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Digital badges for STEM learning in secondary contexts: A mixed methods study

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Digital Badges for STEM Learning in Secondary Contexts: A Mixed Methods Study

Dissertation

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Dedication Page

To my children, Zachariah (Zack) and Sara, with deepest love and appreciation.
I am so proud of you both! You continue to inspire me to be better, always <3

To my parents, Pauline, Gerald and Pat, for nurturing the idea that I could do anything I set my mind to, then cheering me on the way. Much love to you!

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Abstract

The deficit in STEM skills is a matter of concern for national economies and a major focus for educational policy makers. The development of Information and Communications Technologies (ICT) has resulted in a rapidly changing workforce of global scale. In addition, ICT have fostered the growth of digital and mobile technologies which have been the learning context, formal and informal, for a generation of youth. The purpose of this study was to design an intervention based upon a competency-based, digitally-mediated, learning intervention: digital badges for learning STEM habits of mind and practices. Designed purposefully, digital badge learning trajectories and criteria can be flexible tools for scaffolding, measuring, and communicating the acquisition of knowledge, skills, or competencies. One of the most often discussed attributes of digital badges, is the ability of badges to *motivate* learners. However, the research base to support this claim is in its infancy; there is little empirical evidence. A skills-based digital badge intervention was designed to demonstrate mastery learning in key, age-appropriate, STEM competencies aligned with Next Generation Science Standards (NGSS) and other educational standards. A mixed methods approach was used to study the impact of a digital badge intervention in the sample middle and high school population. Among the findings were statistically significant measures which substantiate that in this student population, the digital badges increased perceived competence and motivated learners to persist at task.

Key words: informal and formal learning contexts, NGSS, motivation, assessment, student engagement, scientific practices

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Chapter 1: Introduction and Background

Introduction

Transformed by advances in computers and Information Communications Technologies (ICT), our world has become interconnected and networked on many levels. Perhaps now more than ever, countries are forced to respond to global events, particularly trends in economics. As our systems become more dependent upon knowledge in science, technology, engineering, and math (STEM) disciplines, there is an increasing, yet unmet, demand for workers with expertise in these fields (United States Department of Commerce a, 2012; U.S. Department of Commerce b, 2012; Gmür & Schwab, 2014).

Since the enactment of the *No Child Left Behind* (2002) legislation, there have been substantially increased demands for *accountability* by educators in formal K-12 educational contexts (Darling-Hammond, 2006). In particular, there has been concern and scrutiny in STEM instruction and outcomes because of a widening skills deficit in STEM disciplines and expertise (Committee on Prospering in the Global Economy of the 21st Century (U.S.), 2007). Paradoxically, as the demand for personalized learning paths has increased (Kentucky Department of Education, 2013), the trend toward standardization of curricula and assessments has also increased. An outcome of the focus upon measuring *achievement* through standardized testing has been the narrowing of curricula. Furthermore, standardized testing does not effectively measure the critical thinking or problem skills (Darling-Hammond, 2006) which are critical to STEM learning.

Youth and digital media researchers Ito et al., (2008) noted: “By its immediacy and breadth of information, the digital world lowers barriers to self-directed learning,” (p. 2). Despite the proliferation of lifelong and life-wide learning enabled by ICT and digital media, K-12 schools have not yet fully leveraged technologies in daily learning contexts. As a result students, particularly at the secondary level, experience disconnect between their preferred, self-motivated interest learning and their schools.

The processes of systemic education reform occur within financial, cultural and social contexts within bounds and constraints. Problems within the *K-12 STEM Pipeline* are complex and entangled with equity issues (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000). The outcomes of national standards initiatives will inform curricula and assessment in K-12 formal contexts, but will not advance a system of personalized learning pathways which articulate individual competencies.

A new system called digital badges, has been proposed as a method to scaffold, facilitate assessment, recognize, and communicate learning (Gibson, Ostashewski, Flintoff, Grant, & Knight, 2013). Digital badges are virtual symbols of achievement. *Open digital badges* comply with an open technical standard, the Open Badge Infrastructure, developed by Mozilla (Mozilla Foundation, n.d.). Open badges have eight metadata fields which describe the criteria completed to earn the badge, the issuer, and information such as standards. The digitized evidence or products of learning may also be attached to individual badges. The accumulated badges may be displayed online in learning management systems, e-portfolios and web sites, for example.

Digital badges have been successfully implemented as symbols of achievement and affiliation in game-based learning contexts to motivate learners. Digital badges have unique affordances to confer agency, motivate learners and function as boundary objects recognizing and leveraging learning in both formal and informal contexts. Through the accumulation of badges, learners can share their unique competencies or skills including self-directed, interest learning. An interconnected system of digital badge ecosystems may be used to measure and communicate learning in informal as well as classroom contexts.

Robust, standards aligned digital badges have the promise and capacity to become flexible and powerful instructional tools with associated pedagogies. The premise and promise of digital badges in K-12 contexts, is particularly pertinent to educational leaders who are charged and challenged to continuously improve systems, processes, and outcomes of instruction. As instructional leaders of their districts, educational leaders in K-12 contexts:

> must know principles for sustaining a[n] …instructional program conducive to student learning …This includes knowing how to align and focus work to focus on student learning … and human development theories, proven learning and motivational theories, and how diversity influences the learning process…. Infusing technology into leadership practices has become a recognized domain of practical knowledge essential to effective instructional leadership. (National Policy Board for Educational Administration (NPBEA), 2011, p. 11)

Science, Technology, Engineering and Math (STEM) Skills Deficits

Developments in ICT have also precipitated significant change in the processes and systems of non-STEM workplaces. The result is an increased demand for STEM skills, particularly those associated with creativity, invention, and complex problem-solving. As a result, there is widespread concern about the deficit of skilled STEM workers, a perplexing problem because knowledge and activities in STEM fields are directly linked to innovation. Hence, nations' abilities to compete in the global marketplace are directly impacted by the shortage of STEM skills (Bosworth et al., 2013).

Numerous studies over the past decade have underscored the essential nature of STEM skills for U.S. competitiveness and innovation, especially in the context of a global marketplace (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000; U.S. Department of Commerce b, 2012).

The shortfall of skilled STEM workers is a major concern for the United States:

> Despite the clear demand for STEM talent by domestic employers, the U.S. is failing to produce an ample supply of workers to meet the growing needs of both STEM and non-STEM employers. The existing STEM pipeline leaves too many students without access to quality STEM education, and without the interest and ability to obtain a degree or work in STEM. (U.S. Congress Joint Economic Committee, 2012, p. 3)

Not only are there specific skills deficits, there is significant underrepresentation of large demographic groups, specifically women and minorities, in the STEM workforce.

The reasons for the deficits in STEM workers are complex and varied, which impedes a resolution. For example, there are substantial, persistent, achievement gaps in STEM and other critical areas for some underserved youth; Black and Hispanic students, in particular, must be ameliorated for increased minority participation in the STEM workforce. (U.S. Congress Joint Economic Committee, 2012; Gonzalez & Kuenzi, 2012; Ito et al., 2013).

In addition to achievement gaps for minority students, other concerns in the STEM education pipeline, particularly in the K-12 segment include teacher quality, academic achievement gaps of all students, performance in international assessments *Program for International Assessment* (PISA), and *Trends in International Mathematics and Science Studies* (TIMSS), as well as the comparative position of the U.S. in the global STEM education (Gonzalez & Kuenzi, 2012; U.S. Department of Commerce, 2012). Further issues, particularly for women and minorities, include the lack of student engagement in STEM activities, which is associated with greater academic achievement, persistence at task and effective use of metacognition (Fredericks, Blumenfeld, & Paris, 2004), and the development of STEM identities.

A lack of student engagement in STEM activities results in lower motivation in STEM learning, lower academic achievement, and reduced efficacy in the use of metacognitive strategies. This impacts the developmental processes of STEM identities, which relate to self-concept and self-efficacy, particularly for women and minorities. Ultimately, these factors influence students' interest in STEM activity and education and the decision whether or not to pursue post -secondary education STEM disciplines.

> American students' performance on international standardized tests suggests problems earlier in the STEM pipeline. For example, U.S. 15-year-olds rank 25th in math and 17th in science in PISA scores among Organisation for Economic Co-operation and Development nations (OECD)…that problems in U.S. STEM education may begin as early as elementary school and continue through students' secondary and post-secondary education. (U.S. Congress Joint Economic Committee, 2012)

In the United States there is substantial concern over the decline in U.S. performance in international measures of learning in science and math such as the *Program for International Assessment* (PISA) and *Trends in International Mathematics and Science Studies* (TIMSS) (U.S. Congress Joint Economic Committee, 2012; U.S. Department of Commerce b, 2012). Education, a crucial link in the *STEM pipeline*, is an important conduit to skilled STEM workers. Economists, entrepreneurs, legislators, and policy makers decry not only the gaps in STEM skills, but also skills gaps between the workforce and educational outcomes (Bosworth et al., 2013).

> Among the 34 OECD countries, the United States performed below average in mathematics in 2012 and is ranked 27th … Performance in reading and science are both close to the OECD average. The United States ranks 17 in reading, (range of ranks: 14 to 20) and 20 in science (range of ranks: 17 to 25). There has been no significant change in these performances over time (Organisation for Economic Co-operation and Development, n.d.).

The implications of poor performance on the PISA test are important because "… as the National Science Foundation (NSF) noted, the PISA tests … 'emphasize students' abilities to apply skills and information learned in school (or from life experiences) to solve problems or make decisions'" (Lehming et al., 2010; U.S. Congress Joint Economic Committee, 2012). "Disadvantaged students show less engagement, drive, motivation and self-beliefs than advantaged students" (Organisation for Economic Co-operation and Development, n.d.). "There is a need for more effective communication between the education community and business community to determine what students need to know and be able to do to be successful in the workforce" (Kentucky Department of Education, 2013).

Interest in school reforms. In the past 50 years, federal legislation has been directed at ameliorating educational systems in the U.S., including the Johnson era Elementary and Secondary Education Act (ESEA) of 1965 and its Bush era reauthorization: "No Child Left Behind Act of 2001" (*No Child Left Behind Act of 2001*, 2002). Despite these federal mandates, achievement gaps persist for U.S. students for whom educational reforms have not yet been effective, particularly ethnic and racial minorities and children living in poverty (National Math

+ Science Initiative, n.d.); (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000).

Although there are myriad opinions about the failure of our educational systems, a compelling argument is that at least partial blame for failure may be attributed to Cozolino's (2013) statement,

> … most schools are based on a model of industrial production where uniform materials are converted into a predetermined product. This model has proven itself over the last 150 years and works exceptionally well for making automobiles, washing machines, and chicken nuggets. (p. x-vi)

The skills needed today require more innovation and a deep understanding of math and science.

Industrial models of education based upon Taylorist principles of scientific management, suitable for mass production of goods, constrain development of the human infrastructure necessary for knowledge-intensive economies (Florida, 1995). Patrick and Sturgis (2013) advise that "it is unlikely that they can grow and sustain fully developed systems that let our children soar to new levels of achievement under the burden of the time-based, agricultural schedules and rigid, age-based structures" (Patrick & Sturgis, 2013). Seat time requirements (Kentucky Department of Education, 2013) do not promote or inculcate a vision of life-long, self-directed, learning.

U.S. policy makers have responded with numerous well-intended legislations, mandates, and federal programs to ameliorate these challenging concerns, which have resulted in a network with intermittent gains but little widespread progress (Gonzalez & Kuenzi, 2012) Some reforms have actually exacerbated the problems; for example, one of the outcomes of the No Child Left

Behind Act of 2001 (NCLB) legislation has been an increase in standardized testing to assess *adequate yearly progress* (*No Child Left Behind Act of 2001*, 2002). According to Willis (2006),

> Traditional and especially standardized tests assess only a few parameters such as rote memory, ability to follow instructions, organization, and time management. Testing that emphasizes those parameters gives students the message that those are the primary qualities of thinking inside the box that are valued most. (p. 59)

Many STEM competencies, particularly higher-order thinking skills, are not measured well by standardized testing methods and in fact, have harmful effects caused by the reliance upon multiple-choice format (Frederiksen, Glaser, Lesgold, & Shafto, 2013). The testing regimens required by NCLB may actually force states to abandon higher standards and forward-thinking assessments “that measure critical thinking and performance, just as the labor market increasingly demands these kinds of skills” (Darling-Hammond, 2006).

States must comply with the law and use the most cost-effective methods. The negative impact of standardized testing, however, is a significant concern for a variety of reasons, which are detrimental in developing the creative thinking habits necessary for STEM disciplines. For example, according to Zhao (2012), there is a strong association between countries that score high on international tests, and a low level of entrepreneurship (p. 11). According to researcher Kyung Hee Kim (2011), as cited by Zhao (2012), there was significant decline in several indicators of creativity in adults and children 1990-2008, as measured by the *Torrance Test of Creative Thinking* (p. 13), which coincided with the introduction of NCLB reforms. Norm-referenced tests, ineffective in measuring or cultivating higher-order thinking skills, may also demotivate students (Hatti.e., 2009).

A pivotal report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Committee on Prospering in the Global Economy of the 21st Century (U.S.), 2007) focused attention upon perceived weaknesses in the U.S. STEM education. In response, federal legislation was enacted, the *America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act* of 2007 (America COMPETES Act). Reauthorized in 2010, the Act moved forward toward reauthorization in 2014 with numerous provisions for strengthening STEM learning: incorporating arts and design (STEAM), strengthening the role of the National Science Foundation (NSF) in informal science learning, and bolstering the use of educational technologies and educational research (Democratic Staff of the House Committee on Science, Space, and Technology, n.d.).

Role of Educational Leaders

Educating students for an uncertain future requires a flexible, adaptive approach with a focus upon competencies consistent with a significant epistemological change necessitated by the paradigm shift resulting from myriad ramifications of ICT. For these transformational processes to be assimilated into formal learning environments, new pedagogies must be developed and practiced, which will require time to develop. Nonetheless, 21st century skills are being attained independently through interest-driven learning in informal environments.

However, because there are currently no official mechanisms to measure, reward, or recognize these achievements, learners are disadvantaged because their accomplishments are not formally acknowledged or effectively communicated to interested audiences such as educational institutions or potential employers. Innovators in industry and education are excited about the potential of digital badging systems to ameliorate this deficit.

STEM learning and engagement. Viewed from a sociocultural lens, processes of learning are highly contextual and are both individual and socially constructed. Learning is embedded and defined within social and cultural frameworks (Vygotskiĭ, 1967; Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; Bruner, 1996; Wenger, 2000; Lemke, 2001; Brown & Adler, 2008). Increasingly, our youth, particularly teens, are disengaged from formal educational contexts for a variety of reasons, but because they view them as irrelevant and disconnected to their cultural contexts (Ito et al., 2013). Our youth have grown up in a world with Internet-facilitated communications, digital media, virtual knowledge networks, and constant connectivity as the norm. They engage daily in learning through participatory cultures, (Delwiche & Henderson, 2012), through which communications, knowledge creation, and learning are both interconnected and social processes (Jenkins et al., 2009).

The formal learning environments of young people are a stark contrast, bound by time, location, and resources. Considering learning from a socio-cultural context, it is easy to see why many youth struggle with lack of relevancy and stimulation in formal learning contexts when a strange learning dichotomy exists between learning in school and their preferences for learning informally.

Bruner, observed this dichotomy. Writing in (1966) in *Toward a Theory of Instruction*, he postulated,

> The will to learn is an intrinsic motive, one that finds both its source and its reward in its own exercise. The will to learn becomes a 'problem' only under specialized circumstances like those of a school, where a curriculum is set, students confined, and a path fixed. The problem exists, not so much in the learning itself, but in the fact that what

> the school imposes often fails to enlist the natural energies that sustain spontaneous learning – curiosity, a desire for competence, aspiration to emulate a model. (p. 127)

Youth, especially those in underserved communities, face challenges at school and home, which affect the development of traits, skills, and qualities critical to academic success in STEM learning and their level of engagement. “Research has also shown that youths ’goals for STEM learning, their self-efficacy, and the value that they assign to STEM tasks and activities are likely to influence their level of engagement” (Nugent et al., 2010, p. 395). If learners are disengaged from the content and context of learning, particularly in the context of classroom learning, they may experience *stressful boredom* and may respond by developing negative associations with the topics (Willis, 2014).

Challenges in educational contexts include the lack of qualified teachers and other resources, lack of role models, and out-of-school STEM experiences (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000). As Dörnyei (2001) commented, “…Motivation is highest when students are competent, have sufficient autonomy, set worthwhile goals, get feedback and are affirmed by others … For many, demotivation has more impact than motivation” (as cited in Hatti.e., 2009, p. 48).

A pivotal outcome of the neurological and hormonal havoc of adolescence, is the formation of youth identity, and during this time period, particularly “After age 13 or 14, students develop more differentiated and individualized vocational interests based on a notion of their internal, unique self” (Duschl et al., 2007, p. 200). The lack of engagement in formal schooling, particularly in STEM subjects, inhibits the development of self-efficacy, and in turn, self-concept, which adversely affects the formation of *STEM identities*; if youth do not perceive themselves as competent learners or participants in STEM subjects, they do not pursue STEM subjects in school (Duschl et al., 2007).

Factors in K-12 education that are crucial factors in the decision to pursue STEM learning and/or careers, especially for minorities are, according to Gonzalez and Kuenzi (2012), “parental involvement and support, availability of bilingual education, culturally relevant pedagogy, early exposure to STEM fields, interest in STEM careers, self-efficacy in STEM subjects” (p. 24). In regard to the formation of identity and cultural practices, Bruner (1996) asserted: “A child’s identity as a learner is contested and influenced by different practices in everyday interactions, as well as in the cultural institutions he uses” (as cited in Duschl et al., 2007, p. 200).

According to Pew Internet researcher, Lenhart (2014), 95% of teens use the Internet, and 93% of teens have a computer or access to one. Youth use ICT, forming de facto learning networks, and create and consume digital media and information. In Europe, there has been a movement to *recognize* and articulate the learning and skills of online and informal learning contexts (Werquin & Organisation for Economic Co-operation and Development, 2010). Werquin (2010) suggested the necessity of “…quality assessment of non-formal and informal learning” which “ must above all be valid, transparent and reliable” (p. 79). In short, the merit of informally acquired skills must be recognized.

Why Digital Badges?

Learning is an any-time, anywhere activity, occurring spontaneously in the context of a digitally-mediated and facilitated world (Fontichiaro & Elkordy, 2013a). The recent innovation of *digital badges* has been proposed as a system to recognize and communicate achievement in a variety of learning contexts, particularly informal frameworks. Digital badges are created, displayed, and stored online; they can be implemented as micro-credentials to convey skills acquisition and academic achievement with transparency (Acclaim, 2013). The Mozilla Foundation has created an open technical standard, the Open Badge Infrastructure (OBI), to foster development and interoperability. Digital badges adhering to the OBI standard are known as *Open Badges* (“Badges / about,” 2013).

Here in the United States, led by the Humanities, Arts, Science, and Technology Alliance and Collaboratory (HASTAC), in collaboration with the MacArthur and Mozilla Foundations, diverse digital badging initiatives have emerged since 2013; development of the digital badge concept was accelerated when these organizations launched an international competition, the *Digital Media and Learning Competition 4: Digital Badges for Lifelong Learning,* 2011-2013 (HASTAC, 2013). Thirty winning projects to create various digital badging systems received funding to develop badge ecosystems. Projects submitted by a diverse range of organizations including the *Badges Work for Vets* project by the U.S. Department of Veterans Affairs (Sparkman, 2012), *Disney-Pixar Wilderness Explorers Badges* (Clements, 2012), and *Preparing Librarians to Meet the Needs of 21st Century Teens,* by the Young Adult Library Services Association (YALSA) (Yoke, 2012). Several initiatives specifically for educational systems and educators were funded such as the *Who Built America? Badges for Teaching Disciplinary Literacy in History* project by the American Social History Project for teachers (Potter, 2012) and *Buzzmath*, aligned with the Common Core (Chioniere, 2012).

Large-scale collaborations for digital badging projects are occurring among national organizations such as the *Clinton Global Initiative’s Call to Action* (“Better futures for 2 million Americans through Open Badges -press release,” 2013) . The *Cities of Learning* projects, piloted in Chicago the summer of 2013, engages youth and other learners through a network in which entire cities collaborate to provide interest-driven learning opportunities, recognized by digital badges ("Cities of Learning 2014: Unique, personalized pathways to success with Reconnect Learning," 2014). In 2014, five new cities will be Cities of Learning: Columbus, Dallas, Los Angeles, Pittsburgh and Washington D.C. (Badge Alliance & digital youth network, n.d.). *Digital Promise*, an organization authorized by Congress to spur the use of technologies and innovation in education, initiated a project aimed at credentialing teachers using digital badges ("Digital Promise: Mission + history," n.d.).

The development of the concept of digital badges is an outcome of a convergence of forces: a changing global work force; an evolving educational landscape; the rise of online learning resources, particularly *open* resources and *open* education, e.g. *Massive Open Online Courses* (MOOCs); wide-scale skills deficits in the workforce; intrinsic problems in STEM pipeline and the increase in informal learning. One of the most compelling changes is the proposal to measure competencies and transferable skills.

The concept of digital badges to recognize achievements, to communicate affiliation and to scaffold learning is beginning to have traction in various contexts, particularly where learning has, until now, neither been measured nor communicated. The issue has passionate badge evangelists and vocal detractors as well as early adopters and tentative watchers. The possibilities of digital badges are touted and considered by diverse factions, including business and industry, formal education (higher education and K-12), and informal learning contexts. It may be possible for digital badges, functioning as micro-credentials, to bridge formal and informal learning contexts.

Digital badges are aligned with the idea of competencies or skills-based learning and the measurement of informal learning. The increase of informal learning experiences for pre-college students is recommended, particularly for women and minority students who remain underrepresented in STEM disciplines (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000). Digital badges support recent recommendations to support *evidence-based approaches* in STEM education (Federal Coordination in STEM Education Task Force, Committee on STEM Education, & National Science and Technology Council, 2012).

Digital badges could be used to ameliorate significant challenges in formal learning contexts and create a link with informal learning. This is particularly relevant to STEM informal or out-of-school learning. Informal science education is endorsed and funded at the national level (National Science Foundation, n.d.; Democratic Staff of the House Committee on Science, Space, and Technology, n.d.). Digital badges could be especially useful to articulate learning in goal-oriented out-of-school experiences such as those in the Project Exploration program (Afterschool Alliance, 2013). Project Exploration and collaborating organizations have developed a sophisticated matrix or taxonomy of science learning objectives which, if used in badging contexts, could help cultivate and acknowledge transferable skills across informal sites (Project Exploration, 2011; K. Meisel, personal communication, November 11, 2013).

Digital badges are especially effective with teens, as they understand the social capital and currency of digital badges. This research study explored the careful application of rigorously designed digital badge learning trajectories for STEM learning in an underserved population.

Gibson et al., (2013) called for a research agenda on digital badges examining “several new affordances for education that need additional research…and the impact of digital badges in education on the psychology of learning” (p. 7). They voiced a concern articulated by badge skeptics, specifically about the possibility of digital badges to replace “intrinsic motivation to learn." They pose the question "…would that be a bad thing if they did" (Gibson et al., 2013, p. 7).

Overview of the Study

A mixed methods study was conducted to analyze and assess the impact of a digital badge intervention for STEM learning in a formal secondary learning context. The degree of *Connected Learning Model* (CLM) elements and implementation factors in a model of learning for digital learners may also vary.

Research hypothesis. The expected outcome, or hypothesis, is that the use of digital badge intervention will be more effective in contexts that demonstrate a higher correlation with factors of the CLM. This study sought to understand which CLM factors promote deep learning, and how this varies by student factors such as socio-economic status, use of digital media, and gender. Furthermore, this study explored the perceptions and attitudes of participants regarding the use of digital badge schemata for learning. "Exploratory studies are quite valuable in social science research. They're essential whenever a researcher is breaking new ground, and they almost always yield new insights into a topic for research" (Babbie, 2010, p. 93). Consistently, "A major advantage of MM research is that it enables researchers simultaneously to ask confirmatory and exploratory questions, and therefore verify and generate theory in the same study," (Teddlie & Tashakkori, 2006, p. 20).

Problem Statement

The objective of this research is to explore how digital badges, used as an educational intervention, may impact the learning of STEM in the secondary school sample of underserved students.

Significance of the Study

Although it has been widely assumed that the use of digital badges affects learning, both positively and negatively, there is a lack of empirical data to measure effects; essentially research “related to incentives, motivation, and learning on badge-based learning …in its infancy” (Bowen & Thomas, 2014, p. 25). In particular, the premise that digital badges will affect participant motivation has been asserted, but “there is little research that examines how badges interact with student motivation” (Abramovich, Schunn, & Higashi, 2013, p. 218).

The findings of this study contributed to the emerging knowledge base about the use of digital badges systems for learning in secondary contexts. This research contributed to the practical aspects of designing learning trajectories, which incorporate sound, research-based principles of teaching, learning, and motivation. In addition, the use of digital badges may provide scaffolding and tools for flexible assessment and may propagate the deep learning of key STEM concepts in connected learning contexts.

The ultimate goal of this work was to inform educational practitioners and policy-makers in addressing authentic problems of practice–to enhance learning of STEM knowledge, concepts, and practices to all youth, particularly learners in underserved communities.

Rationale and Purpose

The objective of this research was to explore how the use of digital badges as an educational intervention may impact the learning of STEM in specific, secondary school contexts. Student characteristics important to effective learning and a positive STEM identity, including motivation, persistence, self-efficacy, and task value, were measured. The digital badges are standard-aligned with robust learning trajectories and suggested assessments for and of learning. They were designed for use with STEM content and habits of mind. Data describing the learning environments, which could affect program implementation were collected, including teacher and leadership factors, through both quantitative and qualitative measures and then analyzed.

The use of digital badges (essentially a game mechanic), being used as a learning intervention extricated and applied in non-game contexts, is an emergent area of research. The concept of using digital badging systems in K-12 education is also an emerging area of research. Although digital badges have been used successfully in other technology-mediated instructional systems, such as educational games, how digital badges function as an intervention for learning and instruction is currently unexplored. The “nascent nature of STEM badges,” and in light of the fact “to date, few journal articles focus specifically on badges,” the potential efficacy and methods of application of digital badges in K-12 populations are currently unknown (Riconscente, Kamarainen, & Honey, 2013, p. 2). Funded by the National Science Foundation to explore “Badge-based STEM Assessment,” Risconscente et al. (2013) reported that there are “novel affordances badges bring to the current context of STEM learning,” with “potential …for supporting deeper student engagement, substantive opportunities for learning STEM content, and a greater transparency of underlying assessment criteria,” (Riconscente et al., 2013).

The purpose of this study is to determine the impact of a digital badge intervention upon student learning in the sample populations in secondary formal learning contexts (grades 7-12). In addition to theories of motivation, it was hypothesized that factors of the Connected Learning Model (CLM) proposed by Mimo Ito (2013) and her team would affect the implementation and learning outcomes.

Conceptual Framework for the Study

Based upon social-constructivist theories of motivation and learning in cultural sub-contexts, the Connected Learning Model (CLM) was proposed as the conceptual framework for this research. The CLM proposes a model of learning for digital learners, accounting for their motivations as well as preferences for communication and interactions. In an era when youth especially are constantly connected through electronic devices, when they multitask even when doing homework, an updated theory of constructivist learning for the digital age can contribute to the discourse regarding the teaching and learning for the digital age. The CLM posited that the new model of learning is connected, networked, academic, equitable, interest-driven and peer-assisted ("Connected Learning Principles," n.d.).

Research Questions

Q.1. How does the use of a digital badge intervention for STEM learning impact student:

1) Motivation:
   a. task value
   b. learning goal orientation
   c. self-efficacy
   d. learning behaviors (including persistence-at-task)

Q.2. Which factors of the learning environment affect digital badge acquisition?

Q. 3 Which student- level factors affect engagement in learning processes, using a digital badge intervention?

Study Outcomes

This study was undertaken with expectations to understand:

- the degree of impact of the digital badge intervention upon learner attributes, opinions, or behaviors;
- the degree of effect (if any) for key variables;

- possible associations between learners and program outcomes;
- the extent to which badges elicit the desired learning behaviors, such as sustained or increased effort in the sample populations; and to
- extrapolate a possible agenda for future research.

Definition of Terms

Competency-based learning. This definition of competency learning was developed at the Competency-Based Summit co-sponsored by the International Association for K-12 Online Learning (iNACOL) and the Council of Chief State School Officers (CCSSO) in 2010: Competency-based approaches require alignment around five key elements:

- Students advance upon mastery;
- Competencies include explicit, measurable, transferable learning objectives that empower students;
- Assessment is meaningful and a positive learning experience for students;
- Students receive timely, differentiated support based on their individual learning needs;
- Learning outcomes emphasize competencies that include application and creation of knowledge, along with the development of important skills and dispositions (Patrick & Sturgis, 2013).

Digital badges. “A digital badge is a representation of an accomplishment, interest, or affiliation that is visual, available online, and contains metadata including links that help explain the context, meaning, process and result of an activity” (Gibson et al., 2013, p. 2). Digital badges may be collected and displayed on eportfolios, web sites, or social media. Open badges are digital badges that adhere to the OBI interoperable technical standard, developed by Mozilla (Mozilla Foundation, n.d.).

Engagement. Engagement consists of the three interrelated concepts of behavioral, cognitive, and emotional engagement, often measured together. Hence engagement may be considered a *meta-construct* (Fredericks et al., 2004). Behavioral engagement is related to student participation and conduct. Emotional engagement includes positive and negative reactions to the school environment including teachers and other students. Cognitive engagement is the level of investment, which includes the amount of effort and persistence students will extend in the course of learning. All three kinds of engagement are necessary for learning (Fredericks et al., 2004).

Formal, informal and non-formal learning. Entrenched within the idea of a *learning society*, the boundaries and definitions of formal, non-formal, and informal learning often overlap. Many definitions are derived from the 1973 work of Combs, Prosser, and Ahmed, *New Paths of Learning for Rural Children and Youth* (M. K. Smith, 2001). In this work, formal education is defined as “hierarchically structured, chronologically graded ‘education system’,” informal education is “the truly lifelong process whereby every individual acquires attitudes, values, skills and knowledge from daily experience and the educative influences and resources in his or her environment,” and non-formal education is “any organised educational activity outside the established formal system... intended to serve identifiable learning clienteles and learning objectives” (M. K. Smith, 2001).

Interest learning. The concept of interest is closely associated with intrinsic motivation and may be either situational, fluctuating according to tasks or contexts, or viewed as a more stable, individual trait (Duschl et al., 2007).The interest, i.e. or perceived value, of learning is associated with higher learning outcomes ("Connected Learning Principles," n.d.). Individual interest, argued Hidi (1990), affects engagement, "effort and willingness to persist at a task, and acquisition of new knowledge" (as cited in Duschl et al., 2007). According to Duschl et al., (2007) "situational interest is more influenced than personal interest by characteristics of the classroom and the nature of the task (p. 200). According to Malone and Lepper (1987), for example, challenge, choice, novelty, fantasy, and surprise can increase students' situational interest" (as cited in Duschl et al., 2007, p. 200).

Learning ecology. Learning occurs within interactive, complex systems with multiple elements. A learning ecology approach considers the impact of various elements which may include tasks or problems such as "the kinds of discourse that are encouraged, the norms of participation that are established, the tools and related material … and the practical means by which classroom teachers can orchestrate relations among these elements" (Cobb et al., 2003, p. 9).

Motivation. Motivation is the degree of effort and the direction of individuals' behavior (Reigeluth, 1983) and also, is "the internal circumstance that instigates and focuses goal-oriented behavior" (Schunk, 2004). Dweck (1986, p. 1040), proposed that "students' adaptive motivational beliefs 'promote the establishment, maintenance, and attainment of personally challenging and personally valued achievement goals" (as cited in Velayutham, Aldridge, & Fraser, 2011, p. 2160) Furthermore, Pintrich (2000) argued that "both adaptive motivational beliefs and adaptive self-regulated learning are integral to students' engagement in classroom tasks" (as cited in Velayutham et al., 2011, p. 2160). In this study, motivation is measured as a construct consisting of measures in self-regulatory behaviors, as well as "three components of motivation that have been consistently associated to students' adaptive motivational beliefs …

[which are] …learning goal orientation, task value, and self-efficacy, each of which is integral to successful engagement in self-regulated learning" as described by Zimmerman (2002) (as cited in Velayutham et al., 2011).The construct of motivation is indirectly measured through the concepts of self-efficacy, goal orientation, interest, and self-regulatory behaviors through items modified from the *Students' Adaptive Learning Engagement in Science* instrument (Velayutham et al., 2011).

Participatory cultures. Jenkins et al (2009), describe "A participatory culture is also one in which members believe their contributions matter, and feel some degree of social connections with one another (at least they care what other people thinking about what they have created)" (p. 7).

STEM identity. A well-developed STEM identity is critical to the sustained interest and pursuit of STEM academic coursework and ultimately, employment in STEM fields (Duschl et al., 2007) . The concept of identity is complex, incorporating aspects of self-efficacy and self-concept within the pursuit of STEM subjects (self-efficacy), interests and motivation (Tuan *, Chin, & Shieh, 2005). Ultimately, the formation of a STEM identity is a culturally embedded and culturally shaped set of processes, influenced by society, history and politics (Barton, 1998). Within this study, STEM identity is considered as aspects of *interest* as well as math and science concept (Hughes, Nzekwe, & Molyneaux, 2013).

Limitations and Delimitations

The introduction of a digital badge ecosystem is essentially an intervention to achieve specific learning goals and, as such, the results are highly contextual. The results are influenced, not only by the badge design or content, the learning objectives, or trajectory but also by implementation factors such as the social interactions of participants, teacher attitudes and behaviors, school administrator behaviors during the learning process, the environment, and instructional delivery or support. Individual motivations and abilities further confound the badge development process, as do socio-cultural contexts. Ultimately, the badge intervention is a component of an instructional system *designed* for mastery learning. This study informed the implementation of digital badge interventions in similar contexts.

Summary

A digital badge intervention was developed for use with secondary-aged students in learning specific STEM skills. Data were collected and analyzed before, during, and after implementation of a standards-aligned digital badge intervention in a secondary-aged population.

The CLM and theories of motivation are used as the conceptual frameworks. The study was also informed by research in learning theories, assessment, interest-directed learning, technology-mediated social interactions, and instructional design, aspects of which were were integrated into the CLM framework.

Organization of Chapters 2-5

This study consists of five chapters, which describe the purpose, design, analysis, and findings of this research. Chapter 2 is a review of literature and concepts related to the STEM skills deficit; its ramifications and factors contributing to the under-representation of women and minorities in STEM fields are explored. STEM achievement is viewed through the lens of equity and social justice. The roles of individual traits, attitudes, beliefs, and behaviors that affect learning are discussed. Literature pertinent to youth participant attributes such as motivation, self-efficacy, learning preferences and behaviors, and attitudes toward STEM content are considered. Learning and motivation are reviewed from a socio-cultural approach as the theoretical underpinnings and rationale of the CLM. Completing the chapter is a summary of literature pertinent to the concept of digital badges.

Research methods, the development of the digital badge learning trajectories for the intervention program, and the creation of resources to support program implementation are outlined in Chapter 3, which also includes the procedures of program implementation and the data collection methods. Analysis of data and interpretations of findings are presented in Chapter 4. Study findings and a summary of conclusions with an emphasis on practical applications for educational practitioners working in a variety of environments are described in Chapter 5, which concludes with recommendations for future inquiry and research.

Chapter 2: Literature Review

The literature review section focuses upon: 1) the need for teaching and learning 21st century skills, particularly in STEM, 2) student characteristics (learning preferences, use of digital media and ICT), 3) learning and the Connected Learning Model, 4) motivation in learning and associated concepts, and 5) digital badges in education.

Information Communications Technologies and the Changing Global Context

Reverberating the sentiments of many social commentators and cultural historians, Friedman (2007) described the tipping point of the paradigm shift to Information and communications technologies (ICT) in 1995. When the Mosaic wide web browser was first released, he remarked that the " world has not been the same since" (Friedman, 2007). ICT and related technologies have resulted in second-order change, i.e., change of the magnitude that requires significant, alterations in systems, processes and behaviors (i.e., paradigm shifts) as opposed to the superficial rearrangements of first-order change (Waters & Marzano, 2006).

We are currently immersed in the processes of restructuring our social and technological systems as well as discovering new possibilities of an ICT-mediated and facilitated world. "The late 20th century ushered in vast improvements in computer and information technologies, as well as biomedical technologies. These innovations are changing the way we live, work and play in marvelous and unforeseen ways" (U.S. Congress Joint Economic Committee, 2012, p. 2). Advances made possible by ICT have led to an irreversible course of transformation in regard to manufacturing or industrial economies, as well as to knowledge or information based economies which are often global in scale and scope.

These changes in the workplace have resulted in a shift of the essential knowledge, skill sets and proficiencies critical for knowledge among workers, particularly those in STEM fields

(U.S. Congress Joint Economic Committee, 2012). The changing economic and social contexts compel a parallel shift in the objectives, processes, systems and outcomes of our educational systems.

We are in the midst of emerging new paradigms of global citizenry, social awareness and the formation of participatory cultures. The meaning of what it means to know, in many respects, has evolved as interconnected webs of disparate facts are woven together. Inspired by our nature to learn from others, socially, in the context of meaningful relationships (Cozolino, 2013), we are collaboratively solving tasks socially through the processes of technological mediation and knowledge acquisition. Collaboration is therefore fostered on a completely new scale.

Participatory cultures and communities of practice. Technology and knowledge have migrated towards the formation of participatory cultures, where collaboration is pervasive and dispersed geographically. Delwiche and Henderson (2012), writing about the proliferation of participatory cultures and our increasing reliance upon them observed:

> Our world is being transformed by participatory knowledge cultures in which people work together to collectively classify, organize, and build information … in our daily life, we engage with this form of participatory culture each time we seek guidance from a collaboratively updated website that reviews books, restaurants, physicians and college professors...These knowledge cultures have become an integral part of our lives; they function as prosthetic extensions of our nervous system and we often feel crippled when our access to these networks is curtailed. (p. 4)

When individuals come together for the purposes of learning, both offline and online, *communities of practice* may form; “We are belong to communities of practice. At home, at work, at school … we belong to several communities of practice at any given time” (Wenger, 2000, p. 6). The possibilities of online participatory knowledge cultures expand the learning landscape exponentially. It directly impacts and influences learning in the 21st century. Changes in our learning networks are mirrored in other aspects of contemporary society, for example, in how we communicate using social media.

A whole new world of work. Change is pervasive in research and development domains; demographically, our societies are also changing. Due to advances in health care, as well as a more informed populace, people are living much longer. According to the Center for Disease Control, the average life expectancy at birth (combined for men and women, all races) was 78.7 years in 2011, (Hoyert & Xu, 2012) up from 62.9 years in 1940.

In the United States, life expectancy has increased every decade since 1900, when combined life expectancy was 49.24 years (1900-1902). This age increased to 68.07 years, 1949-1951; to 70.8 years (1969-1971), to 75.37 years (1989-1991), and to 78.7 years in the present (Arias, 2014, Table 19).

Populations are aging globally, and not only are people living and working longer, they are much healthier. Many workers, especially women, remain at least part-time in the work force for much longer periods (Holder & Clark, 2008; Brown, 2013). In addition, the United States is undergoing shifts in demographics which significantly impact the workforce. Increasingly, the population is including more traditionally minority groups, older workers, and a large proportion of underprivileged youth (Lerman & Schmidt, n.d.). In addition to the globalization of the workplace, the U.S. job market is shifting. According to Gallup Education, the average age of retirement has increased to 61, up from 57 in the early 1990's. Furthermore, workers are electing to stay in the workforce past 65 years of age.

The most notable change over time is the increase in those expecting to work past age 65 – the 37% this year is up from 22% a decade ago and 14% in 1995. Meanwhile, the percentage of non-retirees who say they expect to retire before age 65 has declined to 26%, from 49% in 1995 (A. Brown, 2013). Due to the rapid pace of change, workers are forced to retool themselves, perhaps repeatedly, with new skills. Their knowledge set and skills have become obsolete, and hence, no longer viable or relevant to the work place:

> An ageing population makes it even more important to adopt a life-cycle approach to learning in order to maintain and upgrade the skills of an older workforce. Thus, a number of policies to address the development, activation and use of skills in the labour market are needed to complement initial education and training provision. (World Economic Forum Global Agenda Council on Employment, 2014, p. 18)

Concurrently, the impact on our youth is profound: “Today’s American youth are entering a labor market strikingly different from earlier generations” (Ito et al., 2013, p. 15). The changes in the global workplace will continue to reverberate as:

> Young people entering the labour market now may well have to change employers and even occupations several times over their working lives. Seen in this light, preparing for the modern labour market requires being able to manage uncertainty and change. (OECD Skills Strategy, 2011, p. 14)

Therefore, adults and young people must become educated and well-equipped to handle change in the skills necessary for economic and social survival. As the world’s labor forces converge and in some senses, diverge, the need for essential skills for the workforce to be clearly articulated has resulted in national and international projects to identify key skills.

There is broad consensus on the results. Most frameworks identify similar clusters of skills, including basic or foundation skills, such as literacy and numeracy; higher-level cognitive skills, such as problem-solving and analytic reasoning; interpersonal skills, including communication skills; working in teams and ability to negotiate; ability to use technology, particularly ICTs; and learning skills, essentially knowing how to learn. With innovation considered key to economic growth, much attention has focused on the development of skills such as *creativity* and *entrepreneurship* (OECD Skills Strategy, 2011, p. 15).

In addition, the workforce must be prepared for profound changes in social contexts, particularly in regard to information communications, interactions, knowledge production, use, and access. Knowledge is distributed and shared. Crowdsourcing and problem solving conducted through solicitations for help, message boards, and forums, as well as tutorials have become routine (Brabham, 2008).

