STEM BADGES: CURRENT TERRAIN AND THE ROAD AHEAD[1]

DRAFT REPORT
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INTRODUCTION

Badges have a long history as visual markers of achievement, accomplishment and rank. For centuries the military has used physical insignia as visual displays of career highlights (Wyllie, 1921). Since the early 1900s, Scouts and 4H have used badges to encourage, structure and represent informal learning experiences (Duersch, 2003). While military badges are often awarded following heroic or exemplary deeds, scouting badges define specific criteria for activities and achievements that can be pursued by an individual.

More recently, badges—particularly digital badges—have been gaining popularity as a new way to offer, earn and showcase learning achievements in formal and informal settings. Similar to credentials or diplomas, badges signal that an individual has met some stated criteria. In other words, badges encapsulate both a specific standard, together with a judgment by the badge issuer that a person has attained that standard.

Several convergent factors, including new technologies and increased learning opportunities beyond formal school settings, have spurred the adoption of digital badges to certify learning (Young, 2012). Efforts to develop “open badge” technology systems, and to create badge-based assessment systems, have taken hold and have attracted a broad range of stakeholders, from policy makers to informal learning organizations, K–16 educators and funders. The appeal of badges is multifold, and reflects changing workforce demands (Stine & Matthews, 2009), the need to incentivize the acquisition of specialized skills (Johnson, Adams Becker, Cummins, Estrada, Freeman, & Ludgate, 2013), the shortcomings of standardized tests in capturing critical thinking and problem-solving abilities (Braun & Mislevy, 2004; Riconscente & Mislevy, 2006), and the increase in opportunities for individuals to gain expertise through learning experiences that span various contexts (National Science Board, 2010). Moreover, badge systems have the potential to accommodate achievements for a wide range of grain sizes, from a specific skill to a large set of competencies and abilities. Also appealing is the fact a learner’s backpack can accommodate badges based on highly diverse assessment strategies and credentialing processes.

Fundamentally, digital badge systems represent two critical elements: (1) assessment and (2) credentialing. At its core, educational assessment is the process of reasoning from the things that individuals say, do or produce to make inferences about their broader knowledge, skills and abilities (Mislevy & Riconscente, 2006). Innovations in assessment processes and systems have a long history, including the creation of performance-based assessments and the use of portfolios to showcase student work. Even large-scale testing efforts have evolved over time toward richer

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documentation of learning and a broader array of abilities. For instance, the College Board is revamping their Advanced Placement courses to focus more closely on deeper coherent understanding rather than on broad fragmented knowledge; and two large state consortia are hard at work to develop assessments aligned with the Common Core State Standards.

In contrast, the majority of credential systems have remained fairly static for a variety of reasons. The role of credentialing has been played primarily by academic (e.g., universities, schools, colleges) and industry entities (e.g., Cisco, Microsoft), together with professional associations (e.g., state bar associations, medical boards). The credentials awarded by these entities typically remain in their possession, beyond immediate control of the individual earner. For instance, a college graduate does not have direct personal access to the university registrar's records; proof that she has earned her degree must be obtained directly from the academic institution.

Digital badge systems provide a vehicle for organizing and displaying the outcomes of assessment and credentialing processes. Unlike physical badges, digital badges make it possible for these representations to be 'clickable' to a wide array of additional information, such as the specific knowledge and skills targeted by the badge, the processes used to assess learner outcomes, and examples of the work the learner submitted to earn the badge. In this sense, if implemented well, digital badge systems have the potential to bring a new kind of transparency and personalization to assessment and credentialing processes.

The technological support for this transparency is central to the Open Badges Infrastructure (OBI) introduced by the Mozilla Foundation and adopted by developers of badge platforms such as BadgeStack and Purdue University's Passport. Through a set of metatags, the OBI enables increased transparency via options for including specific artifacts of learners' process and product, the criteria applied to them in the context of earning a specific badge, the result of the application of those criteria to the learner's work, and the ways that those outcomes combine to substantiate a badge award. Digital badges created through the OBI carry with them validation of the identity of the badge issuer and badge earner. Importantly, once a learner has earned a badge, it resides in his or her backpack, where the learner can control which badges are visible to various entities, such as would-be employers, peers or college admissions officers.

