The Pennsylvania State University
The Graduate School
College of Education

DIGITAL BADGING SYSTEMS AS A SET OF CULTURAL TOOLS FOR
PERSONALIZED PROFESSIONAL DEVELOPMENT

A Dissertation in
Learning, Design, and Technology

by
Christopher Gamrat

© 2018 Christopher W. Gamrat

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

May 2018
The dissertation of Christopher W. Gamrat was reviewed and approved* by the following:

Heather Toomey Zimmerman
Associate Professor of Education, Learning, Design, and Technology
Dissertation Adviser
Chair of Committee

Susan Land
Associate Professor of Education, Learning, Design, and Technology
Director of Graduate Studies for Learning and Performance Systems

Kyle Peck
Professor of Education, Learning, Design, and Technology

Edward J. Glantz
Associate Teaching Professor of Information Sciences and Technology

*Signatures are on file in the Graduate School
ABSTRACT

Through design-based research, this study examines a digital badging system to support online, independent teacher professional development (PD) in science, technology, engineering, and math (STEM) subjects. Sociocultural learning theory, in conjunction with the mediation triangle, provided a lens through which digital badging systems were examined as cultural tools for planning and wayfinding. This framework supported personalized teacher professional development in the digital badging system, Teacher Learning Journeys (TLJ), and the study examined teacher planning through goal articulation and wayfinding through teacher selection of professional development activities. Data consisted of teacher-generated artifacts, including goal statements, orientation activity reflections, intended PD activities, and completed PD activities. Data collection occurred during two 3-month iterations of teacher interaction with TLJ (I-1 = 30, I-2 = 29), and analyses were conducted using qualitative coding and statistical investigation including independent samples t tests and Pearson r correlations. Findings for teacher planning include a positive impact of reflective writing supports for activity completion, a broadening search for content, and four common objectives in written goal statements. Findings for teacher wayfinding discuss how participants used structures of the digital badging system for organizing and completing professional development in different ways. Analyses uncover differences in organizing intended professional development, 3 time-based patterns of use, and a non-significant relationship between intentions to complete an activity and the completion of activities. The intended and actual use of the TLJ system along with impacts on the teacher-leaners provide valuable insight into design considerations for developers and designers of independent teacher professional development.
# TABLE OF CONTENTS

List of Figures .......................................................................................................................... vii
List of Tables ........................................................................................................................... viii
Preface .................................................................................................................................... x
Acknowledgements .................................................................................................................. xi

Chapter 1 Introduction ............................................................................................................. 1
- Research purpose of studying digital badges ................................................................. 3
- Conceptual framework to understand a digital badging system as a set of cultural tools for teacher professional development .................................................. 3
- Research questions ........................................................................................................... 5
- Problem statement ............................................................................................................ 5
- Social significance of studying digital badges for PD purposes ...................................... 6

Chapter 2 Theoretical Framework and Literature Review ....................................................... 7
- Sociocultural theory and the mediation triangle .............................................................. 7
- The culture and tools within the Teacher Learning Journeys .......................................... 9
- Theoretical influences on digital badge research .......................................................... 11
- Personalization in learning ............................................................................................... 12
- Perspectives on planning with utility to digital badge research ..................................... 14
- Perspectives on wayfinding with utility to digital badge research ............................... 15
- Conclusion ....................................................................................................................... 18

Chapter 3 Teacher Learning Journeys: A design case study of a learner-centered STEM digital badging system ............................................................................................. 20
- Case overview .................................................................................................................. 20
- Travel metaphor guiding the TLJ design ......................................................................... 20
- Learner experience in Teacher Learning Journeys .......................................................... 21
- Analysis ............................................................................................................................ 23
  - Diverse badging activities to meet learners’ expertise and interests ........................ 23
  - Providing badging activities with flexible time offerings ........................................ 24
  - Assessment levels ....................................................................................................... 25
  - Personal reflections as evidence ............................................................................... 26
  - Mentored assessment ................................................................................................. 26
- Design .............................................................................................................................. 27
  - Year 1 initial badge and badging system design ...................................................... 27
  - Year 2 badge and badging system refinement .......................................................... 28
- Development .................................................................................................................... 29
  - Agile development model ......................................................................................... 29
  - Redevelopment from year 1 to year 2 .................................................................... 29
- Implementation ................................................................................................................ 30
  - Overview of Teacher Learning Journeys educators ............................................... 30
LIST OF FIGURES

Figure 1-1. Conceptual framework expanding the mediation triangle to support the use of digital badges as component artifacts facilitating multiple learners’ pursuit of multiple goals/objects. ................................................................. 4

Figure 2-1. Conceptual framework for study supporting the use of digital badges as component artifacts to facilitate multiple learners’ pursuit of multiple goals/objects to personalize professional learning. ................................................................. 9

Figure 3-2. The Exploring Our Earth From Above badging activity within the physics topic area. .................................................................................................................. 22

Figure 3-3. Frequency for all badges and stamps completed. .......................................................... 32

Figure 4-1. I-1 goal statement instructions. .................................................................................. 42

Figure 4-2. I-2 orientation activity instructions. .......................................................................... 43

Figure 5.1. Teachers’ sub-components of the goal statement objectives for professional development needs. ................................................................................................................. 66

Figure 6-1. TLJ participation was positively skewed with the majority of participants using the system for less than 10 days. .............................................................................. 76

Figure 7.1. Teachers’ sub-components of the goal statement objectives can be grouped into short- (light blue boxes) and long-term (white boxes) professional development needs. .................................................................................. 84

Figure A1. Goal statement example submitted by Participant 76 (Sally). ................................. 102

Figure A2. Activity queue example submitted by Participant 76 (Sally). ................................. 103

Figure A3. Completed activities log (stamps and badges) example submitted by Participant 76 (Sally). ................................................................................................................. 104

Figure A4. Evidence submitted by completing an activity example submitted by Participant 76 (Sally). ................................................................................................................. 105
LIST OF TABLES

Table 3-1. Awarded badges and stamps during TLJ’s first 2 years. ........................................ 31

Table 4-1. I-1 and I-2 distribution of participants across years of teaching experience and grade level. ....................................................................................................................... 37

Table 4-2. I-1 and I-2 total completed activities by teacher participant groups across years of teaching experience. ........................................................................................................ 37

Table 4-3. Study research questions for planning and wayfinding in teacher professional development and corresponding data collection methods ............................................. 41

Table 4-4. Alignment rubric for the analysis of goal statement and orientation activity reflections used by participants as a cultural tool for professional development planning. ....................................................................................................................... 46

Table 4-5. Moderate and strong alignment examples in goal statements and orientation activity reflections. ....................................................................................................................... 47

Table 4-6. Four identified objectives from emergent thematic coding from goal statement reflections for participant professional development planning with bolded examples of each objective. ....................................................................................................................... 49

Table 4-7. Overview of objectives identified from goal statements used to articulate personalized learning in professional development. ....................................................................................................................... 49

Table 4-8. Teachers personalized their professional development through access time(s). .... 52

Table 5-1. No significance was found with an independent samples t test analysis to examine the relationship between specificity, number of completed activities, and word count. ....................................................................................................................... 59

Table 5-2. Most participants who completed both the goal statement and orientation activity reflections demonstrated an alignment between the two reflections as identified through an alignment rubric. ....................................................................................................................... 59

Table 5-3. Teachers with moderate alignment differed from those with strong alignment in comparing goal statements and orientation activity reflections because they lacked concrete examples of activity planning. ....................................................................................................................... 61

Table 5-4. Teachers’ used goal statements as cultural tools for professional development planning within the TLJ digital badging system to describe their professional development objectives. ....................................................................................................................... 65

Table 6-1. Range of participant PD as mediated through completion (intended PD activities compared to completed PD activities). ....................................................................................................................... 73
Table 6-2. Teacher participation with TLJ clustered into three time-based patterns with
developer anticipated use, short duration use and a return to use after a hiatus.................77

Table 7-1. Badge system components as cultural tools for planning and wayfinding —
their intended design and actual use compared for the 59 teachers in this study.............87
Preface

Chapter 3 of this dissertation was originally published as the 21st chapter in the book *Digital Badges in Education: Trends, Issues, and Cases* with the chapter title “Teacher Learning Journeys: A Design Case Study of a Learner-Centered STEM Digital Badging System. The author of this dissertation is the primary author of this chapter with the dissertation committee chair as the second author. The chapter is used as a supplement to the Methods section of this dissertation to explain the design considerations of the technological context of the study. The publishers, Taylor and Francis Group LLC, have provided permission to the primary author to reuse the chapter in this dissertation. Reference to the work in the chapter should be attributed to: Gamrat, C., & Zimmerman, H. T. (2016). Teacher learning journeys: A design case study of a learner-centered STEM digital badging system. *Digital badges in education. Trends, issues, and cases* (pp. 215-225).
ACKNOWLEDGEMENTS

To my family and friends, thank you for your support and encouragement. Your faith in me has helped me to become a better self.

To my colleagues and my cohorts, your passion for education has continued to inspire me to learn more. I am lucky to have worked with you, and I have tremendously valued our conversations.

To my committee, my part-time pursuit of graduate school has allowed me to get to know you individually for nearly a decade. Your support and feedback have helped me to grow personally and professionally.

My work on the Teacher Learning Journeys project began in February of 2012. My dissertation makes use of the data created through the development of the Teacher Learning Journeys pilot, as part of the Penn State University and National Aeronautics and Space Administration cooperative agreement (NNX07AQ96A).
Chapter 1 Introduction

As professional educators turn to online resources to build their knowledge and skills, they may find it challenging when they explore unfamiliar topics and techniques. This challenge compounds since personal and professional knowledge and experience vary, with different professionals having different interests, needs, and professional foci. To support teachers facing these challenges, this dissertation offers digital badging systems as a set of tools to support this on-going learning as an innovative concept for adult learning and professional development (PD). Within the context of digital badges in teacher PD, value is placed on the development of serious badges that support professional learning (Diamond & Gonzalez, 2014; Gamrat & Zimmerman, 2015; Gamrat, Zimmerman, Dudek, & Peck, 2014). Although several studies have begun to look at badges within a university or professional learning context (Cucchiara, Giglio, Persico, & Raffaghello, 2014; Diamond & Gonzalez, 2014; Gamrat et al., 2014), research has yet to explore the value of considering digital badging systems as a set of tools for planning and wayfinding toward achievement.

Current digital badging research suggests the value of badges is the capture and display of achievement. For example, in previous work, my colleagues and I define digital badges as “online representations of learning experiences and activities that tell a story about the learner’s education and skills” (Gamrat et al., 2014, p. 1136). However, given my further inquiry into the topic of digital badges, I now suggest an expanded view of how digital badges may support learning. I suggest that a system of digital badges may be used not only to capture what a learner has done, but to support their work toward achievement. Researchers, educators, policy-makers, and administrators would benefit from considering digital badging systems as an interconnected set of tools for learning rather than just a summarization of what was learned.
This dissertation examines how a badging system may support activities toward learning in a teacher professional development setting. Badging systems offer tools to create a plan and pathway for learning. Learner interactions with a badging system act as incremental steps toward achievement with decisions as a reflection of what is valued. Each action in the system affords a transparent micro-articulation of a learner’s goals and path. Consequently, this study adopts my expanded view of a digital badging to examine how teachers personalize their professional development experience by using the badging system as a tool to support planning through goal articulation and wayfinding through learning activity choice in a module-based learning environment. Adopting this expanded view of badging will require a holistic theoretical perspective.

A review of early badge research identified three foci among the literature: motivation, credentialing, and pedagogy (Ahn, Pellicone, & Butler, 2014). This dissertation contributes to the field of education by exploring digital badging systems as a set of pedagogical tools for teacher professional development. While other research examined motivation (Abramovich, Schunn, & Higashi, 2013; Dona, Gregory, Salmon, & Pechenkina, 2014; Filsecker & Hickey, 2014; Kwon, Halavais, & Havener, 2015) and credentialing (Olneck, 2012; Raish & Rimland, 2016), my study focuses on pedagogy as a way to enhance the independent nature of teacher professional development. Within my study, I employ the constructs of cultural tools (Rogoff, 2003; Vygotsky, 1980), Cole’s mediation triangle (1996), and personalized learning (Kearney, Schuck, Burden, & Aubusson, 2012; Watson & Watson, 2017; Wills & Xie, 2016) to investigate how digital badging systems support learners’ goals and choices. I suggest a view of digital badging systems as a set of cultural tools with which learners can identify relevant resources and use them to achieve personalized goals. This dissertation offers an expanded view of digital badging systems for future use as a set of cultural tools to support learner progression toward achievement.
Research purpose of studying digital badges

The purpose of this dissertation is to employ a rigorous 2-year design-based research study to explore how teachers plan and pursue professional development using a digital badging system. I posit that use of a badging system generates articulations of a teacher’s pursuit for professional development and that these articulations may be analyzed to better understand learner engagement with PD activities. This study employs qualitative analyses to identify patterns across these articulations and statistical analyses to examine patterns in two iterations of Teacher Learning Journeys (TLJ), a digital badging system. My research goals are to describe patterns in teacher professional learning goal setting (planning) and patterns in making progress toward those goals (wayfinding).

Conceptual framework to understand a digital badging system as a set of cultural tools for teacher professional development

The conceptual framework for this study starts with Vygotsky’s sociocultural theory (1978). In sociocultural theory, learners are always engaging with culture, and therefore, cultural tools are central to learning because they mediate people’s experiences. Cole (1996) extends cultural tools to describe the mediation triangle, a perspective that expands sociocultural learning theory. The mediation triangle is the relationship between the learner, their objectives (i.e., goals), and the cultural artifacts (i.e., tools and technologies). For researchers adopting a mediation triangle perspective, cultural tools are always used by the learners to achieve these objectives. For this study, I will be specifically referring to cultural tools, a subcategory of cultural artifacts. This study uses a digital badging system as an example of a set of cultural tools used in technologically-enhanced learning. I explore how digital badging systems as a set of cultural tools support learners while they engage in professional development. Figure 1.1 visualizes the
theoretical framework and ideas that support the structure of my research. While the interplay between learner (subject), artifact (tool), and object (goal) is important to understand, the focus of this study is to understand how teachers, as an example of professional learners, use digital artifacts (cultural tools) in different ways toward professional development objectives.

Figure 1-1. Conceptual framework expanding the mediation triangle to support the use of digital badges as component artifacts facilitating multiple learners’ pursuit of multiple goals/objects.

Like other cultural tools, those that make up a digital badging system offer the learner possible supports for achievement of an objective. With my study, I am offering a digital badging system as a set of multi-purpose tools, and I consider (a) how the digital badging system was designed as a set of cultural tools by the badging team and (b) how learners may have used this set of tools with the designed intent or outside of the designed intent for their professional needs. As Figure 1-1 shows, multiple learners interact with the artifact (digital badging system component) to achieve learner objects (goals). These multiple interactions with the digital badging system represent the use of a single artifact in multiple ways. Within this framework,
badges and badge systems like TLJ may support many learners to achieve different learning goals. Learners can use cultural tools for identifying a goal in professional growth (planning) and consider how to make progress toward this goal (wayfinding). Planning activities offer support in describing what a learner wants to achieve. Learner wayfinding offers a means of creating a path along the desired direction toward the set goals. Approaching a digital badging system as a set of cultural tools with planning and wayfinding as considerations supports the independent nature of teacher professional development. By considering digital badging systems as a set of cultural tools for learners in planning and wayfinding, I uncover the emergent uses of these tools by asking the following research questions.

**Research questions**

- How do participants use a digital badging system as a set of cultural tools to articulate planning for their learning goals in the digital badging system?
- How do participants use a digital badging system as a set of cultural tools to engage in wayfinding in a digital badging system?