Knowledge and communication have therefore become decentralized. The contexts for learning are new: networked and connected (Ito et al., 2013). Knowledge has become dispersed and social, in light of the tremendous impact ICT and technologies have had on the world and its systems. It therefore seems reasonable to believe that our students have also been intrinsically transformed.

A New Paradigm

Second-order change is disruptive – and transformational. The advent of advanced ICT has truly resulted in significant change in the way people in developed countries live, work, communicate, conduct business, and relate to one another. In fact, it would be difficult to identify aspects of life which have not been affected by these technologies in developed countries. The change is fundamental, much like the paradigm shifts pursuant to the invention of the writing process or the invention of the printing press and steam engine. However, as Ian Jukes reaffirms *in Living on the Future Edge*, technologies alone do not change people's circumstances: "Revolution doesn't happen when society adopts new technologies – it happens when society adopts new behaviors" (McCain, Jukes, & Crockett, 2010, p. 160). Second-order change needs a paradigm shift to gain momentum.

A paradigm is firmly entrenched in cultural psyches; it "…is a frame of reference that helps us to make sense of new information." It is "…a value system that enables us to determine the significance of events and a filter that interprets these events" (McCain, Jukes, & Crockett, 2010, p. 1). If technology has functioned as a change agent, transforming important aspects of societies, then why has this not occurred within the scope of educational systems? The fact that education has been, for the most part, resistant to the infusion and implementation of technology has been articulated by the U.S. Department of Education, among others, in particular the Office of Educational Technology, in its 2010 National Educational Technology Plan (Atkins et al., 2010). Bigum and Rowan, researchers in teacher education comment:

> To date, schools have managed to domesticate much of what has emerged in the technical landscape. There is a well-established pattern of applying or integrating new technologies into existing practices or, if the new poses risks or threats, to ban or limit its use. *Integrate* continues to be the verb … The logic is to fit the new into the pre-existing, to integrate….Oddly, formal education is the only field in which this way of thinking about ICTs is commonplace (as cited in Selwyn, 2010, p. 28).

As industries and businesses change their operational paradigms, schooling and schools have remained almost unchanged to the point where some educational commentators have noted that educators seem to take pride in retaining old structures and ways of doing things rather than capitulate to a sea of changes. Bigum and Rowan continue:

> Banks, airlines, government bureaucracies or the military don't talk about integration. They do, however, make use of ICTs to rethink and rework the way they do things. An integration mindset privileges existing ways of doing things. It reflects a view of linear, manageable change and, to date, has allowed teacher education and schools to keep up technical appearances (Bigum and Rowan as cited in Selwyn, 2010, p. 29).

It is paradoxical that the educational sector, responsible for preparing future thinkers, leaders, workers, and society apparently resists the technologies in its midst. It would seem reasonable that educational practitioners and policymakers would be at the forefront, leading and guiding the way, toward the implementation and discovery of new technologies, highly useful in education and in societal and economic functions. It is imperative, however, that educational visionaries who currently promote and rethink education continue to vigorously align pedagogical structures, objectives, and methodologies as they implement digital media and ICT. Youth today, especially K-12 students, have been immersed in a digital universe since birth. They are often consumers of digital media and hand-held devices before two years of age. Because our educational systems, for the most part, lag behind in successfully and meaningfully implementing technologies into learning processes and outcomes, students say they have *to tune out* when they go to into the classroom. Not only are students unprepared for the challenges and opportunities of living in the 21^{st} century, a situation has been created wherein our youth feel disengaged in formal schooling (Garcia et al., 2014).

Various proponents say that there is less return on technology investment than they hoped. One of the major reasons for this disconnect is the lack of knowledge regarding suitable pedagogies which leverage technology (Organisation for Economic Co-operation and Development, 2010, p. 14). Additional concerns regarding digital literacy and STEM skills are science curricula and teacher quality (U.S. Congress Joint Economic Committee, 2012), inequitable school funding (Duschl et al., 2007), the pressure to adhere strictly to curricula to increase students' performance on standardized tests. Furthermore, the changing role and responsibilities of school leadership in a digitally-mediated, global context continues to change (Mulford, 2003). Leadership support of technology initiatives continues to gain importance (Anderson, 2005). Most importantly, however, the lack of return is the result of the dearth of instruction which effectively leverages the unique affordances that ICT and digital media can bring for educational systems. As noted by Jukes, in *Living On The Future Edge*, a paradigm shift is critical and imminent in education; but significantly, educational systems have a history of resisting new *technologies.* In his 1992 publication, *Edutrends 2010: Restructuring, Technology and the Future of Education,* David Thornburg shared educator Stanley Bezuska's apocryphal collection of concerns regarding *new* technologies when they emerged:

- Students today can't prepare bark to calculate their problems. They depend on their slates, which are more expensive. What will they do when their slate is dropped and it breaks? They will be unable to write! (*Teachers Conference, 1703)*
- Students today depend upon paper too much. They don't know how to write on slate without chalk dust all over themselves. They can't clean a slate properly. What will they do when they run out of paper? (*Principal's Association, 1815)*
- Students today depend too much upon ink. They don't know how to use a pen knife to sharpen a pencil. Pen and ink will never replace the pencil. (*National Association of Teachers, 1907),* (as cited in Thornburg, 1992, p. 59).

Our educational organizations and educators are expected to prepare 21st- century workers; however, the current systems are still very much modeled upon the objectives, pedagogies, and philosophical constructs of the industrial age. Among visionaries, particularly in the business, industrial, and governmental sectors, there have been numerous discussions regarding the need for educational reform. In the United States, the emphasis upon educational improvement has resulted in the unintended consequence of a culture of educational standards, measurement to evidence *learning*, and teacher efficacy as measured by *student learning*. Popham (1999) described the practice of evaluating "… teachers' instructional effectiveness by using assessment tools that deliberately avoid important content [i.e., standardized testing] is fundamentally foolish." Conceptually, the idea of measuring learning gains is comprehensible and sound; in practice, however, the knowledge sets and skills that are required for the 21st- century, global workplace are difficult to measure (Leighton & Gierl, 2011). As a result, the measures of *student learning* tend to be strongly entrenched in factual recall and lower-order thinking skills, which are more readily assessed. Teachers, in order to *evidence* learning, tend to directly teach to test items so that they may be perceived as *effective* or *successful* (Popham, 2001).

Skills Gaps

There is considerable growing concern, however, about the lack of appropriate skills for the workplace:

> Skills have become the global currency of 21st century economies. Without sufficient investment in skills, people languish on the margins of society, technological progress does not translate into productivity growth, and countries can no longer compete in an increasingly knowledge-based global economy. (OECD, 2012, p. 3)

According to the U.S. Bureau of Labor Statistics in 1967, jobs in the manufacturing sector accounted for 54% of the U.S. economic output whereas by 1997, this was surpassed, at 64%, by information products (as cited by Partnership for 21st Century Skills, 2008). The impact of this trend has resulted in a parallel shift in the skill sets and competencies necessary to function in a knowledge-based global marketplace As a result, economists, policymakers, educational researchers, and educators have recognized a definitive shift in necessary basic proficiencies, often called *literacies*, or more recently, *fluencies*, critical for U.S. competitiveness. Cathy Davidson, citing work on the workplace of the future by the U.S. Department of Labor (U.S. Department of Labor, n.d.) remarked: “by one estimate, 65% of children entering grade school this year will end up working in careers that haven’t even been invented yet” (Davidson, 2011, p.18). A challenge for educators everywhere is to effectively prepare youth for an uncertain future in the workplace.

There are indications that current educational outcomes do not adequately meet workplace needs. A report was recently issued by the World Bank on employment and education in Asia. It cited five key *disconnects* between universities and key sectors of the market, such as schools (lack of vertical articulation), as well as research industries and employers (skill mismatch). The report attributes the relatively high rates of unemployment in China, Indonesia, and the Philippines (6%, 8.5%, and 11% respectively) to the fact that workers “simply do not have the right skills” (The World Bank, 2011, p. 53).

> Many countries have developed strategies to improve the skills level of their citizens, but their success in implementing them varies widely. And many continue to struggle with low levels of adult basic skills, problems of skills mismatch, skills shortages and unemployment. (OECD, 2012)

Furthermore, as the world economies become more interconnected, international comparison of workers' preparation is becoming increasingly important. Methods to compare and articulate skills sets across countries would facilitate that process.

The belief that workers are not prepared is of global concern, and in response various initiatives and research programs are in progress to delineate necessary workplace skills. For example, the *Secretary's Commission on Achieving Necessary Skills* project (SCANS) (U.S. Department of Labor, Employment and Training Division), resulted in a report articulating the competencies schools should teach to effectively prepare students for the U.S. workplace (Skills, 1991). In Europe, there is the ongoing Organization for Economic Cooperation and Development (OECD) *Skills Strategy* project (OECD Skills Strategy, 2011; Organisation for Economic Cooperation and Development, n.d.). In addition, the legislative arm of the European Union has created a publication *Key Competencies For Lifelong Learning* (European Commission, 2007). These initiatives have commonalities in the desired skills: *Systems Thinking*: understanding social, organizational, and technological systems, monitoring and correcting performance, and designing or improving systems; and *Thinking Skills*: thinking creatively, making decisions, solving problems, seeing things in the mind's eye, knowing how to learn, and reasoning (Bloomer, n.d.).

Importantly, we do not yet know what is needed in the work place of the future, and this is part of the problem (U.S. Congress Joint Economic Committee, 2012). What skills will be important for the future? For some time, there has been consensus among policy makers and employers that students are not learning the skills needed in the 21st- century workplace. In response, various frameworks or recommended competencies have emerged from the educational sector. In the United States, frameworks of these skills have been proposed, most notably by the *Partnership for 21st Century* (Partnership for 21st Century Skills, 2009).

Despite the lack of consensus among creators of conceptual models and ontologies proposed necessary knowledge economy proficiencies, the skills and competencies with the framework formulated by *Partnership for 21st Century Skills* have been the most widely accepted (Dede, 2010). In addition to core knowledge (factual competencies), the Partnership advocates knowledge, skill sets, and aptitudes which are critical for an evolving, knowledge-based work place, increasingly reliant upon ICT. Additional recommendations include: core subject knowledge, authentic problem solving, creativity, flexibility, resourcefulness, and enhanced communications skills. (Partnership for 21st Century Skills, 2009)

In addition, the European *Key Competencies* suggests working knowledge of foreign languages, and other skills:

> … *sense of initiative and entrepreneurship* is the ability to turn ideas into action. It involves creativity, innovation and risk-taking, as well as the ability to plan and manage projects in order to achieve objectives. The individual is aware of the context of his/her work and is able to seize opportunities that arise. (Key Competencies, 2006)

Flexibility, the ability to communicate, and independent initiative are all required factors for future success.

Selected 21st Century (Knowledge Economy) Skills

Core Content Knowledge

- Math, Science, Languages, Social Studies, English, Foreign Languages
- Specialized knowledge sets: business, engineering, health

Digital Media Skills and Literacies

- Information fluency
- Digital media fluency
- Digital citizenship
- Social media fluency

Higher-Order thinking skills

- Complex problem solving
- Critical thinking
- Creative problem solving
- Systems thinking
- Entrepreneurial thinking
- Innovative thinking

Interpersonal and Social Skills

- Leadership skills
- Communication skills in a variety of media
- Collaboration skills
- Global awareness of social concerns
- Knowledge of civic responsibilities in a global context

Intrapersonal skills

- Creativity
- Flexibility and Adaptability
- Cultural awareness and sensitivities
- Emotional Intelligence
- Empathy

Figure 1. 21st workplace skills based upon the P21 and other frameworks.

Due to the intrinsic difficulties in teaching and assessing these higher-order thinking skills in formal K-12 educational framework (Figure 1), they are often learned in informal or non-formal environments. As such, they are self-taught and interest-driven. Because they are neither measured nor assessed, they are in many respects, *invisible*, lacking recognition and a means to communicate or compare competencies. Awareness of these difficulties has prompted significant discussion on how to accurately assess student learning. One proposal is a digital badging ecosystem, which would facilitate the measurement and communication of achievements and skills development (Alliance for Excellent Education, 2013).

Need for STEM Knowledge, Skills, Practices and Habits of Mind

While the shift to globally sourced, knowledge-based economies has led to the demise of industrial-based jobs, it has led to opportunities and continued growth in other job sectors, particularly in STEM fields. New knowledge sets, ways of thinking, and professional practices are essential for a rapidly changing world. In particular, knowledge, and practical abilities such as design thinking, creativity, innovation, and cross-cultural knowledge are crucial in Science, Technology, Math, and Technology (STEM) fields. At the time when the needs for innovation and flexibility in the use of technology are most necessary, students in the United States are performing poorly in their acquisition of needed STEM skills:

> ... concerns remain about persistent academic achievement gaps between various demographic groups, STEM teacher quality, the rankings of U.S. students on international STEM assessments, foreign student enrollments and increased education attainment in other countries, and the ability of the U.S. STEM education system to meet domestic demand for STEM labor. (Gonzalez & Kuenzi, 2012, p. 1)

In part, this low interest and low achievement is due to the increased used of standardized testing. ”Standards-based tests can have the unintended consequence of narrowing the focus to memorizing facts, rather than measuring higher-order thinking skills” (Kentucky Department of Education, 2013, p. 9). Again, the need for change is reinforced. “Fully capturing the economic benefits of existing and undiscovered technologies will require a steady stream of Americans equipped with science, technology, engineering and STEM knowledge, skills and abilities” (U.S. Congress Joint Economic Committee, 2012, p. 1).

The business community emphasizes the same concerns. Writing for the World Bank, Fasih states “The current global economy values individuals who, in addition to basic cognitive skills, have core competencies in critical thinking, problem solving, and entrepreneurship” (Fasih, 2008, p. 38).

Government agencies also concur with the need for innovative, technologically equipped STEM proficiency:

> Graduate skill shortages exist, predominantly in the science, technology, engineering and mathematics….business organizations and other groups have issued numerous reports and surveys that suggest there is a heightened need for qualified STEM workers – both those with highly specialized skills as well as those with a more general knowledge of STEM concepts. (U.S. Congress Joint Economic Committee, 2012, p. 2)

For a variety of reasons, essential knowledge and competencies in STEM fields, particularly higher-order thinking skills such as critical thinking, modeling, and scientific reasoning, are neither adequately taught nor assessed in formal learning contexts. This has therefore resulted in skills deficits with widespread repercussions: “This human capital performance gap threatens our nation’s ability to compete in today’s fast-moving and increasingly demanding global economy. It is emerging as our nation's most critical business issue" (Deloitte Consulting LLP, 2005, p. 2). In an updated report with the Manufacturing Institute, the findings were reaffirmed:

> Overall, our survey findings are remarkably consistent with previous Skills Gap studies, with 67% of respondents reporting a moderate to severe shortage of available, qualified workers and 56% anticipating the shortage to grow worse in the next three to five years. In addition, our survey indicates that 5% of current jobs at respondent manufacturers are unfilled due to a lack of qualified candidates. These results underscore the tenacity of a worsening talent shortage that threatens the future effectiveness of the U.S. manufacturing industry. (Morrison et al., 2011, p.3)

New skills are essential for success in a digitally facilitated, interconnected work place, which is increasingly dependent upon the STEM discipline knowledgebase and practices. Furthermore, it is reasonable in this context, that educational institutions, as well as their processes and outcomes, would also be affected by these second-order or systemic changes, in order to prepare youth to be workers and citizens.

Global concerns, global efforts. Our educational systems are now in flux, evidenced by changes in the internal and proximal environments as evidenced by the experimentation with different educational models; the growth of the charter school movement; developments in legislation and policy; increased scrutiny on teachers and call for so-called *accountability* as well as the rewriting of state and national standards. Considerable efforts are focused upon ameliorating the problems in the STEM pipeline in the United States.

Much of the international dialogue over the past few decades regarding these changes have focused upon the need for the work force to adapt, forging new capacities through new skills and competencies. By implication, it has also focused upon the processes of education, specifically the responsibilities and roles of schools and schooling. In particular, a major emphasis has been on the erstwhile failure of educational institutions to prepare a competent work force for a rapidly evolving, global workplace or to successfully prepare our youth, in all aspects, for the future. Selwyn (2011), describes schools as “first and foremost regulatory environments,” and “As such the intersections between digital technology and compulsory schooling entail a range of issues relating to power, control, regulation and (in)equality” (p. 9).

Despite the difficulties inherent in predicting the skills and knowledge necessary for jobs which may not currently exist, it has become apparent now that certain kinds of knowledge, habits of mind, practices, and skills are necessary. These include analytical and systems thinking for STEM disciplines, which are currently insufficient. As the drive for reform gains momentum, particularly in regard to the increasing demand for institutional and individual accountability in educational systems, there has been an emphasis on both content and assessment of learning (Mourshed, Chijioke, & Barber, 2010; Gordon Commission on the Future of Assessment in Education, 2013).

The response has primarily been characterized and shaped by a distinct trend towards educational standards in core areas and by standardized testing to *measure* or document progress towards goals. 21st century skills, such as the ability to solve complex problems, demonstrate creativity, or to communicate well with groups of diverse individuals are inherently incompatible with a system of standardized testing and, as a result, tend not to be taught in formal environment (Darling-Hammond, 2006).

Policy makers as well as business analysts are urging for change: “Educators must emphasize science, math, and technology-related programs in K-16 curricula, invest more in effective teacher education focused on science and math, and ensure that programs regarding career opportunities and requirements for graduation are geared for 21st century employment" (Deloitte Consulting LLP, 2005, p. 7).

Educational standards and frameworks such as the *Common Core State Standards*, (Common Core State Standards Initiative, 2014a) *National Educational Technology Standards for Students* (International Society for Technology in Education (ISTE), 2007), and other standards frameworks are responses to the changing knowledge needs of the global workforce. They were developed to create a shared platform of understanding of essential knowledge, skills, and competencies. The National Research Council of the National Academy of Sciences has published an extensive framework recommending a revised set of benchmarks for STEM learning (NGSS Lead States, 2013b). The model describes three dimensions, which include special knowledge sets and skills, as well as tacit, epistemic practices important to STEM disciplines. Factors include data analysis and interpretation, systems thinking, as well as the ability to obtain, evaluate, and communicate information (National Research Council, 2012).

Institutional factors exist, such as the rate of change in educational organizations, as well as other factors, including funding, teacher professional development and oversight, and school improvement goals. For this reason, there is a trend towards the more easily assessed and measured discrete competencies. Factual knowledge and skills characterized by lower-order thinking skills, is unlikely to change soon. Similarly, the current models of schooling, which originated in the industrial era are unlikely to change because of pervasive political and economic forces. As a result, educators and educational policy makers have unique challenges in fulfilling conflicting roles. They are the masters and gatekeepers of state and national content standards. At the same time, however, they are attempting to negotiate the cognitive and affective needs of an increasingly disenchanted and disaffected student population. Particularly in urban areas, this population has become increasingly culturally and linguistically diverse (Daniel & Friedman, 2005). The critical importance of restructuring and augmenting STEM education is reinforced by numerous reports and supporting legislation. Since December, 2013, these reports have included numerous reports: the National Research Council's *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (National Research Council, 2012)*; Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics* (National Research Council, 2011); the President's Council of Advisors on Science and Technology's *Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future* (Executive Office of the President & President's Council of Advisors on Science and Technology (PCAST), 2011)*;* and the Information Technology & Innovation Foundation's *Refueling the U.S. Economy: Fresh Approaches to Science, Technology, Engineering, and Mathematics (STEM)* (Atkinson & Mayo, 2010).

An unintentional consequence of widespread standardized testing is that effective assessments to measure and communicate some STEM competencies do not exist. This is particularly true for higher-order thinking skills such as critical thinking or abstract reasoning essential for innovation and problem solving. An alternative assessment system, a digital badge ecosystem, has been proposed for articulating trajectories as well as measuring and communicating learning in informal and formal environments. Increasingly, students are leveraging freely available digital assets such as Open Education resources (OER) and tools as well as Internet-enabled communications to acquire new proficiencies through informal channels.

Congressional interest in STEM education heightened in 2007 when the National Academies published a report titled *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Committee on Prospering in the Global Economy of the 21st Century (U.S.), 2007). This influential publication warned federal policymakers that perceived weaknesses in the existing U.S. STEM education system—along with other important factors—threatened national prosperity and power.

Although some analysts disputed its assertions, the report helped focus the federal conversation about STEM education and led, in part, to passage of the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act (or America COMPETES Act). Among other initiatives, this act authorized STEM education programs at the National Science Foundation (NSF), National Oceanic and Atmospheric Administration (NOAA), Department of Energy (DOE), and Department of Education (ED) (Gonzalez & Kuenzi, 2012, p.2). COMPETES was reauthorized in 2010, and it provided for increased STEM education: "A second GAO study, published in 2012, reported 209 programs funded at about $3.1 billion in FY2010 (hereinafter this report is referred to as *GAO-2012* (Gonzalez & Kuenzi, 2012, p.3). Substantial funding has been directed to extending the reach and involvement of national agencies in the creation of out-of-school or informal learning opportunities (Gonzalez & Kuenzi, 2012).

Paradoxically, as the momentum towards standardization has increased, so has the trend for individual participation in self-motivated learning. This has led to a distinct trend towards personalized learning paths, particularly in competency based systems (Kentucky Department of Education, 2013). "The U.S. Department of Education has also shifted its focus to personalized learning and has recently awarded 16 Race to the Top-District Competition Grants to develop or expand personalized learning systems" (Kentucky Department of Education, 2013, p. 3).

Growing Up in a Digital World: Disengaged

The proliferation of digital media and resources, including digital artifacts, experts, communities of practice, or affinity, offers unprecedented opportunity for learners. However, as educational researchers Ito et al., (2013) explain:

> …what is clear from the existing literature is that currently it is generally educationally privileged youth with effective learning supports at home who are able to take full advantage of the new learning opportunities that the online world has to offer and to translate these opportunities to their academic and career success (p. 5).

Today's learners have grown up in an age where digitally mediated communications, connections, and resources are the norm and not the exception, which provides a challenge for educators. Ironically, because of problems with equitable access and use of ICT and digital media, there is a substantial risk to perpetuate existing disparities (Ito et al., 2008). If these issues are not addressed, the persistent achievement gaps for minorities will be exacerbated and extenuated, that will continue to affect participation of these groups in STEM disciplines. There is a need for new educational paradigms. There must be more effective engagement for students in order to encourage them to construct their own meaning in their endeavors. In addition, new ways of assessment must be devised to effectively communicate the skills acquisition occurring in participatory cultures, affinity spaces, and other forms of informal and self-motivated learning.

***Different* youth, brain-wise**. Business, culture, and society have been impacted and are evolving in response to digital communications. So are individuals: this is especially true of children and youth. Due to constant exposure to and immersion in digital media and ICT, their brains are actually connected or *wired* differently, resulting in physical changes in neurological structures. Today's youth has never known a world without computers, video, or smart phones.

We know from neuroscience and learning sciences that our brains assemble clusters of neurons, allowing for quick responses to the things that we pay attention to most. In her recent publication on the science of attention, Cathy Davidson described this clustering, known as the Hebbian principal: "Neurons that fire together, wire together." Learning occurs when the brain is *aroused*, or pays attention, to stimuli which it regards as important in context. Over time, as "Canadian Donald A. Hebb... often called the father of neuropsychology" observed, as "we repeat a certain pattern of behavior… those behaviors become reflexive, then automatic" (Davidson, 2011, p. 45).

During neural blooms (occurring in young childhood and adolescence), a tremendous number of neurons and synaptic connections are produced by the brain, becoming interconnected in meaningful pathways as learning occurs. Neurons which are not *used*, i.e., are not connected to others, undergo a process of programmed cell death. This process results in a *neural pruning*, whereby cells atrophy and die resulting in the brain neuroplasticity or development, growth and reshaping in response to experiences or injury (Huttenlocher, as cited in "Baby's brain begins now: Conception to Age 3," n.d.). If the excess cells did not di.e., the brain would be in constant motion, instead of having the capability to filter, and in some sense control perception (Davidson, 2011, p. 48). In a very real sense, what we pay attention to, is what we learn.

***Different* students, same education?** Along with changes in communication, interactions, and knowledge acquisition, the learning preferences (and brain-controlled perceptions) of our youth have naturally changed. A culture which texts versus phones, collaborates extensively online through social media, and *googles* to find information, also has different expectations in terms of processes, time frames, methods, and media of knowledge transmission (Prensky, 2001; Ito et al., 2013; Garcia et al., 2014). Highly interactive, youth want experiences that allow them to collaborate and learn from one another. They are both consumers and producers of digital information, much of which they share through social media.

As an example, the *Pew Research Center's Internet & American Life Project* recently published a report documenting some of the ways in which smart phone users perform *just in time* searches. Users do this for a variety of activities, ranging from coordinating meetings, *solving unexpected problems,* selecting a business (i.e., restaurant), looking up time-sensitive information such as sports scores or traffic reports, or settling an argument. "Some 70% of all cell phone owners and 86% of smartphone owners have used their phones in the previous 30 days" to perform at least one of these kinds of searches; the prevalence for using this method of problem solving is greater for younger people (Rainie & Fox, 2012).

Furthermore, the way in which digital natives communicate is rapid and interspersed. Youth communicate frequently using social media to document and share their lives through SnapChat, *selfies*, texting, Twitter and interactive polls. The way in which they seem to be interconnected is almost like an organism with distributed intelligence; questions or advice is often *crowd sourced.* This is very much aligned with the theory of knowledge as being constructed by individuals within a social context, i.e., cognition is situated and developed within communities of practice through participation (Greeno, Collins, & Resnick, n.d.; Brown et al., 1989; Brown, 1992; 1994; Lave & Wenger, 1991; Wenger, 2000;Ito et al., 2013).

If the nature of *knowing* is inherently different in the digital age, then it seems logical to conclude that instructional pedagogies must evolve to be effective in teaching and knowledge transmission.

> …The direct alteration of everyday life is evident across all main areas of society such as business, industry, politics and polity, the family news media, entertainment and leisure….many people see the primary concerns of education as resonating especially closely with those of digital technology – i.e., the production and dissemination of information and knowledge through communication and interaction with others. (Selwyn, 2011, p. 8)

Regularly, we use different technologies, engage with one another differently, work and conduct business differently. Although the one room school house, as Christensen remarks, forced educators to "teach in individually tailored ways," there was a paradigm shift to standardization as enrollments grew. This propagated the premise of "categorizing students by age into grade and then teaching batches of them with batches of material" (Christensen, Johnson, & Horn, 2010, p. 35). Yet how we learn in our educational institutions has changed little since the industrial era, which is unproductive in preparing workers for jobs that may not yet exist. Learning how to learn about content areas, versus learning discrete facts which may quickly become obsolete, may be more effective (Corrigan, 2013).

Digital Media in Learning Contexts

New hardware technologies have increased the potential to learn 24/7, in almost any environment, with Internet connectivity. Devices such as iPads are used in classrooms with students as early as first grade. Students use smartphones to share real-time feedback in a Socratic model, to one another, and to teachers, Instructors can then check for understanding, altering the course of instruction immediately when necessary, in order to increase learning. Portable devices allow for seamless connectivity and data collection, permitting a shift in learning environments, and thereby making lessons more authentic and relevant (U.S. Department of Education, n.d.).

Educational games and simulations are among the most exciting developments in educational technologies because they provide a complete environment in which the learner can exercise control and make choices in learning. Prensky (2001), in one of the earlier commentaries on the use of digital game-based learning, asserted that “the key characteristics of games are: rules, goals and objectives, outcomes and feedback, conflict (and/or competition, challenge, opposition), interaction and representation of story” (p. 5). These elements take advantage of the intrinsic benefits to using digital technologies as well as theories of learning and motivation. As such, they are conceived and designed in a manner completely different to a *technology integration* versus *technology as instructional tools* approach.

Cultures: interfacing, coalescing and participating. A myriad of new, global, and local virtual communities or affinity groups continue to be assembled. These include individuals with similar interests in every sphere: suicide pact groups; teenage parents; the massive number of participants in multiplayer, online, role-playing games; online learners; and members of professional groups. Characteristic of many of these groups is the sharing of information in order to connect, inform, transfer knowledge, or to gain social capital (Jenkins et al., 2009). Often, knowledge transmission involves experts sharing tacit or epistemic information with novices, either directly or through crowd sourced publications, such as Wikipedia or FAQs. The distinctive trait of these affinity groups, where individuals form groups along similar interests or passions, is participation. Hence, the description *of participatory cultures* (Jenkins et al., 2009).

Youth are very active in online participatory cultures. They engage in sharing and producing digital content (videos, writing, media), learning (sharing information regarding homework, music, gaming strategies), and organizing meetings or events. In fact, digital activism, made possible by social media outlets, has facilitated powerful change in the political sphere, for example, in the events of the *Arab Spring* (Frangonikolopoulos & Chapsos, 2012). This is important in the context of a digital badging discussion, as the value of the badge is conferred by its target audiences and proximal cultures. Often, participation in an affinity group requires complex language, thinking, and problem solving (Gee, 2003, 2010; Johnson, 2006). Importantly,

> "…the thinking, problem solving and collaboration skills required to engage in video game *modding* (modification) look more like important twenty-first-century skills than do the skills on offer in some of our skill-and-drill-test prep schools. So do the social, technical and organizational skills required to lead a guild in World of Warcraft. (Gee, 2010)

We increasingly live in an age of convergent media, where production, sharing, and participation are the norm and expectation, at least for our youth. There is "fluid group formation and cognitive, social and linguistic complexity, all embedded in popular culture" (Gee, 2010, p. 14). Various theorists have written about the role of language, learning, and cognition. The theory of learning which proposes that learning is embodied, knowledge and intelligence are contextual and distributed ("across various tools and technologies, as well as across groups of people"), is known as *situated cognition.* Its study tends to emphasize whole practices in collaboration with tools and technologies (Gee, 2010). Appropriately, it is the basis of work in learning theories, which informs the study of digital media and learning. The concept of situated cognition is consistent with Social Constructivists' theories of learning which postulate that meaning is constructed by individuals within a larger social context, based upon memory (Bandura & McClelland, 1977; Vygotsky, 1978).

In concept, the awarding of badges as a performance assessment is deeply grounded in current theories of how people learn, including situation cognition and motivation. The process occurs in an open, potentially socially mediated and authenticated assessment system. There is opportunity for guidance and recognition in this informal learning technique. As an example, the clear availability of performance benchmarks affords the opportunity for good self-regulated learning on the individual level (Hattie & Timperley, 2007). In addition, discussion and inquiry, the basis for a participatory culture and knowledge acquisition, allow digital badges to meet the standards of social constructivism. The idea of badging systems for assessment is aligned with the concept of participatory cultures. It is also powerfully aligned with theories of motivation in learning.

Learning and Assessment in a Connected Learning Environment

The premise that learning or meaning is constructed through and within social contexts was initially proposed by Vygotsky. He theorized that learning occurs when individuals internalize concepts mediated through spoken language. Vygotsky (1965) stated that individuals create meaning through the processes of social discourse by internalizing language as individual thought (Vygotskiĭ, 1967). Since then, the social constructivist learning theory has been modified and adapted by educational theorists, including Jerome Bruner, John Seely Brown and Etienne Wenger. Learning is seen as an individual, cognitively-based activity, which is socially-mediated. Meaning is made through a socio-cultural context and interactions with others (Bandura & McClelland, 1977; Vygotsky, 1978). In practice, practitioners and learning theorists have integrated the principles of social-constructivist learning theory through strategies which include class discussions, collaborative learning, or reciprocal teaching (Brown, Collins, & Duguid, 1989). The result is the acquisition of new learning, either directly or vicariously (Bandura & McClelland, 1977). Etienne Wenger called groups of learners collaborating and working together *Communities of Practice* and described "Learning [as] the engine of practice, and practice is the history of that learning" (Wenger, 2000, p. 96).

With the advent of ICT and digitally-mediated learning spaces, the social constructivist tenet, where learning is embedded in its socio-cultural contexts, takes on new meaning. ICT-mediated communications are neither bound by time nor location; a digitally-mediated *socio-cultural context* can now mean online communities, through which an entirely new community is created through affinity groupings (Gee, 2003; Wenger, White, & Smith, 2009). In response to socio-cultural changes, the Connected Learning Model (CLM) has been proposed by researcher Mimo Ito and others, in order to describe how learning occurs in these connected learning environments (Ito et al., 2013).

The CLM is based upon social constructivist tenets of learning, digital media, and participatory cultures. "…[C]onnected learning environments ideally embody values of equity, social belonging, and participation. Further, connected learning environments are generally characterized by a sense of shared purpose, a focus on production, and openly networked infrastructures" (Ito et al., 2013, p. 8). The CLM, developed as a conceptual framework for working with youth in connected learning environments, is an appropriate framework for viewing digital-age assessments.

Teaching, learning and digital age learners. Furthermore, youth who have grown up immersed in digital media, which promotes and facilitates the pursuit of individual interests, are not interested in *one standard fits all* educational paradigms, and they have become increasingly disengaged. Furthermore, teachers are pressured to provide individualized instruction by differentiating instructional goals and strategies, while simultaneously adhering to educational standards. Learning is subsequently measured by standardized tests, which measures learning in only one or two dimensions (Darling-Hammond, 2006) (Zhao, 2012)

Participatory cultures through which individuals collaborate, freely share information as well as tacit knowledge and experience have rapidly developed over the past decade. There is a growing understanding shared by policy makers and educators globally that the skills, competencies, and proficiencies learned in these informal contexts should also be assessed, recognized and communicated. Although it is too early for consensus on the nature of such assessments in a global context, discussions have been necessitated by emerging needs in the workplace and the trend of interest-driven, self-motivated learning propagated by the availability of free digital assets and ICT (UNESCO Institute for Information Technologies in Education, 2012).

Furthermore, from a fundamental perspective, what it means to *know* is rapidly changing from the ability to recall factual information to the capacity for problem solving requiring deep knowledge and understanding. Consequently, it is no longer necessary to memorize vast quantities of information; pertinent, declarative knowledge is retrieved in authentic contexts as needed (Rainie & Fox, 2012).

Learning anytime, anyplace. The idea of assessing, communicating, recognizing and using the outcomes of informal learning as a skills currency, has been gaining traction, particularly in Europe. There has formerly been an interest in the recognition of life-long learning and its values. Part of the process is to make "…the stock of human capital more visible and valuable to society at large" (Werquin & Organisation for Economic Co-operation and

Development, 2010, p. 7). There are various reasons for the trend toward making discrete competencies *visible* through articulation and explication:

- The need to retool several times during the course of a career, as technologies change the way we do business
- The demise of the traditional manufacturing base, and resultant displacement of workers
- Longer life expectancy
- The proliferation of free resources, including Open Education Resources
- The need to recognize and communicate learning in formal and informal settings

Role of educational leaders. Educating students for an uncertain future requires a flexible, adaptive approach, consistent with significant epistemological change. Change of the second order is required (Figure 2), necessitated by the paradigm shift resulting from myriad ramifications of ICT.

First-order Change *When a change is perceived as:*	Second-order Change *When a change is perceived as:*
An extension of the past	A break with the past
Within existing paradigms	Outside of existing paradigms
Consistent with prevailing values and norms	Conflicted with prevailing values and norms
Implemented with existing knowledge & skills	Requiring new knowledge & skills to implement

Figure 2. First versus second order change (Waters & Marzano, 2006, p. 18).

For these transformational processes to be assimilated into formal learning environments, new pedagogies must be developed and practiced, and these will require time to be developed. Effective leadership is crucial in K-12 contexts to create a culture of organizational learning and to guide and to set expectations for instruction. Nonetheless, 21st -century skills are now being attained independently, through interest-driven learning, in informal environments particularly for youth (Ito et al., 2013). Because there are currently no official mechanisms to measure, reward, or recognize these informally-acquired achievements, learners are disadvantaged. Their accomplishments are neither formally acknowledged nor effectively communicated to interested audiences, including educational institutions or potential employers. Innovators in industry and education are excited about the potential of digital badging systems to ameliorate this deficit.

Leadership and Technology Integration

In order for technology to be implemented effectively in schools requires planning, allocation of resources, training and ongoing support:

> …research on the use and integration of technology suggests that technology … can be a powerful tool for educators if it is made part of a comprehensive and systemic effort to change education. Technology is most likely to be widely adopted by teachers and schools if (1) it supports already existing practices and helps to solve problems or address challenges; (2) it is part of a systemic, organization-wide initiative; and (3) teachers have access to ample professional development and ongoing support.(Moeller & Reitzes, 2011)

The successful infusion of appropriate instructional technologies in K-12 contexts clearly requires coordination and leadership support. Until recently, however, K-12 leaders' behaviors and decisions, particularly creating and sharing a vision, setting instructional goals or expectations, and organizational culture, has largely been ignored as contributing factors in the degree of success in building or district technology implementation. As a result, it has not been studied significantly as influencing the diffusion and subsequent adoption of instructional technologies throughout a building.

Effective leadership is critical for any school initiative, “There seems little doubt that both district and school leadership provides a critical bridge between most educational reform initiatives and their consequences for students” (Leithwood, Seashore Louis, Anderson, Wahlstrom, & others, 2004). School leaders set the tone, expectations, and instructional goals, and furthermore, they allocate resources including equipment and materials, time for planning and collaboration and shape professional development. As McKenzie (McKenzi.e., 2003) observed, “Unfortunately, administrators are often more concerned with the frequency rather than the quality of technology use in the classroom” (as cited in Groff & Mouza, 2007, p. 6).

Leadership often requires the creation of a culture of expectation of meaningful technology use in addition to facilitating ongoing support. When there is poor leadership in creating and supporting the vision of technology use within a district, the needs of the students are adversely affected. According to researchers Fishman, Marx, Blumenfeld, Krajcik, and Soloway, (2004) this is the case particularly with cognitively oriented technologies which foster deep learning: “Many of these technologies may not align with the current curriculum, as those who make the technology purchases for the school may not be the same people who design the curriculum” (as cited in Groff and Mouza, p. 8).

The role of leadership in the adoption and integration of technology in schools is critical; according to Mardis, Hoffman and Marshall, “policies and rules are created by people to codify agreed upon values and reflect power structures and cultures,” (2008) For this reason, they propose that these issues are of such importance as to be considered a third digital divide (the first being access to actual hardware and software whereas the second boiling down to be the complexity and richness). Effective leadership is critical to overcome barriers to appropriate technology use in K-12 schools, particularly in economically challenged districts.

Motivation

"Motivation is a theoretical construct used to explain the initiation, direction, intensity, persistence and quality of a behavior, especially goal-directed behavior" (Brophy, 2010, p. 3). Theories of motivation are important in education because they provide a theoretical construct to explain motives, goals, and strategies for behavior. Motives may be described as basic human needs, rooted in pervasive and compelling needs in the physical, affective, and cognitive domains. Hunger, the need to belong, and curiosity, are respective examples of these needs (Deci & Ryan, 2000).

The study of motivation has several main branches of thought: Behavioral, Need and Goal theories. The focus of Behavioralists is upon control, that is, control of behavior by reinforcing desired behaviors when they occur (Gresham, Watson, & Skinner, 2001). To influence behaviors, adherents wish to target behaviors, bringing them under stimulus control until the desired level is attained. In K-12 environments, the behavioral view has proliferated, visible in attempts to modify behaviors through reward systems, grading, strategies to gain student compliance, and negative consequences for breaking rules or failing to comply with targeted manners (Mather & Goldstein, 2001).

One of the major concerns and advantages of using digital badges to recognize learning is the pivotal issue of motivation which is closely associated with engagement and academic achievement (Steinmayr & Spinath, 2009). Skeptics are concerned that badges are a purely extrinsic reward system, which will result in learners working hard to collect badges as rewards (equivalent to good grades or gold stars), rather than learning. Social commentators and technologists, including Mitch Resnick (2012) and Henry Jenkins (2012), consider badges to be a Behavioralist tactic. They are concerned that learning will be cast aside, and that the main goal of learners will be to acquire the badge. Resnick expressed his concerns:

> I worry that students will focus on accumulating badges rather than making connections with the ideas and material associated with the badges – the same way that students too often focus on grades in a class rather than the material in the class, or the points in an educational game rather than the ideas in the game. (2012)

Extrinsic motivation can be a major concern for educators. Misused, extrinsic motivators can act to demotivate learners and create false expectations of reward which may impair intrinsic motivation (Hattie & Timperley, 2007). Motivation is a factor associated with self-concept and academic achievement. It is an important factor for minority students including Arab Americans and African Americans in self-esteem and positive identity formation (Kovach & Hillman, 2002). Malone and Lepper (1987) have proposed a taxonomy of intrinsic motivations, which they suggest "make learning fun" (p. 223). The concepts, including curiosity, control, and challenge, are often incorporated into game-based learning, where they function powerfully to engage learners to the point of *flow*. Significant learning occurs when participants are motivated and engaged.

In his seminal work, *Flow: The Psychology of Optimal Experience*, Csíkszentmihályi (1990) expounds his theory that people are most productive and motivated when they are in a state of *flow*, which is a state of deep concentration. In this state, the participant is completely immersed and engaged in an activity. It is a state in which people are so involved in an activity that nothing else seems to matter. The flow state is an optimal state of intrinsic motivation.

Digital Badges for Learning in Formal and Informal Contexts

The effectiveness of digital badges. An unintentional consequence of widespread standardized testing is that effective assessments to measure and communicate some STEM competencies do not exist. This is particularly true for higher-order thinking skills such as critical thinking or abstract reasoning, essential for innovation and problem solving. An alternative assessment system, a digital badge ecosystem, has been proposed for articulating trajectories, as well as measuring and communicating learning in informal and formal environments (Riconscente et al., 2013; Knight, 2014). Increasingly, students are leveraging freely available digital assets such as Open Education Resources (OER) and tools, as well as Internet-enabled communications, to acquire new proficiencies through informal channels.