Notwithstanding their potential, digital badges are a nascent endeavor, and it remains to be seen whether these opportunities for transparency and personalization can truly be realized given the enormous challenges inherent in such an ambitious undertaking. Our research identified a number of these issues, which include ensuring valid assessment of complex skills and knowledge, credibility and adoption, and a focus on intrinsic rather than extrinsic motivation. Privacy issues, particularly for young learners, will also need to be addressed, as will concerns related to equity of access.

One key point of clarification we identified in our research is the importance of distinguishing among badge systems, assessment systems, and credentialing systems. Digital badge systems offer ways of representing the processes and products that are defined by assessment and credentialing systems. However, in and of themselves, badge systems do not dictate the kind of assessment used, nor do they inherently indicate that the assessments have been established as valid and reliable descriptions of the learner's skills or knowledge.

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THE PRESENT STUDY

Aims

In this report, we will sketch the landscape of science, technology, engineering and mathematics (STEM) badges for K16 learners, and to offer a perspective on ways that digital STEM badges could advance the field. The report is based on interviews with over 40 representatives of badge initiatives; written documentation in the form of journal articles, blog posts and news items; and feedback drawn from a gathering of 100 national leaders to discuss the current state of STEM badges. In the first section of the report, we discuss our findings regarding the novel affordances badges bring to the current context of STEM learning. We then describe the major purposes that badges are being developed to serve, illustrating these purposes with diverse examples from the field. Finally, we summarize perspectives on STEM badges with respect to the steps that need to be taken if the potential of badges for supporting deeper student engagement, substantive opportunities for learning STEM content, and greater transparency of underlying assessment criteria are to be realized.

Our work was guided by the principles of evidence-centered design (Mislevy & Riconscente, 2006; Mislevy, Steinberg, & Almond, 2003), a widely adopted approach to designing and implementing valid assessments in a variety of contexts. From a theoretical perspective, an argument that digital badges will enhance transparency hinges on the ability to make clear the ways that specific kinds of evidence support specific claims about a learner's knowledge, skills and abilities. This explicit linkage of evidence to claims also facilitates the creation of badge ecosystems that can represent learning at finer grain sizes than has been traditionally targeted in formal credential systems.

Methods

The nascent nature of STEM badges required a methodology that could extend beyond that of a traditional literature review. To date, few journal articles focus specifically on badges[2], and much of the writing that does exist is posted to personal or professional blog sites that have not been vetted by the broader community. We therefore crafted a multiple methods approach that included semi-structured interviews, feedback from the STEM Badges Advisory Board members (Appendix A), descriptions of funded STEM badge projects, and a full-day working meeting, in addition to review of related journal, magazine, newspaper and blog articles.

Interviews

We devised a semi-structured interview protocol (See Appendix B) that was used by all members of the research team. The purpose of the interviews was to document the ways that badges are being defined, designed and implemented across formal and informal settings. We also probed interviewees for their organization's rationale for adopting badges, including the problem or challenge being addressed by badges and the reasons why badges were chosen over other approaches. In the interviews we also posed questions regarding the criteria being used to issue badges and the challenges encountered during the design and implementation process.

Interviews were conducted by phone or online videoconference with representatives of 40 badge projects (Appendix C), as well as with experts in the fields of assessment, policy, higher education and technology. Interviewees were identified on the basis of their involvement in the badge projects funded through the MacArthur DML/HASTAC initiative, as well as through nomination by

[2] For instance, a search on the term "badges" in APA PsycInfo yielded no results related to education.

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advisory board members. Authors of badge-related blog posts, and those involved in the development of technologies to support digital badges were also interviewed.

Working meeting

To further inform our research, we convened over 100 national leaders for a daylong working meeting, held at the NSF headquarters on April 1, 2013 (see Appendices D and E). During this meeting, participants provided feedback on key issues related to digital badge design, implementation and research, including motivation, technology development, assessment and policy.

Documentation

The research process also involved a comprehensive search of the peer-reviewed literature, as well as extensive Internet searches for news articles, commentaries and blog posts related to digital badges. We consulted descriptions of badge projects that appeared on organizations' websites, and on the MacArthur/HASTAC badges competition site (dmlcompetition.net). These documents, particularly those produced by the Mozilla Foundation, served as resources for identifying salient issues related to the rationale, designs, implementations and caveats related to digital badges.