**Problem statement**

Teacher professional development presents systemic challenges such as meeting the needs of a varied audience of teachers and faces the possibility of a one-size-fits-all approach that leaves some teachers’ needs unmet (Borko, 2004). Many researchers and practitioners offer support in the area of teacher professional development with varying approaches and contributions. My dissertation focuses on how digital badging systems may support a personalized approach to teacher professional development. My analysis will review how teachers’ made use of a digital badging system to articulate and pursue their professional development.
Social significance of studying digital badges for PD purposes

As businesses and nonprofit organizations look to develop and track their employees’ professional capabilities, they face financial strains to reach a geographically dispersed workforce. These factors have led to the rise in online education and training tools and recognition mechanisms such as digital badges. This dissertation informs professional development efforts by understanding how professionals personalize their experience by making decisions about their learning using an open-ended digital badging system. With decades of learning ahead, professionals and employers may find value in the support of identifying and organizing these decisions. Moreover, this work offers support in the design considerations to support recent and ongoing work related to the development of tools for learners (Gamrat & Zimmerman, 2015; Zimmerman & McClain, 2016). This dissertation contributes to existing principles of design of badges as pedagogical resources (Gamrat, Bixler, & Raish, 2016) through analysis of participant use.
Chapter 2 Theoretical Framework and Literature Review

In the literature review section, to create a theoretical foundation for my work, I unpack the following constructs that are germane to my dissertation study:

- Sociocultural theory and the mediation triangle
- Theoretical influences on digital badge research
- Personalized learning
- Perspectives on planning with utility to digital badge research
- Perspectives on wayfinding with utility to digital badge research

Sociocultural theory and the mediation triangle

Making use of Vygotsky’s sociocultural theory (1980), Bruner (1996) posits that learning is situated within the culture of the learner. The exploration of culture in learning comes in many forms, but this study focuses on the specific concept of cultural tools that can range from basic number and alphabet systems to complex, abstract ideas such as sports or government. As with these examples, Rogoff (2003) explains that individuals make use of cultural tools to serve their cognitive and meta-cognitive personal development. Cole (1996) extends the concept of cultural tools and expands it to cultural artifacts by making the distinction that the term artifact offers a broader definition of ideal and material resources. This use of the term suggests a conceptual abstraction (a definition of what something is) and an embodiment of the tool. For example, as a cultural tool, a group of people may have an agreed upon idea of a language as a tool for communication, and when put into practice, language may vary as an embodiment through its alphabet, vocabulary, and mechanics of speech. With this study, the TLJ digital badging system supports an understanding of the scientific and engineering ideas (concept), but the activities within the badges are an embodiment of the concept with the cultural influences of NASA.
science, educational practices, and the author of the activities. Then these activities are used in a way that is subject to the learner including their culture, experiences, and needs.

Cole (1996) describes the mediation triangle explaining that it visualizes the interactions between the subject (person), object (goal), and the artifact/tool mediating the subject’s understanding or attainment of his or her goal/objective. The mediation triangle provides means for considering the experience of the learner using artifacts to achieve the objectives or goals. This study positions a digital badging system as a set of tools for teachers (the subjects) to articulate the activities of planning (explicitly through writing) and wayfinding (implicitly through selections in the system) during professional development (the objective). Returning to the language example, speakers (subjects) use language (artifact/tool) to convey ideas (goal). I assert that within this study, the subject is the participant, the object is the participant’s learning goal and, the artifact is the use of the TLJ digital badges and badging system.

I intend to expand the mediation triangle to consider artifacts used for multiple learners with unique objectives. Figure 2-1 illustrates multiple connections between the artifacts (badging system components in the case of this study), the subjects (learner participants), and the learning objectives (goals). These connections between learner, artifact, and object, suggest that learners may use digital badging systems as a set of cultural tools in different ways toward their goal of professional learning. This study’s framework offers a unique approach to consider digital badges, digital badging systems, and related research.
Figure 2-1. Conceptual framework for study supporting the use of digital badges as component artifacts to facilitate multiple learners’ pursuit of multiple goals/objects to personalize professional learning.

The culture and tools within the Teacher Learning Journeys

This study makes use of the concepts of cultural tools a theoretical lens through which to examine participants’ use of the Teachers Learning Journeys digital badging system. This section offers a description of the cultural influences of TLJ and the tools designed to support this system. Teacher Learning Journeys was developed with the influences of the National Aeronautics and Space Administration (NASA), National Science Teachers Association (NSTA), and Penn State University. The culture of the NASA Education Office had the greatest influence on the culture of Teacher Learning Journeys. The majority of the badge activities selected were from among NASA’s most popular educational resources. The development of the badge activities (i.e., criterion for completion) were also developed by NASA education experts. The
NSTA influenced the culture of TLJ through recommendations on teacher engagement and experience offering a library of professional development resources. This feedback was provided during regular iterative development meetings. Penn State University influenced the culture of TLJ through the development of structures to support teacher professional development by following best practices in educational research. From the earliest discussions of the TLJ development team, the design team described the importance of teacher professional development as independent and on-going.

The vision for the Teacher Learning Journeys system was to encourage teachers to pursue professional development on their own. The design team added components of TLJ thought to facilitate personalized learning to support independent professional development. First, the design team introduced TLJ as an individual journey of learning using a travel analogy. The goal statement in TLJ was intended to support a reflection on the purpose of a teacher’s professional development. The reflection on goals would be similar to the purpose for traveling. For example, travel as a tourist might include a wide exploration of a destination. The orientation activity was added in the second iteration of TLJ to further articulate goal statements. After setting goal statement, the design team’s analogy of professional development to travel suggested that developing a list of intended activities was similar to creating a travel itinerary. A library of activities was created to offer choice and to encourage continued PD. Cultural decisions were embedded into the completion of activities in TLJ. The design team created two levels of recognition for completing an activity by awarding stamps and badges. Stamps represented a lower level completion by asking the learner to briefly reflect on the activity they completed. Stamps aligned with the travel analogy as being similar to a passport stamp, demonstrating reflection on the activity. Badges, however, required teachers to reflect on their implementation. The TLJ design team intended the implementation reflections to support teachers’ identifying
activities relevant to their own needs and that the completion would further on-going
development by envisioning how they might make use of their gained knowledge and resources.

**Theoretical influences on digital badge research**

Initial studies on digital badges in education attempted to understand the role of badges in
promoting student motivation (Abramovich et al., 2013; Dona et al., 2014; Filsecker & Hickey,
2014; Kwon et al., 2015). As interest in digital badges for educational contexts develop, other
lines of research have emerged to contribute to theory and practice with digital badges. This
research has extended to examine the perception of employers of information literacy credentials
(Raish & Rimland, 2016), student self-regulated learning (Cucchiara et al., 2014), educational
policy (Olneck, 2012), and teacher professional development (Diamond & Gonzalez, 2016;
Gamrat & Zimmerman, 2015; Gamrat et al., 2014).

While there is an increasing body of literature on digital badges, the research is
contextual and largely limited to elementary, secondary, and higher education students. To learn
more about how digital badge use varies in different contexts and which implementations appear
to be successful, Hickey and colleagues (2014) analyzed digital badging pilot programs funded
through the MacArthur Foundation Digital Media and Learning program. This work called
attention to the need for research for and with badges and badge systems to support an
understanding of the contexts and implementation of digital badging programs. Hickey and
colleagues offer early recommendations based on the analysis of successes and pitfalls of many
badging system implementations. Whereas, other digital badge research is largely limited to
single implementations. Current digital badge research largely examines the experiences of
primary, secondary, and university students (Abramovich et al., 2013; Davis & Klein, 2015;
Filsecker & Hickey, 2014; Randall, Harrison, & West, 2013). While early research on students
and digital badges is valuable and informative for elementary, secondary, and higher education contexts, there are fewer published works on digital badges for professional or lifelong learning. In prior research (Gamrat & Zimmerman, 2015), my colleague and I situated digital badges as cultural tools used by teachers to personalize professional learning through decision-making (the selection of what and when to learn) and customization (the adjustment of learning to focus on personal relevance). This dissertation extends my prior work using a sociocultural lens to explore the articulation of personalization in teacher professional development through a digital badging system. This study does not directly examine the design of each badge; rather the research looks to find how teachers personalized their professional development with the TLJ digital badging system.

**Personalization in learning**

In the framework of Cole’s mediation triangle (1996), this study analyzes how teachers (subject) use a digital badging system (cultural tool) to personalize their professional development (goal). Watson and Watson define personalization as, “an aspect of learner-centeredness that supports a significant degree of learner autonomy and direction of the learning process” (2017, p. 104). Furthermore, Kearney and colleagues (2012) assert customization and agency as two sub-components of personalization. Agency is the identification of which learning activities someone may choose to do, whereas learner customization is the determination of how to engage with them. For example, agency would be in the decision to select lessons on the Martian landscape, while customization is the application of a lesson to a specific grade or set of students’ needs. Prior work with personalization in badging leverages these sub-component definitions (Gamrat & Zimmerman, 2015; Gamrat et al., 2014) to differentiate the types of personalized learning in which teachers engage.
Differences in personalized learning research include populations, tools used, and degree of learner choice. However, common among personalized learning research is the supporting structure for learning opportunities and availability of resources to learners as needed (Chong & Lee, 2012; Huang, Liang, Su, & Chen, 2012; Hwang, Sung, Hung, Huang, & Tsai, 2012; Karmeshu, Raman, & Nedungadi, 2012; Kim, 2012; Nedungadi & Raman, 2012; Watson & Watson, 2017). Across the literature, many personalized learning studies focused on elementary, secondary, and university students; however, personalized learning in professional learning contexts is less common. Studies focused on elementary and secondary students (Chong & Lee, 2012; Huang et al., 2012; Hwang et al., 2012; Nedungadi & Raman, 2012; Song, Wong, & Looi, 2012) and attempted to support lessons in science and literacy. Post-secondary learners were included in some personalized learning research (Karmeshu et al., 2012; Kim, 2012). Karmeshu and colleagues (2012) looked at the diffusion of innovation among adopter-teachers, and Kim (2012) explored the use of virtual change agents to support learner progress through support strategies in a remedial university-level math lesson. These studies are informative but did not afford learner choice in content or timeliness.

Watson and Watson offer multiple perspectives on the definition and components of personalized learning that inform this study. They summarize stating, “personalized learning should truly focus on learning, meaning that it should move beyond the systematized approach of system-driven customization for learners and instead incorporate learner-control to develop self-regulated learning skills and not just knowledge” (Watson & Watson, 2017, p. 99). In this study, teachers used the Teacher Learning Journeys digital badging system to make their professional development personally relevant. Watson and Watson (2017) argue that personalized learning should begin with the verbalization of participant goals and the ability to plan for and document progress toward these goals. In this study, the verbalization of goals are discussed as planning and documentation of progress is described as wayfinding.
Perspectives on planning with utility to digital badge research

Sense-making is a learning process which requires learners to develop domain knowledge and metacognitive skills (Butcher & Sumner, 2011) and this development is scaffolded through tools to allow learners (principally novice learners) to develop within a domain with increasing expertise reinforcing the learner’s sense-making ability. Butcher and Sumner (2011) describe the sense-making paradox in which non-experts must find and evaluate personally relevant educational resources without the full understanding of the topic. The sense-making paradox is that novice learners do not know what they do not know. In their research, Butcher and Sumner support automatic algorithms to support personalized learning with the intent to support sense-making in students. These algorithms analyzed written participant scientific explanations and provided resources based on the writing. The software tool used by Butcher and Sumner was intended to help fill in the gaps in learners’ understanding by providing goals and areas of improvement for students (2011). While the feedback was customized to the individual, participants in Butcher and Sumner’s research were all working toward the goal of improved writing. This dissertation, however, looks at the sense-making paradox in professional development planning, in which individuals consider and articulate their learning goals.

To explore how learners identify their learning goals, I look to the two-level framework created by Wills and Xie (2016) for digital badges that combines relevant theory for both the individual learner and the digital badging system in a given context. The first level offers a perspective of the individual, taking into account “cognitive, psychological, and emotional processes” regarding the goal setting and badge pursuing tasks of the digital badging system participants (Wills & Xie, 2016, p. 264). This theoretical framework employs ideas from learning autonomy, self-regulated learning, andragogy, self-efficacy, and goal setting to describe the individual. Wills and Xie (2016) explain the importance of learner autonomy and self-efficacy...
which impacts an individuals’ understanding and awareness of where to improve and the ability to set and pursue goals for personal improvement. This individual focus looks at the learners’ influences on how they might approach the use of a digital badging system. Rather than each theory as a separate consideration, this dissertation takes these influences as a whole and looks at how learners articulate their professional development plans.

The second level in Wills and Xie’s (2016) framework accounts for the design and consideration of the system and context in which digital badges are available to participants. These digital badge system considerations inform designs for goal scaffolding, choice and perspective, personalization, and feedback. Relevant to this dissertation are goal scaffolding, perspective, choice, and personalization. Through TLJ, participants can utilize goal-scaffolding structures for personal reflection to approach their learning from a reflective perspective and to choose what is important and describe what they want and need. This framework offers participants a mechanism to consider the articulation and pursuit of personally relevant learning goals (Wills & Xie, 2016).

**Perspectives on wayfinding with utility to digital badge research**

The personalized learning research examined in this literature review used a defined support structure for the participants to make progress along a prescribed path (Chong & Lee, 2012; Huang et al., 2012; Hwang et al., 2012; Nedungadi & Raman, 2012; Song et al., 2012). Whereas, in my study, I look at how teachers use a digital badging system to define their own learning pathway. The paths described in this literature review aligned with the curriculum of elementary and secondary students. The defined learning pathways in these studies focused on science and literacy lessons integrated into classroom learning. The degree of personalization and structure of the learning pathways varied across the studies. Hwang and colleagues (2012) made
use of a computer game that gave elementary students a way to review a science lesson on plants through a role-playing game that varied based on the student’s learning style. In another study to explore science education, Song and colleagues (2012) researched a mobile-supported personalized science inquiry for elementary students. In the field of literacy, Huang and colleagues (2012) studied elementary student reading with the use of a personal set of e-reader tools such as annotation, bookmarking, search, and progress tracking. In the work of Chong and Lee (2012), the instructors played a greater role in the personalization with the ability to make adjustments to the students’ lesson. Finally, more algorithm-driven approaches to personalized learning are also present in this literature review. For example, Kim (2012) used virtual change agents attempt to support students toward strategies for motivation and emotion regulation for math students in a university setting. Whereas, Nedungadi and Raman (2012) developed a system to support students as they progress through 8th grade science curriculum through tracking of student mastery and growth, identification of needs, and suggestions for remediation. An algorithm-driven approach to personalized learning appears to have some disadvantages, particularly in the context of professional development. This approach to personalized learning presumes that the instructors, designers, and subject matter experts have an understanding of appropriate feedback for both those making smooth progress and those in need of remediation, as in the case of the Nedungadi and Raman with 8th-grade science learning. This algorithm-driven recommendation removes much of the decision power, as learners progress toward their learning goals.

Tattersall, Manderveld, Van Den Berg, Janssen, and Koper (2005, p. 152) define wayfinding as a “cognitive, decision-making process carried out by self-directed learners as they assume responsibility for choosing and sequencing their learning events.” Tattersall and colleagues’ work explores the development of a Learning Network system that offers participants the ability to track learning achievements and learning targets with a guidance system to support
progress. By following lifelong learners, Tattersall and colleagues (2005) intend to study both efficient paths and attractive paths. They defined efficient paths as paths through learning modules that minimize time to reach a target and attractive paths as paths rated highly by learners. The structure for Tattersall and colleagues’ work offers a way of examining the sequencing of learning activities. This work is also continued by Janssen et al. (2007) by providing information about the path taken by previous successful learners through the system to a learning target. Janssen and colleagues (2007) leverage the idea of learners following and reinforcing successful paths in a study of adults taking an online Internet safety course. The participants had control in choosing what learning module to pursue next, but also received recommendations based on success rates of other learners or a random recommendation when not available. Janssen and colleagues (2007) found that the feedback design provided improved effectiveness but not efficiency. While these measures provided value to the development of a recommendation tool, there may also be criticisms for the metrics evaluated such as goal attainment and efficiency. The participants did not define their measure of goal attainment but rather, the researchers assumed completeness as finishing the entire program without this explicitly described by the participants. This assumption of completing the entire program as a measure of success for a participant is a weakness in the study because participants may have discontinued their engagement with the program because they felt as though they have achieved their learning goal. Moreover, efficiency measured the duration of time participants took to advance through the program. The utility of this measure is in question since it is unclear that participants were motivated to complete the activities as quickly as possible.

Taminiau and colleagues (2013) further explored the influence of recommendations on task selection in just-in-time learning. This study investigated two groups of bachelor-level university students, one with no supports and one that received advice on task selection as they progressed toward the goal of learning system dynamics. Contrary to the study’s initial
hypothesis, the group that did not receive advice outperformed the participants who received advice (Taminiau et al., 2013). Taminiau and colleagues (2013) interpret the findings, explaining that participants without the advice may have invested more energy in the deliberation of which learning task would support the goals of the participants. This consideration is relevant to this dissertation study, in which participants engaged with the TLJ digital badging system designed to support personal relevance and implementation in the workplace.

This study is unique from the extant literature on learner wayfinding (pursuing a learning goal) because it focuses on how participants engaged in wayfinding patterns in participant decisions. Participants had open choice for their professional development rather than being encouraged to follow learning paths. This study also examines participant intentions through an intended activities list within the digital badging system. While it is possible to structure professional development in an algorithm-driven manner that meets individuals’ needs, there is the risk of becoming another one-size-fits-all approach to professional development, as criticized by Borko (2004). Instead, this study employs the Wills and Xie framework (2016) which supports the use of badges for personalizing learning by affording a level of flexibility in finding relevant opportunities.

**Conclusion**

In sum, this study employs sociocultural learning theory and the mediation triangle (the relationship of the subject, object, and cultural tool) to create a theoretical base. This frame supports the investigation of teachers’ using cultural tools of a digital badging system to achieve their professional learning objectives. I have identified a gap in the literature for additional research in the area of digital badges used for independent professional development. To address
this need, I utilize the sub-constructs of personalized learning for planning and wayfinding through the written descriptions and interactions with the TLJ digital badging system.
Chapter 3 Teacher Learning Journeys: A design case study of a learner-centered STEM digital badging system

A paper submitted to and published in *Digital badges in education. Trends, issues, and cases*.