Digital Badges and Informal Learning

Core concepts of the new digital badge movement are the ideas of equity, transparency, and recognition of the many ways in which people learn outside of formal learning environments. In many ways, these concept mirror, and are inspired by, the entrepreneurial and open spirit of the Internet itself. In fact, digital badges have significant potential in regard to educational assessment because they embody these tenets ("Major players in the MOOC universe," 2013; Reconnect Learning, 2014). Badges have already been implemented with success in various communities of practice, including software development, and Peer to Peer University and Stack Overflow for content knowledge and skills, which currently do not have equivalent knowledge sets in formal environments (Peer to Peer University & Mozilla Foundation, n.d.).

Furthermore, badges are perceived as a possible way to capture, articulate, and share knowledge and skill sets. A variety of interested audiences may be served, including potential employers, college admissions officers, and peers, in a manner which is not possible with traditional transcripts. Much of this learning occurs in informal contexts and is currently unrecognized. In this manner, digital badges may be used to make acquired skills visible for a variety of target audiences and purposes, from credentialing to unlocking additional user privileges. As the Open Education movement gains speed, particularly with post-secondary content, there is a growing interest in ways to document and measure this learning.

Individuals are more interested now in capturing life-long learning for a variety of reasons:

1) The exponential growth of knowledge, as well as the persistent shrinking of industrial-based economies, has precipitated a tremendous shift in skills necessary for the workplace,
2) Due to increased longevity, individuals may need to retool credentials several times throughout their careers, and
3) The Internet has facilitated and propagated a culture of lifelong learners.

A report published by the *European Centre for the Development of Vocational Training* (2001), which reviewed various European initiatives to quantify and communicate the outcomes of informal learning, is representative of the growing, world-wide interest in the topic. In *Making Learning Visible: Identification, Assessment and Recognition of Non-Formal Learning in Europe*, the author discuss the importance of this issue (Bjornavald, 2001). It is necessary to make learning, which takes place outside formal education and training institutions, more visible. Non-formal learning is far more difficult to detect and appreciate. This invisibility is increasingly perceived as a problem, affecting competence development at all levels, from the individual to society as a whole (Bjornavald, 2001, p. 11). Furthermore, the author urges that "…competencies have to be made visible if they are to be fully integrated into a broader strategy for knowledge reproduction and renewal" (Bjornavald, 2001, p. 21).

The use of a system to assess and encourage learning of essential STEM proficiencies has potential for a variety of reasons. Despite their importance, many of these skills remain untaught, or they go unmeasured through systematic assessment in formal educational environments. Furthermore, the persistent lack of alignment between goals and outcomes of educational systems, as compared to requirements of the workplace, has contributed to the paucity of skills in some areas, and overabundance in others (American Society for Training and Development, 2012).

Making competencies visible: Boundary objects. In his joint report with the OECD, in regard to acknowledging and skills, Werquin asserted that "Recognition generates four different types of benefits" (Organisation for Economic Co-operation and Development, 2010, p. 8). Werquin further discussed various economic benefits of recognizing skills learning in informal environments: shortened time for acquisition of qualifications; more effective deployment of human capital; and increased coordination between employment and individual employee talents. Life-long learning increases educational and social benefits for the learner, fostering equity and improved access to education and employment, particularly for disadvantaged groups. Life-long learning provides a "…psychological boost to individuals by making them aware of their capabilities" (Werquin & Organisation for Economic Co-operation and Development, 2010, p. 9).

The United States is behind other nations in recognizing informal learning. Discussing initiatives implemented in the late 1990's, researcher Jens Bjornavold (2002), of the European Centre for the Development of Vocational Training writes:

> During the last few years, most Member States of the EU have emphasised the crucial role of learning that takes place outside of, and in addition to, formal education and training. This emphasis has led to an increasing number of political and practical initiatives, gradually shifting the issue from the stage of pure experimentation to early implementation. (p. 1)

To meet the demand for new knowledge, new learning and assessment paradigms must be developed in socio-cultural contexts. The use of digital badges for scaffolding, assessing, and communicating learning, within connected contexts, is one possible solution. As such, digital badges can function as *boundary objects*, i.e., objects which exist in different contexts and have context-specific properties, but share enough of a framework to be useful as a construct which traverses these limits or boundaries (Star & Griesemer,1989; Rughinis, 2013). Wenger (1998, 2000) describes badges as the almost ideal *boundary object*, a way of translating the practices and social capital of one community to other, dissimilar communities (as cited in Halavais, 2012, p. 367).

Digital badges for learning. Digital badge ecosystems have been proposed in coordination with the paradigm shift in educational policy, as well as recommendations for personal learning ecologies and environments. In addition, digital badges satisfy the need for new forms of assessment and credentialing (Finkelstein, Knight, & Manning, 2013; Olneck, 2014).

As a result of the paradigm shift in educational policy and recommendations to personal learning ecologies and environments, and the necessity for new kinds of assessment, digital badge ecosystems have been proposed. This concept is consistent with recommendations for assessment of informal learning to be o*pen, transferable and personal* (Kentucky Department of Education, 2013).

Badging systems have been in use since the Roman times to convey belonging and authority (Halavais, 2012). Badges have also been used to convey accomplishments, confer honor, designate affiliations, and to recognize achievement. Currently, there is a rapidly emerging interest in essentially “capturing” learning from non-formal and informal contexts, much of which is participatory and individualized. The approach is grounded in theories of learning, assessment, and motivation. This research will contribute to the emerging national discourse, as well as inform leadership in educational contexts.

The creation and use of digital badge ecosystems has the potential to symbolize and communicate accomplishment in a more detailed and comprehensive manner than grades or certificates. The badge consists of clear criteria, tasks, and potential assessments. A range of target audiences, including employers, peers, and educational institutions (Alliance for Excellent Education, 2013) would be interested in digital badges for credentialing and communication of skills.

Digital Badges. In the two years, there has been significant interest in the idea of using badges, specifically digital badges. While the concept of conferring badges as academic achievements is fairly recent, badges have been used as symbols of identify, affinity, authority, earned privilege, competency and accomplishment for centuries (Halavais, 2012). The Boy and Girl Scout organizations have been awarding merit badges in various performance-related skills since the early twentieth century (U.S. Scouting Service Project & Henning, 1994 ; Girl Scouts, 2014). Badges are also being successfully used in a variety of environments, such as video games, social networking sites, (Antin & Churchill, 2011) and professional environments, to communicate success and social participation, which in this case equates to social capital.

As a supplemental or alternative credentialing, badging systems have been proposed (Olneck, 2012) to measure, recognize, communicate, and reward skills and knowledge acquisition (Finkelstein et al., 2013). Currently, interest is growing in an open digital badge infrastructure, which may be used to assess and subsequently communicate learning in both formal and informal environments (Hickey et al., 2013; Alliance for Excellent Education, 2013). Notice is being taken at every level of education (especially in higher education), for recognition and articulation of competences, proficiencies, and skill sets acquired through informal environments. Although a portion of this learning is specific to certain communities of practice, such as the military, teacher educators, or ICT professionals, much of it is gained through self-motivated, interest-driven learning (Finkelstein et al., 2013). A portion of this learning is vocational, but a great deal of interest is being shown to recognize a wide variety of subjects learned outside of formal school or university environments, for example, course work taken through open education sites, including Khan Academy, Peer-to-Peer University, and MIT Open Courseware (Young, 2012; Peer to Peer University & Mozilla Foundation, n.d.).

Advocates of badging are hopeful: Arne Duncan, United States Secretary of Education, described the use of badges as a “game changing strategy.” “Badges can help engage students in learning, and broaden the avenues for learners of all ages to acquire and demonstrate—as well as document and display—their skills” (MacArthur Foundation, 2011). Firmly grounded in motivational and learning theories, as well as social/educational psychology, badges are successfully implemented as schemes to measure and reward achievement within learning contexts, including epistemic (learning) or serious games (Elkordy, 2012).

An Open Badge Infrastructure (OBI) has been developed by Mozilla, with the support of the MacArthur Foundation, to support and accelerate digital badge development. The framework facilitates the creation and articulation of knowledge criteria which may not be adequately or overtly taught or measured in formal learning environments, particularly skills learned in informal contexts. The OBI also has the ability to structure assessments and provide evidence of learning skills and knowledge acquired formally or informally and can be used for credentialing (Mozilla Foundation, n.d.; Alliance for Excellent Education, 2013; Olneck, 2014).

Badges would create a system of recognition, specifically as a possible tool for assessing, rewarding, and communicating learning. A badge ecosystem would also motivate and channel future learning through the communication of criteria for completion, or rubrics for learning paths while acquiring new badges. This idea has received significant interest and, with projects being conducted by the U.S. Department of Education, the Smithsonian, Microsoft, Intel, the MacArthur Foundation, the U.S. Departments of Agriculture, Veterans Affairs, Disney, The National Oceanic Society, and others (MacArthur Foundation, HASTAC, & Mozilla Foundation, 2012).

This high level of interest has been significantly influenced by both the changing nature of skills needed for the work place and the Open Education movement. Mozilla's premise is a central gathering place for badge ecosystems and schema. Using the open [software] architecture, badge authorizers are able to design *widgets* or plug-ins to interface with the Open Badge Architecture (OBI) (Figure 3). Badge authorizers and credentialing agencies are able to link directly to the OBI, to share performance criteria and issue digital badges using the metadata standard (Finkelstein et al., 2013). Mozilla has streamlined the processes to build and confer open digital badges with a product called BadgeKit, to be made available in 2014 (Mozilla Foundation, 2014).

After criteria have been met, individuals may collect awarded badges in a *digital backpack* for display purposes. In addition, digital badges may be displayed at users' websites, on a digital resume, or in a digital portfolio. A key or a password may be required for authentication to view the portfolio, especially for minors. In addition, digital badges may also be shared or displayed through a variety of personal sites, including social media, e.g., blogs, wikis, or social networking sites (Hickey, 2013), including Facebook, Twitter, or LinkedIn (Bixler & Layng, 2014).

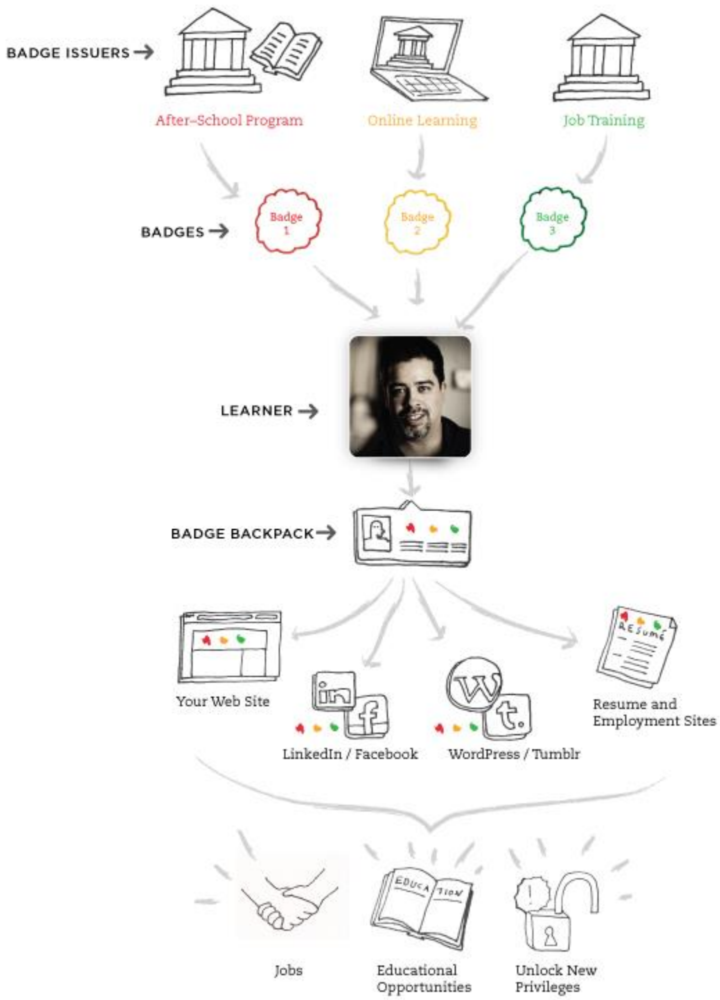

Figure 3. How the OBI works.

Mozilla (http://www.openbadges.org/en-US/about.html#how-it-works)

The organizations awarding digital badges provide both formal and informal learning opportunities and contexts, for example, after-school programs, or online classes available through various peer, for profit, or non-profit enterprises.

Badges have "Baggage." Badges do not come without "baggage," however. (Halavais, 2011). Currently, organizations use badges to reward earners based upon performance assessments and meetings of benchmark measures. Importantly, the criteria and skills are visible, and in some cases, the proficiencies are peer-assessed. In this manner, performance expectations and achievement are transparent and are communicated to all. Therefore, from the beginnings, badges have been crowd-sourced or socially constructed, gaining their symbolic value within organizations, groups, or communities of practice. When used as an assessment for a particular career, the conferring of a badge has been a rite of passage which is earned. As such, acquisition of the badge confers upon the holder certain privileges, honors, rewards, or recognition, as well as social capital, e.g., status or reputation (Halavais, 2012).

There is importance to the use of badges for assessment, with external meaning. The importance arises from the context in which each badge is awarded, the badge's suitability for the purpose of acknowledging informal learning, and the context in which the badge is awarded. The acquisition of badges is an activity which is inspired by self-motivated, interest-driven learning. The learning processes themselves are grounded in Social Constructivist tenets, and they are supported by motivation theories (Perrotta, Featherstone, Aston, & Houghton, 2013).

The Many Facets of Badges. Recent discussions about the digital badges have focused on six major *frames*: 1) as alternative assessment, 2) as a *gamifier* of education, 3) as a *scaffold* to learning, 4) as a tool to develop lifelong learning, 5) as a *driver* for digital media and learning skills, and 6) as a means to *democratize* education (Joseph et al., 2012). As an alternative assessment, badges:

> are viewed as a vehicle for providing evidence-based assessment and correcting the flaws in the formal K-12 learning environment….The new interest in badges, which began tipping within a number of learning communities in 2011, developed as a response to the failings of current assessment models. (Joseph, 2012)

"Introducing badges into an educational ecosystem is like developing a new website within a company or an organization." Barry explained how the seemingly simple process of creating a website often reveals unexamined sources of power and information. In addition, it forces communities to explicate realms of previously tacit information. Introducing badges forces learning organizations to do the same. "Simply drafting a Stage 1 proposal [for the MacArthur Digital Badges Competition] surely led those proposers to consider and reconsider how learning was being acknowledged and rewarded" (Hickey 2012).

Badges: Pro and Con

The idea of using badges in education is controversial, with advocates and detractors having strong opinions on either side. In order for badges to be effective in the long run, it will be important to address the salient points of detractors, and to build a transparent, flexible system. Ironically, the process of responding to badge criticism mirrors the process of how badges can possibly function as formative assessment. The badge ecology can be strengthened in the process, through responses to negative feedback (Elkordy, 2012).

According to Professor David Goldberg, cofounder of the HASTAC organization, and co-sponsor of *Digital Media and Learning Competition*,

> … the deeper point about badges is that where they work, they work always within contexts that socially support them and where their users are invested in their significance. They do not work for everyone, as motivations or modes of recognition. (2012)

However, digital media expert and cultural commentator, Henry Jenkins, recently wrote about several areas of concern for the use of badges. In particular, he expressed concern that youth learning informally may be "alienated" by the formalistic processes of badge acquisition,

> before they have a chance to exert ownership over the knowledge they are acquiring." Furthermore, he noted: "This problem only grows when we seek to move the system of badges from its original American context into a global phenomenon, since badges will mean very different things across a range of different cultural contexts. (Jenkins, 2012)

Badges and Motivations

Some commentators are concerned that badges are an extrinsically motivating behaviorist strategy to reward learning, which will lead to badge acquisition as the goal, versus the learning goals themselves. Dr. Goldberg's response below acknowledges that this may superficially and sporadically transpire, but that in the process of learning and badge acquisition, intrinsic motivations do occur:

> In the Kantian vein, then, we could conclude that badges without effective learning would be empty, even useless; while learning without a badging system that embeds an assessment capacity capable of motivating further learning—both more and deeper—would be missing an opportunity to draw into the lure of learning some, if not many, of those we otherwise are in peril of losing. And that's a good, perhaps even in itself. (Goldberg, 2012)

Although badges have "baggage" from prior use, this may be an advantage. There is recognition of new cultural phenomena arising from the digitally mediated communications. *New literacies* have arisen, based upon ICT and digital media (Gee, 2003). New knowledge sets are required, including digital literacy and visual literacy. In addition, global awareness, sensitivity, and adeptness at various digitally mediated communications are now necessary. The study of these new digital *literacies* is a field which encompasses the intersections of cultural anthropology (including digital ethnography) and technology, in conjunction with media skill sets and proficiencies. These *new literacies*, informed and situated by digital contexts, necessitate the study of digitally facilitated communications and interactions. They are rooted in socio-cultural contexts, with their own language of expression and inclusion (Gee, 2009). Groups of individuals, no matter from which culture they originate, form distinctive cultures in affinity groupings, characterized by norms of behavior and language (Vlieghe, Rutten, & Soetaert, 2011). This is analogous to acculturation processes, including learning a specialized (STEM) *language* (Lemke, 1990; 2001) for participation in communities of practice (Wenger, 2000) and contributes to identity formation. Hence, these concepts inform practitioners cultivating positive, culturally responsive STEM teaching and learning environments, both formal and informal.

Sociolinguist James Gee has studied and written about his observations in regard to video game affinity groups. Interpretations of events, language, and practices have a socio-cultural context, informed and interpreted within the constructed context. Cultural actors adhere to these often tacit boundaries or constraints, which are often communicated from novice to expert through participation in affinity groups. New information is shared through conversations, FAQs, message boards, or learning processes, such as making mistakes. Through this process, individuals become inducted into the micro-society of groups, particularly online, where the affinity group culture and norms take precedence (Gee, 2003).

We increasingly live in an age of convergent media, where production, sharing, and participation are the norm and expectation, at least for our youth. There is *fluid* group formation and cognitive, social and linguistic complexity, all embedded in popular culture (Gee, 2010, p. 14.) Various theorists have written about the role of language, learning and cognition. Within these socio-cultural contexts, when learning occurs, it is contextual. In terms of the theory of situated cognition, learning is embodied, and knowledge and intelligence are contextual and distributed "…across various tools and technologies, as well as across groups of people" (Gee, 2010). Situated cognition emphasizes practices of collaboration, using tools and technologies. Appropriately, work in learning theories informs the study of digital media and learning. The concept of situated cognition is consistent with Social Constructivist theories of learning, which postulate that meaning is constructed by individuals within a larger social context, and that meaning is interpreted using memory and existing schema (Vygotsky, Bandura) (Vygotskiĭ, 1967).

Summary

Conceptually, the idea of awarding badges as a performance assessment in an open, potentially socially mediated and authenticated system to assess, guide and recognize informal learning is deeply grounded in current theories of how people learn, including situation cognition and motivation. For example, the fact that the performance benchmarks are readily available makes for good self-regulated learning on the individual level, while facilitating discussion and inquiry which are the basis of participatory culture and at the heart of knowledge making in a social constructivist manner. The idea of badging systems for assessment is aligned with the concept of participatory cultures. It is also powerfully aligned with theories of motivation in learning.

The goal of the proposed research is to study the use of digital badges as an intervention to scaffold, assess and communicate learning in key STEM with middle school populations. Digital badges leverage many of the strengths of digital media, participatory cultures, ICT, as well as foster mastery learning and the formation of positive STEM identities.

Chapter 3: Methodology

The purpose of this research was to explore the impact of a digital badge intervention for STEM learning, conducted in a formal classroom context using a secondary-age population. Student characteristics and traits were measured, including motivation, persistence-at-task, and self-efficacy, as well as learning behaviors and attitudes towards STEM. Teacher attributes and opinions, were also measured, as well as select factors in the learning environment, including leadership support. Statistically significant relationships between variables could inform instructional practice, as well as promote increased academic achievement in STEM subjects.

A mixed methods research design was developed and implemented. According to Johnson and Onwuegbuzie (2004):

> Mixed methods research is formally defined here as the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study…Its logic of inquiry includes the use of induction (or discovery of patterns), deduction (testing of theories and hypotheses), and abduction (uncovering and relying on the best of a set of explanations for understanding one's results). (p. 17)

To fully answer the research questions to the greatest extent, mixed methods were necessary to provide self-reported information about participants, which could not be directly observed, as well as information about the methods of implementation and instructional contexts. Quantitative data were collected through a pre- and post-testing model whereby youth participants and educators responded to surveys before and after the digital badge intervention program. After the post surveys were administered, participating teachers were interviewed in a semi-structured manner to obtain contextual data about program implementation processes.

The digital badge intervention created for the study was designed to promote mastery learning in specific math and STEM concepts. Badge criteria, essentially learning targets, required participants to apply higher-order thinking skills, important to creative problem solving, including critical thinking, analysis, evaluation, and synthesis. These types of competencies and capacities, although critical in STEM fields, are not adequately measured through standardized testing (Darling-Hammond, 2006).

A mixed methods research design was selected because combinations of methodologies were necessary in order to fully understand the research questions, as well as to grasp the goals of the study. In addition, "…a major advantage of mixed methods research is that it enables the researcher to simultaneously ask confirmatory and exploratory questions and therefore verify and generate theory in the same study" (Teddlie & Tashakkori, 2009, p. 33). Primary data analysis focused on survey data and their quantitative analyses, in order to provide information on internal characteristics, attitudes, and opinions of the participants. Qualitative data was also important to gain an understanding of the learning context, as well as the instructional and assessment processes used with the digital badges. Furthermore, qualitative data were necessary to understand the digital badge intervention as a phenomenon, specifically to generate theory regarding its possible use for motivation during learning and instruction. The study objectives were to explore the impact of an educational intervention consisting of standards-aligned digital badges, and specifically to evaluate the following:

- how the use of digital badges may affect motivation in learning STEM content, as self-reported by participants,
- how select factors of the Connected Learning Model may affect implementation of a digital badge learning intervention,

- students' perceptions about learning using digital badges,
- teachers' perceptions about instruction, assessment, and learning with digital badges, and
- students' learning processes and behaviors, using digital badges in the target population.

Furthermore, the study explored educators' practices, attitudes, and behaviors during program implementation, in order to inform in similar contexts.

Conceptual Framework

The Connected Learning Model is proposed as the conceptual framework (Ito et al., 2013). When applied to formal or classroom learning, connected learning implementations depict "…core values at the foundation of engagement: equity, social connection and participation" (Garcia et al., 2014, p. 9). Select CLM factors were operationalized for quantitative analysis, and they were coded for qualitative, thematic analysis. Principles, including *interest-powered, production-centered,* and *academically oriented*, were integrated into the digital badge learning trajectories ("Connected Learning Principles," n.d.). The treatment of CLM concepts, articulated below, is described in the *Operational Definitions* section:

- *Learning principles*: interest-powered, peer-supported, academic orientation.
- *Design principles*: production-centered, openly networked, and shared purpose
- *Core values*: equity, social connection, and full participation (Ito et al., 2013).

Research Hypotheses

The null hypotheses for the study and statistical analyses were:

1) The use of a digital badge intervention will not have a statistically significant effect on participants' attitudes, traits, or opinions regarding STEM content, and

2) CLM factors in the learning context will not have a statistically significant effect on the processes or outcomes of learning in the implementation of a digital badge intervention.

Research Questions

The research questions framing this study were (Figure 4):

Q.1. How does the use of a digital badge intervention for STEM learning impact student:

2) Motivation:
   a. task value,
   b. learning goal orientation,
   c. self-efficacy,
   d. learning behaviors and strategies, including self-regulation, and persistence-at-task.

Q.2. Which factors of the learning environment affect digital badge acquisition?

Q. 3 Which student- level factors affect engagement in learning processes, using a digital badge intervention?

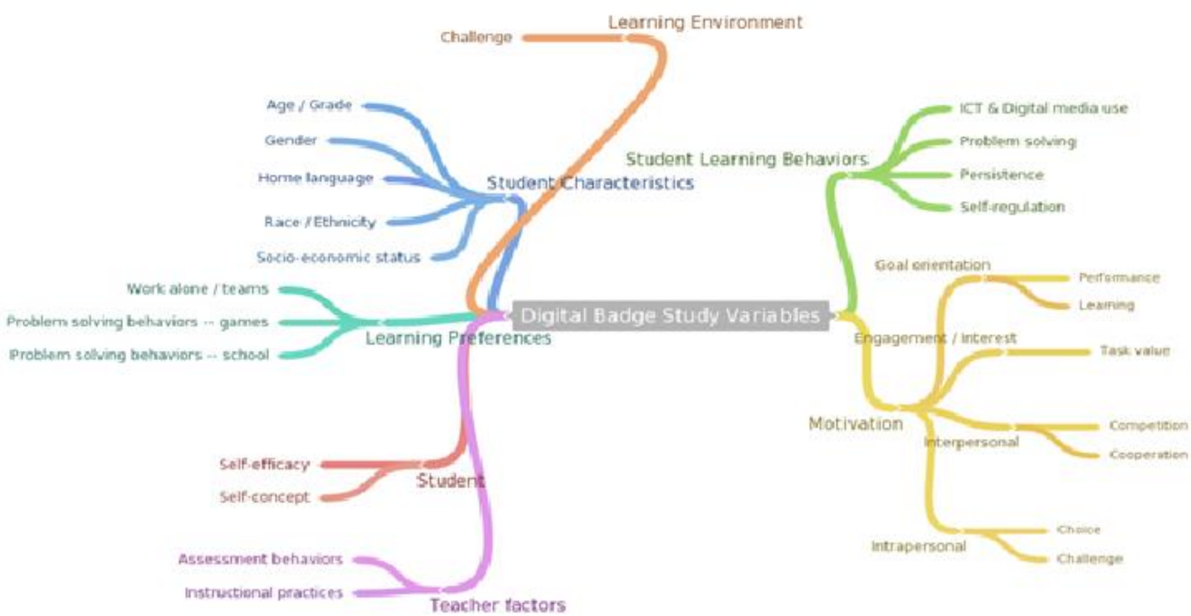

Figure 4. Digital badge study variables.

Operational Definitions

Constructs are abstract, and therefore they are not directly measurable. The variables, essentially concepts, or theoretical constructs, were operationalized. Concrete measures are developed for use in survey instruments (Andres, 2012; Babbie, 2010). The process of operationalizing variables contributes to construct validity That is, the "…degree to which a measure related to other variables as expected within a system of theoretical relationships" (Babbie, 2010, p. 154).

Dependent variable: *Motivation.* Motivation for learning is a complex construct. It has been discussed in the literature through various frameworks, and without consensus, except perhaps for the proposition that motivation concerns the direction and magnitude of behavior. According to Dörnyei, motivation means:

> the choice of a particular action, the persistence with it[and] the effort expended on it. In other words, motivation is responsible for: why people decide to do something, how long they are willing to sustain the activity; how hard they are going to pursue it. (2001, p. 9)

In order to measure the construct of motivation to learn STEM skills, competencies, and knowledge, several sub-scales from the *Students' Adaptive Learning Engagement in Science Learning (SALES)* (Velayutham, Aldridge, & Fraser, 2011) scale were modified. The following SALES subscales, consisting of 4-8 items, were used in the pre- and post-test:

- self-efficacy,
- (learning) goal orientation,
- task value,
- self-regulation, and
- learning behaviors.

In the study, the *motivation* construct corresponds to the CLM factor of *interest* in learning.

Variable tables. Variable tables were created to ensure consistency in research and survey design, as well as data analysis and interpretation (see Appendix B for Variable Tables, Student Pre-Survey and Appendix C for Variable Tables, Student Post-Survey). The tables describe independent and dependent variables as concepts, In addition, the survey questions correspond to each concept. The tables were expanded into code tables, by adding variable names, types, and values, in order to facilitate data identification. In addition, for consistency and clarity, "…a full description of each facet, from conceptualization through to data analysis, holds the researcher accountable in ensuring that the study results are an accurate reflection of the participants' behaviors, attitudes and opinions" (Andres, 2012, p.116).

Research Design

There are a wide variety of mixed methods designs. They are often categorized according to the purpose of the research, the methodological emphasis, or the sequence of methodological integration. An evolving field, mixed methods does not yet have an established nomenclature (Teddlie & Tashakkori, 2009). The study was a concurrent or parallel (Teddlie & Tashakkori, 2009), or concurrent triangulation (Plano Clark & Creswell, 2007) mixed methods design. It was comprised of quantitative analysis of survey data and thematic analysis of qualitative data, collected from a variety of sources. Qualitative data were collected from a post-program, semi-structured interview, personal communications, open-text survey questions, and artifact analysis of student work. This design is used to confirm and corroborate findings, with the data being integrated during the interpretation phase (Plano Clark & Creswell, 2007).

A mixed methods research design (Figure 5), which combines survey data with qualitative methods, is consistent with strategies advocated by researchers working with mixed methods research (Plano Clark & Creswell, 2007; Creswell, 2008; Teddlie & Tashakkori, 2009 ; Creswell & Plano Clark, 2010; Plowright, 2011; Andres, 2012).

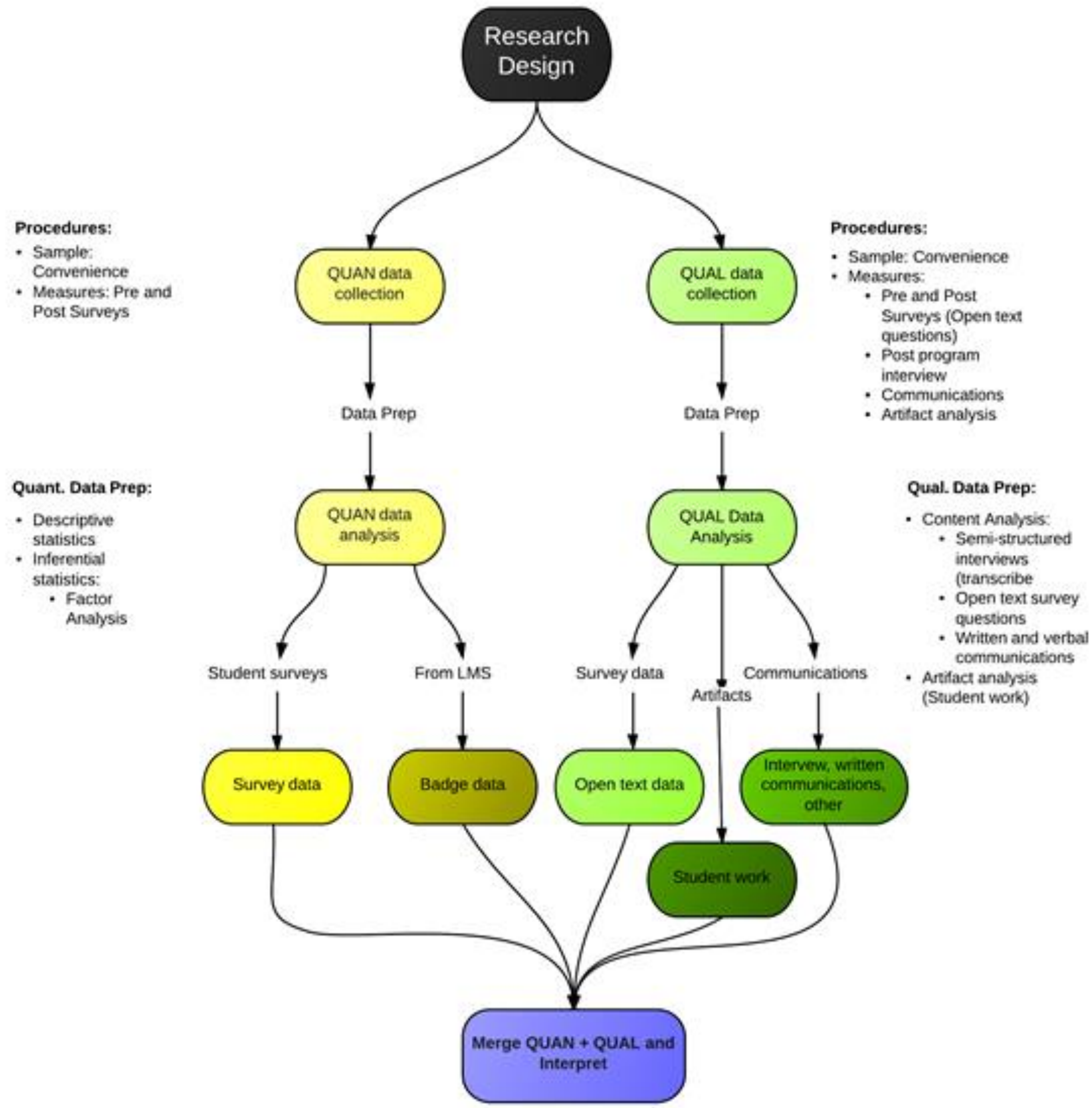

Figure 5. Research design diagram. (Plano Clark & Creswell, 2007).

Theoretical Basis for Mixed Methods Design

The use of mixed methods is based upon the paradigm of *pragmatism* (Johnson & Onwuegbuzi.e., 2004; Creswell, 2008; Teddlie & Tashakkori, 2009), which advocates for the use of the most appropriate research methods necessary, in order to solve the research question and the tasks at hand. Johnson and Onwuegbuzie (2008), describe pragmatism as a philosophical lens which “rejects binary (either-or) choices suggested in traditional dualisms…facts vs. values, subjectivism vs. objectivism” and “replaces the …epistemic distinction between subject and external object with the naturalistic and process-oriented organism-environment transaction” (Teddlie & Tashakkori, 2009, p. 74).

According to Creswell (2008), in a world view based in pragmatism, “Truth is what works at that time…thus, in mixed methods research, investigators use both quantitative and qualitative data because they work to provide the best understanding of a research problem,” (p. 11).

Furthermore, “…pragmatists agree that research always occurs in social, historical, political, and other contexts“ (Creswell, 2008, p. 11), a paradigm consistent with the epistemological and ontological view of learning and motivation, as occurring within socio-cultural frameworks. Mixing of methods is both purposeful and reasonable, appropriate for a research problem which takes place in a naturalistic setting, such as a classroom.

Quantitative methodologies, which entail deductive reasoning, were chosen to test null hypotheses. Using statistical analysis, null hypotheses were accepted or rejected, based upon knowledge from existing frameworks and conceptual underpinnings. The qualitative methods were designed to provide context, additional information about implementation processes, and teacher observations, in addition to analytical triangulation. Mixed methods were necessary because neither qualitative nor quantitative "…methods alone would be sufficient to answer the research questions" (Teddlie & Tashakkori, 2009, p. 29).

The use of mixed methods is inherently a methodological triangulation (Teddlie & Tashakkori, 2009). Triangulation may also occur "at the levels of theory and analysis" (Andres, 2012, p. 182). Data may be triangulated to corroborate or explain results from the primary method: in this case, the findings of the quantitative analysis. In this study, mixed methods were used to provide data for analytical triangulation, "…implemented to answer related aspects of the same basic research question" (Teddlie & Tashakkori, 2009, p. 26). The use of a standards-aligned, digital badge intervention for STEM learning is a new practice, which does not yet have an established research base. Qualitative measures were used to reveal emergent themes, concepts, and procedures, in order to build a theoretical framework for future practice.

"Also, analytical triangulation can be carried out to examine the data from multiple perspectives...The 'oomph' factor of a study, as suggested by Ziliak and McCloskey (2008), can be extended considerably through analytical triangulation" (as cited in Andres, 2012, p. 182). "Oomph" is the potential size of an effect, with a great deal of signal to noise variance, whereas precision alone has a clearer signal (Ziliak & McCloskey, 2008). Triangulation is particularly important in this study because of the use of scales applied to pre- and post- measures of traits, which will affect validity as Babbie, (2008) notes,

> As you may have already imagined, the subject might respond differently to the questionnaires the second time even if their attitudes remain unchanged... This is an example of a more general problem that plagues many forms of social research: The very act of studying something may change it. (p. 231)

After the first survey, the student participants gained awareness of the purpose and processes of the research, which may have affected their responses.

Validity and reliability of quantitative methods.

Survey research

Surveys provide a flexible tool for the effective comparison of large numbers of participant responses. Surveys are often used in real world settings, and the findings are more easily generalizable than experimental approaches (Muijs, 2010). Some variables in this study are constructs assessed by psychometric measures, internal qualities that are self-reported. However, as Andres (2012) observed:

> … measuring behavior with a questionnaire is actually a measurement of what people say they do. … a questionnaire can only indicate what people remember and what they are willing to tell you about their behavior. Selective memory, selective perception and a willingness to be candid all play a role in the validity and reliability. (p. 87)

Muijs (2011) also notes the problem of gathering self-reported data on behaviors, but he states that survey research is *particularly suited* to gather data on opinions, perceptions, and feelings (p. 38).

Almost all assessment of motivation uses a kind of self-reported measure from which inferences are made (Dörnyei, 2001). There are concerns about the validity of self-reported data. People may have reasons not to tell the truth in responding. For example, if respondents can make an educated guess as to the reason behind a question, they may answer according to their understanding of what is socially desirable (Babbie, 2002).

To enhance reliability and validity, survey questions designed to measure the constructs in the target populations were used. They were adapted from instruments with established reliability and validity. In particular, it was important to enhance content and construct validity, ”… the relationship of one or more measures to a construct.” It was important to enhance external reliability and validity (the ability to be generalized beyond the sample population), and ecological validity (“only realistically attainable when it is delimited to certain contexts, cultures, portions of the population”) (Andres, 2012, P. 119). Select subscales were selected from the *Students' Adaptive Learning Engagement in Science (SALES)* instrument for the youth participants, pre- and post-surveys (Velayutham et al., 2011). Caution was exercised in selecting entire subscales to mitigate the negative effects inherent in the partial use of instruments with established internal validity. The SALES instrument has been used in similar populations. It has established construct validity and validity. It measures concepts including aspects of motivation (learning task orientation,) task value (interest), and persistence at task.

Youth participant pretreatment surveys were comprised of select SALES subscales and newly constructed questions. Survey items were designed to measure student characteristics, attitudes, and behaviors: Internet and digital media use; learning style preferences; attitudes and interest toward STEM learning; learning and problem solving strategies (in general and in online games); motivation; affect; and self-efficacy. Student participant post-treatment surveys collected data regarding the learning processes and experiences during the digital badge intervention itself. This included perceptions of learning and student interactions. This also included the data on CLM factors, including participation, problem solving strategies, and interest learning. In addition, SALES and SMTSL sub scales were used, modified slightly, to assess post-program levels of motivation, self-efficacy, and persistence at task values. (See Appendix D and E for student participant survey instruments.)

Educators in the study responded to survey questions about digital badges. Questions were designed to elicit information about attitudes, dispositions, behaviors, and other contextual factors which could impact program implementation. The survey used *Likert* style intensity measures, ranking, multiple choice, and open survey questions. For a detailed description of the survey instruments, see Instrumentation. Due to the small sample size, teacher pre- and post-quantitative data was reported as qualitative data. (See Appendix F and G for Teacher Survey instrument and reports.)

Validity and reliability of qualitative methods.

Semi-structured interviews.

Qualitative research methods are appropriate for emergent ideas and for creating theoretical frameworks through inductive processes. For this study, qualitative data were collected from a variety of sources: “open” questions on youth and educator participant surveys; a Post-Program, semi structured interview/ focus group with educator participants; and analysis of student work for one class.

Artifact analysis.

According to May (2001):

> [Documents] do not simply reflect but also construct social reality and versions of events. The search for documents’ meanings continues…It is not then assumed that documents are neutral artefacts which independently report social reality…Documents are now viewed as media through which social power is expressed. They are approached in terms of the cultural context in which they are written. (as cited in Basit, 2010, p. 139)

The opportunity to view student work arose during a communication with Teacher B in the course of another conversation. Although document analysis was not in the original research design, the 7th grade projects using the *InfoMaker* digital badge series were analyzed. According to Hopkins (2008), “When used in classroom research, documents can provide a context for understanding the curriculum or teaching methods” (Basit, 2010, p. 145). The student work was analyzed with the intent to illuminate issues surrounding the digital badge intervention, and to provide context and background information (as cited in Basit, 2010). The data was used to triangulate information from other sources, to deconstruct instruction and assessment practices, and to analyze student response to the *InfoMaker* digital badge series. A concern regarding the use of documents for data is “authenticity and credibility,” and to verify that they are aligned with the purpose of the research (Basit, 2010, p. 155).

Research Methodology

Sampling and Recruitment

The use of digital badges in K-12 formal learning, essentially a technology-mediated intervention, is an emergent practice. It does not yet have a supportive research base or proven efficacy. Individual educators who were technology *early adopters*, (Cuban, Kirkpatrick, & Peck, 2001) were targeted for recruitment. Individuals working in innovative or forward thinking organizations were invited to participate in the study. They were mindful of the “…social context in which the innovation [would] be used and the social function the innovation [would] serve” (Surry & Farquhar, 1997). The recruitment processes targeted individuals with positional power and social capital to influence others. Leaders and influencers are often catalysts for change, or they provide crucial resources to support innovation adoption and diffusion. The decisions and behaviors of school leadership are particularly critical in technology adoption and innovation diffusion throughout schools (Anderson, 2005). Therefore, institutional leaders and decision makers, for example, assistant superintendents, principals, superintendents, and influential teacher leaders were extended invitations to learn more about the study.

Using a variety of approaches, teachers and educational administrators were recruited extensively over the course of 10-12 months. Personal contacts were invited through email communications, phone calls, and meetings. It was often necessary to follow up extensively, at regular intervals, with teachers and school leaders who had expressed interest in participating in the study. Some follow-up required over six months. A discussion of reasons why some school districts declined to participate is located in Chapter 5.

Recruitment targeted public (urban, rural, and suburban), private, and charter school districts, a multisite after-school program, and individual teachers. Several districts indicated interest in learning more about the digital badges concept, and they specifically inquired about details concerning the research study. Secondary teachers from any content area were invited to participate in the study. Math and science teachers, and technology and media specialists, were recruited in particular. Social media (Facebook) were used to contact and invite participation at the state level (Michigan Science Teachers Association). Nationally, participants were contacted through the Badgebox.net web site and other sites through blog posts.