WHY BADGES? AND WHY NOW?

Many of the people we interviewed suggested that digital badges have the potential to transform the way society conceives of and practices assessment and credentialing. Our research identified several reasons for this optimism, including the affordances of new technologies being developed specifically to support badge efforts, as well as a host of contextual factors, such as the rapid growth of educational games and increased opportunities to engage with STEM topics outside of the formal institutions that have traditionally recognized learning.

New Technologies and the Mozilla Open Badges Infrastructure

The kinds of merit badges that have long been central to the cultures of scouting and the military are often physical representations, taking the form of patches, pins and stripes worn on a sash or uniform. New technologies have significantly enhanced the concept and utility of a badge in several ways (Mozilla Foundation & Peer to Peer University, 2011). First, digital badges are not bound to time and space the way that physical badges are, and can be shared over and over again. Importantly, digital badges are "clickable" to reveal more extensive information, including the criteria for earning the badge, the specific work the person did to earn the badge, and the process for evaluating the person's work in light of the established criteria. As such, digital badges have the potential to dramatically increase transparency of assessment processes beyond that typical of existing systems like grades and certification documents. Digital badges also carry with them a digital verification that the badge issuer issued the badge, and that the badge was earned by the individual in question. Moreover, when digital badges are implemented using the Mozilla Open Badges Infrastructure (OBI; Mozilla Foundation & Peer 2 Peer University, 2011), individuals can assemble collections of their badges in their backpacks, and choose which collections to share which various audiences, regardless of the specific platform through which the badge was issued.

Popularity of Educational Games

Another reason why badges have gained in popularity is the recent application of game environments and game characteristics to educational experiences (e.g., Abramovich, Schunn & Higashi, 2013). Badges are a common technique used by game designers to motivate player persistence, and to help players establish identity and authority in social gaming environments. As

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they have with other aspects of games, educators and instructional designers have begun experimenting with the use of badge-related game features in learning settings. The reasoning is that the strategies that effectively support people to learn new things in game environments might also prove effective in supporting learning of content and skills related to academic subject areas and career readiness. If so, strategic use of badges could help forge effective pathways to STEM engagement.

Changing Workforce Demands

An additional factor that emerged in our research is the changing nature of the workforce, and in particular in the qualities employers seek in new hires. There is growing acknowledgement of a misalignment between current credentials and the information that is important for hiring decisions. This misalignment takes several forms. First, a college diploma provides information at a very large grain size for what a student actually knows and can do. This grain size—bachelor's in engineering, master's of business administration —lacks the specificity employers need to make informed hiring decisions. Even the grain size of a single course may mask a learner's particular strengths and weaknesses within the course content. Moreover, many of the skills and abilities, such as creativity and problem solving, are not clearly represented in traditional transcripts. The Conference Board's 2011 *Ready to Innovate* report includes data showing that 85 percent of employers concerned with hiring creative people say they cannot find the applicants they seek. Their study also found that whereas employers ranked the ability to identify and articulate a problem as being most indicative of creativity, school superintendents ranked it ninth. In contrast, the ability to solve a problem was ranked eighth by employers, and number one by superintendents.

Changing Face of Learning

Another contributing factor to the adoption of badges is the diversification of opportunities that young people have to engage in STEM learning (National Research Council, 2009). From informal organizations, such as museums and after-school programs, to online learning opportunities, to the Maker Movement, learning is happening today in more places than ever before. There is a need to certify the learning that takes place in these informal contexts, and to connect the learning of individuals across the many places in which they learn. These connections are both vertical and horizontal, and reflect the fact that in today's world, learning is becoming increasingly self-directed and interest-driven and is moving away from an educational paradigm driven by an industrial age vantage point. The new forms and contexts of learning demand concomitant innovations in the ways that learning is assessed, and, in turn, in the kinds of information produced by assessments.

BADGE PURPOSES

We found tremendous diversity among projects with respect to the ways that badges are implemented and the kinds of achievements for which individuals earn badges. Beyond serving as markers of some accomplishment, the term 'badges' does not refer to a single, monolithic concept or approach. As we worked to synthesize findings across badge initiatives and to distill a typology of badges, we found it helpful to focus on the purposes being served by badges. We identified four purposes that are being adopted in various forms and in various combinations across badge efforts: (1) fostering motivation and identity; (2) expanding STEM learning areas and contexts; (3) making STEM pathways visible and accessible; and (4) supporting selection processes.