Christopher Gamrat and Heather Toomey Zimmerman

Case overview

Penn State University developed the digital badging system, Teacher Learning Journeys (TLJ), in partnership with the National Aeronautics and Space Administration (NASA) and the National Science Teachers Association (NSTA), to support science, technology, engineering, and math (STEM) professional learning for educators. The partners’ goal for TLJ was to support educators’ STEM learning by enriching educators’ engagement with their pupils in school, university, and museum environments.

Travel metaphor guiding the TLJ design

The research and development team used a travel metaphor to design TLJ. This travel metaphor emphasized the idea of educators engaging in personalized learning journeys (Kearney et al., 2012) where they were empowered to make and record personally relevant choices (Borko, 2004). Consequently, the badging system features were designed using travel symbolism: (a) the educators created an itinerary when badging activities were added to a queue for future
investigation; (b) the lower level badge resembled passport stamps given to travelers upon entry into a country (Figure 3-1, left); (c) the higher-level badge resembled a sewn souvenir patch (Figure 3-1, right); and (d) the reflective written submissions used as evidence of content mastery for each stamp or badge were referred to as logs.

Figure 3-1. A TLJ stamp (left) and TLJ badge (right).

Learner experience in Teacher Learning Journeys

The learner experience in TLJ started with educators setting up accounts and then drafting goal statements. In the goal statements, educators were asked to articulate how they wanted to grow personally and professionally after completing the TLJ badge activities. Educators next selected and added badging activities to their itinerary from the TLJ badging library. In Year 1, 54 badging activities, related to STEM content in three areas (solar system, engineering, and weather and climate), were options in the TLJ library. In Year 2, 80 badging activities related to five STEM content areas in the TLJ library were available to educators: solar system, engineering, and weather and climate from Year 1, plus physics and earth science.
Educators could preview each badging activity to determine if the activity met their needs and was appropriate to their teaching before adding it to an itinerary (Figure 3-2).

Figure 3-2. The Exploring Our Earth From Above badging activity within the physics topic area.

After their itineraries were created, educators worked on the required criteria for a given badging activity. Badging activities included attending and reflecting on webinars, reviewing online materials, and engaging in participatory science activities. Badges were not awarded to learners for participating in events because previously published research has suggested that is not good for maintaining learners’ motivation (Abramovich et al., 2013). Instead, to earn badges in TLJ, learners provided evidence that they understood and could apply the STEM content in classrooms, museums, training sessions or other educational settings. The educators had a choice of assessment in the TLJ badging system—educators choose the depth in which they were assessed by selecting to earn a stamp, badge, or both. To earn a stamp and/or badge, educators submitted reflective logs to their respective NASA mentors who evaluated the materials and determined whether the educators had demonstrated competency in the activity. The mentors provided feedback, and if needed, suggested additions for educators to resubmit their materials.
Finally, upon positive review by the mentors, educators were provided with a stamp or a badge. Recognition could be consolidated to printable certificates and downloadable reports of educator effort that could be used to demonstrate professional learning to supervisors, institutional administrators, and others.

**Analysis**

We based the development of TLJ on theoretical and research considerations and on an evaluation of how to improve the TLJ partners’ current efforts to provide educators with STEM learning opportunities. Prior to TLJ, Penn State engaged in a collaborative effort with NASA to support and conduct STEM educator professional development (PD). In this prior PD effort, face-to-face workshops or similar events provided educators with professional learning experiences in real time. In this face-to-face approach, educators were limited by their ability to attend real-time events in person. The chief consideration in the development of TLJ was the ability of educators to personalize their experiences (Gamrat & Zimmerman, 2015; Gamrat et al., 2014) in terms of variety of content, flexible availability of activities, leveled assessment, reflections as evidence, and mentored assessment.

**Diverse badging activities to meet learners’ expertise and interests**

An important consideration in TLJ was to provide a variety of STEM badging activities to meet educators’ diverse expertise and interests in learning about STEM. Initially, we offered badging activities related to three topics: engineering, solar system, and weather and climate. Then, based on educators’ feedback, we added physics and earth science badging activities in Year 2, which brought the total areas of study to five STEM domains.
These five topics were selected because of their popularity in face-to-face PD events offered by NASA, the quality of available activities for the topic, and the requests of members in a NASA educator online learning community. This topical variety offered learners the ability to learn broadly across STEM domains or to specialize by gaining deep expertise in a particular area of content.

In addition to having five topic options, TLJ learners were offered a range of content in multiple badging activities providing the opportunity to further specialize. Novice educators strengthened their understanding of core STEM concepts, and experienced educators explored new content and pedagogical approaches. Importantly, this allowed educators who were responsible for only one STEM domain or who taught in a specialized science or STEM magnet or charter school to develop deep specialization.

**Providing badging activities with flexible time offerings**

To make STEM learning available to multiple educators, a key consideration was to provide badging activities with flexible availability of offerings. To support educators nationwide, badging activities were designed to offer both synchronous and asynchronous learning experiences.

We provided content for several badging activities via live webinars; the webinars were scheduled at two different times on a given day and also on multiple days to meet various scheduling needs and address time zone issues. In addition, many badging activities included the archived webinar for greater flexibility.

Several badges were designed to have only asynchronous communication requirements. These asynchronous communication badges were particularly popular with the participants who
reported that they often did not have time for professional development until the evening when their children were in bed.

Educators with children valued these as unique experiences not offered by traditional PD. By designing badging activities to allow time flexibility, learners were able to decide when they were best able to participate in their PD (Gamrat et al., 2014), and learners with a variety of needs (e.g., parents) were accommodated.

**Assessment levels**

Our design of TLJ presumed that the educators engaging in professional STEM learning would value multiple learning outcomes. Consequently, in TLJ, two levels of assessment were offered, as stated earlier: stamps and badges. Both stamps and badges captured more than just educator participation in an activity because educators were asked to reflect upon their learning experience. Stamps marked the lowest level of achievement. Stamps offered educators the ability to receive recognition for experiences after demonstrating reflective thinking and cursory application of STEM content in their workplace. Offering a stamp as a lower-level achievement benefited many educators who wanted the exposure to the STEM content but were less interested in meeting the higher-level requirement of an in-depth reflection.

To earn a TLJ badge, educators were asked to focus their reflections on practice-changing considerations (i.e., how to incorporate the learned STEM content into their teaching). Offering a badge as a higher-level achievement offered educators the opportunity to develop lessons, reflect on their pedagogy, and consider how new STEM content resources might be utilized in K-12, higher education, or museum classrooms.

From our own research (Gamrat & Zimmerman, 2015; Gamrat et al., 2014), we found that both levels of assessment provided educators with a means to demonstrate evidence of
learning and capture their experiences and thoughts with the ability to decide how much they wanted to explore a STEM activity. This suggestion also aligns with the recommendation by Hickey et al. (2014) to use leveled badge systems.

**Personal reflections as evidence**

Given that our goal was to create active, engaging STEM learning for the educators, we designed TLJ to include logs of educators’ reflections of how to use the TLJ badging STEM content in their schools, universities, or museum classrooms.

In Year 1 of TLJ, educators were given general guidance on the reflections that were required for a log; they were simply asked to reflect on their experience, which resulted in a wide range in terms of both focus and length. In Year 2, the instructions for logs were redesigned with an implementation focus, rather than open-ended general reflections, to better support the educators as they completed badges and stamps. Using the concept of “channeling” (Pea, 2004, p. 432), educators were guided to create the types of reflection necessary for either a stamp or badge but still were given considerable freedom in their responses. These added suggestions for reflective logs offered learners the ability to focus on specific questions addressing adoption rather than deciding what, of many things, should be the focus of the reflection.

**Mentored assessment**

In Year 1, based on enrollment in webinars and badging activities, NASA education experts took turns mentoring the educators who were using TLJ. In Year 2, we assigned each TLJ participant a mentor who stayed the same for that year. To maximize the mentors’ familiarity with the education standards and current events of their learner’s local area, mentor assignments
were based on geographic proximity. Year 2 mentors provided feedback that included both nationally and regionally relevant information. The use of mentors as badge evaluators supports the badge design recommendation of Hickey et al. to “enhance validity with expert judgment” (2014, p. 3). The goal of having mentors was to provide specific feedback for each badge or stamp completed by an educator and to develop an educator-mentor relationship over time. However, only a few educators used TLJ enough to develop this intended relationship. In future iterations, we intend to increase this mentorship by offering educators more opportunities to interact with their mentors.

**Design**

The TLJ system and badges were developed over two consecutive summers. At the start of the process, strategic discussion, design options, and conversations occurred between the representatives of NASA, NSTA, and Penn State. We established a shared vision of the project’s initial setup and development over time.

**Year 1 initial badge and badging system design**

Several working groups of NASA education experts developed the badges, with each group focusing on a different topic. The topics most requested by the participants in a NASA online learning community were used along with topic-related activities selected by the NASA education experts, which were based on their experience and understanding of a broad library of educational materials. The first author oversaw platform development, which the project’s principal investigator, developer, and graphic designer helped to further drive via weekly discussions.
Year 2 badge and badging system refinement

The Year 2 design considerations focused on the feedback garnered from interviews and surveys of Year 1 learners. Ensuring clear and thorough explanation of the TLJ system and the requirements for a given activity was the project’s most important design improvement. Since all of the participants were engaging with TLJ from a distance, it was necessary to have clear steps for the activity, the criteria required for recognition, and the process necessary to be awarded a badge. When TLJ was launched, learners asked many questions that sought clarification about the system. Their concerns were quickly addressed to support the remote users. The second key design improvement was that all of the badges were updated with clearer instructions and stronger ties to pupil learning outcomes; we accomplished this by adding an educator who had both classroom and online teaching experience to the team. More support was designed and implemented for educators’ reflections at the end of activities to encourage critical thinking about the activities. Additionally, we had an editor review the badge activities to help provide consistency and clarity for the entire badge family. The TLJ system design also faced the challenge of improving metadata for each badge and stamp. While nearly all of the activity development team members had significant experience in curriculum design, the concepts of badges, badging, and metadata were new to them. During each iteration, the activity development team also considered what metadata were to be associated with each badge to communicate learners’ accomplishments as well as to be used by mentors and learners to better support learning within TLJ.
Development

We designed the TLJ system in PHP and went through several development iterations. To provide the desired flexibility and personalization in TLJ, the development approach included the basic structure for badging system functionality: create an account, select badge activities to complete, submit a log to earn a badge or stamp, receive feedback from an assigned mentor, resubmit the log as needed, and access badges in a personal archive. While we intended to integrate with Open Badges (through the Mozilla Open Badges Backpack program), the grant cycle ended before this work was completed.

Agile development model

The system designer, badge developer, and graphic artist used the Agile model to develop TLJ. The initial focus of the development was split into two areas: content and system. The content, with a group of activities per topic area, was developed through the support of NASA education experts. The activities were developed iteratively to help focus the content and to present it in a form that also made sense for a professional learning badge. Features and bugs were identified weekly for development and improvement. The Year 1 development focused on the creation of a system that offered a specific set of core functionality. The Year 2 development attempted to enhance the features that were most popular, update the interface, and add suggestions for missing functionality from the Year 1 feedback.

Redevelopment from year 1 to year 2

Survey feedback from Year 1 educators (described in the Evaluation section) showed that educators were confused about how to earn a stamp or badge. In response, we redesigned each
badging activity to include a thorough explanation of how to complete and submit the log to meet the criteria for the activity. Relatedly, in Year 2, we developed an orientation badging activity; the orientation provided information to support educators earning recognitions within TLJ. To encourage educators to sign up for this badging activity, the orientation badging activity was displayed at the top of every search list.

**Implementation**

Educators were invited to use TLJ through contacts of the NASA education experts. To participate, they had to volunteer as research participants who were testing a new tool for STEM over the summer in Years 1 and 2. Each summer’s group of participants was intended to be small in scope (n = 71) in order to ensure necessary functionality before a larger scale project was attempted.

**Overview of Teacher Learning Journeys Educators**

The TLJ participants were primarily from the United States, and most of them were elementary and middle school educators. Preservice teachers and high school, college, and informal (museum) educators also participated. Over the first 2 years of the TLJ, 71 educators completed 296 badges and stamps. Stamps (lower level) were the most popular form of assessment in both years, comprising nearly 86.48% of all recognitions earned. There was a wide range in the number of badges completed by each educator with an average of four badges per person. Approximately 30% of participants completed three or fewer stamps and badges across the 2 years of the pilot. Several participants each completed over a dozen activities (Table 3-1 and Figure 3-3). From our summative surveys and badge activity logs, the educators responded
favorably to TLJ. Overall, the request that came from the badging participants was to further increase the external recognition of badges with school administrators so that badges could be part of the required recertification effort. The biggest TLJ success was that educators reported that while they appreciated receiving recognition through badges and stamps, they were driven to use TLJ because of the available STEM content. During the 2 years, 174 activity survey responses were collected. An analysis of the survey showed that 94% agreed (or strongly agreed) that the activity they had completed was of high quality; 94% of the respondents agreed or strongly agreed that the “activity was relevant to their teaching.” While most of the educators found TLJ to be a valuable learning experience, only 49% of the educators responded that their supervisor would count the TLJ badges in lieu of in-house professional development.

**Evaluation**

Multiple evaluative tools were used in TLJ and outside of TLJ to understand learning and the learners’ experience with badging. These evaluative tools included learner-submitted bug reports, interviews with focal educators, activity-based surveys, summative surveys at the end of each development cycle, analyses of learners’ logs and reflective statements, and system log files.

Table 3-1. Awarded badges and stamps during TLJ’s first 2 years.

<table>
<thead>
<tr>
<th></th>
<th>Project Year</th>
<th></th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badges</td>
<td>21</td>
<td>19</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Stamps</td>
<td>133</td>
<td>123</td>
<td></td>
<td>256</td>
</tr>
<tr>
<td>Total</td>
<td>154</td>
<td>142</td>
<td></td>
<td>296</td>
</tr>
</tbody>
</table>
Ongoing formative assessment

We conducted formative system assessment in Years 1 and 2 through the use of a learner feedback system called bug reporting. A bug report feature was made available on every page of TLJ badging system. With the bug reports system, all learners had the option to immediately identify and report any problems they experienced. To ensure that the bugs were understood, the first author corresponded with the educators who submitted bug reports. He also confirmed with these educators that an update was made or explained how their suggestions were to be addressed in the upcoming development cycles.

![Frequency Distribution for All Badges and Stamps Completed](image)

Figure 3-3. Frequency for all badges and stamps completed.

Research on teacher learning journeys

We completed a summative assessment of the educators’ TLJ experience through case study analyses based on interviews, learner-created artifacts, and surveys. The TLJ research team
(Gamrat et al., 2014) selected 8 focal educators for interviews, which were completed with educators who represented a range of both years of teaching experience and grade level. This analysis offered an in-depth understanding of why educators signed up for TLJ, what their experience was like, and what they wanted to see in future iterations. A second analysis (Gamrat & Zimmerman, 2015) investigated TLJ more broadly \((n = 36)\) by examining Year 1 educators’ activity logs, reflective statements, activity surveys, and summative surveys. Through the summative survey on the first year, the TLJ participants \((n = 29, 80.5\% \text{ of total})\) answered questions regarding their overall impressions of the user experience and future iterations of design. When asked “If we continued to add and enhance the content, would you be likely to continue using the TLJ system?”, 92% said they either might or definitely would continue. In addition, 96% of respondents agreed with the statement “I would recommend Teacher Learning Journeys to other educators.”

From our analysis, we determined that a number of revisions could improve the overall TLJ program, including creating additional content for learners, developing an easier search feature for users, adding stronger learning analytics capabilities for researchers and administrators, providing learners the ability to follow others to create a stronger community, and integrating the project’s badges with Open Badges and backpack systems. When asked about social components to TLJ, 72% of Year 1 survey educators asked to be able to see resources and badge activities that other educators recommended. This supports educator professional learning by presenting more opportunities to identify learning activities through available metadata.

Conclusions

In this chapter, we presented the case of TLJ as providing and recognizing professional STEM learning via digital badges for K-12 teachers, university educators, and informal museum
educators. From the experiences of the educators in TLJ, we assert the importance of (a) collecting multiple forms of feedback from participants as formative and summative evaluation; (b) including multiple choices in the types of content available for the development of expertise and the support of interest; (c) including at least two levels of badging assessment; (d) providing clear instructions and orienting materials; and (e) developing strong mentoring relationships between the badge assessors and the learners.