Collaborations with contacts via LinkedIn (social media platform), supportive faculty in the Eastern Michigan University, Teacher Education Department, the Makewav.es Team, the Ann Arbor District public library system, and the Catmose school library (Leicester, England) resulted in individuals who responded positively to a mini survey about possible study participation. At the request of several school leaders, the mini survey was also administered in several schools. Participants were actively recruited through an article in the MACUL (Michigan Association for Computer Users in Learning) journal, a statewide educational technology journal

(Fontichiaro & Elkordy, 2013b). Invitations to participate were extended during several presentations at regional and national conferences. Depending upon the organizational context, teachers were approached directly, or through influential intermediaries, including project or school leaders.

Ultimately, over 36 meetings were conducted with school leaders, groups, or individual teachers. Some interested parties began working towards participation through staff training, reviewing digital badge curricula, and exploring the project web sites.

Despite significant interest in the project, teacher participants who successfully completed the study were a team of two teachers at Site D. While various reasons were cited for participants to decline engagement with the study, it is important to note that the research study design or digital badges were not detractors. (In fact, few participants had reviewed the badge criteria or study implementation guide in depth prior to opting out). Chapter 5 includes a discussion of the processes and outcomes of the recruitment process.

Initial contact at Site D, a building in a preK-12 charter school system in the Midwest, was made in June 2013 via an email invitation to the district Superintendent, a personal contact. An optional, professional development workshop introducing the digital badges concept was presented in early August 2013, before the start of school. Following the signing of a mandatory confidentiality agreement, a mini survey was developed to determine potential interest. It was administered in two of the system's buildings during October, 2013. Several teachers indicated interest in learning more about the project, or they indicated that they would like to participate. In November, the school leaders of the two buildings were asked to follow up for a final determination of participants.

The principal at Site D, a building of approximately 630 students, personally followed up with teachers. Two secondary teachers from the building participated. The principal at Site E, a larger building, with over 1,000 students, delegated the task to an administrative aide. Although several teachers had previously indicated interest at Site E, no teachers actually participated. At this point, none of the teachers at either site had reviewed the digital badge intervention or research materials. Ultimately, study participants volunteered or opted in. Therefore, the sample is considered a *convenience* sample (Teddlie & Tashakkori, 2009).

Consent and assent. In consideration of ethical issues (Creswell, 2008) and in accordance with Eastern Michigan University's *Institutional Review Board* (IRB) requirements of *informed consent*, three documents were created according to IRB guidelines. To participate in the research, school leaders, teachers, parents, and youth were required to read, accept, and sign separate consent forms. In addition, the parental consent form was translated into Arabic for a number of non-English speaking parents who spoke and read Arabic only. (See Appendices M, N, P, Q, R.)

Research participants and context of research site. The units of analysis for the study are: 1) individuals (students and teachers), and 2) groups of individuals interacting in learning contexts (e.g., classes or groups of students). The digital badge intervention programs were implemented over a course of 3-6 weeks during the 2013-2014 school year at Site E, a Title I building, in a charter school system in the Midwest. According to Fall 2013 data, the school has a free and reduced school lunch rate of 87% (Center for Educational Performance and Information, n.d.). The total number of student participants was 72, with 20 students in 7th grade, 32 in 10th grade, 2 in 11th grade, and 18 in 12th grade. Although five teachers took the educator pretest, ultimately two teachers successfully completed the entire digital badge study.

Procedures

Study preparation.

The digital badge intervention and supporting program materials were created in the study preparation phase. Participants were recruited, and four surveys were developed and pilot tested. A web site was created with appropriate content to recruit, inform, and communicate with potential participants (Figure 6). The digital badge program was conceived to be minimally dependent upon the subject matter of instruction, instead of focusing upon specific STEM competencies and CLM factors in the learning context.

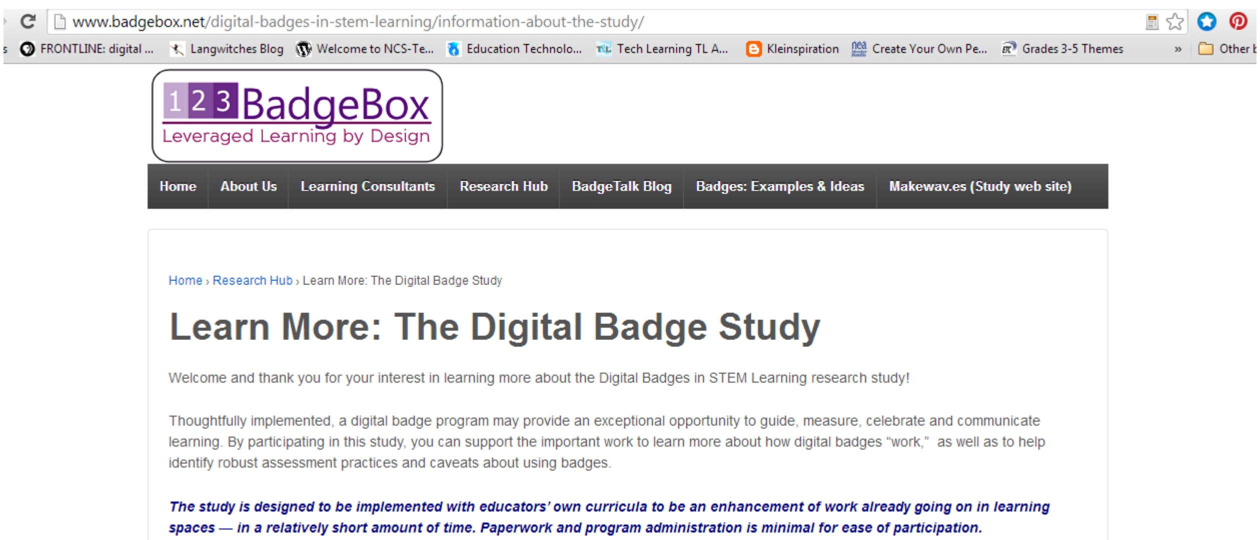

Figure 6. Badgebox Website

Digital badge intervention. Three digital badge series were designed to scaffold learning, provide criteria for measurement, and to establish guidelines for assessment and learning in select STEM concepts and practices. Digital badge learning targets were aligned with standards articulated by the National Academy of Sciences in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (National Research Council, 2012). The core ideas are organized into three dimensions which are recommended for integration into K-12 STEM curricula and instruction (Next Generation Science Standards Lead States, 2013b). The specific digital badge learning targets, performance tasks, and assessment criteria were developed. Collaboration occurred with professional educators teaching STEM subjects who worked with secondary age students.

The National Research Council (NRC)'s Framework is divided into three dimensions: Practices, Crosscutting Concepts, and Disciplinary Core Ideas. *Scientific and Engineering Practices* (Dimension 1) requires significant proficiency in higher-order thinking skills: analysis, evaluation, synthesis,and the application of tacit concepts and ideas. "The NRC uses the term practices instead of a term like 'skills' to emphasize that engaging in scientific investigation requires not only skills but also knowledge that is specific to each practice" (Council, 2013). The practices require opportunities to apply knowledge and to ultimately gain the kind of tacit professional knowledge acquired practicing in the field. Mastery of the practices is consistent with the idea of "epistemic frames," which "are described as the ways of knowing, of deciding what is worth knowing, and of adding to the collective body of knowledge and understanding of a community of practice" (Shaffer, 2006, p. 223). This is also consistent with the view of the learning as *situated cognition*, occurring in communities of practice (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; Wenger, 2000). It also supports the view of "Science as a Process of Participation in the Culture of Scientific Practices" (Duschl et al., 2007, p. 29).

Eight Science and Engineering Practices are described and defined in the *Next Generation Science Standards* framework. Due to their inherent complexity, mastery of these practices is difficult to assess in traditional, formal learning contexts. Formal learning contexts rely heavily upon standardized testing measures (Gilmer et al., 2011). The Practices provide suitable competencies and learning objectives for the pilot digital badge intervention. The badge criteria can include performance tasks which require mastery of concepts, as demonstrated through diverse products of learning.

Three digital badge series were developed for the study. They are aligned with the following:

- select *Next Generation Science Standards* Dimension 1 Practices,
- Common Core State Standards (CCSS) in Math

(Common Core State Standards Initiative, 2014b),

- English Language Arts

(Common Core State Standards Initiative, 2014a),

- National Educational Technology Standards for Students (NETS-S)

(International Society for Technology in Education (ISTE), 2007),

- Partnership for 21st Century Learning (P21)

(Partnership for 21st Century Skills, 2009) standards.

Intentionally, some competencies do not align with standards because existing frameworks are not applicable. In particular, these include competency in higher-order thinking skills, or digital media consumption and creation. The design of the badge curriculum framework incorporates the idea of spiraled curriculum (Bruner, 1976). It also includes Gagne's theory of varieties of learning, and articulation of learning outcomes, as instructional objectives and practices (Aronson & Briggs, 1983). Furthermore, the digital badge design incorporates theory-based practices of mastery learning. The design also incorporates feedback to assess the student learning process and to gauge effectiveness of instruction (Guskey, 1996). The badge learning targets and criteria were designed by working backwards from learning targets (Wiggins & McTighe, 2005). The learning targets represented steps along a learning path or trajectory, consistent with the premise of *instructional design* for effective learning (Reigeluth, 1983; Smith & Ragan, 1999; Dick, Carey, & Carey, 2005; Wiggins & McTighe, 2005).

Two digital badge series, *Data Whiz* and *Data Hacker***,** were developed to align with the fourth NGSS practice of *Analyzing and Interpreting Data*. The third badge series, *InfoMaker*, was based upon the second practice of *Obtaining, Evaluating, and Communicating Information* (NGSS Lead States, 2013a). The badge series were organized into four or five levels of increasing difficulty, according to Bloom's Revised Taxonomy of Cognitive Objectives (Krathwohl, 2002).

As they progressed through the levels, badge earners were expected to demonstrate proficiency in content knowledge and the application of concepts. They ultimately became producers of learning artefacts. Participating educators were instructed to review the criteria of the badge sequences, then to select badge system(s) which naturally aligned with their existing curricula. Youth participants were not required to earn all of the digital badges in a series during the program period. The objectives required badges to be earned sequentially within series. Each badge required a demonstration or evidence in the form of a product. The demonstration or product confirmed learning of the target objective because "the learned capability itself is not in itself observable," (Aronson & Briggs, 1983, p. 81).

The badge learning trajectories were presented as either curriculum documentation for school administrators and teachers, or as *stories* in the Makewaves learning management system and digital badging platform. The *stories* or blog posts, were written in language accessible to target youth participants. The curriculum documentation included the following:

- badge overview,
- learning targets,

- badge skills,
- performance objectives,
- evidence of achievement (examples),
- alignment with (Revised) Bloom's Taxonomy,
- standards and frameworks alignments,
- rubrics,
- learning resources (See Appendices H, I, J, K).

The story versions of the digital badge details included an overview of what the learner must do to earn the badge, an estimate of the time necessary to complete the badge requirements, and a description of the skills to be developed through the process.

The digital badges were created from using stock images, purchased for the purpose, and a freeware vector editing program, Inkscape. Badge images were uploaded to the Makewaves platform, where the badge descriptions were added to create the awardable badges.

Instructional resources and supports. Due to the innovative nature of the digital badge intervention, it was also necessary to develop program materials to explain instructional processes, procedures, and goals. These included documentation, teacher resources, and supports. Training, documentation, and curated resources, in the form of dynamically generated lists or visual aids were created. They were shared in person, through the project web site, (http://www.badgebox.net/digital-badges-in-stem-learning/information-about-the-study/), or through the learning management system (LMS) used for the study at the project site (www.Makewav.es/badgebox). These resources included:

- training modules (PowerPoint presentations), delivered in person and hosted on web site,
- an implementation guide, emailed to participants (se Appendix L),

- curated collections of suggested lessons, activities, and resources on Pinterest boards and Pearltrees (embedded into web pages),
- documentation regarding frequently asked questions, tips, and techniques (on the LMS project site),
- additional information about the digital badging program. and examples of digital badges in use (on the Badgebox site), and
- Makewaves manual (on the learning management system project site).

Learning management system. The Makewaves (www.makewav.es) social learning system was selected as the digital badging platform, one of the original, funded winners of the fourth Digital Media and Learning competition, 10/2011 – 3/ 2012 (MacArthur Foundation et al., 2012). The Makewaves team had developed a secure learning system (LMS) and digital badging platform suitable for minor participants. In addition, the team has also had an interest in supporting digital badge research in the target populations. It has worked with secondary age students (Manning, 2013). The Makewaves product was developed in the United Kingdom. It complies with critical Internet safety and privacy protections required by U.S. federal regulations, including the Family Educational Rights and Privacy Act, FERPA, Title 34 CFR Part 99, (Office of the Secretary, Department of Education, n.d.-b) and the Children's Online Privacy Protection Act of 1998,COPPA,16 CFR Part 312 (Office of the Secretary, Department of Education, n.d.-a)

A project web site was created on the Makewaves platform (www.Makwav.es/badgebox) to share study information, to organize participants into groups, and to award student and teacher digital badges. After joining the Badgebox site, teachers were able to access resources and manage the digital badge awarding process. After an approval process, teachers were enrolled as

Publishers. The Makewaves system is *Open Badge Infrastructure* compliant, meaning that students 13 or older have the option to electronically *push* their digital badges to a Mozilla digital backpack system. At the end of the study, students were asked to “push” their badges (send electronically to their account on the Mozilla repository web site) if they wished to. Student profiles were deleted after the study.

Study implementation.

Study set-up. The units of analysis for the study were individual students, teachers, and classroom groupings of students. This necessitated the acquisition of informed consent from: 1) school leaders, 2) participating teachers, 3) parents of minor participants, and 4) assent from youth participants. Teachers facilitated student sign-up onto the Makewaves site. Approved students, called *Reporters* in the Makewaves system, were encouraged to create minimal online profiles, which were required by the system in order to award the digital badges.

During the study set-up phase, teachers collected consent and assent forms, created coded master lists for use by students when taking the surveys, reviewed curricula, and aligned lessons with selected badge criteria.

Study implementation. The following notes describe the study implementation at site D by Teachers A and B who were the only teachers who completed the digital badge study. In addition, the teachers discussed the study and its goals with the students. They took the educator pre-test survey online, available through a link sent via email.

Pursuant to receipt of appropriate teacher, parental, school consent, and student assent, teachers were emailed instructions on how to administer the surveys to student participants. Surveys were made available in electronic format and sent to teachers as secure links. Teachers A and B at site D opted to schedule laptops for the students to take the surveys in class, rather than on their own time. After students had taken the online surveys, teachers implemented the badge program content. They awarded badges to students through the Makewav.es learning management system. During implementation, on-going support through email and phone conversations was available to teachers. However, substantial support was not required by teacher participants.

Data Collection

Quantitative data were collected through educator and youth participant questionnaires. Questionnaires were administered before and after the digital badge intervention, using SurveyGizmo, a secure, online platform (www.surveygizmo.com). When taking online surveys, the identities of minor participants were coded for anonymity. Participating teachers created and maintained master lists of participating students. Teacher identities, while known, were reported anonymously for confidentiality. Following the implementation of the digital badge program, teachers participated in a semi-structured interview to acquire qualitative, contextual data regarding implementation processes and observations. Due to the small sample size, teacher survey data were reported as qualitative data.

Quantitative data.

Instrumentation. Four survey instruments were designed for pre- and post-testing of student participants and teacher participants. They were administered through the SurveyGizmo online platform. For the student pre- and post-test, subscales from the *Students Adaptive Learning Engagement in Science (SALES)* questionnaire were slightly modified. According to Velayutham et al., students' "adaptive motivated and self-regulated learning engagement in science" are essential to academic achievement (Velayutham, Aldridge, & Fraser, 2011, p. 2160). The SALES instrument was developed to assess these factors, and it was developed specifically for the target population of secondary school students. This is unlike other instruments, such as the *Learning and Study Strategies Inventory* (LASSI/ Weinstein, Woolfolk, Palmer, & Schulte, 1987), or the (*Motivated Strategies for Learning Questionnaire* (MSLQ / (Pintrich, et al., & Office of Educational Research and Improvement, Washington, DC, 1991), which were designed for use with college students. The *Patterns of Adaptive Learning Scales* (PALS (Midgley et al., 2000) instrument, although suitable for use in the target population, focuses upon goal orientations, and it does not include scales to measure study variables such as self-efficacy. However, the *Students' Motivation Toward Science Learning* instrument (SMTSL), was developed to measure similar concepts in high school student populations (Tuan * et al., 2005).

The SALES instrument was selected for use because the questions were worded in a manner which could be easily modified for a more expansive meaning of STEM. For example, corresponding measures in self-efficacy demonstrate the ability to generalize and effectively measure transferable concepts with the SALES instrument, which is consistent with the goals of this study: "Whether the science content is difficult or easy, I am sure I can understand it" (SMTSL) may be contrasted with the SALES option: "I can figure out how to do difficult work;" "Even if the science work is hard, I can learn it;" and "I can complete difficult work if I try" (SALES). In addition, negative items were used extensively on the SMTSL scale, which are not recommended (Babbie, 2010). Select question items were adapted from the SMTSL to assess the concept of "Learning Environment Stimulation" (Tuan * et al., 2005), measures not included in the SALES instrument. In addition, the SALES instrument was selected because of its predictive value and applicability to the evaluation of an educational intervention:

> Practically, this instrument will provide instructors with a reliable, valid, and convenient tool for gathering from science students, information on student motivation and self-regulation to guide classroom teachers in directing and focusing their teaching practices. It also could be used as an instrument for evaluating the effectiveness of instructional strategies and materials designed to increase students. (Velayutham et al., 2011, p. 2160)

The processes of modifications and application will alter the established validity and reliability of an instrument. The SALES instrument was designed using *Trochim and Donnelly's framework for construct validity* (Trochim & Donnelly, 2007). " In sum, the instrument has high construct validity if it can establish content, face, convergent, discriminant, concurrent and predictive validity" (Velayutham et al., 2011, p. 2165) (Figure 7). The SALES instrument fulfilled the requirements of both translation and criterion related validity. It offered consistent internal reliability, with Cronbach alpha values above 0.90 for each of the 4 subscales.

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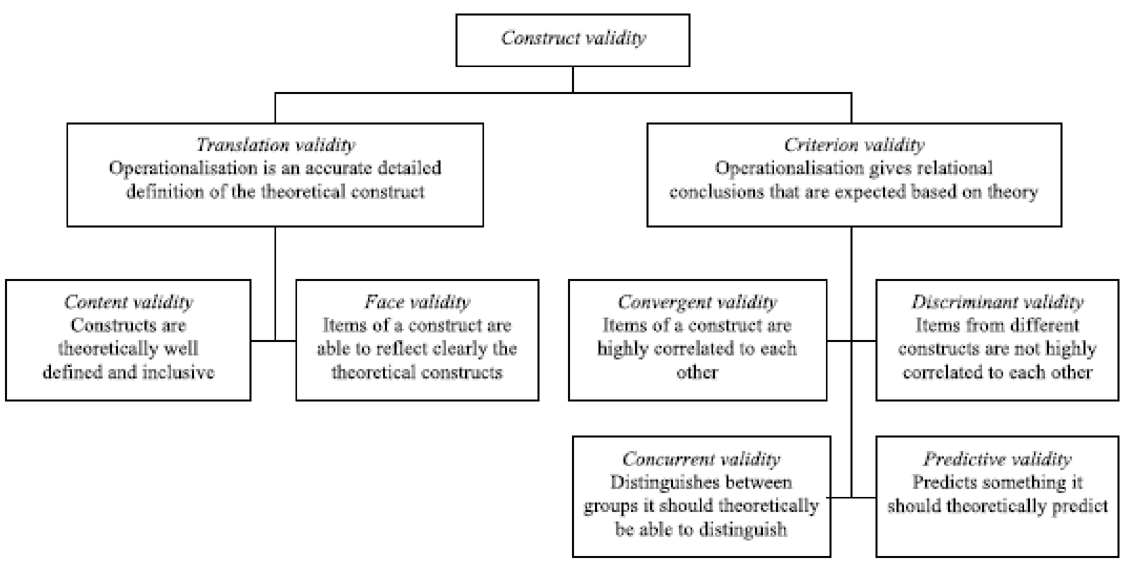

Figure 1. Framework for construct validity (source: Trochim & Donnelly, 2006)

Figure 7. Framework for construct validity.

In the pretest, almost all SALES questions were used, and all of the subscales were used. These included learning goal orientation, task value, self-efficacy, and self-regulation. Items were grouped together on the Youth Participant "Pre" questionnaire to shorten the perceived length; three or four items of the subscales were aggregated into one modified question, with 20 point intensity measures. Data were separated back into individual questions during analysis.

Survey pilot testing. The surveys were pilot tested by youth of the target group and volunteer educators.

Study length and other factors. Site D participated in the study from November 2013 to March 2014. The actual length of the digital badge program varied between 3-5 weeks.

Qualitative data.

Qualitative data for the study were collected from several sources. Date provided contextual information about the learning environment, instructional processes, learning outcomes, and opinions of student participants about the digital badge program. Student comments were collected through open-text questions on the survey questionnaires. Data regarding program implementations were collected through a Post-Program, semi-structured interview conducted with both teachers. In addition, there were on-going communications between the teachers and school leaders which supplemented the data.

Artifacts, in the form of student work from the 7th grade class, were viewed. Data was collected about instructional and assessment processes and practices, the kinds of teacher feedback given to students, student selection of problems, proposed solutions, reflective practices, and student approaches to problem solving.

Data Analysis

The quantitative and qualitative data were analyzed separately, consistently with a concurrent research design.

Quantitative analyses.

Descriptive statistics. Data regarding demographic information, student ICT and digital media use, student problem solving behaviors and preferences were collected. All data from Educator surveys were reported in the qualitative data section in Chapter 5.

Inferential statistics.

The following inferential statistical analyses were conducted:

- Factorial analysis, for variable reduction
- Correlational analysis, to establish associations
- Multiple regression techniques, which are used to establish causal relationships.

Qualitative analysis.

The data were transcribed and then analyzed for emerging themes using nVivo (see Appendix V for interview questions). Open-text questions from the Student Post Survey were coded online using the text analysis tool (see Appendix T and Appendix U for open-text responses).

Limitations and Delimitations

Limitations. It is implicitly acknowledged that the contextual nature of these results prevent generalization or inference as to the nature of students who whom digital badges can help or specific contexts of use. The following factors were not controlled for the study, and therefore, they will cause results to vary:

- differences in learner populations,
- teacher methods of implementation, specifically instructional and assessment practices,
- contexts of learning,
- interactions between participants,
- learning curve for new users (teachers and students),
- variances in content taught,
- the self-reported quantitative data, and
- digital badge design, actual and intended purposes (D. Hickey, 2011).

Delimitations. This study does not seek to directly:

- measure participant learning gains,
- study the digital badge designs (learning trajectory, rubrics and learning assets),
- predict participants' interest in learning goals,
- conduct an ethnographic analysis of the learning environments or users' experiences, and
- evaluate instructional and assessment practices used by teachers.

Chapter 4: Quantitative Data Results and Findings

This chapter presents an analysis of quantitative data collected for the study. Qualitative data findings are presented in Chapter 5. The purpose of this research is to understand the impact of a digital badge intervention upon STEM learning. In particular, the study purpose was to understand the impact upon student motivation, learning habits, and environmental factors aligned with the Connected Learning Model (CLM) as measured, in part, by quantitative survey data. Qualitative data were used for confirmatory analysis and to generate emergent theory about the use of digital badges in similar contexts. Furthermore, qualitative data provided additional insights into instructional and assessment practices and the processes of implementation.

To this end, an educational intervention using digital badges for STEM learning was designed and implemented. Students responded to surveys before and after the digital badge program on their attitudes and opinions regarding STEM learning and the digital badge program. In addition, data were collected about student learning behaviors as well as ICT and digital media use. The surveys consisted of several sub-scales of the *SALES* instrument to measure motivation related concepts in science learning (Velayutham et al., 2011), which were modified and implemented as intensity scales with values of 1-20.

The pre-program questionnaire was comprised of 40 questions. In addition to the *SALES* sub scales, the instrument included ranking and interval items to measure ICT use, digital media use, and learning behaviors. The student post-program questionnaire was comprised of 33 questions. In addition to the *SALES* sub scales, items were included to assess student attitudes about the digital badges and learning behaviors used during the program. The Post-Program student survey included additional intensity measures (from 1-20), ranking, interval, and open-text questions.

In the following sections, descriptive data for the pre-assessment is followed by the descriptive data for the post-assessment. The findings of inferential analyses, including with factor, correlation, and regression analysis, are presented in the section following.

Quantitative Analysis

Student Pre- and Post-Survey Data: Descriptive Statistics

Respondents.

Table 1. *Frequency Table of Student Respondents by Grade (Pre- and Post-Program)*

		Frequency	Valid Percent	Cumulative Percent
Pre-Program	Grade 7	20	28.6	28.6%
	Grade 10	32	45.7	74.3%
	Grade 12	18	25.7	100.0%
	Total	70	100.0	
Post-Program	Grade 7	19	27.5	27.5%
	Grade 10	30	44.9	71.0%
	Grade 12	19	27.5	100.0%
	Total	69	100.0	

Students in 7^{th} (n=20), 10^{th} (n=32) and 12^{th} (n=18) grades, with appropriate parental consent, completed the pre-program survey (n=70 total). Students in 7^{th} (n=19), 10^{th} (n=30) and 12^{th} (n=19) completed the post-program survey (n=69 total) grades. The student population self-identified (in the pre-program survey only) as (split by gender) 1 African American, 37 Arab Americans, 2 Other, 1 Hispanic (girls, n=41 total) and 22 Arab Americans, 5 Other, 1 Biracial (boys, n=29). Four students who identified as *Other* wrote in the comments *Arab, Iraq, Iraqi and Yemeni.* Languages used at home for students were self-reported as 91.4% Arabic, 82.9% English and 2.9% Spanish. The school is a Title I building, with 87% of students eligible for free and reduced school lunch (Center for Educational Performance and Information, n.d.). Students were enrolled in a social studies class (7th grade), Algebra 2 (10th grade), Business Math (12th grade) or Study Hall (12th grade). Students ranged in age from 12 to 18 years old.

A minimal number of students participated in either the pre or post-program surveys (not both), or partially completed surveys. This data was included for most analyses, except for pre- and post-measures. The total number of respondents was n=80 with 10 students (n=5 pre- and n=5 post) taking either the pre- or post-survey, but not both. Minimal identifying data were collected in the post-test survey. To reduce the number of survey questions for respondents, demographic data were not collected in the post-survey.

Pre-Program Data

Surveys were administered to students before engaging with the digital badge program. Data were collected regarding students' ICT use, problem solving behaviors, and learning preferences. Pre-program measures of self-efficacy, learning goal orientation, task value and self-regulation concepts to measure the motivation construct were included in the questionnaire.

When asked where they accessed the Internet and used digital media the most, the top ranking answer for each grade was *home*. The second ranking answer for students in the 7th and 10th grades was *school,* followed by *anywhere with wifi*. For students in the 12th grade, this ranking was reversed.

Problem Solving Strategies

Please rank the methods below in order of your preference for finding information for school assignments, projects and homework.

	Score*	Overall Rank
ask a teacher	656	1
look it up online using a search engine e.g. Google	575	2
look it up in a textbook	484	3
text a friend or class mate	451	4
ask a parent or other adult	359	5
read a book or an article	322	6
I don't usually have questions on my schoolwork	255	7
use social media such as Facebook to ask friends	218	8
other	193	9
none of the rest	130	10
I'm too busy to be curious about school work	114	11

Total Respondents 76

*Score is a weighted calculation. Items ranked first are valued higher than the following ranks, the score is the sum of all weighted rank counts.

Figure 8. Figure showing problem solving strategies: Q. 10.

The top four ranking items were consistent among all students with two exceptions (Figure 8). The top ranking item for students in the 12th grade was *to look it up online with a search engine*, and for 7th grade students, the fourth option was *to ask a parent or other adult*. (The fifth option was to *look it up in a textbook*, which ranked third overall).

Texts per day

Table 2. *Student Texts per day, by Grade (Percentage)*

			Frequency	Percent	Valid Percent	Cumulative Percent
Grade 7	Valid	1-5	7	35.0	36.8	36.8
		6-10	3	15.0	15.8	52.6
		11-15	1	5.0	5.3	57.9
		15-20	2	10.0	10.5	68.4

		more than 20	1	5.0	5.3	73.7
		way more than 20	5	25.0	26.3	100.0
		Total	19	95.0	100.0	
	Missing	System	1	5.0		
	Total		20	100.0		
Grade 10	Valid	1-5	10	31.3	31.3	31.3
		6-10	2	6.3	6.3	37.5
		11-15	3	9.4	9.4	46.9
		15-20	2	6.3	6.3	53.1
		more than 20	4	12.5	12.5	65.6
		way more than 20	8	25.0	25.0	90.6
		I don't have a smartphone	2	6.3	6.3	96.9
		Never	1	3.1	3.1	100.0
		Total	32	100.0	100.0	
Grade 12	Valid	1-5	2	11.1	11.1	11.1
		6-10	4	22.2	22.2	33.3
		more than 20	3	16.7	16.7	50.0
		way more than 20	8	44.4	44.4	94.4
		Never	1	5.6	5.6	100.0
		Total	18	100.0	100.0	

The frequency of texts per day increased with student grade, as shown in Table 2.

ICT and Digital Media Use

occasionally (less than 30 mins.)	11.8%	9
30-60 mins.	36.8%	28
61-120 mins (1-2 hours)	23.7%	18
121-180 mins (2-3 hours)	9.2%	7
181-240 mins (3-4 hours)	9.2%	7
4+ hours	9.2%	7
	Total	76

Statistics

Sum	4,080.0
Average	60.9
StdDev	51.2
Max	181.0

Figure 9. Student ICT use: Q. 12.

On average, how much time do you spend on a typical day using the Internet for information needs and communication (e.g., online searching, reading…)?

occasionally (less than 30 mins)	9.3%	7
30-60 mins	24.0%	18
61-120 mins (1-2 hours)	24.0%	18
121-180 mins (2-3 hours)	16.0%	12
181-240 mins (3-4 hours)	6.7%	5
4+ hours	20.0%	15
	Total	75

Statistics	
Sum	4,055.0
Average	59.6
StdDev	51.6
Max	181.0

Figure 10. Student ICT use: Q. 13.

On average, how much time do you spend using the Internet and digital media for personal use per day (e.g. gaming… reading…social media…)?

Students' daily ICT use incorporated time for working on information seeking and communication (Figure 9) and for personal use (Figure 10). Two younger (7th grade) students described Internet limits imposed by parents. "My mom does not let me stay more than 1-2 hours," and "I really like using electronics and playing lots of games, but my parents only give me 2 hours if I want to play because there's lots of other stuff I can do like homework, cleaning, and many more [sic]." Two 10th grade students described using the Internet for "…communicating with family and friends overseas. Overall, I spend 20-30 minutes, but I keep going back and forth on my phone. I don't have it stuck in my hands 24/7" and "I usually [sic] use the internet for projects only and i don't take that long." Two additional 10th grade students described their usage of the Internet: "when it comes to texting I could text for hours. I love using the internet" and "I use the internet to relax and it's also soothing."

Online Activities

	Score*	Overall Rank
single-player games	604	1
using digital media (watching videos, listening to music etc)	555	2
email and communicating	521	3
social media (Facebook, Tumblr, Twitter)	498	4
research or studying	487	5
group or collaborative games	480	6
reading	432	7
learning -- about anything (what do you like? use comment box to explain)	396	8
writing or blogging or sharing media (pictures, video) (what do you like to share? or write? use the comment box to explain	370	9
creating things (mashups, videos, animation) (what do you like to make? use comment box to explain)	359	10
messing around with digital media or software	291	11
other	157	12
doesn't apply	62	13
professional learning	0	14

Total Respondents 76

*Score is a weighted calculation. Items ranked first are valued higher than the following ranks, the score is the sum of all weighted rank counts.

Figure 11. Student online activities: Q. 15.

Rank the online activities in order of your preference

Students' top ranked activities (Figure 11) were gaming (primarily individually, and collaboratively), digital media consumption, and participatory activities through social media. Activities to produce digital artefacts or media, or *messing around* with digital media or software were ranked low on the scale, as were *mashups* or remixing of digital media.

Students reported ownership or access to a wide array of devices. This is perhaps unexpected due to the low socio-economic status of the population (Figure 12). Due to the family structure and a *collective* cultural framework or society, youth in Arab-American homes may share devices with several siblings, or have access to the technological equipment of extended family. Students would regard these devices as *ours,* i.e., *my family's*.

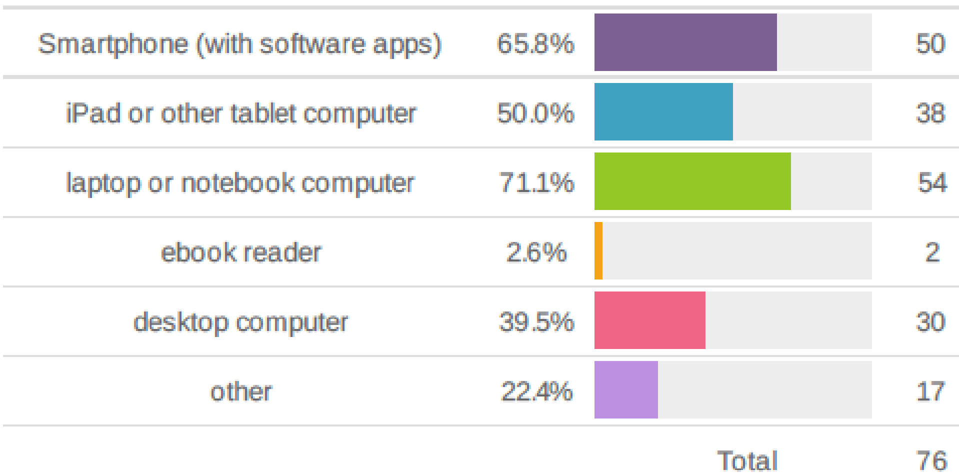

Figure 12. Student ICT use: Q. 14.

Which of the following mobile devices or technology tools do you own (use)? Please check all that apply

Sharing Accomplishments Online

The likelihood of students sharing accomplishments such as good grades diminished from 7th to 12th grade (Table 3). There was a weak, negative correlation (-.107) between grade and sharing behaviors. An apparent reluctance to share reflected a cultural/religious belief that boastful behavior or excessive sharing of accomplishments, rewards, money, or other good things will cause envy or jealousy called *Hasid* in Arabic (Envy (hasad): The enemy inside, n.d.). If someone is *envied* in this context, it is believed that something bad will occur as a result. This belief was evident in several students' comments:

- "I only share my achievements with family and friends."
- "I only share when I be asked to [sic]."

- "I really don't share my accomplishments [sic] and my goals."
- "I don't feel it is safe to show my grades and rewards to the public, due to jealousy and being jinxed."
- "When I achieve something important I don't share that online. That doesn't mean it's NOT important."
- "I don't brag."
- "I never cared about bragging."
- Unless there is a reason: "My dad lives overseas and it's very important to me to share/ tell him about my achievement."

The majority of students, 60.5%, reported that they do not participate in online groups, and 26.3% of students belonged to 1 or 2 online groups. Only 13.2% of students belonged to 3-5 online groups.

Table 3. *Student Sharing Behaviors of Accomplishments*
Q. 18: When you achieve something important, such as a good grade, or meeting a goal, how likely are you to share that online…?

Student Grade	Mean	N	Std. Deviation
Grade 7	10.263	19	6.7482
Grade 10	8.625	32	6.1736
Grade 12	8.444	18	7.8757
Total	9.029	69	6.7475

As students increased in age, their problem solving strategies changed (Figure 13). All participants ranked social or collaborative problem solving strategies as the top three ranked items. Seventh grade students favored asking friends (top 2 ranked choices). Tenth- and twelfth-grade participants ranked *keep trying until you figure it out* (1^{st} and 2^{nd} respectively) and *think* *carefully about what needs to be done to accomplish the task and then try again* (1st and 2nd respectively).

	Score*	Overall Rank
ask a friend who is with you	495	1
keep trying until you figure it out	489	2
think carefully about what needs to be done to accomplish the task then try again	471	3
ask a friend who is online	344	4
look for cheats online	309	5
read the help or FAQ's	276	6
ask a friend to complete the task for you	180	7
give up	99	8
other	70	9

Total Respondents 76

*Score is a weighted calculation. Items ranked first are valued higher than the following ranks, the score is the sum of all weighted rank counts.

Figure 13. Student problem solving behaviors Q. 20.

If you are playing a game online and are stuck on a question, level or task, how would you usually solve the problem?

There was a distinctive trend in students' collaborative work preferences (Table 4). Students in the 7th grade preferred to work in groups or with friends, but by the 12th grade, the preference was reversed.

Table 4. *Comparison of Means for Work Preferences*
Q. 34 and 35 (alone or with a group or friends)

Student Grade	Prefer to Work with Friends	Prefer to Work Alone

Grade 7	Mean	16.176	12.235
	N	17	17
	Std. Deviation	4.1719	5.2741
Grade 10	Mean	15.125	11.250
	N	32	32
	Std. Deviation	5.5344	5.8750
Grade 12	Mean	13.611	12.833
	N	18	18
	Std. Deviation	4.0167	4.7805
Total	Mean	14.985	11.925
	N	67	67
	Std. Deviation	4.8633	5.4141

Post-Program Data

Earn More Digital Badges

Most students indicated that they would like to try to earn more digital badges in the program, if it were longer (Table 5). There was no significant difference in the percentage of students who responded either *agree* or *strongly agree*, 70% (7th grade), 71% (10th), and 66.6% (12th grade).

Table 5. *Frequency Table Showing Student Response by grade: Q. 8 (Post) If the program was longer, I would try to earn more badges.*

Student Grade			Frequency	Percent	Valid Percent	Cumulative Percent
Grade 7	Valid	Strongly disagree	3	15.0	15.0	15.0
		Neutral	3	15.0	15.0	30.0
		Agree	10	50.0	50.0	80.0
		Strongly agree	4	20.0	20.0	100.0
		Total	20	100.0	100.0	

Grade 10	Valid	Strongly disagree	1	3.1	3.2	3.2
		Disagree	1	3.1	3.2	6.5
		Neutral	7	21.9	22.6	29.0
		Agree	16	50.0	51.6	80.6
		Strongly agree	6	18.8	19.4	100.0
		Total	31	96.9	100.0	
	Missing	System	1	3.1		
	Total		32	100.0		
Grade 12	Valid	Disagree	1	5.6	5.6	5.6
		Neutral	5	27.8	27.8	33.3
		Agree	8	44.4	44.4	77.8
		Strongly agree	4	22.2	22.2	100.0
		Total	18	100.0	100.0	

The level of understanding of the digital badge requirements differed by grade, which may reflect the level of instructional goals and support. Students in the 7th grade, as shown in Table 6, responded that they understood what was required to earn the digital badges *usually* or *always*, 100% of the time. Teacher B integrated digital badge content into existing instruction and assessment, whereas for Teacher A, the badge project was *more independent.* Students in the 10th and 12th grade who participated in Teacher A's classes responded that they understood what was required for the badges *usually* or *always* 71% and 61% respectively. The percentage of students who understood the badge requirements *about half the time* or more was at least 75%. A Chi square analysis showed a statistically significant difference of .002 in understanding for the 10th grade (file split by grade).

Using Digital Badges for Learning

Table 6. *Frequency Table Showing Student Response by Grade: Q. 12 (Post)*
I understood what I was expected to do to earn the digital badges.

Student Grade	Frequency	Percent	Valid Percent	Cumulative Percent

Grade 7	Valid	Usually	11	55.0	55.0	55.0
		Always	9	45.0	45.0	100.0
		Total	20	100.0	100.0	
Grade 10	Valid	Some of the time	6	18.8	19.4	19.4
		About half the time	3	9.4	9.7	29.0
		Usually	17	53.1	54.8	83.9
		Always	5	15.6	16.1	100.0
		Total	31	96.9	100.0	
	Missing	System	1	3.1		
	Total		32	100.0		
Grade 12	Valid	Some of the time	4	22.2	22.2	22.2
		About half the time	3	16.7	16.7	38.9
		Usually	6	33.3	33.3	72.2
		Always	5	27.8	27.8	100.0
		Total	18	100.0	100.0	

Most students referred to the digital badge criteria *sometimes*, *often*, or *all the time* to assist with planning their workload, as shown in Table 7. Students in the 7th grade responded that they referred to the badge criteria *usually* or *always* 100% of the time (71% for 10th grade students, and 61.1% for 12th grade students. These differences in learning behaviors could occur for a variety of reasons. For example, the level of maturity of students, the complexity of the badge-related assignments or instructional strategies could have influenced their behavior.

Table 7. *Frequency Table Showing Student Response by Grade: Q. 15 (Post)*
I looked at the digital badge task lists to help me plan what I had to do for assignments.

Student Grade			Frequency	Percent	Valid Percent	Cumulative Percent
Grade 7	Valid	Sometimes	2	10.0	10.0	10.0
		Often	9	45.0	45.0	55.0
		All the time	9	45.0	45.0	100.0
		Total	20	100.0	100.0	

Grade 10	Valid	Never	1	3.1	3.2	3.2
		Not very often	3	9.4	9.7	12.9
		Sometimes	9	28.1	29.0	41.9
		Often	13	40.6	41.9	83.9
		All the time	5	15.6	16.1	100.0
		Total	31	96.9	100.0	
	Missing	System	1	3.1		
	Total		32	100.0		
Grade 12	Valid	Never	1	5.6	5.6	5.6
		Not very often	3	16.7	16.7	22.2
		Sometimes	4	22.2	22.2	44.4
		Often	7	38.9	38.9	83.3
		All the time	3	16.7	16.7	100.0
		Total	18	100.0	100.0	

Students were generally interested in earning additional digital badges and *leveling up*. Responding to the question: *When I earned a badge, I wanted to try to earn a badge at the next level right away,* students either *agreed* or *strongly agreed* 80% (7th grade), 62.6% (10th grade), and 72.2% (12th grade).