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Foster STEM Motivation and Identity Formation

Motivation was a recurring theme in the interviews we conducted, and was frequently highlighted in written documentation of badge efforts. Many initiatives are implementing badges with the goal of improving learner motivation, and fostering the formation of STEM-related identities, often through a sense of belonging to a community. These approaches vary, and include awarding of badges to motivate a young person's initial engagement in an activity or organization; peer-designed and awarded badges for valued activities within a community, such as mentoring someone else; and providing visual and public recognition of large accomplishments, as well as smaller accomplishments that mark steps along the way to valued outcomes.

Many applications of badges to motivate take their cue from games, and are thought of as mechanisms—similar to behavioral stimuli—that motivate individuals toward a goal that derives its meaning from the game context. The idea is to leverage this mechanism in the context of STEM-related engagement, such as participation in a STEM learning community. Reward structures within gaming contexts can induce high levels of motivation and persistence in the presence of a high degree of challenge. An analogy can be made between challenges encountered by gamers and those encountered by STEM learners as they progress toward challenging STEM learning goals that may require a high degree of motivation and persistence.

Closely related to motivation, particularly from a socio-cultural perspective, is the application of badges to foster the development of community and individuals' sense of belongingness and identity within that community. In this vein, badges serve a role in communicating accomplishments and participation within an interest-driven community, and may encourage sustained participation (Erikson, 1950). As with motivational incentives, this role may be particularly important early on in an individual's engagement. Erikson's theory states that identity is a two-sided coin that involves the individual and the recognition of the community (Penuel, 2013). A person's badge collection serves as a visualization of their identity—for the individual as well as the community. Furthermore, badges make visible and highlight individuals' expertise, thus opening the opportunity for mentoring within the community. This is an avenue for personal development, as well as for sustained involvement in the community.

Sense of affiliation can be a powerful driver in formation of identity, and failure to identify with the dominant images of scientists has been linked with lower interest and pursuit of learning in math and science among middle school girls (e.g. Hughes, 2012), and ultimately affects career choice (Hazari, Sonnert, Sadler, & Shanahan, 2010). Given the important relationship between identity, motivation and careers in math and science, it behooves us to examine tools that may aid young learners in developing a sense of identity that highlights an alignment between students' interests, values and attainable STEM learning goals. Badge developers argue that badges may be a tool that can support such formation of identity.

By making engagement and accomplishments visible to the broader community in which people engage in learning, badges may also serve a social cognitive role in promoting certain actions and attitudes through peer modeling (e.g., Bandura, 1997). Consistent with interest theory (Hidi & Renninger, 2006; Riconscente, 2010), individuals' tendency to engage with a particular topic or activity may be sustained by situational factors that over time become less salient as the person develops an individual interest that is part of their sense of self. Many of those who are working with badges cite the need to recognize accomplishments and learning that occur in interest-driven

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learning spaces. Participants in such affinity spaces carry with them some form of motivation that sparked their initial participation. The question then becomes, how might badges be used to recognize, cultivate and sustain interest, motivation and participation so that learners feel they have support and the skills needed to persist when/if the going gets tough? Practitioners in this area suggest that badges can support the development of a learner's identity within a community of practice, and this can lead to a sense of affiliation with the community (e.g., Greeno 1998; Lave and Wenger, 1991).

It remains to be seen whether badges can deliver on these expectations, and in what contexts they might be useful in accomplishing motivational goals that range from initiating participation to sustaining that participation toward accomplishing a meaningful learning goal, or prolonging engagement in a learning community.

Expand Opportunities to Recognize a Broader Set of STEM Skills and Knowledge, Across a Range of Contexts

Expand Skills

Success in STEM fields requires integrated skills and behavior patterns, such as problem solving, persistence and collaboration, that have proven challenging to assess, particularly within the constraints of traditional recognition systems like grades or standardized tests. Many projects are now adopting badges in order to acknowledge assessments of these so-called "soft skills" and/or integrative skills, including an individual's capacity to be strategic, adaptive and creative. Findings from research on non-cognitive predictors of success suggest that many of the important skills that formal education develops and that are valued economically in the labor market are not revealed on traditional tests (e.g., Sedlacek, 2004; Shultz & Zedeck, 2011). Although badges do not serve the role of assessing non-cognitive skills, they do provide a vehicle for representing these skills alongside cognitive knowledge and abilities.