Acknowledgments

The development of the TLJ system and its research were partially supported by the NASA Aerospace Education Services Project and the Center for Online Innovation in Learning at Penn State University. We acknowledge team members Kyle Peck and Jaclyn Dudek for their contributions to the broader TLJ research project.
Chapter 4 Methods and Data Analysis

This study used a design-based research (DBR) approach to (a) improve the design of digital badging systems by informing decision making with regard to future developments and (b) advance theory related to the role of cultural tools for planning and wayfinding during professional development for elementary and middle school teachers. DBR is appropriate for the study as it facilitates advancement in theory and practice (Wang & Hannafin, 2005). The design-based research method allowed for a focus on the research questions of how participant planning for their learning and wayfinding in two iterations of the Teacher Learning Journeys (TLJ) digital badging system. The DBR approach allowed me to reinforce learning theory regarding the concept of digital badging systems as a set of cultural tools and to address practice through recommendations to improve the design of the digital badging in professional learning contexts. This study is similar to other studies on teacher professional development using a design-based research method (Ching & Hursh, 2014; Diamond & Gonzalez, 2016). The analysis leverages Sandoval’s (2014) design conjectures approach which connects theory and the collected data.

Research setting

The context for this study is a teacher professional development (PD) program for elementary and secondary educators in science, technology, engineering, and math (STEM) topics. The study spanned two consecutive summers and was available to teachers in multiple states across the U.S. This research was conducted using a Penn State-developed digital badging system, TLJ. Using the digital badging system, teachers chose, completed, and received feedback and recognition for completing PD activities to support their teaching. The TLJ digital badging system was the result of a collaboration between the National Aeronautics and Space
Administration (NASA), the National Science Teachers Association (NSTA), and Penn State University. Each group involved in the collaboration supported the project with their respective expertise. NASA contributed subject matter experts and financial support. NSTA offered experience with developing online resources for large groups of elementary and secondary teachers. Finally, Penn State University supported the initiative through project management, learning science expertise, development resources, and content organization. All of the research took place at Penn State University.

**Participants in two iterations**

Each participant consented to the research by providing consent in the registration process for TLJ. The participants were recruited from across the United States through several STEM educator email lists. Participants were grouped by teaching experience and grade level taught. Years of teaching experience were categorized in three ranges: 0 to 5 years, 6 to 15 years, and over 15 years. Grade levels that participants taught were also categorized in three ranges: kindergarten to 4, 5 to 8, 9 to 12, which were defined by NASA to represent elementary school, middle school, and high school respectively. Among the registered users, 59 participants were included for this dissertation study. These participants met two inclusion criteria. They had completed at least one badging activity in the TLJ system and were either elementary or middle school teachers. These elementary and middle school teachers were selected for the analysis as they were the primary focus of the project efforts of Penn State, NASA, and NSTA. Table 4-1 provides an overview of the participants and Table 4-2 provides an overview of participants’ completed PD activities.
Table 4-1. I-1 and I-2 distribution of participants across years of teaching experience and grade level.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>0 – 5 Years</th>
<th>6 – 15 Years</th>
<th>15+ Years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary School</td>
<td>Total: 4</td>
<td>Total: 14</td>
<td>Total: 11</td>
<td>Total: 29 (49.2%)</td>
</tr>
<tr>
<td>Middle School</td>
<td>I-1: 3 I-2: 2</td>
<td>I-1: 5 I-2: 8</td>
<td>I-1: 6 I-2: 6</td>
<td>I-1: 14 I-2: 16</td>
</tr>
<tr>
<td></td>
<td>Total: 5</td>
<td>Total: 13</td>
<td>Total: 12</td>
<td>Total: 30 (50.8%)</td>
</tr>
<tr>
<td></td>
<td>Total: 9 (15.3%)</td>
<td>Total: 27 (45.8%)</td>
<td>Total: 23 (39.0%)</td>
<td>Total: 59</td>
</tr>
</tbody>
</table>

Table 4-2. I-1 and I-2 total completed activities by teacher participant groups across years of teaching experience.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>0 – 5 Years</th>
<th>6 – 15 Years</th>
<th>15+ Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total: 14</td>
<td>Total: 48</td>
<td>Total: 62</td>
</tr>
<tr>
<td></td>
<td>Total: 12</td>
<td>Total: 74</td>
<td>Total: 41</td>
</tr>
</tbody>
</table>

**Outline of a design-based research study**

This design-based study examined the two iterations of TLJ (one summer each). Much like the work of Ching and Hirsh (2014), this study identified design-based research as appropriate after the data was collected. This dissertation study also parallels the work of Ching and Hirsh (2014) in the overall goal of offering teacher professional development intended to impact professional practice. The conjectures and associated research questions are elaborated in the findings sections for planning and wayfinding. Sandoval (2014) describes conjectures as
creating a way to outline the connection to the learning environment in the study, theoretical considerations at play, and the anticipated outcomes of these factors. The findings portion of this study will employ this approach to discuss relevant design conjectures. The design of this study uses a qualitative thematic analysis and statistical analysis of participant-generated artifacts and teachers’ interactions with the TLJ system. This analysis allows for both a collective and a comparative understanding of participant experiences in two iterations of TLJ. Selected case study participants elaborate on the findings of the study with qualitative descriptions of participants’ actions and stated intentions. Stake (1995) recommends the triangulation of data in an analysis to strengthen and better understand the findings of a study. The implementation of multiple analytical techniques in this study bolsters the multiple findings furthering the understanding of participant planning and wayfinding (see Table 4-3). Overall, this blend of qualitative and quantitative analyses develops the theoretical and design implications by exploring how participants may engage in planning and wayfinding for their professional learning.

**Data collection**

The primary data sources for analysis were the participant-generated artifacts collected through the participant interaction with the TLJ digital badging system. This study focuses on interaction and uses of TLJ in the lens of sociocultural theory and mediation triangle framework (Cole, 1996; Rogoff, 2003; Vygotsky, 1980) as a conceptual lens for the digital badging system serving as a set of cultural tools for planning and wayfinding activities in a teacher professional development program. Moreover, the research will develop through data triangulation from individual experiences (see Table 4-3).
Participants engaged in the study as part of their interest in professional learning and their involvement with the study was not a required professional development program. Participants chose to use their own time in the summer to engage with TLJ. The data was collected for program evaluation used to deliver reports to the principal investigator and other managing stakeholders of the project and research. All case study examples in this dissertation used anonymized participant-generated artifacts and pseudonyms.

Participant-generated artifacts collected with the TLJ digital badging system included goal statements, the orientation activity reflections, intended PD activities, and completed PD activities (stamps and badges). Goal statements were brief participant reflections of what the participants intend to achieve while using TLJ. The orientation activity acted as unique evidence among the badge activities as it asked participants to reflect further on their PD plans. Intended PD activities were a list of activities that participants wanted to complete. Completed PD activities were activities with evidence submitted for stamps and badges and the time-stamped supporting documentation for completing a given activity. The completed PD activities were awarded by NASA education experts for completing the activity requirements. My prior work (Gamrat & Zimmerman, 2015; Gamrat, et al., 2014) examined data from the first iteration of Teacher Learning Journeys using a ubiquitous mobile learning framework lens (Kearney et al., 2012). This dissertation, however, differs in the data collection and theoretical framing by including both iterations of TLJ and extending the conceptual understanding of digital badging systems as a set of cultural tools.

**Data analysis procedures**

Participant-generated artifacts (such as goal statements, the orientation activity reflections, intended PD activities, and completed PD activities) were the primary data sources
analyzed for this study. Similar to my previous work (Gamrat & Zimmerman, 2015; Gamrat et al., 2014), this study used qualitative coding techniques to understand how participants used the digital badging system. While my prior work used qualitative coding to approach aspects of ubiquitous mobile learning, this study used a combination of qualitative coding and statistical analysis to understand participant activities while using the TLJ digital badging system as a set of cultural tools in the context of professional development. After iteratively reviewing the participants’ goal statements and orientation activity reflections, I developed five approaches to qualitative analysis described later in this chapter. Data analysis includes a comparison of the iterations of TLJ and use of cultural tools within TLJ.

Analysis of participant wayfinding used the TLJ digital badging system artifacts (intended and completed PD activities) across iterations of TLJ. These data supported analysis to understand participant wayfinding and patterns across iterations of TLJ. Descriptive statistical analysis, independent samples t tests, Pearson r, and emergent qualitative analyses supported the identification of TLJ use patterns. Table 4-3 offers an overview of the study’s research questions, data analyzed, analysis techniques, and anticipated patterns in planning and wayfinding.
Teacher use of planning tools for professional development

First, this study looked at TLJ as a set of cultural tools to support participant planning for teacher professional development. The study investigated participants’ use of the TLJ digital badging system to articulate their learning goals. As part of the iterative design, the TLJ digital badging system was changed to promote further written reflection of learning goals. During the first iteration of the study, participants were asked to write a purpose for their professional development in which they were given an open-ended prompt to consider a purpose for their professional learning in the context of the study (see Figure 4-1). During the second iteration of the study, an orientation activity (see Figure 4-2) was added as a way to support incoming participants to TLJ to think about their professional development goals and how they would begin
to pursue these goals. This dissertation study analyzed both goal statements and orientation activity reflections to understand this part of the participant experience.

**Begin here, by stating the purpose for your virtual journey.** In a real journey a traveler's purpose might be "To see the pyramids and learn about Egyptian culture," but for a virtual Teacher Learning Journey (TLJ) the purpose will be more like "To learn more about the solar system and to identify new hands-on activities that make learning this more interesting and more effective for my students." It's a statement of what you want to accomplish, and why. It's quite likely that you may return here to modify the purpose, perhaps even a few times, as you browse the learning activities and discover new opportunities for professional development.

In the future (after this pilot) we may allow you to create and even work on multiple journeys, but for now, you will create a single journey.

**The next step is to browse the learning opportunities we have assembled for you and choose the ones you want to add to your itinerary. To do this, click the "Activities" tab.**

Figure 4-1. I-1 goal statement instructions.
Planning data collection

Data were collected to understand how participants used the TLJ digital badging system to support their learning objectives through written goal statements and the orientation activity reflections. Participants, though not all, created artifacts in the TLJ digital badging system by writing their goal statements (I-1 and I-2 combined, \( n = 50 \)) and a reflective log for the orientation activity (I-2, \( n = 14 \)). When each participant initially registered in TLJ, they were encouraged to write a brief goal statement to help them consider the professional development they wanted to pursue while using the digital badging system. This planning task was framed within the study using a travel analogy shown in Figure 4-1. Planning through the goal statement
in the TLJ digital badging system was intended to support participants as both a point of entry and a direction in which they would want to pursue their professional learning goals. The second iteration of TLJ included an addition of an orientation activity. The orientation activity (shown in Figure 4-2) was in response to participant feedback in interviews, emails, and I-1 participation in setting goal statements. The intent of the change was to support an introduction to the badging system and help participants as they find a starting point for planning what they want to do by selecting PD activities in TLJ that would help to achieve their goals. The orientation activity design offered an introduction to the TLJ digital badging system and the functionality available to the participants. This activity, shown in Figure 4-2, attempted to more closely tie the participant goal statement and initial selection of PD activities by suggesting participants further plan by identifying an approach to meeting their learning goals. The analysis looked at both the goal statements and the orientation activities to understand the use of these two components of the TLJ digital badging system were used by teachers for participant planning. The reflections from the orientation activity provide a supplement to the goal statements and help to understand activity in I-2 of TLJ more clearly. Within the mediation triangle framework, participants (subjects), used the goal statements and the orientation activities (artifact/tool), to articulate their learning goals and how they might make progress toward those goals (objective). This framing supports a view of each participant making use of the cultural tools to personalize the planning for their professional development.

**Planning analysis technique**

The analysis on how cultural tools mediated the teachers’ planning used evidence primarily focused on the teacher-participants’ written reflections posted in the online TJL digital badging system. Written reflections included both goal statements and the orientation badge’s
activity reflections submitted for micro-assessment to the teachers’ mentors. My study’s analysis plan aggregated the participants’ stated factors that influenced participants’ choices. This choice to focus on self-reported data parallels the study design of Ching and Hirsh (2014), who analyzed the factors which led to teacher project choice.

My analysis for participant planning was conducted in three parts: impacts of goal statements and orientation activity reflections, content interests, and objectives in goal statements. The mediation triangle was used to analyze each teacher-participants’ decision toward pursuing professional development, and then I identified teachers’ patterns of use related to goal and tool mediation in terms of the various badge system components. I focused on similarities and differences between the expectations of the TLJ developers and the expectations of the teacher-participants of how planning tools would be used to mediate experiences in our online PD program. The similarities and differences uncovered through qualitative coding and statistical analyses demonstrated how teachers used the TLJ digital badging system to plan their professional development.

First, I compared the participant goal statements and orientation activity reflections using statistical analyses (independent samples t tests and Pearson r) to examine the variables of number of completed activities, word count, completion of goal statements and orientation badge reflection, and reflection specificity. For the statistical analyses, I conducted independent samples t tests to evaluate the differences between participants who made use of the orientation activity and those who only completed the goal statement in terms of word count and number of activities completed. I then used Pearson r to identify a correlation between the number of words written in each teacher’s reflection and the number of completed activities (badge or stamp) completed by each teacher.

Second, I conducted a qualitative analysis, which involved coding goal statements and orientation activity reflection for specificity (scored as either specific or vague) with second
researcher corroborating my codes. Specificity was defined in relation to teachers’ pedagogical or curriculum needs, including the mention of applying PD to specific grade levels, content, or activities within the reflection. Next, I did another quantitative analysis using this binary coding scheme. I conducted a Pearson $r$ correlation to examine impact of specificity on completed activities. To further understand the impacts of these cultural tools for planning, I analyzed the reflections written by participants who completed both the goal statement and the orientation activity. I used the rubric shown in Table 4-4 to compare the two participant reflections from I-2 of TLJ. Table 4-5 offers an example of participants with moderate and strong alignment between their goal statements and orientation activity reflections. My coding was reviewed by a second researcher to strengthen the validity and applicability of the study’s findings.

### Table 4-4. Alignment rubric for the analysis of goal statement and orientation activity reflections used by participants as a cultural tool for professional development planning.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Total # of Participant Reflections</th>
</tr>
</thead>
<tbody>
<tr>
<td>No reflection - Participants did not complete both the goal statement and the orientation activity reflection.</td>
<td>1</td>
</tr>
<tr>
<td>Goal statement only – Participants completed only the goal statement activity.</td>
<td>14</td>
</tr>
<tr>
<td>Orientation activity reflection only – Participants completed on the orientation activity reflection.</td>
<td>2</td>
</tr>
<tr>
<td>No Alignment - Participants responded to both prompts, but there was no clear connection between articulated goals and Orientation reflection.</td>
<td>1</td>
</tr>
<tr>
<td>Moderate Alignment - Participants responded to both prompts, but without specific examples of activities, they indented to complete to support their learning goals.</td>
<td>5</td>
</tr>
<tr>
<td>Strong Alignment - Participants responded to both prompts with specific examples of activities they indented to complete to support their learning goals.</td>
<td>6</td>
</tr>
</tbody>
</table>
Table 4-5. Moderate and strong alignment examples in goal statements and orientation activity reflections.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Goal Statement</th>
<th>Orientation Activity Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate Alignment</td>
<td>My purpose is to engage in educational opportunities in STEM topics for me and my students. Also, I am happy to have this system to keep track of my work to enhance my resume.</td>
<td>Today [NASA EDUCATION EXPERT] described how to use TLJ and noted differences between Scientific and Engineering processes. He described engineering work in many NASA projects.</td>
</tr>
<tr>
<td>Strong Alignment</td>
<td>I am always looking for new resources to increase my STEM knowledge and skills. I was also interested in finding out more about the digital badge “phenomenon.” These things led me to this site. The activities were chosen for multiple reasons. Engineering Design Process was a large part of the curriculum I recently taught, and I am interested in seeing how it is presented in your lessons. My son’s science class is studying the lunar phases, hence the selection of that activity. I am personally very interested in digital photography and loved the idea of being able to combine it with a classroom lesson.</td>
<td>My first activities were chosen for multiple reasons. I chose the Engineering Design Process activities because that was a large part of the curriculum I recently taught and I am very interested in getting other thoughts, ideas, and viewpoints on it. I personally love digital photography, so I thought that being able to integrate it into a classroom lesson would be wonderful! I’m hoping that I can take ideas from that activity &amp; apply them in other areas as well. Since my son is currently studying the lunar phases in school, I thought this would be a good extension activity that would allow us to do something both fun and educational (for both of us) together.</td>
</tr>
</tbody>
</table>
Second, I reviewed the participant goal statements and the orientation activity reflections for the types of activities and content participants were identifying for their PD. This analysis was conducted by reviewing participant artifacts in the TLJ system for mention of topic-specific interests as part of their articulation of planning. Topic-specific included both named activities (e.g., engineering), technology integration, and cross-curricular interests. This analysis reviewed and summarized participant interest in specific content across both iterations of TLJ.