When asked if the way the badges were organized was helpful to their learning, fewer than 12% of students either *strongly disagreed* or *disagreed* (5% of 7th grade students, 6.3% of 10th grade and 11.1% of 12th grade students). As shown in Table 8, remaining students were *neutral*, *agreed*, or *strongly agreed* that the badge design was helpful.

Table 8. *Frequency Table Showing Student Response by Grade: Q. 26 (Post)*

I think the way the digital badges were set up (learning targets, tasks or criteria) helped me to learn the subjects well.

Student Grade			Frequency	Percent	Valid Percent	Cumulative Percent

Grade 7	Valid	Strongly disagree	1	5.0	5.0	5.0
		Neutral	3	15.0	15.0	20.0
		Agree	11	55.0	55.0	75.0
		Strongly agree	5	25.0	25.0	100.0
		Total	20	100.0	100.0	
Grade 10	Valid	Strongly disagree	2	6.3	6.5	6.5
		Neutral	10	31.3	32.3	38.7
		Agree	15	46.9	48.4	87.1
		Strongly agree	4	12.5	12.9	100.0
		Total	31	96.9	100.0	
	Missing	System	1	3.1		
	Total		32	100.0		
Grade 12	Valid	Strongly disagree	1	5.6	5.6	5.6
		Disagree	1	5.6	5.6	11.1
		Neutral	4	22.2	22.2	33.3
		Agree	10	55.6	55.6	88.9
		Strongly agree	2	11.1	11.1	100.0
		Total	18	100.0	100.0	

When asked if their teachers *taught differently* using the digital badge program, students responded *agree* or *strongly agree* at least 50% of the time (10th grade) or greater, i.e., 60% (7th grade) or 61% (12th grade).

Use Digital Badges Again

Students were willing to try working with digital badges again. Fewer than 6% of students were not interested in using digital badges for learning again. As shown in Table 9, none of the 7th grade students was opposed to using digital badges again, whereas 3.2% of 10th grade students and 5.6% of 12th grade students *strongly disagreed* with the idea. No students indicated that they *disagreed* about using digital badges for learning.

Table 9. *Frequency Table Showing Student Response by Grade: Q. 28 (Post)*
I would like to use digital badges for learning again

Student Grade			Frequency	Percent	Valid Percent	Cumulative Percent
Grade 7	Valid	Neutral	4	20.0	20.0	20.0
		Agree	10	50.0	50.0	70.0
		Strongly agree	6	30.0	30.0	100.0
		Total	20	100.0	100.0	
Grade 10	Valid	Strongly disagree	1	3.1	3.2	3.2
		Neutral	9	28.1	29.0	32.3
		Agree	16	50.0	51.6	83.9
		Strongly agree	5	15.6	16.1	100.0
		Total	31	96.9	100.0	
	Missing	System	1	3.1		
	Total		32	100.0		
Grade 12	Valid	Strongly disagree	1	5.6	5.6	5.6
		Neutral	3	16.7	16.7	22.2
		Agree	9	50.0	50.0	72.2
		Strongly agree	5	27.8	27.8	100.0
		Total	18	100.0	100.0	

As shown in Table 10, students responded that they were able to incorporate *knowledge, skills, or ways of thinking* acquired from out-of-school experiences at least *some of the time,* a minimum of 90% (7th grade). Students in the 10th grade were able to incorporate this knowledge, at least *some of the time* or greater 90.6%, and 100% of 12th grade students.

Digital Badge Learning and Out-of-School Learning

Table 10. *Frequency Table Showing Student Response by Grade: Q. 30 (Post)*
Were you able to use knowledge, skills or ways of thinking you learned outside of school to earn badges?

Student Grade			Frequency	Percent	Valid Percent	Cumulative Percent
Grade 7	Valid	Not at all	2	10.0	10.0	10.0
		Some of the time	1	5.0	5.0	15.0
		About half of the time	4	20.0	20.0	35.0
		Usually	8	40.0	40.0	75.0
		Always	5	25.0	25.0	100.0
		Total	20	100.0	100.0	
Grade 10	Valid	Not at all	3	9.4	9.7	9.7
		Some of the time	7	21.9	22.6	32.3
		About half of the time	6	18.8	19.4	51.6
		Usually	14	43.8	45.2	96.8
		Always	1	3.1	3.2	100.0
		Total	31	96.9	100.0	
	Missing	System	1	3.1		
	Total		32	100.0		
Grade 12	Valid	Some of the time	3	16.7	16.7	16.7
		About half of the time	3	16.7	16.7	33.3
		Usually	9	50.0	50.0	83.3
		Always	3	16.7	16.7	100.0
		Total	18	100.0	100.0	

As shown in Table 11, student participants were interested in learning about where to earn more digital badges for learning. Students selected either *agree* or *strongly agree* at a rate of 70% (7th grade), 64.5 % (10th grade), and 72.2% (12th grade).There was no significant differences between grades or gender. Students in grade 10 worked on the Data Hacker badges primarily. Students in grades 7 and 12 worked primarily with the InfoMaker series.

Table 11. *Frequency Table Showing Student Response by Grade Q. 33 (Post)*

I'd like to know more about how to earn digital badges for learning (any subject, including your hobbies or interests out-of-school

Student Grade			Frequency	Percent	Valid Percent	Cumulative Percent
Grade 7	Valid	Strongly disagree	1	5.0	5.0	5.0
		Neutral	5	25.0	25.0	30.0
		Agree	7	35.0	35.0	65.0
		Strongly agree	7	35.0	35.0	100.0
		Total	20	100.0	100.0	
Grade 10	Valid	Disagree	3	9.4	9.7	9.7
		Neutral	8	25.0	25.8	35.5
		Agree	14	43.8	45.2	80.6
		Strongly agree	6	18.8	19.4	100.0
		Total	31	96.9	100.0	
	Missing	System	1	3.1		
	Total		32	100.0		
Grade 12	Valid	Strongly disagree	2	11.1	11.1	11.1
		Neutral	3	16.7	16.7	27.8
		Agree	11	61.1	61.1	88.9
		Strongly agree	2	11.1	11.1	100.0
		Total	18	100.0	100.0	

Digital Badge Sharing

Students selectively shared their digital badge accomplishments, as shown in Table 12. As determined by an Explore SPSS analysis, the data set is not normally distributed and an independent samples, Kruskal-Wallis test analysis was conducted by student grade. There were no significant differences in sharing behaviors across the grade levels. Younger students, in the 7th grade, shared their digital badge accomplishments mostly with friends and parents. Students in 10th grade shared with teachers and parents more, and 12th grade students, mostly with teachers.

Table 12. *Frequency Table Showing Student Response by Grade: Q. 32 (Post) In general, who did you tell about your digital badges accomplishments?*

Student Grade		Friends	Teachers	Adult Group Leader	Share Online	Parents	Other
Grade 7	Mean	14.500	12.800	9.650	7.150	14.800	9.722
	N	20	20	20	20	20	18
	Std. Deviation	4.0328	6.6380	8.1064	7.2277	6.5743	8.2234
Grade 10	Mean	10.897	12.367	11.667	10.207	12.214	9.214
	N	29	30	30	29	28	28
	Std. Deviation	6.8470	7.0392	6.3045	6.5048	6.3266	6.5848
Grade 12	Mean	11.529	14.500	10.941	9.444	10.500	9.588
	N	17	18	17	18	18	17
	Std. Deviation	7.2639	5.2496	5.8574	7.7780	7.1063	7.3319
Total	Mean	12.152	13.059	10.881	9.090	12.530	9.460
	N	66	68	67	67	66	63
	Std. Deviation	6.3591	6.4597	6.7409	7.0919	6.7259	7.1658

Pre and Post-Program Comparative Analysis

Due to the small sample size, the data were tested to meet the assumption of normal distribution using the Explore command with SPSS. The data sets are not normally distributed which necessitated the use of some non-parametric analyses in addition to factor, linear regression, and correlational analysis.

Paired sample T-test analyses were conducted on pre- and post-measures of student attitudes and beliefs of self-efficacy, self-regulation, task value, and goal orientation. Sub scales from the *SALES* instrument were used, which together measure student motivation, in this case on STEM content and using digital badges for learning STEM content. Non-parametric related samples Wilcoxon Signed Rank testing confirmed the results.

There was no statistically significant difference in measures of student goals, except for a comparison of performance goals. *In my class or program, it is important to get good grad*es (Q. 32, pre-program) and *In the digital badge program, it is important to earn badges* (Q.18, Post-Program). For analysis, the file was initially split by grade, then by gender. There was a significant grade level difference of .027 in the 12th grade, significant at the $p \leq 0.5$ level, with the comparison of means, indicating that students responded that grades were more important. Of interest, the comparison for 7th grade resulted in an identical mean value of 16.778 (with SD of 4.0520 and 4.8210 for the pre- and post-measures respectively). There was a significant gender difference for boys at 0.005, which is significant at the $p \leq 0.01$ level; boys responded that the digital badges were not important as grades. The girls' response was similar, except girls valued the badges more, hence the lack of statistical significance between the means.

There was a difference in pre- and post-mean values for the question *What I learn is interesting* of .013, which is significant at the $p \leq .05$ level.

Self-Efficacy Pre- and Post-Measures

There were several items with statistically significant differences between the pre- and the post-measure for self-efficacy, three of which (Table 13) were significant at the $p \leq .01$ level. *I can understand the content taught* has a significant pre- and post-program difference, significant at the $p \leq .05$ level.

Table 13. *Paired Samples Test: Measures of Self-Efficacy*

	Sig. (2-tailed)
I can master the skills that are taught.	.006**
I can figure out how to do difficult work.	.007**
Even if the work is hard, I can learn it.	.001**
I can understand the content taught.	.050*

Significance levels *p < .05, **p < .01

Self-Regulation Pre- and Post-Measures

Several pre- and post-program measures of self-regulation were statistically significant to the $p \leq .01$ level (Table 14). These measures indicated students' willingness to persist at task and to *concentrate* or to pay attention, which was significant to the $p \leq .05$ level.

Table 14. *Paired Samples Test: Measures of Self-Regulation*

	Sig. (2-tailed)
Even when the tasks were uninteresting, I kept working.	.004**
I worked hard even if I did not like what I was doing.	.000**
I continued working even if there were better things to do.	.005**
I concentrated so that I did not miss important points.	.050*

Significance levels *p < .05, **p < .01

ANOVA Analysis

ANOVA with a Tukey post-hoc analyses indicated several significant results for between group differences by grade as shown in Table 15 below. (Table 50, Appendix xxx for Tukey post-hoc output).

Table 15. *ANOVA showing significant differences between groups*

		Sum of Squares	df	F	Sig.
Badge_Value_Post_Final	Between Groups	7.059	2	3.881	.025*
	Within Groups	60.941	67		
	Total	68.000	69		
SE_Post_Final	Between Groups	6.279	2	3.408	.039*
	Within Groups	61.721	67		
	Total	68.000	69		
12_Student_Understanding_Badge	Between Groups	8.566	2	5.073	.009**
	Within Groups	55.724	66		
	Total	64.290	68		
15_Student_Learning_Behaviors1	Between Groups	9.747	2	5.313	.007**
	Within Groups	60.543	66		
	Total	70.290	68		
16_Student_LevelUp_Program	Between Groups	244.052	2	11.490	.000***
	Within Groups	700.934	66		
	Total	944.986	68		
31_Student_Review_Requirements	Between Groups	9.098	2	4.758	.012**
	Within Groups	63.105	66		
	Total	72.203	68		

Significance levels: * $p < .05$, ** $p < .01$, *** $p < .001$

The most significant differences were in 7th grade students' beliefs about the importance of leveling up in the digital badge program (Q. 16), which differed from both the 10th and 12th grade students. Seventh-grade students' understanding of the badge requirements (Q. 12) and use of badge criteria to plan work (Q. 15) also differed significantly between both 10th and 12th grades. The frequency of reviewing digital badge requirements was significantly different between the 7th and 10th grade students, only (Q. 31). There were no significant differences in these measures between the 10th and 12th grade students.

Students in 7th and 12th grades differed significantly in measures of self-efficacy in the post-survey (only), whereas students in the 10th grade differed from the 7th grade students (only) in measures of badge value.

Factor Analysis and Inferential Statistics

Factor Analysis

Factor analysis was conducted using the:

1) Pre-survey questions 18, 21, 29, 30, 31, 32, 34, 35 and 40 (only),
2) Post-survey questions 7, 8, 9, 12, 13, 15, 16, 21, 22, 24, 26, 27, 28, 30, 31, 33 (only),
3) Pre-survey questions 22-28, 33 and 39, (which had equivalent measures in the Post survey),
4) Post-survey equivalents 6, 10, 11, 23, 25, 27, 33.

Specifically, factor reduction to principal components was conducted using the correlational analysis (unrotated) method of extraction and Eigenvalues greater than 1.0. The rotation method was Varimax with a rotated display. Missing cases were replaced by means. A second iteration was completed, omitting any factor loading values less than 0.6. The results were saved as factors. Details are in the tables below:

Table 16. *Pre-Survey Only Factors*

	Component				
	1	2	3	4	5
18_Student_Share_Social	-.118	-.321	.012	.647	.356
21_Student_LevelUp_Games	.106	.002	-.043	.185	.855
31_Student_Learning_Envir3_PerformInClass	.801	-.041	.051	-.064	.102
32_Student_Learning_Envir4_Grades	.640	-.155	.409	-.330	.259
32_Student_Learning_Envir4_Help	.656	.204	.511	-.234	.182
32_Student_Learning_Envir4_Helped	.043	.022	.900	.245	-.085
34_Student_Learning_Pref1_Myself	.034	.858	.155	.078	.253
35_Student_Learning_Pref2_Friends	-.113	-.766	.116	.104	.356
40_Student_Recog_OST	.201	.116	.146	.650	.062
29_Student_Learning_Envir1_Changeable	.833	.033	-.060	.064	.083
29_Student_Learning_Envir1_Variety	.809	.106	.006	-.171	.241
29_Student_Learning_Envir1_Predictable	.787	.032	.295	-.087	-.028
30_Student_Learning_Envir2_Challenging	.849	.090	.109	.308	-.124
30_Student_Learning_Envir2_Discussions	.823	.077	.087	.314	-.105
30_Student_Learning_Envir2_Choice	.839	.126	-.063	.221	-.073

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 8 iterations.

The factorial analysis for the pre-survey (Table 16) initially resulted in 3 factors loading on columns 1, 2 and 4: 1) LE_Pre_Final, 2) LP_Pre_ Final and 3) Share_OST_Pre_ Final. Items loading on columns 3 and 5 in Table 16 were not considered as they have only one high value and hence are not *factors* consisting of multiple items.

Items loading onto LE_Pre_Final are students' perceptions of their learning context. This item split into two factors, LE_Grades_Pre_Final (henceforth, *Learning_Environment_Performance*) and LE_StudentVoice_Pre_Final (henceforth *Learning_Environment_StudentVoice)* when the factor analysis was conducted with only the items loading in column 1 of Table 16. Items loading onto the *Learning_Environment_Performance* factor include:

- a variety of teaching methods are used (Q. 29),
- understanding how they (the students) are performing in a class (Q. 31),
- earning good grades in the class (Q. 32), and
- helping other students in the class (Q. 32).

Table 17. *Learning Environment Performance*

	Component 1
31_Student_Learning_Envir3_PerformInClass	.847
32_Student_Learning_Envir4_Grades	.849
32_Student_Learning_Envir4_Help	.845
29_Student_Learning_Envir1_Variety	.837

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto the *Learning_Environment_StudentVoice* factor are students' perceptions about the classroom culture and instructional methods load onto this factor, specifically preference for learning contexts in which:

- content is *exciting* and *changeable* (Q. 29),
- students know what to expect (Q. 29),
- tasks are challenging (Q. 30),
- students are expected to regularly contribute to discussions (Q. 30), and

- students are permitted to exercise choice in expressing learning by selecting topics or projects (Q. 30).

Table 18. *Learning Environment Student Voice*

	Component 1
29_Student_Learning_Envir1_Changeable	.833
29_Student_Learning_Envir1_Predictable	.791
30_Student_Learning_Envir2_Challenging	.919
30_Student_Learning_Envir2_Discussions	.899
30_Student_Learning_Envir2_Choice	.891

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Factors loading onto LP_Pre_Final (henceforth, *Learning_Preferences*), reflect student preferences in either working alone or with friends. The items have an inverse relationship:

Table 19. *Learning Preferences*

	Component 1
34_Student_Learning_Pref1_Myself	-.836
35_Student_Learning_Pref2_Friends	.836

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Two items loaded onto the fourth factor, Share_OST_Pre_Final (henceforth, *Share_Accomplishments*), the degree students share accomplishments through social media (Q. 18) and the degree students would like out-of-school (OST) learning to be *recognized* in school.

Table 20. *Share Accomplishments*

	Component 1
18_Student_Share_Social	.776
40_Student_Recog_OST	.776

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Table 21. *Post-Survey Only Factors*

	Component						
	1	2	3	4	5	6	7
7_Student_Interest_1_Enjoyed	.168	.060	.877	.014	.089	.173	.067
7_Student_Interest_2_Fun	.267	.136	.876	.104	.058	-.031	.050
7_Student_Interest_3_Interesting	.394	.191	.788	.091	.027	.063	-.100
7_Student_Interest_4_Enjoyable	.339	.219	.748	.238	.099	-.113	.006
9_Student_Perceived_Comp_1_Satisfied	.770	.154	.250	.216	.271	.110	.034
9_Student_Perceived_Comp_2_Skilled	.831	.133	.285	.128	.080	.052	.029
13_Student_Perceived_Comp_1_Good	.748	.155	.283	.029	.019	.319	.028
13_Student_Perceived_Comp_2_Compare	.834	.010	.294	.152	-.085	.075	.185
13_Student_Perceived_Comp_3_Competent	.653	.412	.356	.343	.063	.019	.064
15_Student_Learning_Behaviors1	.121	.179	-.095	.108	.099	.818	.192
21_Student_Share_Badges_1_Spoke	.215	.786	.187	.005	.052	.353	-.133
21_Student_Share_Badges_2_Friends	.199	.799	.147	.062	.051	.255	.127
21_Student_Share_Badges_3_Display	.186	.889	.074	.153	.078	.013	-.031
21_Student_Share_Badges_4_Online	.059	.911	.043	.014	.011	-.036	.071
22_Student_Choice_1_Choice	.286	.226	.002	.732	.170	.143	-.113
22_Student_Choice_2_Want	.098	.025	.153	.825	-.007	.064	.132
22_Student_Choice_3_dbchoice	.590	.233	-.019	.488	.330	-.003	-.075
22_Student_Choice_4_dbprogram	.155	.037	.144	.860	.137	.083	.114
26_Student_Badge_Setup2	.198	-.130	-.172	.127	.695	.089	.453
27_Student_Teacher_Taught	.144	.106	.094	.092	.785	.002	.069
28_Student_DB_Again	.103	.045	-.055	.077	.106	-.060	.870
30_Student_OST_Learning2	.004	.209	.166	.032	.141	.319	.611
33_Student_Learn_Other	-.043	-.077	.193	.098	.857	.101	.019
18_Student_Learning_Envir4_Post_1_Badges	.365	-.006	.326	.293	.062	.614	-.104
18_Student_Learning_Envir4_Post_3_Help	.012	.808	.149	.114	-.203	-.099	.185

The factorial analysis for the post-survey (Table 21) resulted in 7 factors: 1) PC_Post_Final, 2) SB_Post_Final, 3) Interest_Post_Final, 4) SC_Post_ Final, 5) Badge_Learn_Post_Final 6) Badge_Value_Post_Final and 7) Badge_OST_Post_ Final.

Factors loading onto the first factor, PC_Post_Final (henceforth, *Perceived_Competence*), concern students' perceptions of their performance in the context of the digital badging program:

- level of satisfaction with their performance in the activity (Q. 9),
- perceptions that they are *pretty skilled* in the activity (Q. 9),
- perceptions that they are *pretty good* in the activity (Q. 13),
- perceptions that they performed *pretty well compared to other students* in the activity (Q. 13),
- perceptions that they felt *pretty competent* in the activity after working at it for a while (Q. 13), and
- perceptions that the badge program provided students with a *lot of choice about what I could do to show my learning* (Q. 22).

Table 22. *Perceived Competence*

	Component 1
9_Student_Perceived_Comp_1_Satisfied	.898
9_Student_Perceived_Comp_2_Skilled	.894
13_Student_Perceived_Comp_1_Good	.828
13_Student_Perceived_Comp_2_Compare	.860
13_Student_Perceived_Comp_3_Competent	.877
22_Student_Choice_3_dbchoice	.725

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 2, SB_Post_Final (henceforth, *Sharing_Behaviors*), relate to students' behaviors regarding the digital badges they earned. All four survey items measuring badge-related activities (Q. 21) loaded onto the factor, as well as students who helped others with their work:

- *spoke about* their badges,
- *asked about friends' progress* and if they had *earned any digital badges*,
- *displayed or showed* badges to *other people,*
- *would like to display badges online* but didn't know how, and
- helped others who were *having trouble with the work (Q. 18).*

Table 23. *Sharing Behaviors*

	Component 1
21_Student_Share_Badges_1_Spoke	.853
21_Student_Share_Badges_2_Friends	.868
21_Student_Share_Badges_3_Display	.923
21_Student_Share_Badges_4_Online	.894
18_Student_Learning_Envir4_Post_3_Help	.806

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 3, Interest_Post_Final (henceforth, *Interest_Activity*), describe students' interest in the badge program activity. All four items (Q. 7) loaded onto the factor with high values, students who:

- *enjoyed the activity very much,*
- describe the activity *as fun to do,*
- describe the activity *as very interesting, and*
- describe the activity *quite enjoyable.*

Table 24. *Interest Activity*

	Component 1
7_Student_Interest_1_Enjoyed	.875
7_Student_Interest_2_Fun	.944
7_Student_Interest_3_Interesting	.919
7_Student_Interest_4_Enjoyable	.887

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 4, SC_Post_Final (henceforth, *Student_Choice*), relate to students' perceptions about choice in regard to participating in the program activity. A subsequent factor analysis loaded all four of the question items onto the factor (Q. 22), including an item which a low but substantial Eigenvalue of .488. The items loading onto this factor are the students' perceptions:

- *of choice about participation,*
- *they had choice in learning product,*
- participated in the activity *because I wanted to, and*
- participated in the badge activity *because I wanted to.*

Table 25. *Student Choice*

	Component 1
22_Student_Choice_1_Choice	.849
22_Student_Choice_2_Want	.823
22_Student_Choice_4_dbprogram	.902

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 5, Badge_Learn_Post_Final (henceforth, *Badge_Instruction*), describe student perceptions about the use of digital badges for learning and teacher instruction. The items loading onto this factor are the students' beliefs that:

- the badge setup (learning targets, tasks or criteria) *helped me to learn the subject well (Q. 26),*
- *the teacher taught differently* using the digital badges (Q. 27), and
- they would like to know *more about digital badges for learning in any subject, in or out-of-school* (Q. 33).

Table 26. *Badge Instruction*

	Component 1
26_Student_Badge_Setup2	.818
27_Student_Teacher_Taught	.817
33_Student_Learn_Other	.839

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 6, Badge_Value_Post_Final (henceforth, *Badge_Value*), describe student perceptions about the importance of digital badges in the program, and their behaviors referring to criteria for planning. The items loading onto this factor are the students' beliefs that:

- *in the digital badge program, it is important to earn badges* (Q. 18), and
- *I looked at the digital badge task lists to help me plan what I had to do to complete assignments* (Q. 15).

Table 27. *Badge Value*

	Component 1
15_Student_Learning_Behaviors1	.838
18_Student_Learning_Envir4_Post_1_Badges	.838

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Items loading onto factor 7, Badge_OST_Final (henceforth, *Badge_Again*), describe student perceptions about the importance of digital badges in the program and their behaviors referring to criteria for planning. The items loading onto this factor are the students' beliefs that:

- they would like *to use digital badges for learning again* (Q. 28), and that
- they were able to incorporate *knowledge, skills or ways of thinking they learned out-of-school* to earn digital badge in the program (Q. 30).

Table 28. *Badge Again*

	Component 1
28_Student_DB_Again	.815
30_Student_OST_Learning2	.815

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Table 29. *Factors of Pre-Measures with Post- Equivalents*

	Component				
	1	2	3	4	5
22_Student_SE1_Master	.091	.114	.779	.294	-.028
22_Student_SE1_Figure	.351	.125	.748	.209	-.109
22_Student_SE1_Hard	.445	.312	.620	.083	-.079
22_Student_SE1_Diffcult	.334	.106	.715	.162	-.082
23_Student_SE2_Good	.110	.408	.750	.153	.170
23_Student_SE2_Understand	.083	.275	.814	.168	.075
23_Student_SE2_Learn	.285	.262	.749	.234	.017
23_Student_SE2_Grades	.663	.066	.474	.031	.124
24_Student_Task_Value1_Daily	.081	.808	.250	.059	.116
24_Student_Task_Value1_Interesting	.279	.722	.148	.211	.093
24_Student_Task_Value1_Useful	.202	.785	.302	.105	.100
24_Student_Task_Value1_Helpful	.292	.815	.154	.039	.114
25_Student_Task_Value2_Relevant	.117	.774	.214	.119	.027
25_Student_Task_Value2_Practical	.163	.830	.194	.099	.160

25_Student_Task_Value2_Curiosity	.172	.824	.017	.072	.117
26_Student_Self_Reg1_Uninteresting	.764	.264	.216	.172	.106
26_Student_Self_Reg1_Hard	.738	.332	.128	.223	-.041
26_Student_Self_Reg1_Concentrate	.782	.295	.077	.174	-.012
27_Student_Self_Reg2_OnTime	.871	.051	.216	.198	.104
27_Student_Self_Reg2_GiveUp	.759	.192	.253	.330	.131
27_Student_Self_Reg2_Concentrate	.853	.180	.153	.284	.052
27_Student_Self_Reg2_Finish	.888	.170	.196	.129	.038
28_Student_Goal_Orient1_Skills	.356	.176	.362	.634	.044
33_Student_Goal_Orient2_Learn	.413	.083	.094	.724	.029
33_Student_Goal_Orient2_Knowledge	.283	.229	.194	.781	.098
33_Student_Goal_Orient2_Skills	.174	.223	.286	.816	.101
33_Student_Goal_Orient2_Understand	.159	-.013	.257	.852	-.050
39_Student_Recog_Pref_Friends	.141	.165	.033	-.075	.843
39_Student_Recog_Pref_Teachers	.007	.150	.099	.087	.843
39_Student_Recog_Pref_Adults	-.005	-.021	.033	.208	.866
39_Student_Recog_Pref_Online	.105	.240	-.214	-.084	.633

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 7 iterations.

The factorial analysis for the pre-survey items with post-survey measures (Table 29) resulted in 5 factors: 1) SR_Pre_2, 2) TV_Pre_2, 3) SE_Pre_2, 4) LG_Pre_2, 5) Rec_Pre_2. The composition of these factors is aligned with the constructs of the SALES items, with some items being eliminated. The items which describe students' wish to be recognized cluster together. Additional details follow:

Items loading onto the first factor, SR_Pre_2 (henceforth, *Self_Regulation_Pre*) reflect students' responses to questions about their self-regulatory and persistence in learning behaviors as self-reported in the pre-survey in *science, math, design-like or similar subjects.* In addition, students' belief about the grades they will earn loaded onto this factor. Items loading onto this factor include students':

- Persistence in working when *tasks are uninteresting* (Q. 26),
- Persistence in working hard when *I do not like what I am doing* (Q. 26),
- *Concentrating* to *not miss important points* (Q. 26),
- Finishing *work and assignments on time* (Q. 27),
- Persistence *even when the work is difficult* (Q. 27),
- *Concentrating in class or in the program* (Q. 27),
- Persistence in working until the tasks are completed *(Q. 27), and*
- Belief that they *will receive good grades (Q. 23).*

Table 30. *Self-regulation (Pre)*

	Component 1
23_Student_SE2_Grades	.758
26_Student_Self_Reg1_Uninteresting	.860
26_Student_Self_Reg1_Hard	.830
26_Student_Self_Reg1_Concentrate	.847
27_Student_Self_Reg2_OnTime	.913
27_Student_Self_Reg2_GiveUp	.883

27_Student_Self_Reg2_Concentrate	.924
27_Student_Self_Reg2_Finish	.928

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 2, TV_Pre_2, (henceforth, *Task_Value_Pre*) describe student beliefs about *science*, *math*, *design-like or similar subjects* they learn in school (Q. 24 and Q. 25). Items loading onto the factor, reflect students' beliefs about what they learn is:

- *Use in daily life (Q. 24),*
- *Interesting (Q. 24),*
- *Useful for me to know (Q. 24),*
- *Helpful for me to know (Q. 24),*
- *Relevant to me (Q. 25),*
- *Practical value (Q. 25),*
- *Satisfies my curiosity (Q. 25), and*
- *Encourages me to think (Q. 25).*

Table 31. *Task Value (Pre)*

	Component 1
24_Student_Task_Value1_Daily	.854
24_Student_Task_Value1_Interesting	.824
24_Student_Task_Value1_Useful	.877
24_Student_Task_Value1_Helpful	.882
25_Student_Task_Value2_Relevant	.806
25_Student_Task_Value2_Practical	.879
25_Student_Task_Value2_Curiosity	.836

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 3, SE_Pre_2, (henceforth, *Self_Efficacy_Pre*) describe student beliefs about their performance in math and science they learn at school (Q. 22). Items loading onto the factor, reflect students' beliefs about their abilities or performance:

- *Master the skills taught (Q. 22),*
- *Figure out how to do difficult work (Q. 22),*
- *Even if the work is hard, I can learn it (Q. 22),*
- *Complete difficult work (Q. 22),*
- *I am good at these subjects (Q. 23),*
- *Understand the content taught (Q. 23), and*
- *Learn the work we do (Q. 23).*

Table 32. *Self-efficacy (Pre)*

	Component 1
22_Student_SE1_Master	.814
22_Student_SE1_Figure	.874
22_Student_SE1_Hard	.809
22_Student_SE1_Diffcult	.795
23_Student_SE2_Good	.841
23_Student_SE2_Understand	.855
23_Student_SE2_Learn	.865

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 4, LG_Pre_2, (henceforth, *Learning Goals_Pre*) describe student learning goals in learning *science, math, design-like or similar subjects.* The items loading onto this factor are goals to :

- importance to *improve skills* (Q. 28),
- quantity of learning (*as much as I can*) (Q. 33),

- learn *new knowledge* (Q. 33),
- master new skills (Q. 33), and
- importance of *understanding my work (Q. 33).*

Table 33. *Learning Goals (Pre)*

	Component 1
28_Student_Goal_Orient1_Skills	.821
33_Student_Goal_Orient2_Learn	.832
33_Student_Goal_Orient2_Knowledge	.887
33_Student_Goal_Orient2_Skills	.907
33_Student_Goal_Orient2_Understand	.863

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 5, Rec_Pre_2, (henceforth, *Recognition_Pre*) describe student tendencies to work harder if recognized by various groups (Q. 39, below). All of the responses except parents/family loaded onto the factor :

- *friends,*
- *teachers,*
- *adult group leaders* (e.g. after-school, sports), and
- *online groups.*

Table 34. *Recognition (Pre)*

	Component 1
39_Student_Recog_Pref_Friends	.870
39_Student_Recog_Pref_Teachers	.859
39_Student_Recog_Pref_Teachers	.854
39_Student_Recog_Pref_Online	.677

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Table 35. *Factors of Post Measures with Pre Equivalents*

	Component				
	1	2	3	4	5
6_Student_SE1_Post_1_Skills	.460	.316	.631	.053	.169
6_Student_SE1_Post_2_Difficult	.167	.188	.861	.120	.183
6_Student_SE1_Post_3_Hard	.280	.034	.855	.041	-.073
6_Student_SE1_Post_4_Try	.061	.234	.816	.188	-.008
10_Student_SR1_Post_1_Uninteresting	.807	.377	.135	.174	-.096
10_Student_SR1_Post_2_Like	.857	.222	.077	.114	.064
10_Student_SR1_Post_3_Better	.811	.147	.197	.198	-.030
10_Student_SR1_Post_4_Concentrated	.782	.354	.163	.106	-.025
11_Student_TaskValue2_Post_1_Relevant	.006	.002	.001	.732	.142
11_Student_TaskValue2_Post_2_Practical	.080	.184	.105	.814	.100
11_Student_TaskValue2_Post_3_Curiosity	.162	.137	.117	.867	.029
11_Student_TaskValue2_Post_4_Think	.203	.192	.153	.795	.025
17_:Student_Goal_Orient2_Post_4_Understood	.688	.418	.292	.147	-.011
18_Student_Learning_Envir4_Post_1_Badges	.668	.240	.209	-.017	.218
18_Student_Learning_Envir4_Post_2_Helped	.273	.325	.229	.134	.738
18_Student_Learning_Envir4_Post_3_Help	-.130	-.125	-.027	.187	.886
23_Student_SE2_Post_1_Good	.260	.731	.322	.153	.148
23_Student_SE2_Post_3_Learn	.587	.631	.128	.073	.034
23_Student_SE2_Post_4_Grades	.447	.703	.183	-.028	-.111
29_Student_SR2_Post_1_Finished	.145	.848	.136	.269	.156
29_Student_SR2_Post_2_GiveUp	.471	.752	.124	.000	-.075
29_Student_SR2_Post_3_Concentrated Class	.322	.845	-.012	.237	.012
29_Student_SR2_Post_4_Kept	.246	.822	.259	.154	.028

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

The factorial analysis for the post-survey items with pre-survey measure (Table 35) resulted in 5 factors: 1) SR_Post_2a_Final, 2) SR_Post_2bSE_Final, 3) SE_Post_Final, 4) TV_Post_Final, 5) Collab_Post. The post measures items clustered into factors differently than the pre-measures factors.

Items loading onto the first factor, SR_Post_2a_Final, (henceforth, *Self_RegulationA_Post*) reflect students' self-regulatory and persistence in learning behaviors as self-reported in the *digital badge program.* In addition, students' belief about the importance of understanding the work and earning badges in the program loaded onto this factor:

- persistence in working when *tasks are uninteresting* (Q. 10),
- persistence in working hard when *I do not like what I am doing (Q.10),*
- *concentrating* to *not miss important points (Q.10),*
- persistence when there *are better things to do (Q.10),*
- importance that *I understood my work* (Q. 17,) and the
- importance of earning *badges in the badge program* (Q. 18).

Table 36. *Self-RegulationA (Post)*

	Component 1
10_Student_SR1_Post_1_Uninteresting	.918
10_Student_SR1_Post_2_Like	.882
10_Student_SR1_Post_3_Better	.854
10_Student_SR1_Post_4_Concentrated	.880
17_:Student_Goal_Orient2_Post_4_Understood	.845
18_Student_Learning_Envir4_Post_1_Badges	.742

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 2, SR_Post_2b_Final (henceforth, *Self-RegulationB_with Self-efficacy_Post*), describe students' self-regulatory learning behaviors regarding in the digital program as well as measures of self-efficacy about their performance:

- *I am good at these subjects (Q. 23),*
- *I can understand the content taught (Q. 23),*
- *I will receive good grades (Q. 23),*
- finishing *work and assignments on time* (Q. 29),
- persistence *even when the work is difficult* (Q. 29) ,
- *concentrating in class or in the program* (Q. 29), and
- persistence in working until the tasks are completed *(Q. 29).*

Table 37. *Self-regulationB with Self-efficacy (Post)*

	Component 1
23_Student_SE2_Post_1_Good	.845
23_Student_SE2_Post_3_Learn	.831
23_Student_SE2_Post_4_Grades	.842
29_Student_SR2_Post_1_Finished	.864
29_Student_SR2_Post_2_GiveUp	.880
29_Student_SR2_Post_3_ConcentratedClass	.910
29_Student_SR2_Post_4_Kept	.885

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 3, SE_Post_Final (henceforth, *Self_Efficacy2_Post*), relate to student self-efficacy beliefs about their performance in the badge program. Specifically, items loading onto this factor are measures of self-efficacy that did not load onto the Self-RegulationB_with_Self_Efficacy_Post factor:

- *master the skills taught (Q. 22),*

- *figure out how to do difficult work (Q. 22),*
- *even if the work is hard, I can learn it (Q. 22),and*
- *I can complete difficult work (Q. 22).*

Table 38. *Self_efficacy2 (Post)*

	Component 1
6_Student_SE1_Post_1_Skills	.837
6_Student_SE1_Post_2_Difficult	.921
6_Student_SE1_Post_3_Hard	.871
6_Student_SE1_Post_4_Try	.844

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 4, TV_Post_Final (henceforth, *Task_Value_Post*), relate to student beliefs about the value of activities in the digital badge program:

- *relevant to me (Q. 25),*
- *practical value (Q. 25),*
- *satisfies my curiosity (Q. 25), and*
- *encourages me to think (Q. 25).*

Table 39. *Task Value (Post-)*

	Component 1
11_Student_TaskValue2_Post_1_Relevant	.716
11_Student_TaskValue2_Post_2_Practical	.863
11_Student_TaskValue2_Post_3_Curiosity	.900
11_Student_TaskValue2_Post_4_Think	.857

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Items loading onto factor 5, Collab_Post_Final (henceforth, *Collaboration_Post*), relate to students' collaborative activities in the badge program (Q. 18):

- *I helped other students, and*
- *I got help from other students.*

Table 40. *Collaboration (Post)*

	Component 1
18_Student_Learning_Envir4_Post_2_Helped	.860
18_Student_Learning_Envir4_Post_3_Help	.860

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Regression Analysis

Backward, multiple linear regression analyses were conducted to evaluate which, if any, of the pre-survey independent variables (IV) were predictors for post-dependent variables (DV). The following results were significant:

Table 41. *Self-Efficacy (Post DV)*

Variable	B	Std. Error	β
(Constant)	-1.030	.303	
Student_Texts (Q. 11)	.108	.048	.244*
Student_Program (Q. 8)	.309	.132	.257*
SR_Pre_Final	.300	.107	.298**

a. Dependent Variable: SE_Post_Final
b. $F(3, 66) = 7.405$, $p < .001$
c. Adjusted $R^2 = .218$, $R = .502$, * $p < .05$, ** $p < .01$

The pre-survey measures of Student_Texts, Student_Program and SR_Pre_Final independent variables are predictors (Table 41) for the dependent variable SE_Post_Final. The combined effect accounts for 21.8% of the variance, and has a moderate effect of R = .502. This result suggests that the measures of self-regulation, frequency of text messaging, and the student program affected the self-efficacy measures in the post survey.

Table 42. *Badge Learn Post Final (DV)*

Variable	B	Std. Error	β
(Constant)	.426	.227	
LE_StudentVoice_Pre_Final	.341	.168	.339*
Student_Texts (Q. 11)	-.113	.052	-.255*
SHARE_OST_Pre_Final	-.290	.129	-.290*
SE_Pre_Final	-.444	.170	-.441*

a. Dependent Variable: Badge_Learn_Post_Final
b. $F(4, 65) = 2.889$, $p < .05$
c. Adjusted $R^2 = .099$, $R = .389$, * $p < .05$

The pre-survey measures of LE_StudentVoice_Pre_Final , Student_Texts, Share_OST, and SE_Pre_Final independent variables are predictors (Table 42) for the dependent variable, Badge_Learn_Post_Final. The combined effect accounts for 9.9% of the variance, and has a small, moderate effect of R = .389. This result suggests the pre-survey measures of students' self-efficacy, frequency of text messaging, sharing of accomplishments and beliefs that out-of-school learning should *count,* are predictors for the attitudes of students about the digital badge learning experience as measured in the post survey. Specifically, the measures impacted were: 1) the badge *set-up* was helpful in learning, 2) teachers taught differently in the program and 3) interest in learning about other badge learning opportunities. Of interest, three of the predictors are negative, indicating an inverse relationship.

The results of a linear regression indicate that the *Share_OST* pre survey factor is a predictor of the *Badge Again* post-survey factor (Badge_OST_Post_Final). In other words, the degree to which 1) students share school accomplishments online and 2) would like out-of-school (OST) learning recognized is a predictor for the degree students 1) would like to use digital badges for learning again, and 2) belief that in the digital badge program, they were able to use skills learned OST, $F (1, 68) = 6.033$, $p < .05$. The unstandardized slope (.285) and the standardized slope (.285) are significantly different to 0 ($p < .05$). For every unit increase in the Share_OST_Pre_Final factor, the Badge_OST_Post_Final factor increased by 0.285. The adjusted R^2 value of .068 indicates that 6.8% of the variance is accounted for by the predictor variable. $R = .285$ indicates a small effect.

The results of a linear regression indicate that the *SR_Pre_Final* pre survey factor is a predictor of the *SC_Post_Final* post-survey factor. In other words, the degree of self-reported self-regulatory learning behaviors is a predictor for the degree students believed they had choice in the participation and learning products in the digital badge program, $F (1, 68) = 5.150$, $p < .05$. The unstandardized slope (.267) and the standardized slope (.265) are significantly different to 0, ($p < .05$). For every unit increase in the SR_Pre_Final factor, the SC_Post_Final factor increased 0.267. The adjusted R^2 value of .057 indicates that 5.7% of the variance is accounted for by the predictor variable. $R = .265$ indicates a small effect.

Post-Independent and Post-Dependent Variable Regressions

Select post-survey items, measures which may have changed during the process of the badge intervention, were also analyzed with backward, multiple linear regression.

