth their effort as teacher PD because it was effective for student learning in their own classrooms. This researcher found that teachers in Bland County STEM-UP also found the badge training to be an important part of their STEM learning ecosystem. The findings imply that the badge PD was effective teacher training in these two different settings and could possibly be applied to other situations with success.

Suggestions for Future Research

This study involved ten, 2017-2019 BCPS STEM-UP program, K-12 teachers who participated in NASA STEM EPDC Digital Badging training and earned at least one badge. If aspects of this study were replicated and further studied, recommendations include the following.

1. Research should be done on teachers' perspectives of how interacting with components of the NASA STEM EPDC Digital Badging process, that required ongoing practice with STEM concepts and skills, affects STEM learning in various learning ecosystems.
2. A study should be conducted to determine the needs of kindergarten and 1st grade educators to better support STEM teaching and learning in their classrooms.
3. Research should be conducted on the perspectives of pre-service teachers on the effects of NASA STEM EPDC Digital Badging for STEM PD.
4. A study should be conducted on the perceptions of administrators, concerning the digital badging used for teacher PD, and what kind of support they could they provide.

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APPENDIX A

IRB APROVAL LETTER

www.marshall.edu

Office of Research Integrity Institutional Review Board One John Marshall Drive
Huntington, WV 25755

July 21, 2021

Edna Meisel, Ed.D.
COEPD, Curriculum & Instruction

RE: IRBNet ID# 1789497-1
At: Marshall University Institutional Review Board #2 (Social/Behavioral) Dear Dr. Meisel:

FWA 00002704
IRB1 #00002205
IRB2 #00003206

Protocol Title: [1789497-1] TEACHERS' PERSPECTIVES OF THE NASA STEM EPDC DIGITAL BADGING SYSTEM AS A MODEL OF PERSONALIZED PROFESSIONAL DEVELOPMENT: A CASE STUDY

Site Location: MU
Submission Type: New Project APPROVED
Review Type: Exempt Review

In accordance with 45CFR46.104(d)(1&2), the above study was granted Exempted approval today by the Marshall University Institutional Review Board #2 (Social/Behavioral) Chair. No further submission (or closure) is required for an Exempt study **unless** there is an amendment to the study. All amendments must be submitted and approved by the IRB Chair/Designee.

This study is for student Ruthanne Cole.

If you have any questions, please contact the Marshall University Institutional Review Board #2 (Social/ Behavioral) Coordinator Anna Robinson at (304) 696-2477 or robinsonn1@marshall.edu. Please include your study title and reference number in all correspondence with this office.

Sincerely,

Bruce F. Day, ThD, CIP
Director, Office of Research Integrity

APPENDIX B

INTERVIEW PROTOCOL

Teachers' Perceptions of the NASA STEM EPDC Digital Badging System as a Model of Personalized STEM Professional Development

Participant: _____

Participant Title: _____ **Date:** _____

Thank you for agreeing to participate in this interview. As a reminder, this research is being conducted through the Graduate College of Marshall University to explore teachers' perceptions of the NASA STEM Educator Professional Development Collaborative (EPDC) digital badging system as a model of personalized professional development. The information you provide will be integrated with that of other interviewees and confidentiality will be maintained at all times. Participation is completely voluntary and you can elect to stop participation at any time.

As a Bland County teacher that has participated in the STEM-UP program and earned a digital badge through the NASA STEM EPDC digital badging system during the 2017-2019 STEM-UP training, you are in a unique position to give your perspective. My interest is in learning from your experiences and your perceptions of the NASA STEM EPDC badging system. I anticipate the interview will take at least 45 minutes. As a reminder, video recording of this interview will occur using Microsoft Teams on the researcher's computer during the online interview. Following initial data collection, interview videos will be kept safe until transcribed. Afterwards, the video will be erased from the researcher's computer. The transcriptions will be

destroyed after the data analysis is completed. The information you supply is confidential and no individual will be identified by name or other identifying information.

Interview Questions

Teacher Demographics. To begin, let's start the conversation with some preliminary questions about your teaching experiences, and specializations.

1. How long have you been teaching?

2. What subject and age groups have you taught?

3. What are your previous experiences with digital badging for professional development?

4. Describe your level of comfort and abilities when using online technology such as digital badging.

Educational Advantages and Persistence. In the next questions, I am interested in your perception of the education advantages of using the NASA STEM EPDC digital badging system for STEM-UP PD.

5. Describe the digital badges you have earned and your experiences while earning them. Do you plan to earn more?

6. Describe your experiences with and through the process of earning digital badges that you started but didn't complete. Why didn't you finish all required lessons to earn the badge? What could be done to better support your learning through each step to badge completion?

7.The NASA STEM EPDC digital badging lessons are aligned with the National Education Standards and some Virginia Standards of Learning. In your view, how well does the NASA badging content fit into the SOLs that guide your curriculum?

8. Digital badges can document your professional development and provide a pathway for continued professional education. How have you used your NASA EPDC digital badging experience to show your learning path? How has it moved you toward your PD goals?

Personalized Learning. These questions are about how you view the NASA EPDC Digital Badging Program for personalized professional development and as a resource for your classroom.

9. How do you view the digital badging as a program for personalized learning?

10. Other than badge earning, how have you used the digital badging online site as a resource for your classroom?

11. How did the earning process encourage you to learn more STEM concepts and skills? What part of the badging program was motivating? What part of the program did not inspire you?

Successful Strategies. We will now focus our discussion on NASA STEM EPDC Digital Badging Program teaching strategies that you successfully used in your own classroom and could be used to improve other STEM programs.

12. What parts of the digital badging training have positively affected your STEM teaching in your own classroom and boosted student learning? In your opinion, what parts of the program could be used to improve less successful STEM PD programs?

13. How would you describe the NASA STEM EPDC digital badging experience compared to other professional development experiences?

14. The digital badging program was designed to deepen your STEM subject knowledge and provide successful teaching strategies. Due to the digital badging, how prepared were you to implement the hands-on activities and expanded inquiry approaches, compared to previous abilities?

15. Student achievement is the ultimate goal of any professional development. Due to your participation in the digital badging PD, how well prepared were you to teach the science concepts, related to the STEM topics, in your own classroom? How did it affect student learning? Please give an example.

STEM Ecosystems in Bland County. In this final section, I am interested in your view of how the NASA STEM EPDC digital badging concepts and methods fit into your school STEM culture as well as the overall learning community in Bland County?

16. How does digital badging PD fit into the Bland STEM-UP learning ecosystem and the unique culture and community of teacher learners in Bland County?

In Conclusion. You have been most patient, thoughtful, and reflective in your responses. Do you have any other comments, observations, or suggestions that you would like to contribute? Thank you so much for your time and willingness to be a part of this study.