Third, I reviewed participant goal statements for teachers’ stated objectives written as part of the intended professional development plans. This dissertation study approaches data analysis for participant goal statement by utilizing emergent qualitative coding. In previous work, my colleagues and I (2014) utilized emergent qualitative coding with a focus on personalization and the sub-categories of customization and agency in participant reflections looking at activity reflections. Data analysis through qualitative coding was completed over six iterations of review and refinement with other researchers providing feedback at the third, fourth, and sixth iterations. Table 4-6 lists the emergent codes, explanations, and examples for participant orientation and Table 4-7 summarizes frequency of codes across iterations of TLJ. These examples provided insight into the participant experiences of planning professional learning goals. The emergent codes were refined to identify participants’ objectives for professional development and are discussed in greater depth in the Findings section of this dissertation.
Table 4-6. Four identified objectives from emergent thematic coding from goal statement reflections for participant professional development planning with bolded examples of each objective.

<table>
<thead>
<tr>
<th>Thematic Code</th>
<th>Explanation</th>
<th>Example for the TLJ data set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivate</td>
<td>Engage or inspire students</td>
<td>Dana: “... and <strong>how it can be taught in a very hands-on manner</strong> to elementary students.”</td>
</tr>
<tr>
<td>Improve</td>
<td>Developing knowledge or skills</td>
<td>Ava: “I've been at a professional workshop for the last two weeks, and while there have certainly been ah-ha moments and resources that will make me a better teacher (such as this site), it has also shown me that <strong>it is EXHAUSTING to sit for hours listening to others.</strong>”</td>
</tr>
<tr>
<td>Share</td>
<td>Communicate experiences and resources with students or colleagues</td>
<td>Brenda: “...Then I will be able to <strong>share with my students and my colleagues...</strong>”</td>
</tr>
<tr>
<td>Collect</td>
<td>Gather educational resources or professional development recognition</td>
<td>Trisha: “... <strong>while earning Professional Development Units (PDU) to renew my credential.</strong>”</td>
</tr>
</tbody>
</table>

Table 4-7. Overview of objectives identified from goal statements used to articulate personalized learning in professional development.

<table>
<thead>
<tr>
<th></th>
<th>I-1</th>
<th>I-2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivate</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Share</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Collect</td>
<td>5</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>Improve</td>
<td>24</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>No Written Reflection</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>

**Teacher use of wayfinding tools for professional development**

In addition to investigating planning, this study also explores learners’ experiences using digital badging systems as a set of cultural tools to support wayfinding for teacher professional development. Wayfinding is defined as “the cognitive, decision-making process carried out by self-directed learners as they assume responsibility for choosing and sequencing their learning events” (Tattersall et al., 2005, p. 110). In this study, digital badging systems function as a set of
cultural tools for wayfinding, which support a learner as they construct a unique sequence or pathway of PD activities to their learning goals. From a digital badging system perspective, my colleagues and I described multiple approaches to structure wayfinding in the design of digital badges ranging from defined paths (a direct sequence) to individual navigation through a collection or badge family (a related grouping) which supports different goals of learners and educators (Gamrat, Bixler, & Raish, 2016). Badges within this study did not include prerequisites but gave an open choice across a badge family. This analysis focused on how participants approached open-ended learning experiences to build personal learning paths in I-1 and I-2 of TLJ. Similarly, Ching and Hirsh (2014) emphasize decision-making for teachers in their design-based research study by examining participant project choice.

Wayfinding data collection

This study explored how participants used badges for wayfinding toward their learning goals. The intended and completed PD activities across two iterations of TLJ were the primary data for the wayfinding analysis. Intended and completed PD activities were data tables stored as part of TLJ to track participant interactions. The TLJ digital badging system offered the intended activities list as a queue function allowing participants to maintain a list of the badge activities they intended to complete. Participants using the intended PD activities list could organize participation in PD across the span of weeks and months. By utilizing the badge queue function, participants could identify and organize a list of activities they wanted to accomplish soon, and maintain a list of new things to learn later. As participants completed badge activities, the associated information was stored in a log of evidence and acted as a list of completed activities. Each badge activity required evidence of personal reflection on the completed activity that supported personal relevance (Gamrat et al., 2014). The reflection logs served a secondary
purpose as a resource for teachers to revisit during the school year for implementation in their professional practice. Moreover, the intended and completed PD activities were designed to serve as organizing lists for the participants to see a personalized past and potential future of PD engagement. This analysis looked at the data as a window into participants’ approaches to PD wayfinding in the badging system.

**Wayfinding analysis technique**

The analysis identified patterns in teacher wayfinding. An independent samples \( t \) test with each iteration of TLJ as a sample offered an initial understanding of intended and completed PD activities. An independent samples \( t \) test showed that the number of activities educators completed during I-1 \( (M = 4.23, SD = 3.78) \) and I-2 \( (M = 4.17, SD = 4.47) \) did not significantly differ, \( t(57) = 0.06, p = .955 \). The mean of itinerary items also did not differ between the two iterations \( (M_{I-1} = 12.30, SD = 7.37; M_{I-2} = 11.66, SD = 7.28) \) \( t(57) = 0.34, p = .737 \). This nonsignificant result supports the statistical analysis of the participants as a whole and allowed for comparing the two iterations of TLJ and analyzing the full dataset.

I looked at how teachers made use of the functionality of the TLJ digital badging system to support their PD wayfinding through the orientation activity and the intended activities list. A combination of intended PD activities and completed PD activities data was used identify patterns of time-based interactions with the TLJ digital badging system afforded identification of intended PD activities list uses such as wish list, checklist, and no list. The findings section of this dissertation discusses each of these patterns. As a cultural tool for wayfinding, a Pearson \( r \) correlation was used to identify a relationship between intended and completed PD activities. Completion rates were analyzed through the ratio of the number of unique completed activities (stamps or badges) compared to the number of intended activities with descriptive statistics. The
orientation activity was analyzed for impact on intended and completed PD activities through an independent-samples \( t \) test. This analysis compared I-2 participants who completed the orientation activity with those who did not complete the orientation activity. The wayfinding analysis offered a way to understand participant decisions about their professional learning paths.

Participant wayfinding analysis consisted of reviewing participant use of the TLJ digital badging system to support professional development through time-based interactions with the cultural tools that made up the TLJ digital badging system. Time-based patterns of wayfinding were uncovered through emergent pattern identification. These patterns were found by organizing participant intended and completed PD activity data into a single spreadsheet. The combination of these participant interactions with the TLJ digital badging system allowed for the identification of use patterns across the two iterations of TLJ. The three emergent time-based participant patterns were Weekend Warriors (a single period of engagement lasting 1 to 2 days), Little Loopers (cycling in and out of the system), and Big Loopers (a return to the system after the conclusion of a TLJ iteration) (see Table 4-8).

Table 4-8. Teachers personalized their professional development through access time(s).

<table>
<thead>
<tr>
<th>Pattern</th>
<th>I-1</th>
<th>I-2</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekend Warriors (1 -2 Days)</td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Little Loopers (&lt; 3 Months)</td>
<td>26</td>
<td>20</td>
<td>46</td>
</tr>
<tr>
<td>Big Loopers (&gt; 3 Months)</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

**Trustworthiness**

Stake (1995) describes methodological triangulation as offering a way to support or refute findings from a singular methodology. Maxwell (2005) supports this technique purporting the utility of multiple methodological approaches to reduce bias inferred by a given method. This
study made use of this approach by leveraging analysis both across all participants and examining iterations of TLJ. Moreover, this approach supported triangulation through multiple analyses of planning and wayfinding. Statistical analyses and emergent pattern analysis supports a triangulated approach to wayfinding.

This study’s design developed emergent codes supported by secondary coders to develop agreement on identification and application. The secondary coder reviewed the identified codes, examples provided, and worked through approximately 25% for the goal objective analysis. The remaining 75% were then coded alone using the agreed upon application of codes. The specificity and alignment analyses were reviewed fully with a peer researcher together with me to develop a consensus. This technique supported a more consistent development and use of codes for the dataset when comparisons between iterations are needed.

**Ethical considerations**

This study was reviewed and approved by the Pennsylvania State University’s Institutional Review Board. Participants consented to the study as part of their registration to use the badging system. Participants were able to end their involvement with the study at any point and were not required to engage with Teacher Learning Journeys. The research design guaranteed the confidentiality of this study by removing identifiable information from the participant-generated data and use of pseudonyms for the participants.

This study focused on the context of a system to support teacher professional development with the intent that the awarded badges and stamps would then be able to act as a way to demonstrate PD experiences and receive recognition from school districts for completing PD activities. While the TLJ digital badging system was intended to offer a mechanism to
recognize learning, this study does not focus on the recognition aspects external to Teacher Learning Journeys (i.e., how the form of credentials was used or perceived outside of TLJ).

**Methodological strengths and weaknesses of this study**

This study was intended to explore the use of digital badging systems as a set of cultural tools within the context of elementary and middle school STEM teacher PD. The structure of the study resulted in the previously described time and duration, sample size, collected data, and system development. TLJ offered badges for non-credit learning as compensation for participation. This access to educational resources as compensation was available to participants willing to engage in outside professional learning. The study spanned two iterations (one summer each) which resulted in limitations on timing and duration. As with the compensation limitation, participants may have been extraordinary among their peers as they volunteered time during their summer vacation. Moreover, all participants were only involved in one iteration of the TLJ, resulting in two cohorts. TLJ system development was on-going throughout the duration of the study which included updates to the interface, functionality, and activities. For these reasons, it is important to understand the context and how to make use of this analysis provided.
Chapter 5 Participants Exhibited Similar Patterns in Professional Development Planning Across Iterations of the Digital Badging System

Chapter 5 investigates how participants used the Teacher Learning Journeys (TLJ) digital badging system as a set of cultural tools for professional development planning. I collected and examined goal statements (I-1, \( n = 25 \); I-2, \( n = 26 \)) and orientation activity reflections (I-2 only, \( n = 18 \)) from 59 teacher participants. The conceptualization of cultural tools (Rogoff, 2003; Vygotsky, 1980), the mediation triangle (Cole, 1996), and individual personalized learning (Gamrat & Zimmerman, 2015; Kearney et al., 2012; Wills & Xie, 2016) served as the theoretical lens for an in-depth analysis of the data. Iterative qualitative analysis yielded insight into participant interaction with the badging system. This qualitative analysis coupled with statistical analyses offered perspective on the TLJ system, differences in iterations of the system (I-1 and I-2), and how future badge system design may benefit. Overall, this chapter offers three findings related to digital badging systems serving as a set of cultural tools to mediate teachers’ PD planning:

- Cultural tools for reflection added in Iteration 2 of TLJ supported planning and wayfinding.
- Cultural tools of I-2 of the digital badging system supported teacher goal articulation beyond the scope of the anticipated design.
- Four common objectives were identified from teachers when writing a personalized goal statement for their professional development in the digital badging system.

Cultural tools for reflection added in Iteration 2 of TLJ supported planning and wayfinding

The TLJ digital badging system offered teachers a set of cultural tools for professional development planning by elucidating individuals’ goals. Both iterations of TLJ encouraged teachers to write a reflection on their professional goals before selecting and completing badge PD activities. From I-1 to I-2 of TLJ, the TLJ design team provided teachers one additional
support as a badge for planning via an optional orientation activity encouraging further articulation on how their PD choices tie to their personal learning goals. The intended design of the goal statement activity and orientation activity anticipated that the teachers would use both activities as cultural tools for planning by recognizing individual choice through reflection on personalized learning needs. Additionally, within each badge, prompts for reflection were added in I-2 of TLJ to support the required written retrospection for completing an activity within the badging system.

**Impacts of cultural tools for planning**

Of the 29 participants in I-2, 28 teacher-participants completed at least one of the planning activities (goal statement and/or orientation activity reflection). We found that 14 teachers wrote just a goal statement, 2 teachers wrote only an orientation badge activity reflection, and 12 teachers wrote both. To examine the impact of the orientation badge activity on reflection through word count and engagement through completed activities, I removed (from this analysis only) the teachers who did not complete any other badge activities aside from the orientation badge activity; 7 participants in I-2 were excluded from this analysis. Therefore, I compared the participants who completed both the goal statement and the orientation activity \( (n = 8) \) to those who only completed the goal statement \( (n = 14) \).

An independent samples \( t \) test found a statistically significant difference in the number of completed activities \( (p = .044) \) between teachers who completed both the goal statement and the orientation activity \( (M = 8.38, SD = 6.32) \) and those who only completed the goal statement \( (M = 2.86, SD = 2.18) \). I interpret the statistical significance to mean that, for the teachers in my study, there was benefit in completing more professional development when completing both reflection
activities. The statistical significance suggests value in further exploring the impact of the orientation activity on participants.

I next conducted an independent samples t test to further compare the two groups of teacher-participants that completed the orientation badge activity and the goal statement and the teacher participants that completed only the goal statement to assess the impact on reflection depth through word count ($M_{\text{Orientation\_activity}} = 47.13, SD = 26.15$; $M_{\text{Goal\_statement}} = 45.14, SD = 26.94$). I found no statistically significant difference in word count of the teachers’ goal statements ($p = .867$) when comparing goal statements between those that did and did not write an orientation activity reflection. This suggests that goal statement reflections are similar across these groups and that the orientation activity makes little impact on the size of the written reflections. However, when I conducted another independent samples t test including the second reflection in the orientation activity, the teachers who completed both the goal statement and the orientation badge ($M = 165.25, SD = 104.42$) had a statistically significant higher word count ($p = .014$) compared to those who only completed the goal statement ($M = 45.14, SD = 26.94$). I interpreted this positive relationship between completing both the goal statement and the orientation badge and the amount of teacher reflections written to suggest that teachers utilized the orientation badge to further articulate their professional development goals beyond those written in the goal statements. This suggests a possible benefit to including multiple planning cultural tools for mediating orientation through reflection in online digital badging systems.

Furthermore, I ran a Pearson $r$ correlation to determine a relationship between word count and number of completed activities. When comparing only word count of the goal statements and number of activities, there is a weak negative relationship with the number of completed activities ($r = -.181, p = .420$). It is possible in this case, more may not be better; the teacher-participants who do use the provided cultural tools in the online TJL digital badging system may have had a focused set of PD activities competed. While it is unclear if the TLJ digital badging system serves
as a cultural tool for orientation through reflection on personal professional development the
digital badging system did serve as a cultural tool to make teachers’ interests more transparent for
professional development providers. This is demonstrated when the word counts of the goal
statement and the orientation activity reflection are combined and compared to the number of
completed activities, there is a moderately positive correlation \( r = .396, p = .068 \). The positive
correlation indicates the benefit of the two combined orientation activities activing a useful
cultural tool in regards to positioning participants to complete more activities towards their own
personal PD goal. The positive correlation suggests a benefit of the orientation activity to
completing additional PD modules. Additional research examining the relationship between word
count of written goals and progress toward goals in the form of completed professional
development activities would benefit future professional development support systems.

To determine the role of the badging system cultural tools in mediating specificity in
teacher planning, I applied a binary coding scheme to the participant planning reflections,
reviewing both the goal statements and the orientation activity reflections in I-1 and I-2 of TLJ.
Reflections were coded as specific if they included mention of a teacher’s grade, content area
interests, or activities they wanted to complete. Independent samples \( t \) tests were conducted
across the iterations of TLJ to examine the influence of specificity in planning reflections on the
reflection word count and number of activities completed. As shown in Table 5-1, there is no
statistically significant relationship between specificity, word count, and number of completed
badging activities. The lack of relationship between specificity, word count, and number of
completed badging activities suggests an organic progress in professional development on the
part of the teacher-participants with teachers beginning with initial considerations rather than
specific plans to execute. Future research may further examine the role of specificity for planning
reflections for teacher professional development.
Table 5-1. No significance was found with an independent samples $t$ test analysis to examine the relationship between specificity, number of completed activities, and word count.

<table>
<thead>
<tr>
<th></th>
<th>I-1</th>
<th>I-2</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Word count</td>
<td># Completed activities</td>
<td>Word count</td>
</tr>
<tr>
<td>$M$</td>
<td>$S = 44.786$</td>
<td>$S = 5.14$</td>
<td>$S = 160.857$</td>
</tr>
<tr>
<td></td>
<td>$V = 28.818$</td>
<td>$V = 3.45$</td>
<td>$V = 55.200$</td>
</tr>
<tr>
<td>$SD$</td>
<td>$S = 40.8415$</td>
<td>$S = 4.704$</td>
<td>$S = 123.413$</td>
</tr>
<tr>
<td></td>
<td>$V = 18.904$</td>
<td>$V = 2.207$</td>
<td>$V = 32.216$</td>
</tr>
<tr>
<td>$p$</td>
<td>.244</td>
<td>.285</td>
<td>.065</td>
</tr>
</tbody>
</table>

To further extend my analyses of the impacts of goal statements and orientation badge activities, I conducted a qualitative analysis on teacher reflections in goal statements and the orientation activities. This qualitative analysis found textual evidence of alignment (described in Table 5-2) between teachers’ reflections on goal statements and the orientation activity reflection. The rubric in Table 5-2 describes the criterion for alignment between teacher goal statements and orientation activity reflections including definitions used and total number of teachers meeting the rubric criterion. In I-2 of TLJ, 12 teachers completed both activities. The majority of these teachers, 91.7% ($n = 11$), had moderate or strong alignment when writing how their professional development choices in the Teacher Learning Journeys digital badging system supported their learning goal statements.