Table 43. *Perceived Competence (Post)*

	B	Std. Error	β
(Constant)	3.526E-16	.076	
SR_Post_2a_Final	.252	.117	.252*

SR_Post_2b_Final	.286	.117	.286*
SB_Post_Final	.259	.083	.259**
Interest_Post_Final	.274	.095	.274**

a. Dependent Variable: PC_Post_Final

b. F (4, 65) = 25.467, p < .001

c. Adjusted R^2 = .587, R = .781, * p < .05, ** p < .01

The post-survey measures of SR_Post_2a_Final, SR_Post_2b_Final, SB_Post_Final and Interest_Post_final independent variables are predictors (Table 43) for the dependent variable, PC_Post_Final. The combined effect accounts for 58.7% of the variance, and has a large effect of R = .781. This result suggests the post-survey measures of students' self-regulation, some measures of self-efficacy and badge sharing behaviors and interest in the badge activity independent variables are predictors for the perceived competence of student participants.

Table 44. *Badge Value (Post DV)*

Variable	B	Std. Error	β
(Constant)	.992	.339	
2_Student_Teacher_Code_Post	-.575	.190	-.259**
SB_Post_Final	.242	.085	.242**
SR_Post_2a_Final	.586	.086	.586***

a. Dependent Variable: Badge_Value_Post_Final

b. F (3, 66) = 24.702, p < .001

c. Adjusted R^2 = .511, R = .730, ** p < .01, *** p < 0.001

The post-survey measures of SB_Post_Final, SR_Post_2a_Final and Student_Teacher_Code_Post are predictors (Table 44) for the dependent variable, Badge_Value_Post_Final. The combined effect accounts for 51.1% of the variance, and has a large effect of R = .730. This result suggests a differential in value, by teacher, which came about during the badge program itself. In addition, student badge sharing behaviors as well as self-regulatory behaviors and select self-efficacy beliefs influenced the value of the digital badge for student participants.

Table 45. *Student Perceived Choice (Post DV)*

Variable	B	Std. Error	β
(Constant)	2.684E-16	.092	
Collab_Final	.236	.096	.236*
SR_Post_2b_Final	.546	.096	.546***

a. Dependent Variable: SC_Post_Final
b. F (2, 67) = 23.822, $p < .001$
c. Adjusted $R^2 = .398$, $R = .645$, * $p < .05$, *** $p < .001$

The post-survey measures of SR_Post_2b_Final and Collab_Final are predictors (Table 45) for the dependent variable, SC_Post_Final. The combined effect accounts for 39.8% of the variance, and has a moderately large effect of R = .645. This result suggests student collaborative and self-regulatory behaviors are influenced by the degree of choice in participation in the activity and learning products.

Table 46. *Badge Learn (Post DV)*

Variable	B	Std. Error	β
(Constant)	-1.858	.519	
6_Student_SE1_Post_1_Skills	.085	.041	.339*
6_Student_SE1_Post_2_Difficult	-.076	.038	-.324*[A]
23_Student_SE2_Post_1_Good	.103	.034	-.396**

a. Dependent Variable: Badge_Learn_Post_Final
b. F (3, 66) = 2.6.417, p < .001
c. Adjusted R^2 = .191, R = .475, *A p < .052, ' * p < .05, ** p<.01

A backward regression analysis was conducted on all of the self-efficacy items individually, in the pre- and post-survey with the dependent variable of Badge_Learn_Post_Final . None of the pre-survey items were predictors, but the post-survey measures of SE1_Post_Skills, SE1_Post_Difficult and SE2_Post_Good are predictors (Table 46) for the dependent variable. The combined effect accounts for 19.1% of the variance, and has a moderate effect of R = .475. The self-efficacy measures are specific, and apparently focused upon the task than other, more general items about self-efficacy. For example:

- Q. 6 SE1_Skills_Post, *I can master the skills that are taught*,
- Q. 6 SE1_Difficult_Post, *I can figure out how to do difficult work* and
- Q. 23 SE2_Good_Post, *I am good at these subjects*.

This result suggests students who felt positively about the learning in the digital badge program experienced growth in aspects of self-efficacy, particularly in being able to complete difficult work.

The results of a linear regression indicate that the *gender* is a predictor of the *SR_Post_2a_Final* post-survey factor. In other words, the degree to which 1) persisted, 2) believed earning badges and performing well in the program were important was predicted by gender, F (1, 68) = 10.063, p < .01. The unstandardized slope (-.718) and the standardized slope (-.359) are significantly different to 0, (t = -3.172, df = 1, p < .01). For every unit increase in the Gender variable (0=girls, 1=boys), the SR_Post_2a_Final factor will decrease 0.718 (meaning boys score). The adjusted R^2 value of .116 indicates that 11.6% of the variance is accounted for by the gender differences. The R = .359 indicates a moderately small effect.

The results of a linear regression indicate that the *Badge_OST* post-survey factor is a predictor of the *Badge_Learn_Post_Final*. In other words, student beliefs that they could incorporate out-of-school learning in the digital badge program and interest in using digital badges for learning again is a predictor for the degree students 1) would like to use digital badges for learning again, 2) belief that the badge setup was helpful to their learning and 3) would like to learn more about digital badges for learning in other subjects, $F(1, 68) = 4.036$, $p < .05$. The unstandardized slope (.340) and the standardized slope (.340) are significantly different to 0. For every unit increase in the Badge_OST factor, the Badge_Learn_Post_Final factor increased by 0.340. The adjusted R^2 value of .056 indicates that 5.6% of the variance is accounted for by the predictor variable. R = .237 indicates a small effect.

Chapter 5: Qualitative Data Results and Findings

This chapter presents an analysis of qualitative data collected for the study. Qualitative data were used for confirmatory analysis and to generate emergent theory about the use of digital badges in similar contexts. Furthermore, qualitative data provided additional insights into instructional and assessment practices, and it also described the processes of implementation. These insights are harder to capture using quantitative data alone.

Qualitative data were collected through comments on student surveys and open-text questions in order to learn more about participants' attitudes and perceptions pertaining to the experience. After the completion of the digital badge intervention, a follow-up interview was conducted during a focus group with teachers. This provided additional information about the processes of program implementation, digital badge use, and teacher observations.

Although teacher pre- and post-program surveys were developed, the small sample size (n=2) precluded meaningful quantitative analysis. Data collected from the surveys were reported as descriptive data in the Educator Pre and Post section below.

Educator Pre- Survey Data: Descriptive Statistics

The small sample size of teachers participating in the study to its completion (n=2) precluded the use of statistical analysis.

Teacher A and Teacher B were both at the beginning of their teaching careers, with 1-2 years of experience. They were "29 or less." Both teachers ranked "school" as the top choice to access the Internet for professional practice. Teacher B reported using the Internet for 61-120 minutes daily for professional use, and a similar time for personal use. Teacher A reported use of 121-180 minutes daily use of the Internet for professional use, and 30-60 minutes for personal use. Top ranking recreational uses were "using digital media, social media, and email," and "email, research, and social media," respectively. Both teachers' top ranked information seeking behavior (for professional practice) was to "look it up online." Teacher A participated daily in online courses for professional development, whereas Teacher B commented "I hate online classes."

Teachers ranked the ways "the school or program leader currently supports the integration of technology." The items "encourage innovative ideas, modelling technology use, and resource allocation" were the top three ranked for both teachers, in a slightly different order. Teachers' responses differed, however, when asked how the "school or program leader currently promotes technology use in the building." Teacher B's top ranked response was "provide time for planning," whereas that was Teacher A's 5th ranked response. Similarly, Teacher A's top ranked response, "facilitate collaboration among the staff" was Teacher B's fifth ranked response.

When asked about instructional supports the teachers would like for technology integration for teaching and learning, the responses again differed considerably; Teacher B's top ranked response, "resource allocation," was Teacher A's fourth ranked response. The perceptions of school leaders' priorities for technology use within the building also differed substantially; Teacher B's top ranked response was "student assessment," which was Teacher A's fifth ranked response. "Record keeping" and "differentiation of instruction" were ranked second and third (Teacher B), but reversed for Teacher A. Use of technology for "teaching and learning" was Teacher B's fourth ranked response, and Teacher A's eleventh ranked.

Teachers' beliefs regarding student-level factors which were most important in learning differed greatly, although both were in agreement of the importance of student engagement (Teacher B, No. 1 rank, Teacher A, No. 2 rank). "Recognition of effort" was ranked eighth by both teachers, and students' "interest in the subject matter" was ranked thirteenth and fourteenth by Teachers B and Teacher A, respectively.

There was agreement that the most important teacher level factors (Q. 26) were "attitude, teacher-student relationships, and caring." Although the order differed slightly, these responses were ranked in each respondent's top three ranked items. Of particular interest, "intrinsic motivation" was ranked sixth and seventh, and "teacher knowledge of content" ranked ninth and eighth by Teachers B and A respectively.

When asked which kind of classroom level factors impacted learning most, both teachers agreed on the top ranked item of "adequate behavioral management." "Formative assessment" was ranked fourth (Teacher B), and third (Teacher A), and perceived as more impactful than "summative assessment," which ranked lower. Both teachers ranked "administrative support in the classroom" as seventh. In response to a question about impactful pedagogies, both teachers ranked "direct instruction" as the lowest ranked item. "Interest or student/youth driven learning" ranked third (Teacher B), and second (Teacher A).

In response to a question about responsibility for learning, Teacher B chose "agree" to the statement that "Teachers can only do so much; students should take ownership of their own learning to succeed." Teacher A "disagreed" and commented "It is part of a teacher's responsibility to motivate students to take ownership of their learning. Some students do this naturally, but for others that do not we must create an environment that intrinsically motivates them to care."

Teacher B required students to take part in the project assigned for the digital badge program. Teacher A made the program available and encouraged participation, but she made it optional. Both teachers agreed that digital badges could be a "useful tool for professional goal setting."

Teacher A engaged students in the digital badge program periodically (approximately 30 minutes a week) over the course of six weeks. Teacher B ran the program over the course of 3 weeks, for 180-240 minutes per week.

Teacher A responded 15 on a scale of 20 (Teacher B responded 12/ 20). when asked if the badges lead to mastery of the material, and Teacher A observed: "The classes where I allowed time in class and designed the project with them were more effective. The students that were working independently in creating their own projects struggled more." In addition, Teacher A responded: "The program helped incentivize some students that normally would not have been interested in completing the activities." The teachers responded that the digital badges "could be a valid measurement of learning higher-order thinking skills for my students" (20 and 15, respectively).

Although their experience with the digital badge program was positive, the teachers were not optimistic about other teachers' participation. Teacher A commented: "Some teachers are very on board with integrating technology and trying new strategies, but they are the minority at the school. Most do not implement anything unless it is required," and "Many teachers would not want to add this to their curriculum because it adds another level of difficulty to their already busy planning time."

When the teachers were asked if the digital badges increased student understanding of the learning objectives, Teacher A responded 15 on a scale of 20.Teacher B responded 9. When asked how likely it was that they would use digital badges again, they responded 20 (B) and 14 (A) on a scale of 20. Teacher B remarked*: "I would like to change the assignment a little because I now have an idea how it works. I think this would be an excellent idea for 11th grade students. I could have an out- of- school assignment that spans across months."*

Both teachers indicated that they used the digital badges *"As summative feedback* ***of*** *learning (to measure understanding)."* (Since completing this survey both teachers have asked to use the materials again for next year, moving to the Edmodo platform.)

When asked about instructional practices for the digital badge program, Teacher A responded "slight modifications," whereas Teacher B implemented "a completely new approach." The teachers elaborated upon their pedagogical approaches: "Increased emphasis on the students being original and creative, and using problem solving to come up with their own solutions, vs. simply demonstrating a learned procedure*"* (A) and "I had very little direct instruction for this assignment. I expected the students to work at their own pace and level" (B).

"I think staff would be resistant [sic] to trying something new without being forced*"* (A). Teachers differed in the kinds of supports they thought would be needed from administrators to implement a wide scale digital badge program throughout the building. For example, Teacher A's top ranked answer was "*technology-related* professional development," which was Teacher B's eleventh ranked item. Of interest, both teachers ranked the response "I don't think a wide scale implementation would work for my building" as 12th out of 13 options.

Teacher response to Q. 20 " *To successfully implement a digital badge intervention, in your opinion, which teacher/group leader level factors would be most impactful in student or youth learning*" were particularly interesting (Figure 14 and Figure 15). This question was a variant of the important "teacher/group level factors" which appeared in the Educator pre-program survey, where teachers' responses were more aligned. Factors valued in the pre-program survey were ranked differently in this variant (Q. 26 referenced above).

1. technology or technical knowledge
2. other
3. additional training on digital badge technologies
4. attitude (teacher)
5. ability to effectively manage the classroom
6. teacher-student relationships
7. teacher- administrator relationships
8. high expectations
9. understanding of performance-based assessment
10. caring
11. knowledge of content/subject
12. persistence at task
13. intrinsic motivation (from within, such as challenge, cooperation)
14. extrinsic rewards (incentives, pay structure)

Figure 14. Teacher A response to Q. 20 in the post survey

1. high expectations
2. ability to effectively manage the classroom
3. attitude (teacher)
4. teacher-student relationships
5. understanding of performance-based assessment
6. persistence at task
7. caring
8. extrinsic rewards (incentives, pay structure)
9. intrinsic motivation (from within, such as challenge, cooperation)
10. technology or technical knowledge
11. knowledge of content/subject
12. additional training on digital badge technologies
13. teacher- administrator relationships
14. other

Figure 15. Teacher B response to Q. 20 in the post survey

Teachers' responses regarding pedagogies suitable for a digital badge program were more aligned. Each teacher ranked "use of technology for instruction, problem-based or inquiry learning, or experiential learning" within the top three choices (in slightly different order).

Asked if digital badges "may be an effective way to support, assess, and communicate learning" Teacher A strongly agreed, and Teacher B agreed. They commented, respectively: "Allows for more student intrest [sic] and student choice" and "Kids like to learn at their own pace. They also like to pick the topics that they are learning about."

Teachers ranked "Authorized the program" as the top ranked choice for the ways administrators supported the implementation of this program. They both indicated an interest in earning digital badges for use in professional environments, and to communicate their skill sets to "administrators, colleagues, parents, and other interested audiences." Additional comments included: "Thank you for the opportunity to participate" (Teacher A), and "I think this program has a lot of potential. Individual teachers need to work with it and make it their own." A suggestion for improvement: "I would allocate more in class support and provide student samples in the future to guide student participation."

Using Digital Badges: Students

Repeatedly, student participants were afforded opportunities to add comments in both the pre- and post- survey questionnaires. Two open-text questions were included in the post-program survey, specifically to elicit students' ideas and opinions about learning with digital badges. The first question was conceived as a query about the process and design of the digital badges. Student respondents, as shown in Figure 16,shared thoughts (in their own words [sic]:

- Their level of participation ("I would earn more digital badges," "I would have spent more time trying to get to know digital badges.")
- Their attitude or approach ("my perspective," " I would change the way I looked at things because in the begining [sic] I didn't want to do it I thought it would be too difficult but after I did it I found out it was fun and easy to do and understand.")
- Or their own work habits or choices for project topics ("my performance," "my mestakes [sic], "what im [sic] researching about").

use again / more badges	5.0%	4
change own work habits	32.5%	26
change the work requirements	11.3%	9
change my topic	3.8%	3
the processes to earn db	18.8%	15
the processes of the program /study	10.0%	8
change my approach or attitude	32.5%	26
change nothing / idk	17.5%	14
didn't understand	1.3%	1
not clear	10.0%	8
fun, enjoyable	2.5%	2
	Total	80

Figure 16. Student Post-Survey Responses:

Q. 20,“If my class or group used digital badges again, I would change:”

Some students did specifically address the digital badges or the processes. Students commented that they would change:

- “Nothing,” “nothing, it is perfect the way it is”
- Or aspects of the processes or design, “the amount of writing,” “the ruls,”and “steps more easier to gain more badges and master them.”

To view all student responses to this item, see Appendix T.

Using Digital Badges: Students Say

When students were asked “what they would say” about using digital badges for learning, recurring themes (Figure 17) included:

- Enjoyment (fun, cool, like, good) (“It fabulous,” “Its a fun way of wasting time at school,” “i love it gets fun when you satrt vto creat it”)
- Motivating, inspiring or encouraging (“All class should use them because they encourage students to work harder,” “They encourage me to do my work because I compete with other students and makes me participate more in class”
- New ideas or learning (“Its one of the best ways to learn!” “its something cool to do and it teaches you a lot”)
- Helpful, interesting or made things easier (“It is very interesting and fun to be creative,” “It is very helpful and the skills used can help me in the future,” it is way easyer [sic]” “ Using the digital badges for learning was fun and something new I never tried before and it made everything easy for me,” “They help master new skills.”)
- Would like to use again (“I hope we can do this again,” “it was fun hope i can do it a again,” “i Wish i wouldve learned more.”)
- Collaborating with others (“Master Skills and teach others to master them too,”
- Nothing to say or “I don’t know” (idk).

fun / cool / like	25.0%	20
good / very good	7.5%	6
good / great way to learn	11.3%	9
motivating / inspiring / encouraging	16.3%	13
learned new things	11.3%	9
would like to use again	8.8%	7
ideas / experiment	2.5%	2
helpful / makes thing easy / interesting	16.3%	13
nothing / idk	17.5%	14
collaborate	11.3%	9
	Total	80

Figure 17. Student Post-Survey Responses:

Q. 25,“ What else would you like to say about using digital badges for learning?”

To view all student responses to this item, see Appendix U.

Focus Group

A focus group was conducted with both teachers after the digital badge program was completely finished. The interview was transcribed and coded for themes (Figure 18). The purpose of the discussion was to gain additional insight into teacher instructional and assessment practices while using the digital badges. The purposed was also to solicit suggestions for improvement in processes, and to learn about any problems in implementation and digital badge applications. The main points of the discussion are summarized below.

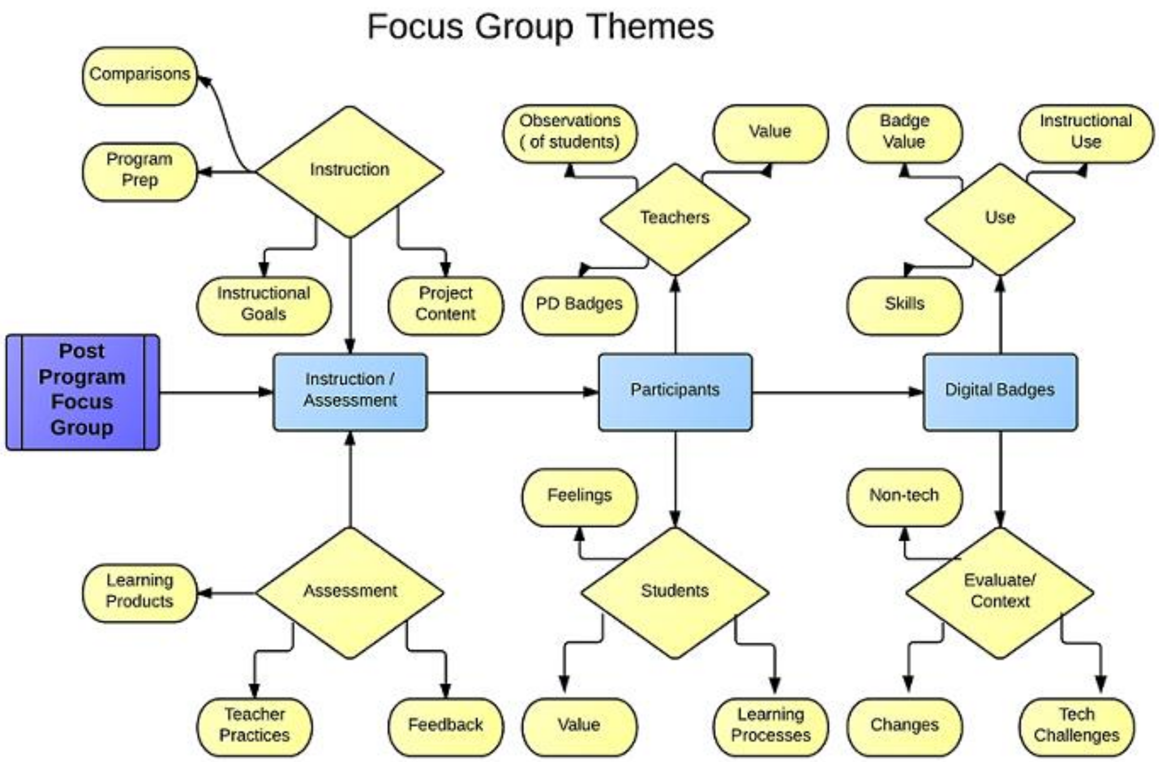

Figure 18. Buckets or major themes: Focus Group

Instructional Processes

The preparation necessary for the Digital Badge program was “minimal (Teachers A and B). It consisted of reviewing the materials, including the badge criteria (2-3 hours each), and preparing student materials: “So it didn’t take that much planning time. And again, it’s planning that you already would have done for your classes anyway.”

Teacher A had made a shift in goals for the school year and she considered the digital badge program aligned with these objectives: “I think with my class this year—and this is not just digital badges – I shifted the focus from content to skills. So I’ve tried to build skills-based assessments throughout the year, and this just kind of played into that.” Teacher B concurred, ”This is probably the way I would prefer to teach, because it’s all of them doing it on their own, and figuring out that they can, and that's cool." Regarding the overall process: "So it was a little bit additional extra work, but a lot of that I think just came from the pre- and post-surveys. If I was to do it next year, it would run a lot more smoother." (Teacher A).

The digital badge program was viewed as a strategy or pedagogy: "It's just one more strategy to get that one little cohort *[hard to reach]* of students on board with something." (Teacher A).

About the authentic applications or context: "Usually they totally shut down on that stuff. But to tell them 'I want you to work through it so you can earn this [digital badge]' … then they are a little more persistent with that" (Teacher A). Teacher B used a different teaching strategy and an authentic context: "The biggest thing was that in *Infomaker*, they had to come up with resources that they needed, and all the materials to fix their problem. And I made them be extremely specific with that. I made them come up with basically everything that they could ever possibly imagine needing: how much each thing costs. And when they really had to think about that, that was pretty tough. That was probably one of the hardest things for them, is to *really* explain what's needed to fix their problem."

Assessment Practices

Teacher B implemented the digital badges as part of an extensive array of formative feedback strategies (see **Feedback processes in artifact analysis**, below). Although the program was optional for some of Teacher A's students, the digital badge frameworks were integrated into an existing, similarly differentiated framework: "I think it might help a little, because students, they kind of get stuck in a track, and they're ok -- with the conferencing –'OK, this is where I am' -- you know, and I always give them an option. You can do the basic, medium, or advanced problems. It's up to you every time. You know, if you're really good at this topic, then do the advanced problems." The particular affordances of the badges were explained to the students in context: "Well, before we started, I had a whole conversation about how what you guys know how to do, and how do we assess that in school. And they all kind of recognized they have a lot going on for them as little people, but that doesn't always show."

Products of learning. Teacher B remarked on the quality of the 7th grade Social Studies projects which were created for the digital badges program:

> There were definitely different products, and some of them were actually phenomenal. That was maybe five of them, were … incredible. And holy smokes, I can't believe they put that much work into it .And then 10 of them were pretty dang good… Anyway, I was very impressed with some, and not so impressed with others. Some students want to put in more work than others.

For Teacher A, the results were aligned with other projects:

> Well, I feel like you still kind of get the same sort of distribution with – you get a certain number of products that are just awesome, like better than I did when I was in school. Some that are really great and exceed or meet your expectations, some are what you wanted, and then there's a couple that are below.

Teachers – General observations and comments

In comparison to the regular class work, the digital badge program provided opportunities for authentic applications: "Yeah, I have the same problem in math, too. I need you to learn the procedure, but the whole point is to apply it to real world context. So I can get 90% of my students to understand how to solve an equation, but when you go put that equation in the context of a real problem, they completely wig out. Which the digital badges was nice, because we are taking a real world problem, or real world data, using those procedures we use in class normally. But there's a whole other point to it now" (Teacher A).

About watching students as they worked through problems, Teacher B commented: "Which was kinda nice for them - - and me - - because I got to watch them be proud, and then they really got to be frustrated before they figured something out, and then they were really proud of it as well... I'd say [thinks] 30% of them kinda, when they were really at a wall, they didn't have any clue what to do from then on." The theme of students being frustrated, and not really knowing what to do next, occurred repeatedly through the interview. The teachers viewed the students: "I feel like with our students, there's a lot of learned helplessness. So when they had a wall with something, it was their first reaction is, "OK, Miss Teacher, how do I do this?" [B: Yep]…So they'll try and get the answer out of you for some time. And once they give up on that, he's saying, they'll usually go to classmates to figure out 'how did you do this/"

Teacher B elaborated on the learning processes and using the digital badges to encourage students to persist at task: "No, it was fun. It was really frustrating for the students that have absolutely no confidence, and they just would not believe that they could do it. That was really frustrating because I know that's not true. And, well, it's frustrating [laughs]." Teacher A also commented: "But students get the mentality that this is the kind of student that I am. And this is the kind of work that I do, and that's that. But if you have something that they are interested in, like badging, or making it more like a game, or levelling up, then they might motivate them more to try the harder stuff, versus, 'Oh, that's a word problem. I'm not going to touch it.'"

When asked about digital badges for professional skill sets, and who would constitute an important audience: "Obviously, people hiring … They have little value now, because most people don't know about them. And then, if there's a way where you could earn badges, and get, obviously, get bonuses…Yeah, merit pay with badges would be excellent" (Teacher B).

"I mean, you kind of want other teachers to know how much work other teachers put in. The administrators, or people that are evaluating me, or people and central office doing your raises, do not necessarily know how to quantify the amount of work and passion you're putting into your classroom. So, well, having something like badges, to, you know, track how many PDs you go to, or how many times you've had collaborative meetings, or how many times you've created such and such activity for the students, would be just another way to try and communicate to them you're doing a good job. Digital badges would be a nice way to standardize a set criteria so that in order for a teacher to be recognized by this, they must do a A, B, and C, versus...random" (Teacher A).

The teachers value the relationship building with parents and students. Teacher B: "I wish there was some way… I wish that you could quantify students' feelings in a classroom." Teacher A: "Even us, with our evaluations…'builds positive relationships with students is a little checkbox. It's yes, you do, or you don't. [Teacher B: That's a crazy thing to say *yes* or *no* to.] So you know to have badges, or have other things that kind of quantify more what actually goes into that. And, what having good relationships with your students gets you as a teacher. And for them, in terms of fewer referrals, better grades, and things like that."

Of particular interest, Teacher A compared the grading experience of students with job performance metrics:

> I mean, it's the same with the students. We take you and all of these wonderful things about you, and all of these interests you have, and then we bubble down a GPA letter, or number or something. As a teacher, you kind of feel the same way. You put in all this

> work, and now you're just checking boxes. So is there another way to kind of supplement that, to show what you are good at?"

Students

In the beginning, students were apparently confused about how to proceed, and they struggled with the format of the digital badges: "Some of them thought it was really strange, that they got to do whatever they wanted. And that…there wasn't an obvious answer, and that they… really had to think about it" (Teacher B).

> With Algebra, it's more like we do a unit, and you take a test kind of thing. So with this being more open and independent, there was some anxiety, that we talked about. When you kind of give them this freedom, they don't know what to do with it. (Teacher A)

Teacher B explained:

> Our students here are, I think most students…Just the way the curriculum is made in textbooks, and all that stuff. They are used to Question, Scan, Answer, Copy, Paste, and then you know, write it down. So with this… so that they were pretty confused when there wasn't an obvious answer to things. There's not so much creative learning that this provides.

Initially, the students were concerned about the expectations and work for the digital badges: "So there was more anxiety, and a lot more questions in the beginning. 'How do I do this?' and 'How am I going to get the grade?' and 'How…' this and that, but once you kind of get past that stage, I think they kind of appreciated more" (Teacher A). In Teacher B's class, the two-step system was used, where students were asked to go through their own checklist of badge criteria before work was submitted to the teacher. "Yeah, but sometimes they were pretty frustrated, because they were positive they were done, and they weren't."

As the program progressed, the students enjoyed working with the badges: “I think with my students, they really got on board with the idea that this is supposed to measure things that you are good at… that you are not getting measured at school.” Teacher A described how students felt about traditional grading systems: “I guess at the high school level that there are a lot of students that feel either disenfranchised or misrepresented by their grades, or kind of the whole system, traditionally, how their academics are.” The capabilities of digital badges transcend *grades*. Teacher A continued: “So to tell them so to look at some of the students who are not doing well academically, but are really great with other skills, other tasks, and letting them know this is the whole point, this is for you to bring that in, a lot of them got on board with that and thought that was nice. They like the connection, the gaming, like just having fun, and earning something… that to them is outside what you would normally do in class.”

The students were curious and excited about participating in a doctoral study, as explained by their teachers: “They really liked that it was part of a doctoral study, too!” (Teacher A.). Teacher B explained: “They didn’t even know what that meant. Wait! Yeah. That was pretty funny. They really wanted to meet you.”

Teacher A discussed my visit to one of her classes:

> So for them, I think it makes it more real. So when I tell you, ’You know you're taking part of a research study, to actually speak to the person…’. And then, I think this is nothing to do with the study, but it was funny. Because the whole time I would say, ‘Dr. Elkordy is coming in to talk to you guys,’ and they created in their mind an image of what this doctor looks like [laugh]. And then you walked in the room, and that was really great for the students – to look…’ she’s a woman!’ Yes, women, can be doctors. So, and to see you, well she's a woman. So I think it was just good for them cultural [B: ‘She has

a scarf on!'] So, only, not only can the students be a part of this, but there's no reason why you cannot be an adult doing this kind of work, too, at some point. So for them, I think it just made it more real for them.

You met with 7th graders, and they were extremely interested … It's pretty obvious that you were a teacher, and they… you…. I don't know if it changed the way they did the project, to be honest, but they certainly liked it when you came in. (Teacher B)

Note: the Arab tradition of personal respect is an important cultural tradition. Professionals, particularly middle aged and upwards, may be addressed as *Ustaz (Ustazah),* or *Doctor* (*Doctorah*), which means *Professor* in Arabic. For example, this term of address may be used for respect, regardless of actual qualifications. The administration and teachers were aware, and specifically notified, that I had not yet completed the requirements for the doctorate degree, but they used that term of address regardless.

Teacher A viewed the badges as a tool:

A way to get more of those bottom kids with the program. Because maybe they don't … it's almost like each kid almost has to have their own reason for doing something. Some of them do it just because it's graded, and some of them do it because they just want to learn. And some of the students don't care about the grades, but they might care about this. Also, especially for the students that traditionally don't do really well, that wouldn't do really well like on a paper-based exam, to give them a project, or to give them something else to look at, they did better on it than usual. So it was good. (Teacher A)

Digital Badges

Students were able to bring in skills learned in other learning environments:

> Especially … the seniors, because they're thinking about what they want to do in the future. And they have a lot of random skills, but they don't get to bring that into the classroom a lot. So doing that for them made, I think, the badges more worthwhile" (Teacher A).

Challenges

Although the teachers and students in the study reported using ICT and digital media daily, Internet access at school and in the home was a significant challenge while implementing the digital badge program. "Not all of our students have Internet access at home, or computers at home. And we don't have easy access to them at all in school," explained Teacher B. The equipment available at the school were older laptops; Teacher B continued, "The ones I have access to are from 2002 probably, and they're…. it's rough. If it were easier to use laptops in school, or if it were more possible for all of our students to go home once a week and do an hour of homework with this stuff, then I could award different badges for different things. Then they could have 50 to choose from."

Internet access was a consistent challenge. Because students were not able to access the digital badges easily or frequently, Teacher A printed out the badges and mounted them on a window in the small classroom. "…so I ended up getting paper badges and writing their names on it, and putting them on the window in the classroom. So that was more instantaneous and visual for them, and could be shared by everyone, not just something they saw on their online profile… if they had access to the computer."

Changes

Asked what changes the teachers would make in using the digital badges in the future, Teacher B suggested changing the badging platform: "I would want the web site to be simple…

absolutely simple as possible. Where literally, they log in, and they have a screen that they can look at, and literally, on that screen there's badges, or there's not badges. That's it."

Using the Digital Badges in the Future

Teacher B commented, "And we are going to… I'm going to steal the materials for next year probably [laughs], so I already have them saved." Teacher A shared a plan to use badges for longer periods next year, with more hands-on guidance to the students (as opposed to a primarily independent project). "I would like it to be something that kind of ran throughout the whole course of the year…and kind of focused… At least with math, there are so many spiraling skills and things that keep coming up. So it's more integrated with the whole year's worth of coursework" (Teacher A). The teachers elaborated:

> I think in some classes, like the *InfoMaker* badge, or some of them, like the *Data Hacker*, naturally lent themselves to what my curriculum is. Obviously, for the Algebra 2 class, the *Data Hacker* is really easy for them to use because you're already doing statistical analysis. And then for Business Math, the one about finding a problem and making a solution naturally fit… I think the levelling naturally scaffolds stuff. I mean the skill is still statistical analysis, but whether you do that at level 1, 2, 3,4 or 5 kinda just depends on the kid. And it's a little easier to scaffold with math. My students are kinda used to scaffolding. They're used to everyone working on the same objective, but that might look different for each student. But there are other things, too, in class. Their technology use with the graphing calculators and things, or their literacy, that I would kind of like to track… that I have a hard time tracking already. (Teacher A)
>
> I would actually like to do this two or three times a year, where I… we…go through textbook stuff, with geography specifically. Maybe…Well, any of the topics. We learn

> the background information in class, then they pick any topic that fits in that category, and they get to go and do the work themselves. I would like to do it. Three times is probably more than is possible, but maybe two, every year. Only I'll tweak it, and I'll… I will have more strict requirements about what the projects will be about. (Teacher B)

Artifact Analysis

Over the course of three, two-hour sessions, the student projects for the 7th grade social studies project using the *InfoMaker* digital badge series were analyzed. The initial purpose of the analysis was to view the body of work as a whole to learn more about the instructional and assessment practices implemented in the digital badge program. Further analysis was conducted regarding students' choice of topics and solutions in response to the badge criteria.

Instructional Processes – Teacher B

Teacher B described the assessment practices used for digital badges as "summative feedback *of* learning (to measure understanding)."About instructional practices, "I did not give the students a lot of help completing each level of the badges because I wanted them to use their problem solving skills and the Internet to figure out a solution to their problem." Upon examination of the student products of learning, however, Teacher B's implementation of the digital badge program was complex and rich, in both instruction and the use of the digital badges in assessment.

Figure 19 is a flowchart of the instructional and feedback processes used in the social studies class for the digital badge packet. Teacher B created a packet of materials for each student which included:

- A colorful outer cover.
- Lined paper for student responses / work.

- A document with *Power Standards* rubric/guidelines for internal standards alignment and grading (front of packet).
- A new document with the digital badge criteria only, in checklist format. Important modifications were made to track the progress of students: Student Checklist and Teacher B Checklist. These were located in the front of the packet.
- At the back of the packet were photocopies of each of the 5 *story* versions of the *InfoMaker* levels.

Teacher B permitted the students to pick their own topics for investigation. The students were directed to pick a country and to pick a problem to solve. The topic choice was then approved.

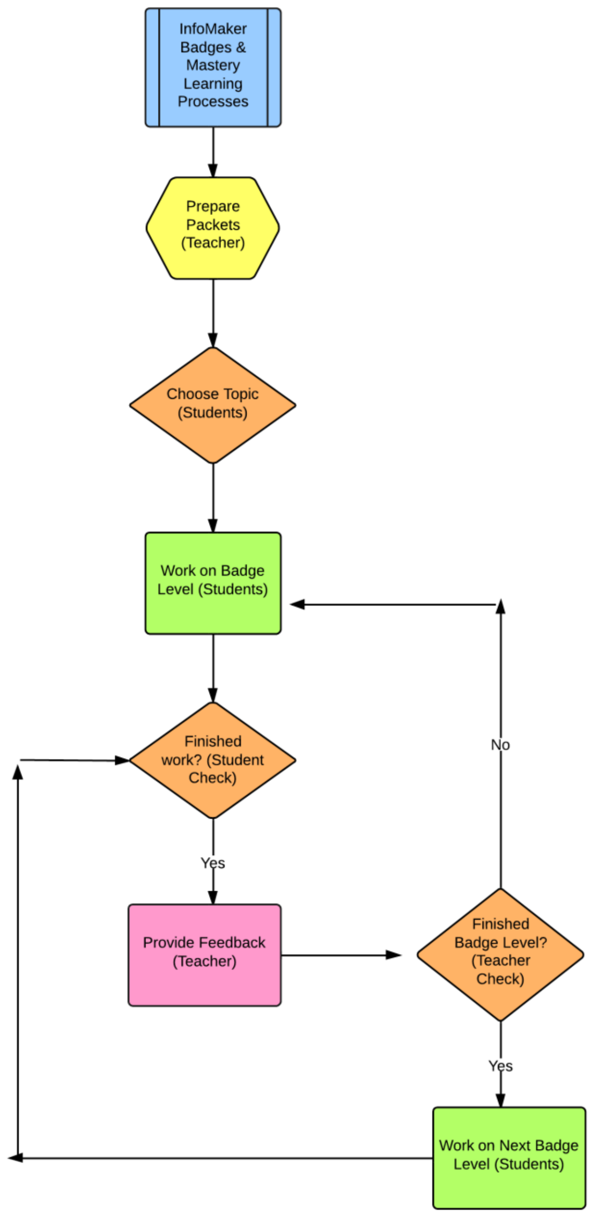

Figure 19. Digital badge workflow (7th Grade, Social Studies)

Students worked through the criteria of each badge level. They used the packet to record notes and to journal their progress. Teacher B instructed the students to first review the digital badge criteria themselves. When students thought they had completed the necessary work, then Teacher B reviewed the check list. Students who had successfully completed all criteria were awarded the appropriate badge level through the Makewav.es system.

Feedback Processes

As see in Figure 20, Teacher B integrated the digital badges and their criteria into a complex system of formative feedback for student learning. Teacher B used various criteria to assist students to evaluate their own learning. In addition, as viewed through the student learning products, various written feedback functioned to correct, direct, encourage, evaluate, and elicit deeper thinking.

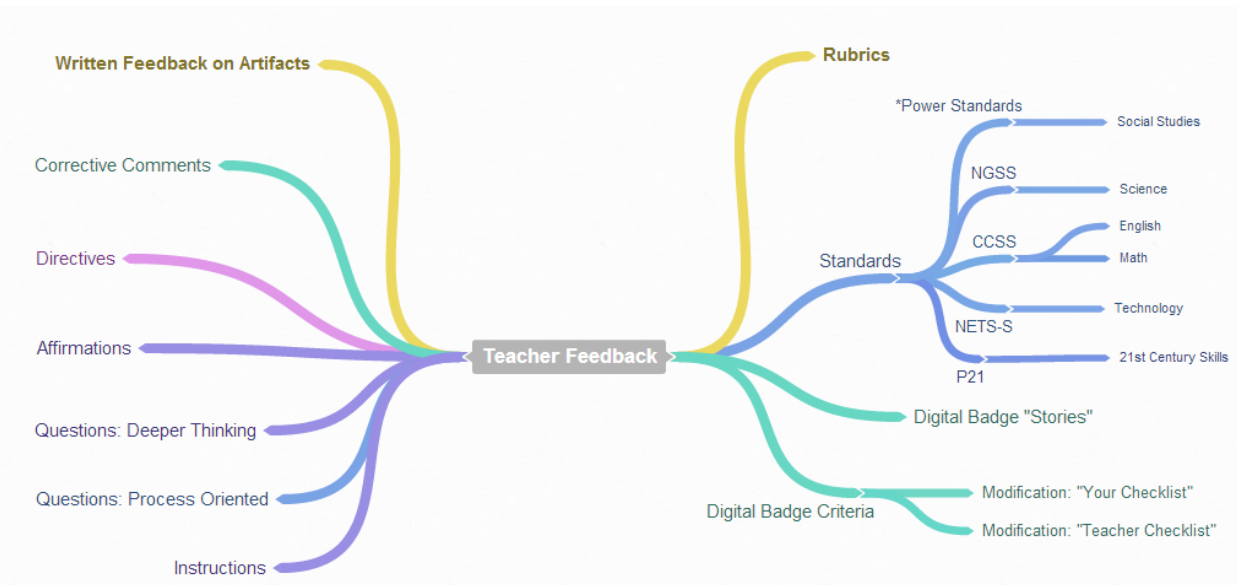

Figure 20. Teacher Feedback Taxonomy

Teacher B's feedback contained clear details. Examples are below:

- Corrective: "I need proof that you did ______," spelling corrections.
- Directive: "You really need to research this," "Fill out the steps to complete this process. Be specific."
- Instructional comments: "Your data will look like charts/graphs," "Be specific."

- Affirmations: "Good notes," "Excellent research!" "Cool!" "Keep up the good work!"
- Questions to clarify student processes: "How?" "Can you give out an information packet?" "How many?"
- Questions to elicit deeper thinking: "Explain __________." "How would a city afford this?" "How do new laws get created in Yemen? Make sure to think of this." "What will it look like?" "How will it work?"

Student learning products.