Table 5-2. Most participants who completed both the goal statement and orientation activity reflections demonstrated an alignment between the two reflections as identified through an alignment rubric.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Total # of Participant Reflections</th>
</tr>
</thead>
<tbody>
<tr>
<td>No reflection - Participants did not complete both the goal statement and the orientation activity reflection.</td>
<td>1</td>
</tr>
<tr>
<td>Goal statement only – Participants completed only the goal statement activity.</td>
<td>14</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Orientation activity reflection only – Participants completed on the orientation activity reflection.</td>
<td>2</td>
</tr>
<tr>
<td>No Alignment - Participants responded to both prompts, but there was no clear connection between articulated goals and Orientation reflection.</td>
<td>1</td>
</tr>
<tr>
<td>Moderate Alignment - Participants responded to both prompts, but without specific examples of activities, they intended to complete to support their learning goals.</td>
<td>5</td>
</tr>
<tr>
<td>Strong Alignment - Participants responded to both prompts with specific examples of activities they intended to complete to support their learning goals.</td>
<td>6</td>
</tr>
</tbody>
</table>

Moderate alignment and strong alignment between their goal statements are differentiated where teacher goal statements and orientation activity reflections used related and specific examples describing what teachers wanted to learn related to their goals. Table 5-3 provides a comparison between moderate alignment and strong alignment. The examples in Table 5-3 demonstrate teacher reflection on how they might utilize TLJ to pursue their learning goals.
Table 5-3. Teachers with moderate alignment differed from those with strong alignment in comparing goal statements and orientation activity reflections because they lacked concrete examples of activity planning.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Goal Statement</th>
<th>Orientation Activity Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate Alignment</td>
<td>My purpose is to engage in educational opportunities in STEM topics for me and my students. Also, I am happy to have this system to keep track of my work to enhance my resume.</td>
<td>Today [EDUCATION SPECIALIST] described how to use TLJ and noted differences between Scientific and Engineering processes. He described engineering work in many NASA projects.</td>
</tr>
<tr>
<td>Strong Alignment</td>
<td>I am always looking for new resources to increase my STEM knowledge and skills. I was also interested in finding out more about the digital badge “phenomenon.” These things led me to this site. The activities were chosen for multiple reasons. Engineering Design Process was a large part of the curriculum I recently taught, and I am interested in seeing how it is presented in your lessons. My son’s science class is studying the lunar phases, hence the selection of that activity. I am personally very interested in digital photography and loved the idea of being able to combine it with a classroom lesson.</td>
<td>My first activities were chosen for multiple reasons. I chose the Engineering Design Process activities because that was a large part of the curriculum I recently taught and I am very interested in getting other thoughts, ideas, and viewpoints on it. I personally love digital photography, so I thought that being able to integrate it into a classroom lesson would be wonderful! I’m hoping that I can take ideas from that activity &amp; apply them in other areas as well. Since my son is currently studying the lunar phases in school, I thought this would be a good extension activity that would allow us to do something both fun and educational (for both of us) together.</td>
</tr>
</tbody>
</table>

The use of the provided cultural tools within I-2 of TLJ for goal setting structures was common (i.e., 28 of the 29 participants). For those using the provided goal setting cultural tools, these tools offered a means for teacher-participants to align their activities and goals – as shown with the relationships found via correlations between the participant goal statements and orientation activity reflections. These findings inform theoretical literature by supporting the
assertion of digital badging systems as a set of cultural tools for participants to extend their goal reflections and further personalize their learning by identifying activities to support those goals. Moreover, the I-2 design of TLJ may also act as a cultural tool for badge system developers as the reflections provided support for the participants to articulate their plans and goals. With greater learner articulation in written form, not only do the teacher-participants benefit; badge developers and system mentors can use participants’ reflective data for system improvement. For instance, badge developers and system mentors could utilize learner information as a tool to provide improved feedback and recommendations to learners, allowing a revised system with new tools allowing teacher-participants to target to their individual PD goals.

**Impact of cultural tools for activity reflection**

The TLJ design team hypothesized that suggested prompts for reflection to complete a badge activity would encourage teachers to write their assessment evidence with greater elaboration of professional lessons learned. To test this hypothesis, I conducted an independent samples t test comparing word count in the completed activity reflections from the first iteration of TLJ without the extra prompts within the badging activities (n = 119, M = 244.1, SD = 193.3) to the second iteration of TLJ with the additional prompts (n = 134, M = 233.6, SD = 157.3); there was no statistically significant difference (p = .635) between the word count of the prompted and unprompted badging reflections. This lack of significance, we posit, is an important finding, demonstrating that the reflective prompts may not have had influence over the depth or length of teacher reflections. Given the small sample size of our project, future research may find value in further examination of the use of reflective prompts for professional development progress. It may be that teachers are reflective professionals who did not need prompts or it may be that our study populations (with 30 teachers in I-1 and 29 teachers in I-2) were not large enough to detect
a change. So, while we did not find a value in these prompts for our teachers, a larger sample size or a different population may provide better insights on how reflective may impact a learner’s work.

Cultural tools of I-2 of the digital badging system supported teacher goal articulation beyond the scope of the anticipated design.

In this analysis, I found that participants used the digital badging system as a set of cultural tools to customize their professional development planning by identifying topic-specific goals (I-1, n = 8; I-2, n = 11). As a cultural tool, the design of the TLJ digital badging system intended to support the articulation of teacher goals related to learning within the system. Teachers made use of the goal statements and orientation activities as cultural tools for cognitive, reflective purposes with content knowledge acquisition as a common focus for professional development. Teachers of I-1 described interest in topics that were available in TLJ (aligning with the system’s topic search feature). While I-2 teachers discussed interest in topics available in the TLJ library of activities and others outside, such as math and cross-curricular instruction. This finding suggested that I-2 teachers reflected more broadly; considering what was searchable and what was wanted.

Specific topics (engineering, solar system, weather and climate, and earth science) were common when teachers utilized purpose statements and orientation activity reflections as cultural tools for goal setting. Most of the topics discussed aligned to topics available in the design of the TLJ system. For example, in I-1, Rebecca reflected on an interest to, “find activities to better teach the engineering design process in [my] Advanced Robotics class.” Rebecca’s professional goal demonstrated clear focus to improve on a specific topic in the TLJ system. Whereas, Patricia identified math, a subject not specifically listed in I-2 of TLJ, reflecting, “My purpose is to
increase my knowledge of how to implement STEM into my classroom through engaging activities. I also wanted to increase my content knowledge of science and math.” Patricia’s reflection, while broad, described an interest in furthering her knowledge of math and science. However, it is unclear if Patricia’s goal reflection was a general interest statement or aimed to personalize future PD with activities containing math content available in TLJ. Other teachers leveraged the reflective, cognitive tools for goal setting to express interest in drawing more connections in their classes a cross-curricular approach to teaching. Kristina wrote, “I added several activities that revolved around weather, climate change and cross-curricular connections between math and science. These items were selected to better focus my PD goals in my 6th grade Math/Science classroom.” This goal provided insight into Kristina’s approach to education and role responsibilities. Kristina’s reflection with cross-curricular considerations suggested an intention to expand and synthesize the available PD to meet her instructional needs.

Teachers expressed a range of topic focus for content both inside the TLJ system (i.e. engineering, solar system, weather and climate, earth science, and physics activities) by I-1 teachers and inside and outside the TLJ system (i.e. math, technology, and cross-curricular activities) by I-2 teachers aligns with Cole’s mediation triangle (1996). This finding demonstrates goal setting with cultural tools to mediate the articulation of goals with flexibility to support a broad range of interest (Wills & Xie, 2016). While teachers appeared to identify activities that interested them, it was not clear that structure and badge activity information available in TLJ aligned with the teachers’ articulated needs. For example, physics activities were not mentioned in any of the teacher reflections, but teachers chose 36 physics intended activities and completed 16 physics activities. Future badging systems for professional development and other similar personalized learning tools may better support independent learning by considering such a system as a set of cultural tools for reflection and personalization with structures to further support goal
articulation. In the example of Teacher Learning Journeys, the digital badging system supported reflection for professional development needs without constraining the teachers.

Four common objectives were identified from teachers when writing a personalized goal statement for their professional development in the digital badging system

Teachers used written goal statements as cultural tools as the TLJ system designers intended; to articulate personally relevant professional development goals. Of the 59 participants, 51 wrote goal statements. I found four objectives common across both iterations of TLJ in the written goal statements as elaboration for their professional development needs. Table 5-3 provides a summary of the objectives appearing in the two iterations of TLJ. Through written teacher reflection on professional development, the majority of teachers discussed more than one goal objective in their written statements (I-1, n = 43.3%; I-2, n = 65.5%).

Table 5-3. Teachers’ used goal statements as cultural tools for professional development planning within the TLJ digital badging system to describe their professional development objectives.

<table>
<thead>
<tr>
<th>Objective</th>
<th>I-1</th>
<th>I-2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivate Students</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Share Resources</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Collect Artifacts</td>
<td>5</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>Improve Teaching</td>
<td>24</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>No Written Reflection</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>

The objectives of the teachers remained consistent from I-1 to I-2. In this analysis, each objective had two sub-components (illustrated in figure 5-1). Objectives and sub-components are further elaborated below.
Figure 5.1. Teachers’ sub-components of the goal statement objectives for professional development needs.

**Improve teaching**

Teachers utilized the goal statement as a cultural tool to reflect on practices to support their varying needs to improve. Throughout I-1 and I-2 of TLJ, 48 of the 51 teachers reflected on the perceived utility of professional development for personal improvement. Commonly, teachers discussed the goal to improve their content knowledge and performance as an educator. I-2 teacher, Amy, described wanting to use PD to improve teaching by incorporating STEM lessons into technology classes. She wrote, “The purpose of my journey is to learn new ways I can integrate science, technology, engineering, and math into my computer classes for my kindergarten through 8\textsuperscript{th} grade students.” This participant’s reflection demonstrates an approach to learning which supports the cross-curricular integration of content. This goal statement maps on to my adaptation of Cole’s mediation triangle (1996) by demonstrating the use of the TLJ badging system as a set of cultural tools to support learning that is personally relevant.
Moreover, teachers identified intent to be better, more effective educators. Articulating improved pedagogical practices also included reflection and empathy for students. For example, in her goal statement, Ava, reflected on her own learning and empathized with her students on the difficulty of lecture-style instruction. Ava wrote, “I’ve been at a professional workshop for the last two weeks, and while there have certainly been ah-ha moments and resources that will make me a better teacher (such as this site), it has also shown me that it is EXHAUSTING to sit for hours listening to others.” Ava’s reflection connected her professional development and her own teaching practices, stimulating interest in improving her teaching. Ava demonstrated an interest in learning about and emulating the practices of high-quality instruction, which was embedded into each badge activity as part of the culture of NASA Education. Ava’s goal statement informs future badge design. Given a conceptualization of digital badging systems as a set of cultural tools, evidence suggests that goal statement activities may act as a cognitive tool for introspective reflection on personal improvement.

Collect artifacts

Another component of the personalized approach to goal articulation is the teacher objective to collect other cultural tools (resources and credentials) for future use. Reflections on collecting credentials and relevant resources occurred in 31.4% of participant goal statements. This objective of collecting in the goal statements appeared to be an opportunity for teachers to discuss their job-related needs. Teachers’ articulated needs may be considered as goal structures or as perceived environmental influences to their goals (Kaplan, Middleton, Urdan, & Midgley, 2002). Of the 51 teachers who wrote goal statements, 16 expressed a practical interest in pursuing PD in the Teacher Learning Journeys digital badging system to improve their professional role and fulfill external requirements. The articulation of collecting as an influence on learner goals
appeared by describing the value of finding and organizing educational resources. Samantha wrote, “I want to find more resources to use in my classes that are online, free, secure, and ‘tried and true’ by other teachers. I hope to find resources that are useful across a wide range of topics and levels.” Samantha’s reflection suggested value in using the badging system to find recommended resources for future use. From a cultural tool perspective, the TLJ digital badging system may benefit the learner through the identification and curation of resources.

Professional certification-driven participants were looking for ways to continue to ensure they were meeting the professional teaching requirements of their region. For example, Trisha wrote in her reflection, “My goal in the Teacher Learning Journeys is to learn about Earth Science, Engineering, and Technology while earning Professional Development Units (PDU) to renew my credential.” This goal likely was shared by all teachers. While some teachers were tacit with regard to their requirements for regional teaching certification, professional certification remains a reality. The importance of collecting in regard to professional development suggests additional benefit in future systems by allowing users to further personalize their learning by adding organizational function and notation to complete activities such as grouping or labeling. Teacher objectives for collecting resources and certifications demonstrate perspective of TLJ mediating non-mutually exclusive goals.

**Share resources**

Teachers used their goal statement as a cultural tool to communicate what they learned with their students and colleagues. With a focus on sharing, 9 of 51 teachers discussed value in their personal exploration of available resources and then communicated this new learning to others. Teachers looked to find resources, ideas, and activities that they could bring back to their students. For example, Brenda wrote, “…Then I will be able to share with my students and my
colleagues…” This reflection suggested focus on finding professional development that offers new and interesting content and pedagogy. Moreover, Martha described an approach to PD with an objective to share with colleagues, “…Through this participation, I will learn about a possible way to communicate personalized PD to other teachers in my school so that we will increase our success as a STEM program…” The articulation of sharing with colleagues suggested teachers’ interest in co-learning. Teachers who described an objective of sharing may extend their experience with the badge activities they have collected and introducing these resources to others.

**Motivate students**

Considering goal statements as a cultural tool within the TLJ digital badging system with the mediation triangle as an analytical lens (Cole, 1996) provided a view of teacher reflections on individual learning goals including motivating others. Of the 51 teachers, 20 used their goal statements to describe objectives for personalizing their learning with a focus toward motivating their students. The objective of motivation appeared in teacher reflections, discussing both in-class engagement and an inspiration for future learning. Teachers who were looking to develop engaging lessons discussed searching for ways to support their students with real-world examples and providing hands-on demonstrations. For example, Dana reflected on the importance of engaging young students, writing, “The purpose of my journey is to learn about the engineering design process and how it can be taught in a very hands-on manner to elementary students.” While some teachers discussed an eagerness to engage their students in a particular lesson, others discussed intentions to inspire their students’ enthusiasm for science beyond a particular lesson or grade. These teachers expressed a value in lasting student excitement. Laura wrote, “…I teach first grade, which to me is of utmost importance because it lays the foundation on which the students will build their entire educational career. I am a life-long learner, and I want to inspire
my students to become life-long learners. I also want them to be aware of the practical uses of
everything that they are beginning to learn in the classroom, and to apply it their lives on a daily
basis.” Laura espoused the importance of early elementary school as a formative time to develop
opinions on science and learning in general. Whether in a lesson or a lifetime, motivating students
was an important element of 20 teacher goal statements and aligned strongly with a core value of
NASA Education to “inspire and motivate students to pursue careers in science, technology,
engineering, and mathematics” (NASA, 2017). By utilizing NASA Education resources, the TLJ
system supported teachers motivating their students to explore new things.

Summary of planning

Teachers’ approaches to personalized learning in TLJ demonstrates the use of a digital
badging system as a set of cultural tools for independent professional development planning. In
planning for professional development, teachers made use of the structures in TLJ to support
teacher goal articulation. The TLJ goal statements and orientation activity reflections acted as a
two-part cognitive tool for reflection to personalize professional goals, offering participants the
ability to reflect on their goals and elaborate on how to achieve them. Goal statements were
cultural tools for further elaboration of PD envisioned both in and out of the TLJ platform.
Teacher professional development planning exhibited multiple approaches to personalized
learning with which participants identified interests, objectives, and ways to pursue learning
goals.
Chapter 6 Participants Used the Digital Badging System to Personalize How and When to Engage in Wayfinding for Professional Development

This chapter investigates the role of digital badging systems as a set of cultural tools for teacher professional development wayfinding. My work mirrors that of Sadaf, Newby, and Ertmer (2016), with findings focused on the learners’ intentions and actions; however, my study does not attempt to identify specific contributing factors to participants’ decisions. Instead, the focus is on patterns of engagement with the intended and completed professional development (PD) activities. The wayfinding analysis utilized teachers’ intended PD activities (n = 835), completed PD activities (n = 266), and associated timestamps to examine how teachers navigate through the digital badging system. Independent samples t tests, Pearson r correlations, and qualitative analyses contributed to answering this research question and forming an understanding of the participant experience. As a design-based research study, the findings elaborate on differences between two iterations of the TLJ system and contribute to related theory and design.

My findings were formulated with Vygotsky’s cultural tools (1980) as a theoretical lens to observe teacher interaction TLJ digital badging system as a cultural tool to achieve progress toward professional development goals. From the analyses described below, I found:

- Teacher use of the TLJ digital badging system differed from anticipated design in the use of functionality for intended and completed activities.
- Teachers used the digital badging system to personalize their PD in three time-based patterns: Little Loopers, Weekend Warriors, and Big Loopers.
Teacher use of the TLJ digital badging system differed from anticipated design in the use of functionality for intended and completed activities.

Teachers used the TLJ digital badging system as a set of cultural tools to identify, organize, and complete relevant professional development but in some cases differently than anticipated by the TLJ development team. PD activities were complete when awarded a stamp or badge from a NASA education expert in recognition for the required evidence for the badge activity submitted for review by the teacher. The TLJ I-2 design was modified by the design team to encourage more teacher wayfinding (number of PD activities intended and completed) through a more expansive set of PD activities and the addition of a badge for an orientation activity. The TLJ orientation badge was designed to serve as a cognitive, cultural tool to support the articulation and planning of learning goals, an aspect of personalized learning emphasized by Watson and Watson (2017). The TLJ orientation activity intended to support teachers’ describing how they planned to fulfill their learning by selecting and completing PD activities in the system. From my analysis utilizing a mediation triangle lens (Cole, 1996), I found that teachers used the intended PD activities list and the orientation activity to mediate different goals and personalize their wayfinding.

Wishlist, checklist, and list bypass

Teachers personalized their intended activities for professional development through varying approaches to organization. The designers of TLJ hypothesized that there would be a relationship between intended and completed PD activities. That is, participants would approach this cultural tool as a checklist. However, my findings suggest the digital badging system served in more personalized ways. A Pearson $r$ correlation tested the relationship between the number of intended PD activities and the number of unique completed PD activities. A significant
relationship between the two variables was not found, \( r(59) = -.07, p = .582 \). The difference between the number of intended activities and the number of unique completed PD activities between I-1 and I-2 was examined with an independent samples \( t \) test. For I-1, teachers planned to complete an average of 12.30 activities \((SD = 7.67)\). Those who participated in I-2 planned to complete an average of 11.67 \((SD = 7.28)\) activities. The analysis revealed that the difference between the means was not significant, \( t(57) = 0.34, p = .737 \). The same pattern of results was found for the number of unique completed activities \((M_{I-1} = 3.63, SD = 2.91; M_{I-2} = 4.00, SD = 4.26)\), \( t(57) = 0.39, p = .700 \).

I examined completion rates through the relationship between intended and completed activities. For this study, the activity completion rate is the ratio of the number of unique completed PD activities (stamps or badges) compared to the number of intended PD activities. Teacher completion rates, shown in Table 6-1, ranged from 4.8% to 150% with an average of 47.0%. This analysis resulted in a statistically not significant \((p = .532)\) relationship between intended PD activities and completed PD activities. Notably, the variability for completion rate (measured by the standard deviation) was high in both iterations but greater in I-2. The average rate of completion and standard deviation offer perspective in the wide range of experience for teachers in TLJ.

Table 6-1. Range of participant PD as mediated through completion (intended PD activities compared to completed PD activities).

<table>
<thead>
<tr>
<th></th>
<th>Average Completion Rate</th>
<th>Standard Deviation</th>
<th>Low Completion Rate</th>
<th>High Completion Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-1</td>
<td>44.1%</td>
<td>29.3</td>
<td>4.8%</td>
<td>100.0%</td>
</tr>
<tr>
<td>I-2</td>
<td>50.0%</td>
<td>41.5</td>
<td>7.7%</td>
<td>150.0%</td>
</tr>
</tbody>
</table>

Furthermore, by examining the data through the theoretical lens of the mediation triangle (Cole, 1996), evidence suggests that teachers personalized their use of the TLJ digital badging system intended activities list to support their wayfinding. Five teachers used the TLJ intended
activities as a checklist by completing every intended PD activity they chose. Across the two iterations of TLJ (I-1, \( n = 4 \); I-2, \( n = 2 \)), 6 of the 59 teachers completed eight activities bypassing their respective intended activities lists. This suggests teachers personalized their use of TLJ for just-in-time learning rather than the developer-anticipation of mediation through organization and planning. Two other teachers finished all of their intended activities and then completed additional activities outside their itineraries. Short-term use, defined in this study as completing a singular activity, was also common in both iterations of TLJ (I-1, \( n = 9 \); I-2, \( n = 9 \)). Unique practices among teachers illustrates that a flexible design affords the adoption of cultural tools for personalized learning and accommodates teachers’ planned organization and spontaneous decisions about their PD.

While many teachers used TLJ to find and complete professional development activities, there was a range of approaches in which TLJ was used as a set of cultural tool for wayfinding. Teachers who only complete a small number of their intended PD activities appeared to utilize TLJ as a wish list for PD they intend to complete at some future time. Whereas other teachers made use of TLJ as a checklist, acting as a cultural tool organize and complete PD within a few months. Still, others leveraged the TLJ tools for just-in-time learning, bypassing the intended PD activities list. This view of badging systems as a set of cultural tools affords a further understanding of the choices learners make while selected their professional development with each learner uniquely using these tools to mediate their own goals.

The orientation activity did not impact teachers as TLJ developers expected

An independent-samples \( t \) test was conducted to determine if the completion of the orientation activity (in I-2 only) had an effect on teacher selection of intended PD activities compared to I-2 teachers who did not complete the orientation activity. I compared I-2 teachers
who did (I-2_{orientation}) and did not (I-2_{no orientation}) complete the orientation activity with the variables of the number of intended PD activities and the number of unique completed PD activities. This resulted in no significant difference between the number of intended activities, \( t(57) = 0.12, p = .909 \) between I-2_{orientation} and I-2_{no orientation}.

While the TLJ orientation activity did not produce a statistically significant impact on the number of teacher-selected intended, the orientation activity impacted the number of participants’ completed activities as shown earlier in this study. Moreover, I found that teachers who completed both goal statement and orientation activity demonstrated an alignment between the two activities and furthered their reflections by elaborating on their intended professional development. The qualitative impacts of the orientation activity are also discussed in the previous chapter.

Similar to my findings, Taminiau and colleagues (2013) reported confounding inferences. Contrary to the expectations of their study, Taminiau and colleagues found that the participants who were responsible for selecting their own learning path outperformed those who received recommendations. A suggested hypothesis was offered that when the onus was on the participant that the participants were more engaged in their learning (Taminiau et al., 2013). Finding no statistically significant impact of the orientation activity on intended PD activities suggests that while teacher decision-making onus may play a factor, other factors may also influence the quantity of teacher work. Furthermore, this finding contributes to the understanding of learner wayfinding by offering a view of teacher independent learning supported by a set of cultural tools. Viewing badges as cultural tools and leveraging the mediation triangle framework (Cole, 1996) offers benefit to research in understanding the wayfinding of learners.
Teachers used the digital badging system to personalize their PD in three time-based patterns

Similar to prior work, teachers in TLJ demonstrated agency in selecting when to make use of TLJ to pursue professional development (Gamrat & Zimmerman, 2015; Gamrat et al., 2014). This section describes three time-based patterns in which teachers used the Teacher Learning Journeys digital badging system as a set of cultural tools for wayfinding. This finding demonstrates the flexibility described in the framework presented by Wills and Xie (2016) and offers a conceptualization of the digital badging system as a set of cultural tools supporting multiple needs as visualized in Cole’s mediation triangle (1996). An initial view of teacher use provided perspective through total days and total unique days using TLJ. This tacitly articulated the teacher navigation of the badging system. Overall, unique day participation was positively skewed with most teachers spending time with TLJ in 10 days or fewer as shown in Figure 6-1.

Figure 6-1. TLJ participation was positively skewed with the majority of participants using the system for less than 10 days.
I-1 and I-2 of TLJ were both limited to two consecutive summers, each iteration with a unique cohort of teachers. Though examination with mediation triangle theoretical lens (Cole, 1996), I found that teachers accessed TLJ in different ways, demonstrating three time-based patterns of engagement: Little Loopers, Weekend Warriors, and Big Loopers. As shown in Table 6-2, TLJ time-based teacher interaction was similar in both iterations. Of the 59 teacher participants, 46 used TLJ in the way in which we designed it; engaging with the system and then returning a few days or weeks later to continue their PD. In addition to these Little Loopers, Weekend Warriors, and Big Loopers were two other patterns that emerged as different, less common styles of approaching professional development.

Table 6-2. Teacher participation with TLJ clustered into three time-based patterns with developer anticipated use, short duration use and a return to use after a hiatus.

<table>
<thead>
<tr>
<th>Pattern</th>
<th>I-1</th>
<th>I-2</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekend Warriors (1-2 Days)</td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Little Loopers (&lt;3 Months)</td>
<td>26</td>
<td>20</td>
<td>46</td>
</tr>
<tr>
<td>Big Loopers (&gt;3 Months)</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

**Weekend warriors**

During the study, 8 teachers (I-1, n = 2; I-2, n = 6) were active for 1 or 2 (back-to-back) days. These teachers, referred to as Weekend Warriors, used the TLJ badging system as a cultural tool for PD in a single period. Weekend Warriors demonstrated an immediate need and pursuit of PD. However, the reasoning for this type of participation is unclear because data that might enable understanding of the motivation behind using the system for this short duration does not exist. However, teachers did demonstrate wayfinding by adding activities to their intended and completed lists. During their singular use, teachers averaged 10.9 intended activities and 1.8 activities completed. Notably, Sheryl demonstrated the heaviest use during this short time with 21 intended activities 5 completed activities.
Among the Weekend Warriors, some teachers used their time in TLJ for reflection on learning goals. Three Weekend Warriors only completed the orientation activity. These teachers utilized their time to consider their future learning options and identified an average of 12.3 activities they intended to return to as part of their PD. This documentation for participant use of TLJ offers a view of teachers’ initial organization of their activities. However, it is unclear why the teachers discontinued their engagement with the study after this short period. Future design may benefit from the use of reminders to encourage return for further professional learning.

**Little Loopers**

The majority of teachers (I-1, \( n = 26; \) I-2, \( n = 20 \)) in the TLJ digital badging system had variation in the number of intended and completed activities, but they utilized the available cultural tools within the parameters of TLJ’s envisioned use. The design assumed the teachers would use TLJ as a summer supplement to their professional development (late May to early September). The designers of TLJ also assumed an ebb and flow of teachers in which they would use the website, leave, return for more PD, and then repeat within the summer time frame. This regular use ranged from 2 non-consecutive days to 18 unique days.

**Big Loopers**

Three teachers (I-1, \( n = 2; \) I-2, \( n = 1 \)) returned to TLJ months after TLJ was announced to be closed for revisions to the system and no longer being supported. Overall, time for teachers accessing TLJ ranged from 1 to 313 days from starting. These large stretches of time included several months before returning to the system. Samantha completed her participation in August of I-1 and then returned in May the following year before I-2 added six new intended activities and
earn a badge. Debbie completed one activity in August of I-1 without using the intended activities list during the study and then returned in February and March the following year to add five activities to her intended activities list. Finally, Emily began in September, the last month of I-2, and continued documenting intended activities and completing activities through mid-December.

The unexpected use of TLJ in I-1 and I-2 went past the intended summer span. While the system was not inaccessible to teachers, they received communication that revision of the system would occur at the end of each summer and that certain supports would not be available. Despite this, teachers continued to use the systems well after support ended. This continued access demonstrates that TLJ was used for wayfinding through PD options even in isolation. Teachers continued to engage with TLJ, completing and seeking new PD opportunities.

**Time-based patterns summary**

Within the theoretical lens of the mediation triangle, this study examined the TLJ digital badging system to support participant PD wayfinding decisions. In this analysis, I found that teachers used the considerations of a digital badging framework, such as flexibility and choice, afforded through the identified time-based patterns for their PD. The findings described in this section support the wayfinding literature in the identification of decision patterns (Janssen et al., 2007; Taminiau et al., 2013; Tattersall et al., 2005). This study offers time between activities as another variable to consider in wayfinding in addition to time to learn new content. This between time, a variable not described in prior research (Janssen et al., 2007; Tattersall et al., 2005), may inform future designs of recommend learner paths. The time-based patterns also suggest the use of TLJ for tacit articulation of decision-making which, when further analyzed, may suggest future recommended paths for learners. In addition to considering the next step along a learner’s path, this finding suggests the importance of considering the time between steps. The finding reinforces
the need for additional research in the decision-making process of teachers to understand reasoning for when people decide to pursue professional development. Further understanding these time-based factors, may support PD to meet the needs of ongoing and just-in-time learning needs.

Wayfinding summary

Findings in this chapter suggest the use of cultural tools for wayfinding in TLJ are personalized through the choices of how and when to use the system. Through the theoretical lens of the mediation triangle (Cole, 1996), I have demonstrated an understanding of how teachers utilize the TLJ digital badging system for different purposes and engage with the badge activities in different orders, numbers, and speeds. Watson and Watson (2017) point to learner-centeredness and autonomy as key to personalized learning and Taminiau and colleagues (2013) found that their participants with decision power outperformed their peers without decision power. However, Butcher and Sumner (Butcher & Sumner, 2011) temper complete autonomy in personalized learning, discussing the problem of learners (particularly novices) not knowing what they need to know to make progress. The findings in this chapter present challenges and opportunities to design supports for professional development and independent learning. If completion of a given set of activities is desirable in future PD tools, there may be value in exploring “badge anatomy” (Rughinis, 2013) as a mechanism to suggest learning pathways to better support learner intentions and actions. While recommended paths reduce learner choice, structure may better support less experienced professionals that are unsure of what they need to improve, or their scope may support those who only want to commit for a certain duration of time. Similar to the support structure of a degree map for an undergraduate degree, learning
pathways using badges may offer a way of supporting learners that allows for both structure and flexibility.
Chapter 7 Discussion

In this dissertation, I purported the need to extend previous views of digital badging systems as a mechanism for recognizing accomplishments (Gamrat & Zimmerman, 2015; Gamrat et al., 2014; Halavais, 2012) to a set of cultural tools to support progress toward achievement. To provide support for this extended definition, I employed a sociocultural lens to investigate a digital badging system as a set of cultural tools to support teacher professional development in planning and wayfinding. From this perspective, I suggested that these tools could support the articulation of personalized learning explicitly (through written reflection) and implicitly (through choices made in the system). I focused on elementary and middle school teacher professional development in the Teacher Learning Journeys (TLJ) digital badge system. Across the design-based research study, I examined how two cohorts of teachers planned for and pursued their PD. This chapter focuses on the implications of a digital badging system as a set of cultural tools for personalized learning in the areas of planning and wayfinding.

Findings from this study contributing to planning literature

The examination of teacher written goal statements and orientation activity reflections provided insight into teacher PD. When writing, teachers demonstrated their use of the digital badging system as a cognitive, cultural tool by using the prompts to describe professional development goals, influences, and choices. In this dissertation, I-1 teachers maintained a focus on PD within the scope of TLJ. Some teachers in I-2 reflected on content and pedagogy not explicitly offered in the system. Teachers further discussed their learning needs in the I-2 prompts provided. This reflection in I-2 provided greater insight into the variety of content needs not explicitly discussed in I-1.
This dissertation showed that teachers’ approach to personalized professional development is multi-faceted. I identified four goal objectives consistent across this design-based research study. These objectives and their sub-components (shown in Figure 7-1) represent teacher considerations described as influences for professional learning goals. Each teacher objective was described with sub-components grouped into short- and long-term areas of professional growth. The short duration considerations described developing content knowledge, engaging students in a class or lesson, sharing resources with students, and collecting a library of educational resources. Each of these short-term considerations appears to highlight a reflection on what can be improved in days, weeks, or months. Whereas, the long-term considerations included performance, inspiration, sharing resources with colleagues, and collecting PD recognition toward teaching certification. The longer-term considerations are issues for professionals that may be career-long endeavors and require significant time investment.