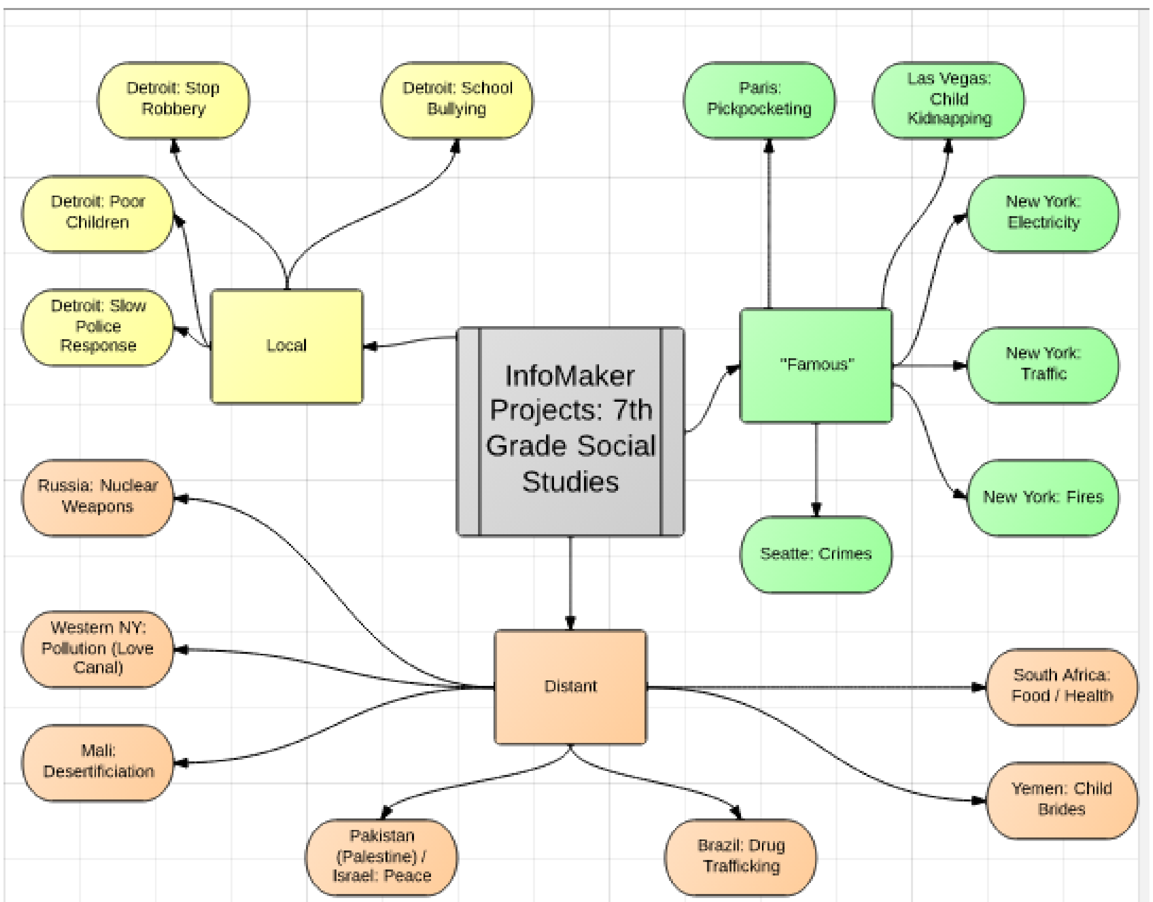

Figure 21. Student project themes.

Students selected their own topics for the research project (Figure 21) using their textbooks and a set of laptops which were scheduled for use. The research topics were then approved by Teacher B. Many students chose to work together in teams of two.

The students selected ideas from three main areas: local concerns, with which they were familiar; issues in famous cities, such as New York or Las Vegas; and distant places, such as Mali. There was a range of complexity in the proposed solutions for the country problems, and concerning methods for collecting data. According to Teacher B, several projects were "awesome." For example, one student investigated a *Passion Project* (Teacher B's description) involving the eradication of child brides in Yemen. The proposed solution was a web site, which the student actually created, and a brick-and-mortar Help Center in a city in Yemen. The purpose of both ideas was to spread awareness and to provide a contact point for information and assistance.

Other proposed solutions were inventions, such as a device called *The Seeker,* which alerted the user when *touched* (to prevent pickpocketing). Another invention was a device that switched on water (to quench fires). In general, the complexity of the projects reflected the digital badge level attained by students. For example, one team investigated how to prevent desertification in Mali. To test their proposed solutions, the boys built a model using trees and sand. A hair dryer provided wind resistance. They conducted three trials to determine which solution might work best to solve the problem: a fence (with gaps), a line of trees, or a solid wall. The data and results were recorded in the boys' journals.

The concept of a science or design journal for reflection on processes was new to the students. Teacher B set a minimum of 10 pages over the course of the badge program, which was 3 weeks. In general, students wrote a considerable amount in the journals, including processes, planning, reflections on results, and responses to Teacher B's reflective questions. Many students included stream-of-consciousness reports concerning events in the school day, or their thoughts in general.

Digital Badge Design – Suggested Modifications

In the process of artifact analysis, Teacher B shared several observations and suggestions for badge design modifications:

- "I thought I might need to rewrite [the badge criteria] into simpler language, but I didn't need to."
- Share "worked examples."
- "Differentiate between middle and high school" [badge criteria].
- The "jump to Level 2 was too hard."
- Provide "models."
- "Communicate more about options, and perhaps provide a set of resources."

Chapter 6: Conclusions

Digital Badges for STEM Learning

The outcomes of research on student motivation and engagement in STEM learning are important to our nation's future success and prosperity. The workforce needs for the global economic marketplace as well as existing gaps in STEM achievement and participation among our youth must be addressed. Research is necessary to discover ways to motivate students to select courses of study and careers linked to STEM disciplines. It is necessary to bridge gaps in the STEM pipeline, and to ultimately ameliorate skills and knowledge gaps in the workplace. Science is driving life-enhancing improvements which both augment the quality of life and extend it. Innovations spurred by STEM knowledge, practices, and research fuel these developments. The result is a transformation which extends beyond STEM disciplines to effect sustained, systemic changes.

Demographic shifts in the U.S. population, equity, and social justice concerns compel a paradigm shift in the current direction of K-12 STEM education. The engagement, participation, and academic success of at-risk, marginalized, minority and girl students must be increased to minimize the growing skills gaps in STEM disciplines. Furthermore, motivation and engagement are critical to improving academic outcomes in STEM subjects for all students.

The purpose of this research was to measure the impact of a digital badge intervention for STEM learning upon student attributes, attitudes and learning behaviors. In particular, a goal of this study was to measure:

1) the effect, if any, of the use of digital badges upon STEM learning in the target secondary age students' attributes:

a) Motivation,

b) self-efficacy,

c) affect (liking for STEM learning, interest, engagement),

d) learning strategies, self-regulatory behaviors.

2) factors in the learning environment that affect digital badge acquisition.

3) student-level factors that affect engagement in the learning process, using a digital badge intervention.

To be an effective intervention, the intended STEM skills would be learned by the badge earners. The impact of the digital badges on student achievement as well as the reliability and content validity of the badge learning trajectories are beyond the scope of this research. A design based research methodology would be appropriate to inform the badge design and mode of implementation. Measures of student attitudes and learning behaviors, including motivation, self-efficacy, and self-concept were measured in this study. These student characteristics are important attributes for the student interest and engagement required to sustain effort at task and investment in academic outcomes. The findings of this study indicate that several measures of these attributes were increased in pre- to post- intervention program in this student population.

Self-Efficacy

There were several statistically significant increases in measures of student self-efficacy.

The pre- and post-t-tests of several survey items which measured the concept of self-efficacy indicated significant increases to the level of $p \leq .05$ ($p = .014$) (Table 13). There were also significantly increased post-program measures for self-regulation, specifically indicators which measure students' capabilities to persist at task (Table 14).

Items loading onto the factor SE_Post_Final included items associated with self-regulation (pre-survey measures), the number of student texts and student program as predictors but no pre-survey self-efficacy measures (Table 38). This result suggests that self-regulation, frequency of text messaging and the student program (or teacher) impacted self-efficacy.

In addition, predictor variables for the Badge_Learn_Post factor have an inverse (negative) relationship to items loading on self-efficacy, sharing accomplishments and recognition of out-of-school time and the number of texts. Learning environment factors indicative of *student voice* are also associated with this factor. This suggests that students who enjoyed a particular kind of learning environment (interactive, discussions, see Table 18) but lacked these skills or attributes (self-efficacy, ICT skills, desire for recognition of out-of-school learning) became digital badge advocates.

Affect

The majority of student participants enjoyed using the digital badge program to learn. This was particularly evident in the qualitative data, students' written responses, and as reported by the teachers. For example, students reported that the digital badges for learning were *cool*, *a fun way to learn*, that they would like to use them *again*.

Students were interested in earning additional badges if the program were longer (Table 5). The majority of students reported understanding the badge requirements *usually* or *all the time* (Table 6). If the digital badge program were longer, students wanted the opportunity to earn more badges.

There were no significant differences in task value (interest), with the exception of a difference in pre- and post- measures of student interest, significant at the $p \leq .05$ level ($p = 0.13$). Interest is an essential component of student engagement, necessary for academic achievement.

Learning Behaviors

Learning behaviors were also influenced by the use of the digital badges. Students referred repeatedly to the badge criteria (Table 7) to gauge the completeness of their work. As reported by their teacher, in the social studies class students notably used the badge criteria to check their performance. Such learning behaviors, scaffolded by digital badges, promoted increased levels of self-regulation in learning, enhanced metacognitive skills and perceived competence.

The majority of students agreed that the way the badges were structured helped to learn the subject well (Table 8), and all but 6% of students were interested in using digital badges for learning again (Table 9). Students at every level (7^{th}, 10^{th} and 12^{th} grades) indicated that they could incorporate learning from other contexts into their assignments using the digital badges *some of the time* or more (Table 10). Furthermore, a minimum of 60% of students at every grade level were interested in where to earn digital badges for out-of-school learning (Table 11).

The younger students in particular, indicated that they understood the content more using the digital badges. The 7^{th} grade students and their Teacher (B) worked collaboratively through formative feedback using the digital badge criteria as learning (and assessment) targets. Students thought the organization of the badge criteria was helpful in the learning process.

Motivation

As a complex construct, motivation is inferred by the presence of other attributes, such as self-efficacy, choice, persistence-at-task, and interest. For this population, many of these indicators had measurable, statistically significant differences. It is important to note that the pre- and post-measures were comparable, but did not measure the same constructs (self-efficacy in STEM subjects versus the digital badges based around STEM content).

When students were asked what they would say about working with digital badges, the responses were positive. They spoke about how the badges were *motivating*, *fun*, *make things easy*, and that they were a *good way to learn* (Figure 17 and Appendix T). Of particular interest, when students were asked what they would change about the experience of learning with digital badges, many talked about changes they would make in their *own attitudes or approaches*, versus the badging processes or design (Figure 16 and Appendix U).

Teachers also agreed that the digital badges were motivating for students, particularly students who weren't regularly successful with traditional assessments.

Students were able to include learning from other contexts, and liked this aspect of the digital badges.

Student-Level Factors

Despite a low income context, the students are very much interconnected via ICT. Their favorite online activities are using digital games and media, communications and social media which reflect use as consumers versus producers of digital artefacts. Most students had access to mobile technologies smartphones (65.8%), iPads or tablets (50.0%) and laptops (71.1%). Their second most popular way of locating information was to *look it up online*, second only to *ask a teacher* (in school). Older students communicated extensively via text.

Digital badges are designed to reside online, to be shared with select audiences. The student population for this study did not actively share their badges. This may be due to cultural biases against *bragging*, or concern for *envy* and a cultural/ religious propensity for modesty. Students may have equated the digital badges earned in class as analogous with grades or other accomplishments, which they tended not to share (Table 3).

During the digital badge program, students reported being able to integrate learning from other contexts into their assignments a substantial amount of the time (Table 10). Students agreed that they would like skills and knowledge from out-of-school learning to *count*, mean of 14.6, with a SD of 5.1. They wanted to know where they could earn more digital badges for learning.

Student accomplishment / sharing behaviors differed by age; younger students tended to share their accomplishments with friends and parents more. In general, students preferred to collaborate to solve problems when given the opportunity to do so.

Learning Environment and Implementation Factors

As an instructional tool, the digital badges supported existing curriculum; Teachers A and B reported a shift in learning goals and outcomes toward learning skills or competencies, and the badge learning trajectories were aligned with this goal. The digital badges aligned with an instructional goal for the school year to emphasize transferable skills or competencies (Teacher A). This idea of flexibility of content and context for learning skills was demonstrated by Teacher B who successfully integrated *InfoMaker*, a badge series aligned with Next Generation Science Standards, into a social studies class. Use of the digital badges required minimum preparation *that you would do anyway* (Teacher A).

The digital badges functioned as both formative and summative feedback strategies, and the students persisted with their tasks to earn the badges. Due to limited technology resources, students in the 10^{th} and 12^{th} grades were more likely to view actual printed badges on the windows of their classrooms (Teacher A).

Carefully Designed and Applied, Digital Badges Could Lead to Good Learning

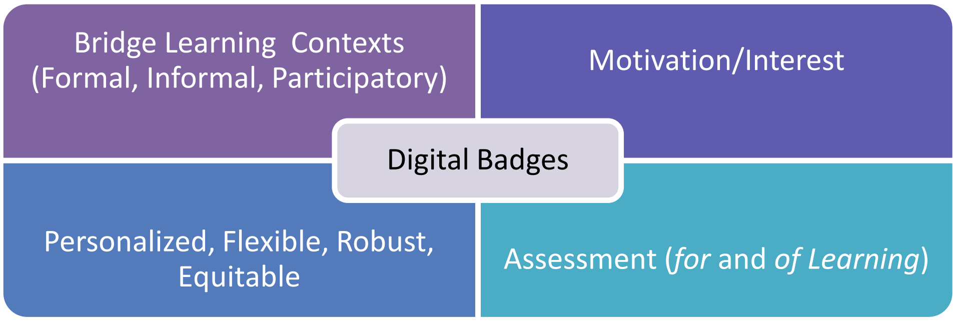

Figure 22. Components of learning with digital badges

Outcomes of this study support the premise that the use of well designed, robust, standards-aligned digital badges could effect significant positive change upon student attributes and learning behaviors. Furthermore, the outcomes of this study indicate that digital badges can be associated with important principles of learning and motivation (Figure 22). The digital badge program significantly increased levels of self-efficacy, self-regulatory behaviors, and student interest in the content. Of interest, these findings were consistent across grade level and gender in regard to various subject content and classes.

Students indicated that the digital badge learning trajectories were helpful in the processes of learning. They viewed learning with the digital badges as motivational, fun, helpful, and something they would like to do again. Due to the small sample size and the homogeneity among participants, these results may not be generalized. However, both null hypotheses may be rejected because there were significant differences in student attributes as a result of the digital badge program. This study will inform future implementation in similar contexts.

To implement a newly developed educational intervention is a challenge under any circumstances. The methodology is uncertain, and factors which may be essential to success may not yet be identified; the design of the digital badges in the study was new, and also the premise of using badges extricated from a game-based educational model was a new application. While a mixed methods research approach was used to glean information to inform future implementation of the digital badges, the fact remained that the new, untested aspect of the intervention design would impact the research substantially. A design-based research methodology would be useful in informing the future development and design of the digital badge series used in the intervention.

Implications for K-12 School Leaders

Digital badges can motivate, engage and help to inculcate productive learning habits for secondary students. By enhancing self-efficacy as well as effective student learning and metacognitive behaviors, digital badges can be helpful in the process of building academic identity. Student engagement and *interest,* a *positive self-concept* and *motivation* to learn STEM subjects can be critical elements to the formation of STEM identities for youth. Robust, standards-aligned, criterion based digital badges can scaffold learning and provide affordances for personalized learning. Student learning in other contexts, particularly in digital media and ICT, may be incorporated into learning products using digital badges.

In general, building leaders were interested in the ideas behind digital badges for learning when approached directly. In many senses, the challenges encountered during the recruitment phase of the research study reflect challenges present in the school districts in south-eastern Michigan. There were several recurring themes:

Recruitment challenges.

The study recruitment period and its degree of success was a reflection, in many ways, of the challenges and opportunities currently faced by school districts and K-12 educators. The educational leaders, including central office staff and building leaders, were impressed by the ideas and possibilities of digital badges (Elkordy, 2013). The challenges, it appeared, were in the processes of implementation and allocation of resources. The study recruitment was open to educators at every level, including teacher leaders.

District level challenges.

- **District consolidation**. This challenge affected two of the larger school districts which had initially expressed interest in the study. As a result of downsizing the district, schools were closed, and teachers were laid off. Building and district leadership were changed in the process, which resulted in a difficult transition in rebuilding a new school culture and new relationships. Communities were in a difficult process of restructuring. Several teachers retired early or were laid off, which caused a loss of a significant tacit knowledge base. In addition, staff members were relocated within districts to fill gaps left as a result of termination or retirement. As a result of these challenges, school leaders often felt that they could not introduce another new element, such as a study.
- **New initiatives.** Other districts faced challenges in implementing new district-wide initiatives, such as teacher-evaluation tools or assessment initiatives.
- **Staff turn-over.** One of the more difficult challenges for some districts, particularly in under-resourced, high-poverty urban areas, occurred because of high staff turnover. In these circumstances, leadership was faced with the task of inducting a substantial percentage of teachers, many of whom were not only new to the district, but were newly certified teachers who required additional support.
- **Under-resourced environments.** Several private school teachers and leaders indicated interest in participating in the study. Ultimately, however, the teachers were not able to participate, due to workload and responsibilities associated with a lack of resources.

- **Wait and review results.** Although school leaders were interested in the premise of digital badges, some leaders, particularly in buildings which were part of a larger system, such as a consortium of charter schools, adopted the approach to review others' experiences.
- These changes resulted in a climate where new methods or strategies were difficult to review, even for a relatively short amount of time, particularly in public school systems. The school building which eventually completed the entire study was a relatively small, agile charter school system, with several buildings, and a total enrollment of approximately 3,000 students.

Digital badges for K-12 districts.

Educational leaders in K-12 contexts face a myriad of challenges; diverse student populations with an array of different needs; the lack of adequate funding or resources; and demands for personalized curricula for students in an era of renewed focus upon standardization. There is a growing chasm of skills deficits, particularly in STEM disciplines, and agile, creative-thinking, and achievement gaps persist. K-12 educators are viewed as the cause and cure of these societal issues. Ironically, however, the pressure to perform and conform to *performance measures* for professionals, as measured by student performance on standardized tests, discourages systemic change. Teachers and educational leaders are forced to focus upon the measures of student *achievement*. This leaves little opportunity or incentive for teachers to experiment with new pedagogies, new instructional tools, or to teach concepts or ways of thinking which are not aligned with standardized measures of achievement.

This situation is unlikely to change for the foreseeable future. In a world of digital media, where our youth are connected socially and individually expressive, their education is standardized. Digital badges may ameliorate the situation by bridging standardized curricula and the out-of-school learning experiences which are particularly critical to STEM learning and identity formation.

By making performance criteria, learning objectives, and the processes of assessment transparent, digital badges may be useful in creating district-wide initiatives for students and teachers. Not only are the badges motivating to many, they communicate the acquisition of diverse skill and knowledge sets. When implemented as an ecosystem with levels or groups of skills, digital badges can facilitate differentiation of outcomes, processes, or products of learning.

In spite of the small sample size of teacher respondents, teachers' opinions were diverse regarding the supports actually received or needed from school leaders for technology integration or digital badge program implementation. In addition, perceptions on organizational priorities and technology use, or colleagues' potential interest, varied considerably. Critical tasks for educational leaders are to effectively communicate goals and objectives of technology-based initiatives (or other initiatives) and to foster staff buy-in. An effective way to align mental models may be to use digital badges in the capacity of *boundary objects*, for discussion and planning.

Educational leaders in K-12 contexts can use digital badges as powerful advocacy tools for students and teachers. By fostering, measuring, and communicating personalized learning, students become more engaged, develop positive self-concept, and experience increased self-efficacy. Hence they develop identities as successful learners. By making learning in the classroom visible and recognized, teachers can showcase the often crucial learning which occurs in their classrooms and which often goes unnoticed.

Implications for K-12 teachers and practitioners

Digital badges can be an effective instructional strategy to motivate students to learn STEM subjects. Successful teachers understand that building trusting relationships is essential to engage students in their own learning processes. Through the use of robust digital badges, teachers can empower students in their own learning by providing familiar ICT tools. In addition, by personalizing or expanding learning pathways and products of learning, digital badges increase relevancy to learners. This is particularly important to STEM learning for traditionally marginalized groups for STEM learning (Russell, 2014). In addition, choices of learning products and demonstrations of learning can be expanded, and this contributes to building relationships and student interest. As Teacher A stated:

> We might be discussing a certain content, but then it's up to the students. However you want to synthesize that knowledge is up to you I just need to know whether you can analyze data. Whether you want to do that with class attendance reports, or fundraising for the senior class, whatever it is, it's the skill I'm looking for. And the students like that because it's more transferable to other things they are doing.

Digital badges provide affordances for differentiation of content, processes, and products of learning. Because much of the learning which occurs in classrooms has not been measured or acknowledged until now, the use of digital badges can allow learning to be visible to administrators, parents, and the community.

The teachers in this study felt that several aspects of using the digital badge program were particularly effective. For example:

- creativity in learning and teaching,
- skills-based approach and focus,

- ability to measure skills and ways of thinking which are not measured using *standardized testing*,
- ability to engage students in their own learning,
- application of skills to authentic problems,
- ability to motivate a wide variety of learners.

Digital badges can also assist in cultivating communities of learners within the classroom, building teams, and developing affinity groups. These applications are important for growth of domain-specific language, an important component of developing identities as for example , scientists (Gee, 2010). By traversing learning contexts, digital badges can provide a common language of criteria and guidance for assessments. Teachers and informal educators can collaborate to bridge learning contexts through skills and knowledge building using digital badges.

Educators, as professionals, are required to participate in professional development activities. A digital badge ecosystem could capture and describe this learning. It could also provide context to discussions between teachers and administrators when goal setting and planning professional development opportunities.

Implications for K-12 students

The use of digital badges for learning can provide unique affordances to learners (Riconscente et al., 2013). Diverse knowledge and skills sets may be effectively evaluated and communicated. Individualized pathways of interest-motivated learning may be pursued, and learning from non-school contexts can be recognized and valued. Youth who may struggle to evidence academic achievement in formal learning environments may be more motivated to learn when the products and pathways of skills acquisition incorporate self-motivated learning behaviors and preferences.

Youth face challenges in equities of opportunity in education, which subsequently transfer to work place and economic opportunities (Ito et al., 2013). A digital badge ecosystem provides opportunities for youth to develop and demonstrate competencies in a variety of learning contexts. The circumstances of learning are no longer bound by location or proximal resources, including access to qualified teachers.

As the chasm between interest and classroom learning widens in regard to both content and preferences, students have become increasingly disengaged. Digital badges can be used to create personalized learning spaces or pathways which serve to re-engage learners in the process.

Implications for Theory

Connections to Connected Learning Model

The Connected Learning Model (CLM) is based upon social-constructivist ideas of learning and includes aspects manifested through digitally facilitated and mediated interest learning. It is articulated as *learning principles*, *design principles* and *core values*.

The incorporation of interest learning, shared purpose, and focus upon production of learning artifacts is aligned with the CLM. Principles of the Connected Learning Model were influential in the study learning context, especially the use of digital media and ICT (networked and participatory); interest-powered learning; academic orientation; social connection; and production centered.

The findings of this study support the implementation of a CLM model in this population. For example:

- Students' problem solving behaviors tended to become more social,

- *Interest* was the only statistically significant difference measure in the task value construct, increasing with the use of digital badges,
- Students' preference to collaborate when given the opportunity.

Applications of digital badges for motivation

The results of the factor analysis of the post-survey variables indicated a shift in the constructs of self-efficacy and self-regulation. For example, factor Self-RegulationA_Post (Table 36) was comprised of 4 measures of self-regulation (there were 8 total) as well as a goal orientation which reflected understanding of the work and importance of the digital badge program. Measures of student self-efficacy and self-regulation loaded onto the factor Self_Regulation_B_Post (Table 37), however. In the pre-survey measures, self-efficacy and self-regulation items loaded separately and mutually exclusively. This would seem to indicate a distinct relationship between the items which was created as a direct result of the digital badge program.

Of particular interest, students did not share their achievements extensively. Nor did they view them online frequently. However, the digital badges functioned to motivate and propagate behaviors associated with academic achievement, suggesting that the badges were functioning as intrinsic motivators.

The students' perceived competence in the digital badge program -- which was built around STEM content and competencies – could be predicted by several independent variables including measures of self-efficacy and self-regulation. However, students' post-program behaviors of badge sharing and interest in the program were also predictors, indicating a causal link between the digital badge and perceptions of confidence in the program (and by extrapolation, the STEM content). Further research is needed to study this finding which could be especially important.

Summary

The outcomes of this research suggest that a robust, standards-aligned digital badge program could function to increase student motivation, self-efficacy, and interest in STEM learning. In this student sample, the use of digital badges to scaffold, guide assessment, provide feedback, and communicate learning in STEM subjects had a significant, positive impact in several measures.

Digital badges may provide potential for deep and lasting knowledge, including the following:

- contextual learning situations (situated learning and cognition),
- scaffolding through learning trajectories,
- socially constructed/mediated learning, particularly in connected environments, which facilitate, mediate, and promote content or skills-related content,
- participatory learning,
- motivational and interest learning,
- ongoing, formative feedback,
- creating learning paths; encouraging reflection and self-regulation,
- building social capital, self-esteem, and self-efficacy.

The Benefits of Badges

Student interest and affect:

- foster engagement
- motivate learners to accomplish goals
- foster self-efficacy
- develop metacognition and effective learning behaviors

Assessment; provide feedback:

- create a continuum between formal and informal environments
- can be integrated into existing frameworks
- incorporate the self-regulatory aspects, but not limitations, of rubrics
- foster self-regulation and metacognition

Fit into cultural currency or understanding of kids (games/ social media):

- already in use in gaming contexts
- are recognized within peer groups and confer social capital
- are historically symbols of achievement (in our culture)
- foster identity, affinity with others, and self-concept

Can be skills-based:

- can provide ways to measure informal learning
- interdisciplinary
- foster transdisciplinary skills development
- incorporate good learning strategies
- may align with standards or criteria
- can guide learning through criteria

Performance assessment -- linked to criteria

- good assessment for socially constructed knowledge because is *open* and socially constructed
- choice of learning products
- communicate skills acquisition to interested audiences

Aligned with Connected Learning Model principles:

- chunked information, aligned with constructivist learning tenants, i.e. zone of proximal development
- participatory, social
- academically oriented and transferable
- networked
- interest-driven

Figure 23. The possible benefits of badges in K-12 contexts.

Recommendations for Future Research

"Thank you for doing this research" -- 12th grade student, December 2013.

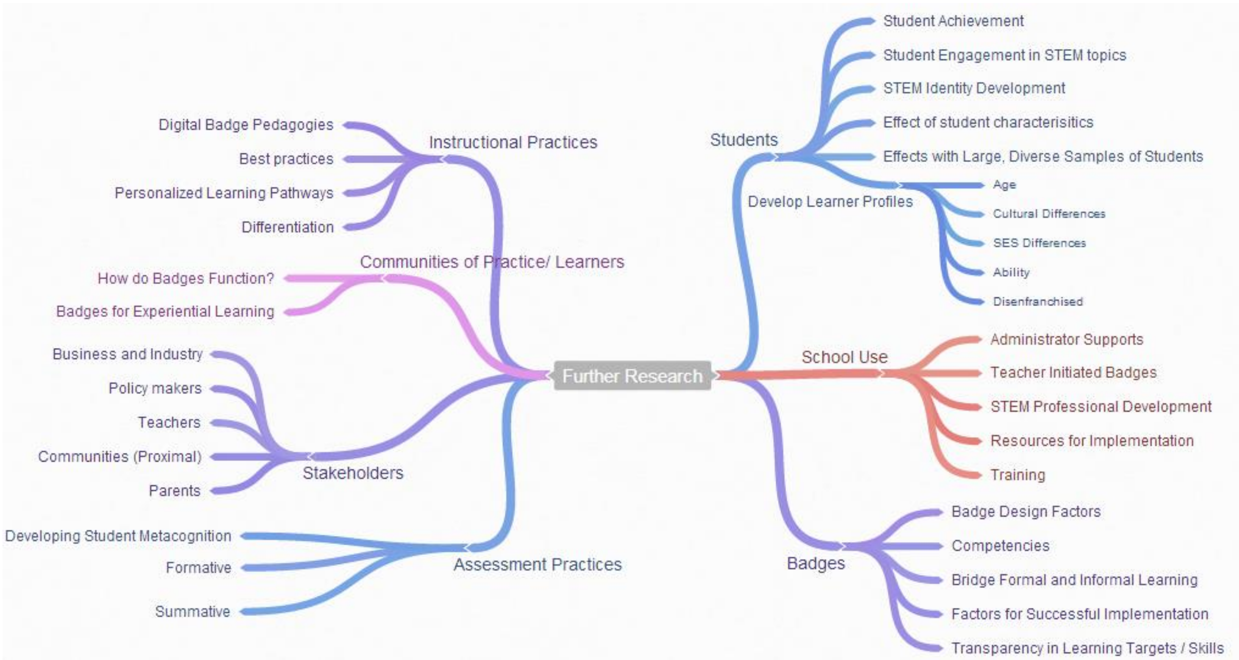

*Figure 24.*Suggested directions for future research.

These findings are of substantial interest to educators and policy makers. Although it is not possible to generalize the findings of this research, due to the small, homogenous student sample, the results of the study are promising. A great deal of research is needed, however, to understand how digital badges may function in different learning contexts and for whom (different student groups). Various categories of suggested topics for future research regarding the use of digital badges in secondary age learners in formal context are shown in Figure 24.

- Instructional practices,
- Students,
- Assessment practices,
- Learning contexts,
- Badges,

- Communities of practice,
- Stakeholders.

Learners languish as skills gaps widen. A paradigm shift in our educational outcomes and processes is clearly necessary. Although many questions remain about the use of digital badges to scaffold, evidence, and communicate learning, crucial conversations about learning have reached a tipping point. Globally, there is interest in acknowledging and leveraging skill sets earned in out-of-school contexts for economic growth and equity.

To describe Teachers A and B as early adopters may be accurate in some regards, but it would also be accurate to acknowledge their technology awareness as members of a generation which has largely reached adulthood immersed in digital media and ICT. Despite the limited access to technology, Teacher A and B both used digital tools for instruction (Edmodo) and classroom management (Class Dojo). An educational intervention derived from the world of gaming, digital badges, included familiar elements which could be adapted for classroom use.

The premise of using digital badges in K-12 contexts is at the very heart of discussions about teaching and learning in the digital age. What kinds of knowledge, skills, and ways of thinking should youth know to prepare for a rapidly evolving workplace? What kinds of pedagogies leverage the affordances of technology? How can the skills youth bring to the classroom be leveraged? What steps should be taken to create equity of opportunity for youth when substantial amounts of learning may be out-of- school? How should learning be measured? What should be measured? What kinds of learning should be evaluated and recognized?

In a rapidly changing, digitally-mediated context, how can the trends toward educational standardization be reconciled with youth who value independent learning? How should innovative and entrepreneurial thinking be cultivated? There is urgency in this question; it appears inevitable that unless K-12 educational systems evolve to greater alignment with how youth are already learning through interest or self-motivated pathways, learners will become increasingly disengaged.

Digital badges with robust learning trajectories may ameliorate the situation and facilitate more personalized learning pathways. The badges designed for this study were aligned with the expectations of national and state standards. In addition, the badges accommodated a variety of learning products, as well as personalized demonstrations of learning competencies. Participants were encouraged to incorporate learning from informal contexts. Not only were they able to incorporate out-of-school learning, but the student participants in this study enjoyed this aspect of the digital badge program.

Digital badges with robust learning trajectories can empower and motivate learners. They have potential to foster skills and habits of mind for engaged STEM learning. Digital badges can evidence the creativity, higher-order thinking and problem solving skills necessary for STEM disciplines and careers. Youth can learn the skills and language of communities of practices, and in the process of acculturation, develop positive STEM identities.

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Appendices

Appendix A: Human Subjects Approval

EASTERN MICHIGAN UNIVERSITY

Education First

May 18, 2013 **UHSRC Initial Application Determination: EXPEDITED APPROVAL**

To: **Ms. Angela Elkordy**
Leadership and Counseling

Re: **UHSRC #130410** **Category: Approved Expedited Research Project**
Approval Date: **May 18, 2013**

Title: **Digital Badge Outcomes for STEM Learning in Formal and Informal Contexts: A Comparative Analysis Using Hierarchical Linear Modeling**

The Eastern Michigan University Human Subjects Review Committee (UHSRC) has completed their review of your project. I am pleased to advise you that **your expedited research has been approved** in accordance with federal regulations.

Renewals: Expedited protocols need to be renewed annually. If the project is continuing, please submit the **Human Subjects Continuation Form** prior to the approval expiration. If the project is completed, please submit the **Human Subjects Study Completion Form** (both forms are found on the UHSRC website).

Revisions: Expedited protocols do require revisions. If changes are made to a protocol, please submit a **Human Subjects Minor Modification Form** or new **Human Subjects Approval Request Form** (if major changes) for review (see UHSRC website for forms).

Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events, or any problem that may increase the risk to human subjects and change the category of review, notify the UHSRC office within 24 hours. Any complaints from participants regarding the risk and benefits of the project must be reported to the UHSRC.

Follow-up: If your expedited research project is not completed and closed after three years, the UHSRC office will require a new **Human Subjects Approval Request Form** prior to approving a continuation beyond three years.

Please use the UHSRC number listed above on any forms submitted that relate to this project, or on any correspondence with the UHSRC office.

Good luck in your research. If we can be of further assistance, please contact us at 734-487-0042 or via e-mail at gs_human_subjects@emich.edu. Thank you for your cooperation.

Sincerely,

Jennifer K. Fritz

Dr. Jennifer Kellman Fritz
Faculty Chair
University Human Subjects Review Committee

University Human Subjects Review Committee · Eastern Michigan University · 200 Boone Hall
Ypsilanti, Michigan 48197
Phone: 734.487.0042 Fax: 734.487.0050
E-mail: human.subjects@emich.edu
www.ord.emich.edu (see Federal Compliance)

The EMU UHSRC complies with the Title 45 Code of Federal Regulations part 46 (45 CFR 46) under FWA00000050.

Appendix B: Variable Tables – Student Pre Survey

Code Book						
Student Pre Treatment						
Demographics & Program Info.						
Q. #		Survey question	SPSS Variable Code	Construct / Variable	Data Type	Data Values
1		Please provide your code number, and the school or program group's code number.	Student_Code	Identifier	Nominal	
2		What is your teacher or group leader code?	Student_Teacher_Code	Identifier	Nominal	1=3122, 2=3111
3		What grade are you in?	Student_Grade	Demographic	Nominal	7=Grade 7, 10=Grade 10, 11=Grade 11, 12= Grade 12
4		Are you male or female?	Student_Gender	Demographic	Nominal	1=Boy, 2=Girl
5		How old are you?	Student_Age	Demographic	Scale	
6		What is your family race or ethnicity?	Student_Race	Demographic	Nominal	1=African American, 2= Arab American, 3= Other, 4=Biracial, 5= Prefer not to say
7		What are the main language spoken in your home(s)? Please check all that apply, adding more languages as appropriate, to the "Other" text box.	Student_Home_Lang	Demographic	Nominal	1=English, 2=Arabic, 3=Spanish, 4= Other
8		What is the name of the class(es), club or program through which you are earning digital badges?	Student_Program	Identifier	Nominal	1=Social Studies, 2=Algebra 2, 3=Business Math, 4= Study Hall
ICT and Digital Media Use						
9		Where you access the Internet and use digital media the most?	Student_Internet_Access	ICT Use	Ordinal	
10		Please rank the methods below in order of your preference for finding information for school assignments, projects and homework.	Student_Info_Seeking_School	Problem Solving Behaviors	Ordinal	
11		On average, how often do you send texts per day?	Student_Texts	ICT Use	Nominal	1=1-5, 2=6-10, 3=11-15, 4=15-20, 5=more than 20, 6= way more than 20, 7=I don't have a smartphone, 8=never

Appendix C: Variable Tables – Student Pre Survey

Code Book						
Student Post Treatment						
Demographics & Program Info.						
Q. #		**Survey question**	**SPSS Variable Code**	**Construct**	**Data Type**	**Data Values**
1		Please provide your code number, and the school or program group's code number.	Student_Code_Post	Identifier	Nominal	
2		What is your teacher or group leader code?	Student_Teacher_Code_Post	Identifier	Nominal	1=3122, 2=3111
3		What grade are you in?	Student_Grade_Post	Demographic	Nominal	7=Grade 7, 10=Grade 10, 11=Grade 11, 12= Grade 12
4		Are you male or female?	Student_Gender_Post	Demographic	Nominal	1=Boy, 2=Girl
5		What is the name of the class(es), club or program through which you are earning digital badges?	Student_Program_Post	Program Info.	Nominal	1=Social Studies, 2=Algebra 2, 3=Business Math, 4= Study Hall
Self-Efficacy						
6	a	I can master the skills that are taught.	Student_SE1_Post	Self-efficacy	Ratio	SALES sub scale
	b	I can figure out how to do difficult work.			Ratio	
	c	learn it.			Ratio	
	d	I can complete difficult work if I try.			Ratio	
7	a	I enjoyed doing this activity very much.	Student_Interest1	Motivation – Interest	Ratio	
	b	This activity was fun to do.			Ratio	
	c	I would describe this activity as very interesting.			Ratio	
	d	I thought this activity was quite enjoyable.			Ratio	
Performance						
8		If the program was longer, I would try to earn more badges	Student_Prog_Longer		Nominal	1=Strongly agree, 2=Agree, 3= Neutral, 4=Agree, 5=Strongly agree
9		I am satisfied with my performance at this task.	Student_Perceived_Comp1	Perceived Competence	Ratio	Intrinsic Motivation Inventory item
		I was pretty skilled at this activity.			Ratio	
Self-Regulation						

Appendix D—Youth Pre-Program Survey

Digital Badges Study: Youth Participant Pre Program Survey

Section A: Demographic Information

Page description:
Information about you, your school or program and location.

ID 40

This questionnaire asks about your use of the Internet and digital media as well as your opinions about learning. There are no right or wrong answers – it's your opinion that counts! *No one will be able to identify you personally from your answers.* We appreciate your time and thoughtful responses as we work to improve your learning experiences. Your results will be saved if you run out of time and would like to come back and finish the survey. You may quit or discontinue at any time. Thank you very much for participating!

VALIDATION **Min. answers = 1** *(if answered)* Max character count =
DATA Variable name: **Student_Code**
ID 4
1. Please provide your code number, and the school or program group's code number. *

Your code number

School or group code

Comments

Appendix E – Youth Post-program Survey

Digital Badges Study: Youth Participant Post Program Survey

Section A: Demographic Information

Page description:
Information about you, your school or program and location.

ID 40

This questionnaire asks about your experience and opinions about the digital badge program for learning. There are no right or wrong answers – it's your opinion that counts! *No one will be able to identify you personally from your answers.* Your results will be saved if you run out of time and would like to come back and finish the survey. You may quit or discontinue at any time. Thank you very much for participating! -- You are being part of a movement towards change in schools for learners like you!

VALIDATION **Min. answers = 1** *(if answered)* Max character count =
DATA Variable name: **Student_Code_Post**
ID 4
1. Please provide your code number, and the school or program group's code number. *

Your code number

School or group code

Comments

Appendix F –Educator Pre-Program Survey

Digital Badges Study: Educator Pre Program Survey

Welcome! Section A: Demographic Information

Page description:
Thank you for being an innovative educator! Your time and willingness to engage in the study are greatly appreciated. The findings of this study will inform educators and researchers about the use of digital badges in educational settings. Please answer the survey questions before implementing the digital badge program with your group. If you wish, you may save your answers and return to complete the survey within the next day or two. You are appreciated!

DATA Variable name: **Teacher_Name**
ID 2
1. What is your name? (first name, last name) *

DATA Variable name: **Teacher_School_Code**
ID 4
2. What is your school name? *

DATA Variable name: **Teacher_Gender**
ID 5
3. What is your gender?

Male
Female

Appendix G – Educator Pre-Program Survey

Digital Badges Study: Educator Post Program Survey Final

Welcome! Section A: Demographic and Program Information

Page description:
Thank you for being an innovative educator! Your time and willingness to engage in the study are greatly appreciated. The findings of this study will inform educators and researchers about the use of digital badges in educational settings. If you wish, you may save your answers and return to complete the survey within the next day or two. You are appreciated!

DATA Variable name: **Teacher_Name_Post**
ID 2
1. What is your name? (first name, last name) *

DATA Variable name: **School_Code_Post**
ID 4
2. What is your school name? *

Section B: Digital Badges as Instructional Tools

Page description:
About the use of digital badges for instructional purposes.

Appendix H – Digital Badge Design Documents (InfoMaker)

InfoMaker Digital Badge Series

About the

InfoMaker

(Obtaining, Evaluating and Communicating Information)

Badge Track:

The focus of this badge series is: "learner as innovative problem solver." During the process of design or investigation during trials, the learner obtains, evaluates, creates and ultimately communicates data, procedures and outcomes. Working initially as an information consumer, the learner seeks to define and understand a problem within the context of previous solutions or research. The learner's goal is to design a new or innovative object, tool or process which improves upon or refines previous designs; in the process, information is obtained, evaluated and communicated.

As the learners work through the badge levels, information is both consumed and produced in the process of problem solving a design challenge or investigation. A problem or challenge is investigated, assessed, built and tested, during which time information is obtained evaluated and outcomes communicated. "Design" is viewed as a cyclical process, during which the learner is immersed in "design thinking:"

- defines a problem or a challenge;
- seeks information to inform a design solution (previous research and needs analysis);
- proposes a potential solution;
- creates a working model where possible, or conducts several trials to collect data;
- evaluates results and hence the design, in light of specifications or objectives;
- communicates outcomes, including reflections/ recommendations on how to improve or refine the design for another iteration of design cycle.

Badge earners use a variety of written and visual means to communicate the purposes, processes and outcomes of the design. At the challenge level, badge earners build upon the results of their own designs or research, completing another iteration of the design cycle.

Innovation is grounded in understanding of the problem parameters, needs and prior solutions perhaps designed and tried by others.

Appendix H (ii) – Digital Badge Design Documents (InfoMaker – Student Version, Level 1)

InfoMaker Level 1

This badge is awarded to learners who demonstrate an understanding of the information needs of designers, scientists and engineers at the introductory level. The badge tasks include selecting, collecting and using information in the process of design or investigation

What do I have to do to earn the badge?