The identified objectives and sub-components offer perspective on ways in which teachers personalize their professional development planning. This dissertation offers a set of factors considered as teachers are deciding how they want to grow as professionals. Increasingly, the literature on digital badges is utilizing a personalized learning perspective (Diamond & Gonzalez, 2014; Diamond & Gonzalez, 2016; Gamrat & Zimmerman, 2015; Gamrat et al., 2014; Wills & Xie, 2016). The influences identified in this study align with agency and autonomy as aspects of personalized learning as described in the extant literature (Kearney et al., 2012; Watson & Watson, 2017; Wills & Xie, 2016). Future research would benefit teacher professional development providers by examining a larger body of open-ended goal statements. More research in this area may help to refine the objectives identified in this study and to consider impacts on teachers’ reflection scaffolding utilizing these objectives.
Goal articulation is further developed and made transparent through additional supports in I-2 of TLJ with the orientation activity as a cognitive, cultural tool. This study describes a relationship between completed the goal statement and the orientation activity reflection and the number of completed activities. Further, there is also an alignment between goal statements and orientation activity reflections that allows the teachers to further their plans to pursue PD and allows PD providers and mentors to provide more robust resources for this development. This structure may be better organized in subsequent badging systems. While this system offered transparency, insight on specific learning goals, intentions for planning may not be readily gained from the data. Future design may benefit from a refined flow between the goal statement and the orientation activity since more than half of the teachers did not complete the orientation activity.
Findings from this study contributing to wayfinding literature

Through the lens of Cole’s mediation triangle (1996), I identified variation in teacher use of the intended PD activities, the orientation activity, and the completion of PD activities. This dissertation demonstrated that the TLJ digital badging system provided support for teacher to progress through professional development but allowed for learner autonomy to personalize their experiences (Kearney et al., 2012; Watson & Watson, 2017; Wills & Xie, 2016). Teachers personalized their learning by using the TLJ digital badging system in ways that both aligned with the developers’ intentions and exceeded the initial expectation of the developers. Teachers demonstrated use of the TLJ digital badging system as set of cultural tools to mediate their wayfinding. This study informs research in learner wayfinding regarding teachers organizing PD activities, completing PD activities, and how they engage in their PD.

First, I found multiple approaches to the use of the TLJ digital badging system to organize intended PD activities. This variety in approaches to intended PD activities demonstrates the utility of such a list for different learner needs. Many, though not all, of the teachers used their intended PD activities lists, which suggests teachers may value tools to organize future wayfinding in PD. However, this type of tool may also benefit from leveraging research in wayfinding to provide analysis and recommendations based on what PD activities a teacher may have already completed or intends to complete.

Next, my research on the orientation activity did not find a statistically significant relationship between completing the orientation activity and the quantity of PD activities identified by teachers for the intended activities list. However, as described in the findings related to teacher planning, the orientation activity did provide support for learners to articulate their professional development needs. This suggests that future wayfinding studies that support
professional development may explore how to effectively design learning activities to support efficient learning goal attainment or brief modules that allow for just-in-time learning.

Finally, I found that teachers used the TLJ digital badging system to personalize their PD in three time-based patterns. Similar to prior work, these findings demonstrate how teachers can use a digital badging system to personalize their learning through the selection of what is individually relevant (Gamrat & Zimmerman, 2015; Gamrat et al., 2014). My research suggests that choice in wayfinding should not be limited to content but also engagement time(s). Since professional learners have varying schedules, there may be value in examining the benefits or detriments of a flexible design in time influences on wayfinding.

My research has demonstrated that the TLJ digital badging system supports teachers’ decisions with this wayfinding objective. Butcher and Sumner’s sensemaking paradox (2011) suggests benefit in providing tools to support learner decision making as the learner progresses from novice to more expert. Next generation digital badging systems may offer a valuable set of cultural tools for wayfinding by providing useful recommendations to guide a learner’s planned goals. With these tools and informing designs, I suggest for further research to support the wayfinding literature to create recommendations such as illustrating the paths of learners that have come before and optimal paths such as paths from activity to activity in a short completion time.

**Designed and actual cultural tool use overview and recommendations**

This section reviews the way in which the goal statement, orientation activity, intended activities list, and the completed activities lists were used as cultural tools for planning and wayfinding. I compare the designed intentions for the badge system components to their actual use to make recommendations for future learners and developers of learning technologies. Table
7-1 offers a summary of the intended and actual use of the TLJ digital badging system components and design principles that may be of use to future projects with considerations for learners and educational tool developers.

Table 7-1. Badge system components as cultural tools for planning and wayfinding — their intended design and actual use compared for the 59 teachers in this study.

<table>
<thead>
<tr>
<th>Badge system components</th>
<th>Intended Design</th>
<th>Actual Use by Teachers</th>
<th>Future Learner Recommendations</th>
<th>Developer Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal Statement (Planning)</td>
<td>Goal statements were intended to support teachers describing the professional development they want to complete within TLJ.</td>
<td>51 of the 59 participants in the study completed the goal statement. Goal statements ranged from two words to about two paragraphs of professional development planning discussing a range of needs and with frequent mention of content.</td>
<td>Goal statements may be better organized through considerations of the common goal objectives. Awareness of these types of objectives may influence interest and awareness of peer teachers’ approach to professional development. Consider what professional development is valuable, in and out of the scope of the tool being used.</td>
<td>Provide clarity in how teachers may be able to pursue the common professional development objectives through examples and prompts or scaffolds. Offer multiple tags or related categories to help teachers find content areas of interest that are known and unknown (i.e., An activity categorized as engineering may also be a math activity).</td>
</tr>
<tr>
<td>Orientation Activity (Planning)</td>
<td>The orientation activity was intended as an activity for teachers to see the process of earning digital badges and asked teachers to write their</td>
<td>Of the 14 participants who completed the orientation activity, 2 did not complete the goal statement. However, 11 of the 12</td>
<td>Complete both orientation activity reflection and goal statement to further reflect on PD goals. Identifying specific grades, content, and PD activities in</td>
<td>Require completing both the goal statement and the orientation activity as part of the initial professional development planning process to support</td>
</tr>
<tr>
<td>Intended Activities List &amp; Completed Activities List (Wayfinding)</td>
<td>goal statements, identify relevant professional development activities to support this goal, and describe what was selected and why.</td>
<td>participants who wrote both reflections demonstrated alignment between their reflections. Completing the orientation activity reflections paired with goal statements result in completing more PD activities than goal statements alone.</td>
<td>the reflections is not necessary to impact the number of completed activities.</td>
<td>completing more activities. Complete the Orientation badge activity as it mirrors the process for earning other badges.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
| Teacher utilized the intended activities list in three different ways: wish list, check list, and list bypass. Two of these patterns were beyond the anticipated use. Teachers navigated employing 3 time-based patterns: periodic engagement across days or weeks, engagement after the intended offering of TLJ, and engagement in 1-2 | Leverage system structures in ways that fit personally relevant needs for engagement. Organize intended activities to support completing professional development selected. Consider time between activities to determine a regularity for pursuing professional development. | Collect information regarding learner satisfaction to better understand
As referenced in Table 7-1, the goal statement and orientation activity (I-2 only) were used by the teacher-participants as cultural tools for planning in professional development. The planning tools were used by teachers to organize their thoughts and describe what was important to them. Teachers articulated four common objectives within their reflections with many reflecting on two or more objectives (I-1, \( n = 43.3\% \); I-2, \( n = 65.5\% \)). These objectives were common among peer teachers in TLJ. Teachers used one or both of the cultural tools for planning within TLJ to further describe their professional needs, to think beyond the scope of what TLJ may offer. Approximately a third of teacher reflections were content-specific (I-1, \( n = 8 \), 26.7%; I-2, \( n = 11 \), 37.9%). The orientation activity appeared to support teacher planning through reflection via a statistically significant positive impact on word count \( (p = .014) \) when comparing teachers that completed the goal statement and the orientation badge \((M = 165.25, SD = 104.42)\) to those who only completed the goal statement \((M = 45.14, SD = 26.94)\). The orientation activity influenced teacher wayfinding with a statistically significant difference in the number of PD activities completed \((p = .044)\) when comparing teachers that completed the goal statement and the orientation activity \((M = 8.38, SD = 6.32)\) with teacher that only completed the goal statement \((M = 2.86, SD = 2.18)\).

The wayfinding tools of the intended activities list and the completed activities list were use in anticipated and unanticipated ways by the teacher participants. The orientation activity did not impact teachers’ number of intended activities, \( t(57) = 0.12, p = .909 \). Moreover, the findings suggest that there was not a relationship between number of intended PD activities and number of completed PD activities, \( r(59) = -.07, p = .582 \). My findings suggest that the intended activities list appears to be used in different ways for organizing intended PD activities. Time-based
patterns of use emerged with 77.97% of teachers using TLJ as expected by the development team and 13.6% spending a short period in TLJ or 8.5% returning after a long period for selecting and completed professional development activities. These time-use patterns uncovered in the qualitative findings suggest offering flexibility in the process of wayfinding or navigating through professional development opportunities to identify and complete what is perceived as useful.

Based on this study’s findings, I recommend that badge systems include the following components to support learners’ wayfinding and planning:

- Flexibility with activity choice and when to engage with professional development. Data suggest that teachers accessed and utilized organizational structures in ways beyond those intended by the designers.
- Include both a goal statement and orientation activity to enhance teachers’ reflections on their professional learning within badging activity. Data suggests that these two activities combined result in longer written reflections on professional development planning and more PD completed activities.
- Structured reflective prompts, as opposed to free-form reflective prompts, within badges may not be needed to support teachers’ PD aims. Analysis found no significant relationship; however, additional research with a larger sample or with other types of professional may yield different results.

**Methodological implications**

With this dissertation as an example, I have demonstrated a method to analyze learner personalization in a digital badging system. In my study, participant-generated artifacts in the system, written or otherwise, form traces of teacher professional development paths visible to the learner, the education provider, and the researcher. This methodological approach provided insight into patterns of teacher professional development personalization. A methodological approach to identify patterns in teacher use of a digital badging system supported an understanding of the traces teachers left within the system.

Traces of teacher navigation through an open-ended professional development system may translate from previous research in a physical space to research in a virtual space. Similar
prior work looked to understand the experience of museum visitors in which participants were able to annotate their experiences in the museum space (Stevens & Martell, 2003). This dissertation offers a form of trace analysis that utilizes a digital badging system to collect and understand how teachers navigated through the system to pursue professional development. An advantage of this method is that it supports research on teachers’ professional development without interrupting teachers. Instead, the method would capture teachers’ decisions as they are being made.

Future research may benefit learners, PD providers, and researchers by exploring the traces created in a digital badging system. Examining trace patterns may provide another perspective in the research to develop recommended pathways to benefit learners (Janssen et al., 2007; Tattersall et al., 2005). Traces through activities built into a badging system may provide refinement for improved structure and content to support independent and on-going professional development. This research for structure and content refinement could help PD providers to identify activities that learners do not select and how the activities may be improved. Researchers intending to make use of a similar methodological approach may be well-served to identify refined methods for data analysis. The analysis in this study developed over multiple iterations of technique and data organization. Emergent patterns from participant data may be further refined using larger datasets.

**Theoretical implications of using the mediation triangle to understand digital badging systems as a set of cultural tools for teacher professional development**

In this dissertation, I purport that digital badging is contextual to the designer, the intended learner, and the content. Badging systems act as a set of cultural tools that represent the ideas and values of the developers. By considering digital badging systems as a set of cultural
tools, the mediation triangle (Cole, 1996) offers a useful theoretical lens to examine personalized teacher professional development. The mediation triangle offers a view of how learners leverage cultural tools embedded in a digital badging system to meet their own goals. Furthermore, the mediation triangle lens is well suited to research a learner-centric approach to PD in which all learners personalized planning and wayfinding toward personally relevant goals. Further research may be done using the mediation triangle with digital badges to explore evidence associated with completing badging activities. In the example of TLJ, to earn a digital badge, teachers were asked to describe how they would implement what they learned in the activity that they completed. This type of activity to earn a digital badge further highlights how teachers can use digital badges as a reflective tool to support a personally relevant professional development. Researchers may also use the mediation triangle lens to further explore the use of digital badges as cultural tools to articulate achievement from the perspectives of digital badge earners, schools, and employers. These perspectives would provide valuable insight into how digital badges may be used among these groups.

Directions for future research

Future work in the area of a digital badging system as a set of cultural tools for personalized learning presents numerous possibilities. Upon reflection, two areas which present themselves as interesting for exploration by other research teams are:

- Utilizing digital badging systems to support recommended learning pathways
- Exploring digital badging systems as a virtual trace supporting professional development

Research in learning pathways may advance understanding of wayfinding in structured, semi-structured, and free-form approaches. Digital badging systems present resource for
exploring these supports for professional development. This type of future research may extend Rughinis’ (2013) suggested method of badge design that leads from one badge to another in a prerequisite structure. With Rughinis’ design recommendation of a series of connected badges, further research can examine how wayfinding may be impacted through different learning pathway structures. Such a study in which teachers may select in structured, semi-structured and free-form ways may help to inform design of future professional development resources. In this dissertation study, I found that completion of activities ranged widely between teachers. Future research for digital badging systems may benefit from the examination of these systems as virtual traces of learner navigation. Such research may investigate learning pathways with particular attention paid to structure such as the number of activities in a path, the range of depth or breadth covered in the content, and the degree of mentoring for the learners.

Future research for digital badging systems may benefit from the examination of these systems as virtual traces of learner navigation. This research will further my work and provide a broader view of learner navigation through a digital badging system. Utilizing traces may also offer understanding of teachers’ views of the system and its components. As previous work has explored the navigation of a physical space (Stevens & Martell, 2003), future studies can incorporate the idea of traces into a virtual learning experience. Since digital badging systems capture data associated with learner interaction, the development of a research design in this area may be possible with little or no modification to some current badging platforms.

Conclusion

This research contributes to the literature by expanding the view of digital badging systems. Researchers, practitioners, and policymakers may benefit from considering digital badging systems as a set of cultural tools to engage in and articulate personalization practices in
professional learning. Within the context of independent teacher professional development, a digital badging system was used as a support structure to articulate a plan for professional learning and to navigate through the decisions necessary to achieve learning goals. Through an analysis using the mediation triangle as a theoretical lens (Cole, 1996), this study found that teachers made use of the existing structures and flexibility of the TLJ digital badging system to identify and pursue what was personally relevant. This addition to the literature supports badges as not only a summarization of what a learner has completed but also a structural support for the reflection and decisions en-route.
References


https://doi.org/10.1080/07370024.2011.556552


https://doi.org/10.1007/s11423-012-9242-9


https://doi.org/10.1016/j.chb.2012.07.028


https://doi.org/10.1007/BF02504682


https://doi.org/10.1007/978-3-319-15425-1_14

https://doi.org/10.1002/tea.21254
Appendix

Example participant interaction with the Teacher Learning journeys digital badging system

Appendix A provides an overview of the Teacher Learning Journeys (TLJ) badging system interface for teachers of the study. The screenshots are done with Sally (Participant 76) of the system. Sally was selected as an example because her participation in TLJ was among the best in quality and highest in quantity.

![Screenshot of a goal statement example submitted by Participant 76 (Sally).](image)

Figure A1. Goal statement example submitted by Participant 76 (Sally).
Figure A2. Activity queue example submitted by Participant 76 (Sally).
Figure A3. Completed activities log (stamps and badges) example submitted by Participant 76 (Sally).
Weather Science: Hands-on Activities Webinar

"If you don't like the weather, just wait a few minutes." This is a popular saying. This webinar will explore NASA's role in our study, understanding and forecasting of weather. NASA STEM resources and curriculum will guide us through a "storm" of engaging science demonstrations and classroom activities, come rain or shine.

Overwhelmed with resources!!!!

July 17, 2012

This was a great webinar with some outstanding resources. The first source I will be using is the http://www.nasa.gov/centers/langley/science/met-guide.html. (1) To introduce meteorology students would research some old adages that relate to weather and identify if they can be explained scientifically. (2) For developing a basic understanding of the interrelationship between temperature and pressure students would set up a devices (pint canning jars, rubber bands and rubber balloon) to examine this relationship. Then using the same items go further and construct a barometer. The second source I will be using is the https://nice.larc.nasa.gov/node/7. I have already downloaded the literacy principles in order to cross reference my powerpoints to ensure they have the necessary information to assist my students with their understanding of the aspects of the Earth system. The third source http://climate.nasa.gov/kids/. My students will be given one of the seven big questions and working in pairs they will take notes from the notecard style lesson and then answers the questions provided. Upon completion they can engage in a game or activity of their choosing. The fourth source http://svs.gsfc.nasa.gov I will be using this site to download videos and images to enhance lessons. This site has outstanding images and videos!! I will also use the site http://science.edu.larc.nasa.gov/SCOOL/index.php. My students will watch the S'COOL Online Cloud Types Tutorial. Then lab groups will be given their assigned day to complete the S'COOL Report and record the information on the Weekly Observation Log. This log will be kept in the Weather Log Notebook (one for each class). We will log on to S'COOL and become a participant in order to incorporate cloud science and satellite data in our classroom. Using our weather station we will include all the optional measurements and submit them online. We will begin comparing SFCMS report with the Satellite report after the first week of submitting information, print the report and include it in our Weather Log Notebook. Overall this was a very informative webinar. There are many more sources that I want to incorporate and share with my partner teachers.

Figure A4. Evidence submitted by completing an activity example submitted by Participant 76 (Sally).
VITA of Christopher W. Gamrat

Education
M.Ed. The Pennsylvania State University, Instructional Systems, Dec. 2010
B.S. The Pennsylvania State University, Management Information Systems, May 2017

Academic Positions
Instructional Designer, The Pennsylvania State University, Nov, 2013 – Present

Publications

Selected Presentations

Awards
2014 Paul W. Welliver Outstanding Student Award, Pennsylvania Association for Educational Communications & Technology
2013 Ralph T. Heimer Award from the Learning, Design, and Technology Department, Penn State University