Badge Tasks – successfully do the following:

- Select a project, challenge or assignment which is appropriate for available time and resources (within guidelines provided by teacher or group leader if applicable)
- Write a design or problem statement for a project
- Collect 3-8 reliable and credible information from different kinds of sources such as: journals, magazines, web sites, personal communications (discussions, emails, or interviews with experts), kits, books, blogs, online publications
- Explain your thinking -- make it "visible" to others -- while documenting the design process through InfoMaker Journal entries:
    - problem definition (description of the problem, why it is important)
    - information seeking processes (how and why information was located and selected)
    - descriptive summaries from three different information sources (one paragraph or more)
    - ideas for possible solutions

    You can create a page on Makewav.es for each journal entry, link to a blog entry, use a paper journal and upload a picture, or ask your teacher to approve a written journal at your school or program.

How can I show my learning? (Be creative!)

Evidence of learning (examples):

- InfoMaker journal entries (upload or link to files or pictures, or mentor-approved)
- links to electronic artifacts (e.g. to a set of curated articles, blog entries, Pinterest board, student eportfolio, mind maps, digital bibliography collection, video summaries)
- pictures (sketches, mind maps or concept maps, supplies and/or materials, design idea, labeled objects)

How long will it take me to earn the badge?

- It depends! Depending on your interest and knowledge about the topic you choose, this badge will take 3-8 hours to earn.

When will I get my badge?

Appendix I – Digital Badge Design Documents (Data Whiz)

Data Whiz Digital Badge Series

About the

Data Whiz

(Analyzing and Interpreting Data)

Badge Track:

This digital badge system scaffolds, assesses and communicates learning in basic data and statistical concepts for middle and high school age learners. It is designed to be used in a variety of content areas in addition to science and math.

The badge system consists of two tracks; **Data Whiz** (grades 6-8) and **Data Hacker** (grades 8-10), each with five levels. The grade range is approximate (allowing for differentiation at educators' discretion) and level 5 is an additional, challenge level.

Beginning at level 1, the learner demonstrates competency in understanding introductory data and statistical concepts by identifying characteristics and features in existing data sets. In level two, badge earners create their own accurately labeled charts or graphs from existing data. Data is collected, analyzed and interpreted in level three and in level four, the learner demonstrates the ability to construct a simple collection tool to collect appropriate data to solve an authentic problem or inquiry (survey, observation, repeated trials or simulation). The learner communicates findings in appropriate visual formats along with a proposed solution or summary to the problem/inquiry which requires interpretation of the data in context.

The challenge level, five, requires the calculation and interpretation of best line of fit, that is, correlational analysis, in addition to collecting, interpreting and displaying data in context.

Appendix J – Digital Badge Design Documents (Data Whiz – Student Version, Level 1)

Data Whiz Level 1

This badge is given to learners who have demonstrated understanding of data and statistics at the introductory level. The badge tasks include remembering, identifying and understanding vocabulary as well as to understand basic concepts about data.

What do I have to do to earn the badge?

Badge Tasks – successfully do the following:

Using existing data sets (from teachers, your own or from other sources such as the Internet. See "Learning Resources" for more ideas):

1) Accurately label three different kinds of graphs or charts (bar charts, histograms, pie charts, etc), identifying key features (units of measurement, data, correctly labeled data, axes, sectors or columns)
2) Draw four to six points of data for each chart or graph on a number line (dot plots, histograms or box plots). For example, one point, marked with an "x" could be described as 36% of the class liked red M&M's, or 6 runners took over 12 minutes to finish 1 mile)
3) Show the average (mean), most often occurring number (mode) and middle value (median) for one of the three charts or graphs. What is the range of numbers? Show your work as numbers or objects (take or make a picture).

You can create a page on Makewav.es for each journal entry, link to a blog entry, use a paper journal and upload a picture, or ask your teacher to approve a written journal at your school or program.

How can I show my learning? (Be creative!)

Evidence of learning (examples):

- Graphs or charts appropriately labeled (upload or link to files)
- Illustrated glossary of data terms
- Pictures (labeled graphs or drawings) (upload or link to files)
- Pictures (e.g. various units of measurement, to show understanding)
- Vocabulary quiz

How long will it take me to earn the badge?

- It depends! Depending on your interest and knowledge about the topic, this badge will take 1-3 hours to earn.

When will I get my badge?

Appendix K – Digital Badge Design Documents (Data Hacker)

Data Hacker Digital Badge Series

About the

Data Hacker

(Analyzing and Interpreting Data)

Badge Track:

This digital badge series functions to scaffolds, assesses and communicates learning in introductory and intermediate data and statistical concepts for middle and high school age learners. It is designed to be used in a variety of content areas in addition to science and math.

The badge system consists of two tracks; **Data Whiz** (grades 6-8) and **Data Hacker** (grades 8-10), each with five levels. The grade range is approximate (allowing for differentiation at educators' discretion).

Beginning at level 1, the learner demonstrates competency in understanding basic and intermediate data and statistical concepts by identifying characteristics and features in existing data sets. In level two, badge earners create their own accurately labeled charts or graphs from existing data. Data is collected, analyzed and interpreted in level three. By level four, the learner has demonstrated the ability to construct a data collection methodology to collect appropriate data to solve an authentic problem or inquiry. The learner communicates findings in appropriate graphic format along with a proposed solution or interpretation to the problem/inquiry which requires interpretation of the data in context.

Appendix K (ii) – Digital Badge Design Documents (Data Hacker)

Data Hacker Level 1

This badge is given to learners who have demonstrated an understanding of data and descriptive statistics at the introductory level. The badge criteria include objectives to remember, understand and apply statistical terms as well as to understand basic concepts in data analysis and interpretation.

What do I have to do to earn the badge?

Badge Tasks – successfully do the following:

Using existing data sets (from teachers, your own or from other sources such as the Internet (see "Learning Resources" for more ideas):

1. Calculate the mean (average), mode and median for three different sets of data which have two variables such as: number of Facebook "likes" for a post and time of day, volume of ice cream sold per unit time and outside temperature etc
2. Write a brief summary (one to two paragraphs) to describe the data collections, using use appropriate vocabulary, including: measures of central tendency (mean, mode and median) and other characteristics such as shape and skew of the distribution, outliers, range and interquartile range
3. Create and label charts, scatterplots, graphs, infographics or computer generated analyses from the existing data sets (one for each data set)

> ***You can create a page on Makewav.es for each journal entry, link to a blog entry, use a paper journal and upload a picture, or ask your teacher to approve a written journal at your school or program.***

How can I show my learning? (Be creative!)

Evidence of learning (examples):

- Audio file (data description)
- Blog or journal entry of written descriptions (Makewave.es or other link or picture)
- Graphs and charts, appropriately labeled (upload or link to files)
- Illustrated glossary of terms
- Infographic or computer generated graphics (e.g. http://books.google.com/ngrams)
- Images (labeled graphs or drawings) (upload or link to files)
- Podcast or audio file of participants' explanations, reteaching or discussion
- Visual media accompanied by explanations

How long will it take me to earn the badge?

- It depends! Depending on your interest and knowledge about the topic, this badge will take 1-3 hours to earn.

Appendix L – Program Implementation Manual

InfoMaker 1

Digital Badges Study:

Project Guidelines and Procedures

Angela Elkordy, Principal Investigator

aelkordy@emich.edu

Appendix M – Informed Consent (Parents, English)

Statement of Consent

Participation in Digital Badges Study Research

(Parents' Consent for Minor)

November, 2013

Dear Parent (or Guardian):

Thank you for taking the time to learn more about this study! My name is Angela Elkordy; I am a doctoral student at Eastern Michigan University. I am sending this letter to explain the purpose of my research and to request permission for your child to participate.

Purpose of the Study: As a middle or high school student, your child is learning continuously in school and in other environments. The purpose of this research is to study a new strategy to enhance, measure and communicate student learning, called Digital Badges. Much like boy or girl scout badges, digital badges are symbols of achievement with the potential to measure a variety of skills which are important, but which may not currently be measured by grades or tests. Digital badges may be earned by demonstrating learning in specific knowledge or skill sets. The difference between grades and digital badges is that parents, college admissions or potential employers will be able to click on the badge to see the skills demonstrated by the student in the course of earning it. A "grade" however, does not really describe what students are actually able to perform. In addition, we know from other contexts where digital badges are used, for example in online games, that the badges can be very motivating to youth.

In the educational community, many educators are excited about the potential of digital badges to give students the tools they need to succeed for learning not only in the classroom, but also in informal context such as museums, after school, libraries or other clubs. However, educators need to learn more about how this promising new educational innovation, digital badges and their designs, work in learning contexts. The results of this study will contribute to this understanding. The study consists of two online surveys and possible participation in a secure, online learning context (Makewaves.com) where youth participants can interact with each other, teacher or mentors.

Description of the Study Procedures: The digital badge program will be used in the normal learning context, either in school or in an after school setting. Participants will have the opportunity to earn badges by demonstrating knowledge in how to recognize and use data, for example. The digital badges may be viewed online, here: www.makewav.es/badgebox. It is anticipated teachers or group leaders will use the digital badge program for 2-4 weeks in their regular instruction.

Appendix N – Informed Consent (Parents, Arabic)

بيان موافقة

المشاركة في دراسة بحث الشارات الرقمية
(سماح الوالدين بمشاركة الأبناء)

نوفمبر / تشرين الثاني، 2013

عزيزي الوالد / الوالدة (أو الوصي):

شكراً لك على وقتك لمعرفة المزيد عن هذه الدراسة. إسمي أنجيلا الكردي، طالبة دكتوراه في جامعة ميتشيجان الشرقية. أبعث هذه الرسالة لشرح الغرض من بحثي وطلب الإذن لطفلك في المشاركة.

الغرض من البحث:
إبنك أو بنتك، كطالب في المرحلة الاعدادية أو الثانوية، يتعلم باستمرار داخل المدرسة أو خارجها. الغرض من هذا البحث هو دراسة وسيلة جديدة لدعم وقياس ما تعلمه الطالب، ومكافأة ذلك بالحصول على الشارات الرقمية. مثل شارات الكشافة، فإن الشارات الرقمية تعتبر رموز إنجاز وإمكانية قياس العديد من المهارات الهامة، التي لا يمكن حالياً قياسها خلال التقييم المدرسي أو الإختبارات المدرسية. ويمكن الحصول على الشارات الرقمية بعد التحقق من إكتساب معرفة متخصصة أو مهارات معينة. الفرق بين التقييم المدرسي والشارات الرقمية هو أن الشارات يمكن للوالدين أو تنسيق الجامعات أو شركات التوظيف أن تستخدم الانترنت للتحقق من المهارات التي اكتسبها الطالب للحصول عليها. بينما التقييم المدرسي لا يتضمن وصفاً لقدرة الطالب الفعلية. بالإضافة لذلك، فإننا نعلم من سياقات أخرى تستخدم فيها الشارات الرقمية، على سبيل المثال الألعاب عبر الإنترنت، أن استخدام الشارات يعتبر عاملاً مشجعاً جداً للشباب.

٢

في الدوائر التعليمية، كثير من المدرسين متحمسون لإمكانية إستخدام الشارات الرقمية لإعطاء الطلاب الأدوات المطلوبة لنجاحهم في التعلم، ليس فقط في الفصول الدراسية، ولكن في سياق غير رسمي مثل المتاحف أو المكتبات أو الأندية أو أي فصول خاصة بعد إنتهاء اليوم الدراسي. بيد أن المعلمين بحاجة إلى معرفة المزيد عن هذا الإبتكار التعليمي الواعد، وكيفية الاستفادة من هذه الشارات الرقمية وتصميمها في العملية التعليمية. نتائج هذا البحث سوف تسهم في هذا الفهم. ستكون الدراسة من إستطلاعين على الإنترنت موجودين على موقع إنترنت تعليمي مؤمن (Makewaves.com) حيث يمكن الشباب المشارك في التواصل مع بعضهم البعض بالاضافة إلى معلميهم ومربيهم.

وصف خطوات الدراسة:

برنامج الشارات الرقمية سوف يستخدم في السياق التعليمي الطبيعي سواء أثناء اليوم الدراسي أو بعد إنتهاء الحصص الدراسية. الطلبة المشاركين يمكنهم إكتساب الشارات عندما يثبتوا معرفتهم بالتعرف واستخدام البيانات المطلوبة. هذه الشارات الرقمية يمكن التعرف عليها على موقع الانترنت (www.makewav. es/badgebox). من المتوقع أن يشرف المدرسون وقادة المجموعات على برنامج الشارات الرقمية لمدة تتراوح من أسبوعين إلى أربعة أسابيع خلال الفصل الدراسي. كجزء من هذه الدراسة، سيطلب من طفلكم ملء إستطلاعين على الانترنت (يستغرق كل منهما حوالي ١٥ إلى ٢٠ دقيقة). الإستطلاع الأول قبل المشاركة في البرنامج والثاني بعد مشاركته في برنامج الشارات الرقمية. الاستطلاع الأول سوف يسأل عن الطرق المفضلة للتعليم، ومدى إهتمام الطالب بالعلوم وما إذا كان الطالب يستخدم الكمبيوتر أو الإنترنت. الإستطلاع الثاني بعد المشاركة في برنامج الشارات سوف يتضمن أسئلة عن استخدام الشارات الرقمية ومدى الاهتمام بالعلوم والموضوعات الشيقة ونوعية الأنشطة التعليمية داخل الفصل (مثلا توجيهات المدرس أو التعاون مع صديقه بالفصل) وذلك بالاضافة إلى الرغبة والدافع للتعلم بنظام برنامج الشارات.

3

الطلبة يمكنهم المشاركة في نظام تعلُّم إجتماعي على موقع إنترنت آمن اسمه Makewaves حيث بالتعاون مع إشراف الكبار من مدرسين وقادة مجموعات) والتواصل مع بعضهم البعض، يخلق ذلك مناخاً للتعلم.

المشاركة الطوعية أو رفض المشاركة:
مشاركة طفلك في هذه الدراسة هي طوعية تماما ولن تؤثر على الأداء الدراسي بأي شكل. ويمكن لطفلك أن يتوقف عن المساهمة في أي وقت دون عقوبة.

المخاطر المتوقعة من الدراسة:
لا توجد مخاطر متوقعة من المشاركة في هذه الدراسة.

الفوائد المتوقعة من الدراسة:
لا يوجد مقابل مادي للمشاركة في الدراسة للطلبة أو أولياء الأمور. ولكن "الشارات الرقمية" سوف تمنح للمشاركين الذين سيكملون بنجاح المتطلبات الدراسية والتقييم، ويمكن اعتبار ذلك جوائز للمشاركة. وبناء على تقييم مواقع الانترنت، من الجائز أن يحصل المشاركين على الفانلات (T-shirt) أو الشهادات أو جوائز مشابهة للمشاركة.

سرية المعلومات التي يتم الحصول عليها:
لحماية خصوصية طفلك، هوية الطالب سيتم استبدالها برقم كودي يحفظ في المدرسة أو موقع البرنامج. ولن تتكون أي سجلات محتوية معلومات عن هوية المشاركين. وسوف يستخدم المشاركين الأرقام الكودية المعطاه لهم من المدرسين أو قادة المجموعات، ولن تظهر أسماء المشاركين على مواقع الاستطلاعات على الانترنت. والطلبة المشاركين سوف يدخلون على موقع (Makewaves) باستخدام كنية ورقم كودي، وبالتالي فالباحثة لن تتمكن من التعرف على هوية أي مشارك.

إستخدام نتائج البحث:
نتائج الاستطلاعات سيتم تنزيلها ثم إزالتها من موقع الانترنت (Survey Gizmo). نتائج الإستطلاعات سيتم عرضها فقط على الباحثة الرئيسية ورئيس اللجنة المشرفة الدكتور جيمس بيري. البيانات الجماعية لا الفردية سوف يتم نشرها في رسالة الدكتوراه وقد تنشر في الدوريات المتخصصة أو على الأنترنت. المشاركين لن يتم تحديدهم فرديا.

أسئلة أخرى:
إذا كان لديك أسئلة إضافية، يرجى الإتصال بأنجيلا الكردي (Angela Elkordy) الباحثة الرئيسية على (aelkordy@emich.edu) تليفون (734-494-0640) أو زيارة موقع المشروع على الانترنت: (http://www.badgebox.net).

مجلس المراجعة للأبحاث المعنية بالإنسان:
بروتوكول البحث وبيان الموافقة تمت مراجعته والموافقة عليه بواسطة مجلس المراجعة للأبحاث المعنية بالإنسان لجامعة ميشيغان الشرقية (UHSRC) ويمكن استخدامه في الفترة من ١٨ مايو، ٢٠١٢ إلى ١٨ مايو، ٢٠١٤. إذا كان لديك أسئلة عن عملية الموافقة، من فضلك إتصل بـ (UHSRC) على (human.subjects@emich.edu) أو إتصل على (734-487-0042).

الموافقة على المشاركة:
قرأت بيان الموافقة أعلاه. وفيه أصبح واضحا لي طبيعة المشروع ومتطلباته ومخاطره وفوائده، وأنا مدرك أن لدي الفرصة لطرح أسئلة عن البحث. وأنا أتفهم أن بإمكاني سحب موافقتي وإيقاف مشاركة طفلي في أي وقت دون عقوبة. وبتوقيعي على هذا النموذج، أنا لا أتنازل عن أي مطالبات قانونية، أو حقوق أو تعويضات.

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إسم الطفل المدرس / الفصل الدراسي

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توقيع ولي الأمر أو الوصي التاريخ

رجاء إرجاع هذا النموذج إلى ______________

بتاريخ ______________

Appendix P – Statement of Assent (Students)

Statement of Assent (Participation in Research)

Using Digital Badges for Learning with Middle and High School Students

November, 2013

Purpose of the Study: My name is Angela Elkordy. I'm a doctoral (graduate) student at Eastern Michigan University. I'm interested in helping educators learn more about ways to teach middle and high school students using approaches youth might choose for themselves such as using technology or working in teams of friends.

I'm also interested in ways youth can demonstrate "all" their learning -- even when that learning happens outside of school and not necessarily directly related to school subjects. I'm inviting you to take part in a research study about the use of digital badges for learning, which is a new strategy educators are using to make learning more interesting for youth who have grown up using digital media and the Internet. In the gaming world, digital badges are symbols of achievement with the potential to measure and show skills in a variety of subjects

Why might you be interested in doing this? You can show your teachers, family and perhaps college admission officers your valuable learning whether in school, at the library, in a museum or after school group. You are learning all the time and digital badges can give you a way to communicate your learning with others. Learn more about the study at http://www.badgebox.net (Research Hub) or at the study web site: www. Makewav.es/badgebox.

Description of the Study Procedures: To earn digital badges, you will show your learning in design thinking, science, or math as well as presentation skills by completing assignments. You'll be given information on the kinds of things you can do to show you understand the ideas, as well as how to earn the badge. The digital badge will be yours, once you have earned it. You can have a paper copy, or display it on your blog, Facebook and other social media. If (or when) you are over 13, the digital badges can eventually be collected and displayed in something called a "digital backpack" (free, http://backpack.openbadges.org/backpack/login)

If you agree to participate in the study, you will be asked to fill out two online questionnaires (one before the digital badge program, and one after) which will take about 15-20 minutes each. Your name will NOT be on the questionnaire, but you will be asked to provide information such as your age, grade, and gender (whether you are male or female) on the form. **Please note that it will not be possible to link your name with your questionnaire.** To complete the entire badge program will probably take 2-4 weeks, depending on your teacher or group leader.

Revised November, 2013

Appendix Q – Informed Consent (Teachers)

Statement of Consent

Participation in Digital Badges Study Research (Teachers or Program Leaders)

November, 2013

Dear Colleague:

Thank you for taking the time to learn more about this study! My name is Angela Elkordy; I am a doctoral student at Eastern Michigan University. I am sending this letter to explain the purpose of my research and to request your consent to participate.

Purpose of the Study: As a professional working with middle or high school students, you know that they are learning continuously in school and in other environments. The purpose of this research is to study a new strategy to enhance, measure and communicate student learning, called Digital Badges. Much like boy or girl scout badges, digital badges are symbols of achievement with the potential to measure a variety of skills which are important, but which may not currently be measured by grades or standardized tests. Digital badges may be earned by demonstrating learning in specific knowledge or skill sets. The difference between grades and digital badges is that parents, college admissions, potential employers or other interested audiences will be able to click on the badge to see the knowledge and/or skills demonstrated by the student in the course of earning it. A "grade" however, does not really describe what students are actually able to perform, to understand or to apply. In addition, we know from other contexts where digital badges are used, for example in online games, that the badges can be very motivating to youth.

In the educational community, many educators are excited about the potential of digital badges to be tools for student success in learning, not only in the classroom, but also in informal contexts, such as a science museum, after school or other clubs. However, educators need to learn more about how these promising new educational innovations, digital badges systems and their designs, work in learning contexts. The results of this study will contribute to this understanding. The research consists of two online surveys for students and teachers (before and after using a digital badge program) as well as possible participation in a secure, online learning system (Makewaves) where youth participants can interact with each other, teacher or mentors.

Description of the Study Procedures: The digital badge program will be used in the normal learning context, either in school or in after school settings. Student participants will have the opportunity to earn badges by demonstrating knowledge in how to recognize and use data, for example. The digital badges may be viewed online at the project web site (www.makewav.es/badgebox). It is anticipated that

Appendix R – Informed Consent (Principal)

Statement of Consent

Participation in Digital Badges Study Research

November, 2013

Dear Principal/ Program Director:

Thank you for taking the time to learn more about this study. My name is Angela Elkordy; I am a doctoral student at Eastern Michigan University. I would like to request permission for your teachers/staff and students/youth to participate in a research study. This letter explains the purpose of my research and requests your consent for participation. The study has been designed for to be appropriate in variety of learning contexts; this will minimize teacher participants' task load and to work with existing curricula to provide a new instructional tool for learning.

Purpose of the Study: Middle and high school students are learning continuously in school and in other environments. The purpose of this research is to study a new strategy to enhance, measure and communicate student learning, called Digital Badges. Much like boy or girl scout badges, digital badges are symbols of achievement with the potential to measure a variety of skills which are important, but may not currently be measured by grades or tests. Digital badges may be earned by demonstrating learning in specific knowledge or skill sets. The difference between grades and digital badges is that parents, college admissions or potential employers will be able to click on the badge to see evidence of the skills and knowledge acquired. A "grade" however, does not really describe what students are actually able to perform or understand. In addition, we know from other contexts where digital badges are used, for example in online games, that the badges can be very motivating to youth.

In the educational community, many educators are excited about the potential of digital badges to give students the tools they need to succeed for learning not only in the classroom, but also in informal contexts, such as a science museum, after school or other clubs. Importantly, however, educators need to understand more about how this promising new educational innovation, digital badges and their designs, work in learning contexts. The results of this study will contribute to this understanding, informing educational practitioners and leaders. The study consists of two online surveys for students and teachers (one before and after implementing the digital badge program) as well as possible participation in a secure, online learning system (Makewaves) where youth participants can interact with each other, teacher or mentors.

Description of the Study Procedures: The digital badge program will be used in the normal learning context, either in school or in an after school setting. Student participants will have the opportunity to earn badges by demonstrating knowledge in how to recognize and use data, for example.

Appendix S: Select Statistical Analyses

Paired Sample T-Tests

Table 47. *Paired Samples Test: Measures of Self Efficacy*

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	I can master the skills that are taught	1.9701	5.7366	.7008	.5709	3.3694	2.811	66	.006
Pair 2	I can figure out how to do difficult work.	1.9552	5.7404	.7013	.5550	3.3554	2.788	66	.007
Pair 3	Even if the work is hard, I can learn it.	2.3731	5.4961	.6715	1.0325	3.7137	3.534	66	.001
Pair 4	I can complete difficult work if I try.	.4776	4.8566	.5933	-.7070	1.6622	.805	66	.424
Pair 5	I am good at these subjects.	1.0896	5.6454	.6897	-.2875	2.4666	1.580	66	.119
Pair 6	I can understand the content taught.	1.1343	4.6446	.5674	.0014	2.2672	1.999	66	.050
Pair 7	I can learn the work we do.	.2388	5.0755	.6201	-.9992	1.4768	.385	66	.701

Pair 8	I will receive good grades.	.1493	4.4526	.5440	-.9368	1.2353	.274	66	.785

Table 48. *Paired Samples Test: Measures of Self-Regulation*

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Even when the tasks were uninteresting, I kept working.	1.9701	5.4577	.6668	.6389	3.3014	2.955	66	.004
Pair 2	I worked hard even if I did not like what I was doing.	2.5000	5.4863	.6753	1.1513	3.8487	3.702	65	.000
Pair 3	I continued working even if there were better things to do.	2.0159	5.5605	.7006	.6155	3.4163	2.878	62	.005
Pair 4	I concentrated so that I did not miss important points.	1.4091	4.8579	.5980	.2149	2.6033	2.356	65	.021

Pair 5	I kept working until I finish what I am supposed to do.	-.6364	6.7679	.8331	-2.3001	1.0274	-.764	65	.448
Pair 6	I did not give up even when the work is difficult.	1.0299	5.9211	.7234	-.4144	2.4741	1.424	66	.159
Pair 7	I concentrated in class or in my program.	.5970	6.0605	.7404	-.8812	2.0753	.806	66	.423
Pair 8	I finished my work and assignments on time.	.1364	5.9249	.7293	-1.3202	1.5929	.187	65	.852

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Table 49. *Paired Samples Test: Measures of Task Value*

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	What I learn can be used in my daily life.	.7015	6.1324	.7492	-.7943	2.1973	.936	66	.353
Pair 2	What I learn is interesting.	2.0000	6.3318	.7794	.4434	3.5566	2.566	65	.013

Pair 3	What I learn is useful for me to know.	.5455	5.0480	.6214	-.6955	1.7864	.878	65	.383
Pair 4	What I learn is helpful to me.	-.1667	5.9707	.7349	-1.6344	1.3011	-.227	65	.821
Pair 5	What I learn is relevant to me.	.7910	6.1510	.7515	-.7093	2.2914	1.053	66	.296
Pair 6	What I learn is of practical value.	.7424	7.0652	.8697	-.9944	2.4793	.854	65	.396
Pair 7	What I learn satisfies my curiosity.	.2769	6.1910	.7679	-1.2571	1.8110	.361	64	.720
Pair 8	What I learn encourages me to think.	.8030	6.0795	.7483	-.6915	2.2976	1.073	65	.287

ANOVA

Table 50. *ANOVA comparing means of interest measures by gender: Q. 7 (Post) Girls*

Tukey HSD

Dependent Variable	(I) Student Grade	(J) Student Grade	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
I enjoyed doing this activity very much.	Grade 7	Grade 10	.4542	1.3697	.941	-2.890	3.798
		Grade 12	.8542	1.5879	.853	-3.023	4.731
	Grade 10	Grade 7	-.4542	1.3697	.941	-3.798	2.890
		Grade 12	.4000	1.6068	.966	-3.523	4.323
	Grade 12	Grade 7	-.8542	1.5879	.853	-4.731	3.023
		Grade 10	-.4000	1.6068	.966	-4.323	3.523
This activity was fun to do.	Grade 7	Grade 10	-.6500	1.3449	.880	-3.934	2.634
		Grade 12	-.0278	1.5593	1.000	-3.835	3.779
	Grade 10	Grade 7	.6500	1.3449	.880	-2.634	3.934
		Grade 12	.6222	1.5779	.918	-3.230	4.475
	Grade 12	Grade 7	.0278	1.5593	1.000	-3.779	3.835
		Grade 10	-.6222	1.5779	.918	-4.475	3.230
I would describe this activity as very interesting.	Grade 7	Grade 10	.5000	1.4035	.933	-2.927	3.927
		Grade 12	.9444	1.6271	.831	-3.028	4.917
	Grade 10	Grade 7	-.5000	1.4035	.933	-3.927	2.927
		Grade 12	.4444	1.6465	.961	-3.575	4.464
	Grade 12	Grade 7	-.9444	1.6271	.831	-4.917	3.028
		Grade 10	-.4444	1.6465	.961	-4.464	3.575
I thought this activity was quite enjoyable.	Grade 7	Grade 10	-.2458	1.5391	.986	-4.004	3.512
		Grade 12	1.1319	1.7844	.802	-3.225	5.489
	Grade 10	Grade 7	.2458	1.5391	.986	-3.512	4.004
		Grade 12	1.3778	1.8057	.728	-3.031	5.786
	Grade 12	Grade 7	-1.1319	1.7844	.802	-5.489	3.225
		Grade 10	-1.3778	1.8057	.728	-5.786	3.031

a. 4_Student_Gender = Girl

Table 51. *ANOVA comparing means of interest measures by gender: Q. 7 (Post) Boys*

Tukey HSD

Dependent Variable	(I) 3_Student_Grade	(J) 3_Student_Grade	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
I enjoyed doing this activity very much.	Grade 7	Grade 10	.6339	1.0946	.832	-1.991	3.258
		Grade 12	.9278	1.2400	.736	-2.045	3.901
	Grade 10	Grade 7	-.6339	1.0946	.832	-3.258	1.991
		Grade 12	.2939	1.1310	.963	-2.418	3.006
	Grade 12	Grade 7	-.9278	1.2400	.736	-3.901	2.045
		Grade 10	-.2939	1.1310	.963	-3.006	2.418
This activity was fun to do.	Grade 7	Grade 10	.6887	1.0854	.802	-1.914	3.291
		Grade 12	.2944	1.2295	.969	-2.654	3.242
	Grade 10	Grade 7	-.6887	1.0854	.802	-3.291	1.914
		Grade 12	-.3943	1.1214	.934	-3.083	2.295
	Grade 12	Grade 7	-.2944	1.2295	.969	-3.242	2.654
		Grade 10	.3943	1.1214	.934	-2.295	3.083
I would describe this activity as very interesting.	Grade 7	Grade 10	1.5758	1.1085	.336	-1.082	4.234
		Grade 12	.6833	1.2557	.850	-2.328	3.694
	Grade 10	Grade 7	-1.5758	1.1085	.336	-4.234	1.082
		Grade 12	-.8925	1.1454	.717	-3.639	1.854
	Grade 12	Grade 7	-.6833	1.2557	.850	-3.694	2.328
		Grade 10	.8925	1.1454	.717	-1.854	3.639
I thought this activity was quite enjoyable.	Grade 7	Grade 10	.1290	1.2160	.994	-2.787	3.045
		Grade 12	.0556	1.3775	.999	-3.247	3.358
	Grade 10	Grade 7	-.1290	1.2160	.994	-3.045	2.787
		Grade 12	-.0735	1.2564	.998	-3.086	2.939
	Grade 12	Grade 7	-.0556	1.3775	.999	-3.358	3.247
		Grade 10	.0735	1.2564	.998	-2.939	3.086

Student Gender = Boy

ANOVA with all Factors

Table 52. *ANOVA by Student Grade (no significant difference between groups)*

		Sum of Squares	df	Mean Square	F	Sig.
WorksHard2	Between Groups	.033	2	.016	.016	.985
	Within Groups	64.293	61	1.054		
	Total	64.326	63			
WorksHard1	Between Groups	2.484	2	1.242	1.389	.257
	Within Groups	54.560	61	.894		
	Total	57.045	63			
Recog1	Between Groups	3.435	2	1.717	1.755	.181
	Within Groups	65.562	67	.979		
	Total	68.997	69			
TaskValue1	Between Groups	.002	2	.001	.001	.999
	Within Groups	66.563	67	.993		
	Total	66.565	69			
TaskValue2	Between Groups	1.258	2	.629	.611	.546
	Within Groups	68.996	67	1.030		
	Total	70.254	69			
TaskValue3	Between Groups	.825	2	.413	.445	.643
	Within Groups	62.184	67	.928		
	Total	63.009	69			
Sharing1	Between Groups	.615	2	.307	.301	.741
	Within Groups	68.392	67	1.021		
	Total	69.006	69			
Sharing2	Between Groups	1.344	2	.672	.672	.514
	Within Groups	66.955	67	.999		
	Total	68.299	69			

LotsOfFun	Between Groups	.580	2	.290	.289	.750
	Within Groups	67.150	67	1.002		
	Total	67.729	69			
Self-efficacy1	Between Groups	2.377	2	1.189	1.271	.287
	Within Groups	62.668	67	.935		
	Total	65.046	69			
Self-efficacy2	Between Groups	5.119	2	2.560	2.996	.057
	Within Groups	57.237	67	.854		
	Total	62.356	69			
GoalOriented 1	Between Groups	.399	2	.199	.204	.816
	Within Groups	65.528	67	.978		
	Total	65.927	69			
GoalOriented 2	Between Groups	1.590	2	.795	.801	.453
	Within Groups	66.521	67	.993		
	Total	68.111	69			

Appendix T- Student Open-text Question 20:

Count	Response
1	working harder and doing exactly everything I needed to complete all the tasks I needed to do.
1	CHANG THE CIASS
1	How I prepared my work and time.
1	How to use them based on skills.
1	I badges the class chage
1	I don't know what would I do.
1	I used like thim
1	I world change by my class
1	I would actually be more involved
1	I would change
1	I would do everything on time.
1	I would do more practice work in class and at home.
1	I would earn more badges.
1	I would give more opportunities.
1	I would have spent more time trying to get to know how to get digital bagdes.
1	I would have worked harder
1	I would not change anything.
1	I would spend more time on my didgital badges.
1	I would take more time into completing my task to earn a badge.
1	I would work on enough
1	InfoMaker 1
1	Make it easier steps or way to get badges from bottom to top.
1	More time
1	My time and how I divided it for school and work.
1	NON
1	Not having the time to do it.

Count	Response
1	Nothing.
1	Steps more easier to gain more badges and master them.
1	The amount of work and time I put into it
1	The constant survey taking it gets annoying after a while
1	The fact that we had to work for weeks when we can only work like a day just to finish
1	The steps of getting badges.
1	The writing or the model.
1	anything that I don't about it at that time
1	do better in class
1	everything
1	gym
1	i did not grt badges
1	i would change the requirements.
1	i would let every one participate
1	i would start over and do something batter
1	i would worck harder
1	i would work harder and try to earn more badges
2	idk
1	in some ways yes
1	inaa besss
1	more changes that can help
1	my journal entries
1	my mestakes
1	my performance
1	my perspective.
1	my point of view on the project.
1	not change anything
3	nothing

C ount	Response
1	nothing
1	nothing it perfect the way it is .
1	nun
1	people can use my information inthere homework
1	showing my work
1	student involvement. How to inform others on how to do assignments in other ways.
1	the amount of time given to work on badges
1	the amount of writing.
1	the boss
1	the directions
1	the ruls
1	the time allowed for each badge
1	the topic or what they want to change the learning environment
1	the topic.
1	the work
1	weel maybe not because the one i choose could be good.
1	at i would what to change is i would work even harder and i would want to finish more bagdes.
1	what im researching about
1	when the group in my class i think is help match
1	work hard
1	yes
1	ould love to use them again. I would try working harder and always put my effort into my work.
1	ULD CHNAGE THE WAY I LOOKED AT THINGS BECAUSE IN THE BEGINING I DIDNT NT TO DO IT I THOUGHT IT WOULD BE TO DIFFICULT BUT AFTER I DID IT I FOUND OUT IT WAS FUN AND EASY TO DO AND UNDERSTAND

Appendix U - Student Open-text Question 25:

Count	Response
1	All class should use them because they encourage students to work harder.

Count	Response
1	I don't know
1	I else digits 'to hype
1	I hope we can do this again
1	I would like
1	IT IS GOOD FOR SHOPPING
1	IT VERY HELPFUL
1	ITs experiancable and really encouraging!
1	It fabulous.
1	It is cool and inspiering.
1	It is very helpful and the skills used can help me in the future.
1	It is very interesting and fun to be creative.
1	It is very motivational.
1	It motivates you to learn and explore new things!
1	Its a fun way of wasting time at school
1	Its an interesting incentive
1	Its one of the best ways to learn!
1	Learn to live.
1	Master Skills and teach others to master them too.
1	Not sure.
1	Nothing
1	There wasn't enough time
1	They are a good way to show progress and reward you for such progress.
1	They help master new skills.
1	earn more
1	encourages learning
1	good
1	i Wish i wouldve learned more.
1	i am glad i learned it
1	i dont know how to learn how to earn more digital bagdes.

Count	Response
1	i learnd alot and did expierment
1	i like to learn match
1	i love it gets fun when you satrt vto creat it
1	i would like to say its a great way for the kids to learn and a good motovation
2	idk
1	it help match
1	it helped me it was fun
1	it is a fun experience
1	it is fun
1	it is great
1	it is really helpful
1	it is very motivational.
1	it is way easyer
1	it makes it fun
1	it very good
1	it was fun hope i can do it a again
1	it was great to lrean
1	it was interesting
2	it's fun
1	its a good goal to earn one.
1	its fun and id like to do it again
1	its important to learn what we are doing
1	its pretty nice
1	its something cool to do and it teaches you a lot.
1	its very encouraging
1	learning more badges
1	like the say abut subjects
1	my family
1	No

Count	Response
6	Nothing
1	nothing
1	nothing everythibg is really good
1	Noyhing
1	pretty good sometimes gets hard but its all right.
1	thank you very much
1	they make me get lot of naloge.
1	we should have a seperate time/class for digital badges.
1	weel i have not much to say but using digitial badges for school helped me,it also gave me ideas.
1	what i would want to say is that it would be fun to use instead of books and writing alot
1	They encourage me to do my work because I compete with other students and makes me participate more in class.
1	I would say that I learned some new things from doing this project. Some stuff like when I researched i discovered new stuff and also new ways to do different stuff. I learned it from my classmates and from myself.
1	you work hard to earn those badges and that helps you in school because you get in the habit of working hard
1	USING THE DIGITAL BADGES FOR LEARNING WAS FUN AND SOMETHING NEW I NEVER TRIED BEFORE AND IT MADE EVERYTHING EASY FOR ME TO LEARN MORE ABOUT DIFFERENT PLACES ALL OVER THE WORLD

Appendix V -- Interview Transcript (Questions by PI)

1) So the first question is -- and we've talked a little bit about this in terms of the processes – what were the processes when you introduced the digital badges to the kids? How did you do that? What were your goals with the kids when you were doing this?
2) So the kids knew, at every point, you were giving them feedback? (Follow up question)
3) And how did you communicate to them about what else they needed to do?
4) They corresponded to the tasks of the badges, the criteria? (Follow up question)
5) Interesting. And how did you communicate to the students where they were in terms of the process, you've earned Badge 1 but you haven't [earned 2] -- you have this, that and the other criteria to complete?
6) So what did you students say about working with this process, if you can remember? What were their concerns, what did they like?
7) In terms of your own instruction, do you see a place for a system like this within your own instruction? Or do you think that this isn't aligned with your instructional strategies and techniques?
8) Would you like to design your own badges? Or use in your own work? Or would you use the badges that worked for the study? Or both?
9) Do you feel that you have enough knowledge to be able to construct your own badges now? (Follow up question)
10) The challenges that you are facing in implementation are definitely part of the question, since we are looking at what circumstances this might work, what supports you do you need.

11) I wanted to talk about your approach to the project implementation in terms of the planning. Could you just say a little bit about the planning processes?
12) The first time with anything is really challenging. Did you feel like you taught any differently? in terms of your own instructional processes, what kinds of thinking were you employing? Did you look, as you said, more to, how to show these competencies, or how to earn the badge?
13) When they were frustrated, what did they do? Did they give up or try it another way or did they talk to one another?
14) So how did you feel about having that as processes with your students and watching them go through that? Do you feel that it was good for them or do you feel that it was frustrating or? (Follow up question)
15) How do you think that you could scaffold their learning more using digital badges as a tool? Not just these digital badges but if you created your own.
16) What other additional support materials do you think would be…? (Follow up question)
17) So if you were to increase the value of the badges for students, how would do you that or how *did* you do that? How did you communicate that the badges are something good to do or have?
18) So you mean outside of school? (learning) (clarifying)
19) So additional privileges? (clarifying)
20) Tell me a little bit about the kids who were allowed to participate, because they had the parental permission, and the – we discussed this a little bit earlier—the kid that wanted to come on board after, and actually did participate but were not respondents in the actual study.

21) Interesting…so since I visited your classrooms that becomes part of our circumstance, our environment, of this project. So talk to me about the difference that made or didn't make or what the students thought before and after. Did it change, was it the same?
22) And what class was that? (clarifying) But do you think that they valued the badges, more or less?
23) What did you notice about the student learning processes? Was it the same or different, or do you think that we've already addressed that?
24) This provides creative learning or the text book? (clarifying)
25) So in terms of the learning processes and/or products were you happy with the processes and outcomes of the digital badges?
26) Were the quality of the learning products, that the kids produced was that -- you've mentioned that these are different processes and they may not be used to it so do you feel that the learning and the outcomes were reflective of that difficulty, that if they did it another time, that it would be better or were you pleased that there were different products, or.?
27) Just a couple of quick questions. If you were to do this project again, what would you do differently?
28) What would you change about the digital badges themselves? As you understand it, this is the first iteration, the first really go through entirely and there are going to be changes -- and that's part of the design process. So what did you feel needed to be changed? Or maybe written into another level of badge? did you have those kind of insights?

29) So in terms of the InfoMaker, the learning trajectories or scaffolding, what would you change about that? or the data Hacker? did you think that maybe something was in the level one, and it really needed should have been and level2?

30) Definitely that is something that could be calibrated. I think my last question will be regarding the badges that you got or will get. What will add more value to your badges earned as professionals and who would you like to be the audiences for your badges?

31) Do you think like maybe a portfolio kind of thing?

32) But what did you do to earn that [Teacher of the Month]? what are the criteria?

33) So I know I said we were done with the question, but what would you like to earn digital badges in? What you think would be criteria that would be important?

34) Planning?

35) You think that the parental badge involvement would be a good badge opportunity. What else do you value?

Appendix W -- Nodes