Badges are being considered in formal environments to recognize accomplishments and competencies beyond those reflected on traditional transcripts. For instance, in the Douglas County School District (Colo.), Superintendent Fagen and her staff are creating badges that will be part of students' transcripts. The idea is that while academic content tends to be learned within distinct courses, the additional skills of collaboration, creativity, critical thinking and communication are learned *across* courses over time and cannot therefore be represented on a traditional course-based transcript.

Bridge Contexts

Another common thread that emerged in our research is the potential of badges to create connections across the learning that takes place in formal and informal settings. Currently, these two spaces remain disconnected, with little information about what happens in one becoming accessible to the other. This is less than optimal for multiple reasons. First, the lack of communication across contexts makes it challenging for learners to establish connection and relevance of their own learning in different places. Second, educators miss out on valuable opportunities to connect their goals to the experiences of learners outside that context.

Increasingly, it is recognized that informal and interest-driven learning spaces provide opportunities for learners to acquire STEM-related skills, knowledge and abilities, yet learning in these free-choice

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spaces is often not recognized across contexts (between school and informal settings, or between different informal learning spaces). Badges may help everyone recognize and visualize the learning that happens in diverse contexts, making porous the boundaries between formal and informal settings. Moreover, through linking formal and informal spaces, instructors may be able to better tailor instructional materials to match the background and interests of their students.

Expand Certification
Badges have also been proposed in the context of alternative credentials, akin to the GED, but for specific subject areas, and at potentially very high levels of attainment. In their 2011 Commentary published in *Education Week*, Collins and Pea (2011) suggest the creation of national certification exams for all subject areas in the Common Core. One affordance of such exams would be the capacity for students to take them once they have attained competency rather than after they have logged a certain number of hours in school (Horn & Mackey, 2011; US Department of Education, 2010).

Make STEM Pathways Visible and Accessible
When organized into cohesive systems, badges may provide a novel route for making STEM pathways visible to learners, and supporting active choice and exploration of STEM topics and careers. For students who already have a clear goal, an interconnected system of badges could serve to illumine steps along the way, particularly when goals are long-term and it may be difficult to know what kinds of experiences and learning would support progress to the goal. Badges can also trace horizontal pathways that help learners see where they can go next to build on various aspects of what they have accomplished. In this way badges serve as branching points.

Peer-reviewed literature and popular media note and predict a disparity between the supply of STEM graduates and the demands of the current and anticipated U.S. STEM marketplace (Carbonaro et al., 2010; Kuenzi, 2008; National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007). Yet research also highlights the diversity of STEM-related skills, knowledge and abilities that learners engage in during interest-driven activities. This disconnect signals an area ripe for research into how one might recognize and link STEM learning in affinity spaces to STEM skills, knowledge and abilities typically recognized and valued in more formal contexts. Such efforts are in line with current attention being paid to lifelong and life-wide learning, connected learning, and other efforts to characterize and support learning across contexts.

We identified aspects of badging efforts that align with the goals of increasing visibility and accessibility of STEM career pathways. First, discussions and practices within badge system design bring to the forefront questions about how to best initiate learner interest in STEM areas; how might interest be broadened and/or deepened; and how might initial engagement grow into persistent interest and possible pursuit of a STEM career. Second, the technological affordances of badging systems may offer new opportunities to connect and sustain interest and effort across contexts.

Taken together, the badge systems, proposals and literature we reviewed suggest that badges may address some of these challenges by helping learners name and recognize their own learning, by increasing connections among interest-driven learners and real people in STEM careers, and by making explicit the STEM skills and knowledge embedded within informal learning contexts.

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A number of badging efforts involve the learner in the process of defining criteria for badge acquisition. Research supports the idea that involving learners in reflecting on their own learning objectives activates important metacognitive processes and assists in the development of self-awareness and self-regulated learning (e.g., Zimmerman, 2002). Initial efforts suggest that badges can provide a mechanism through which learners engage in a conversation about learning objectives, shared goals and criteria for recognizing accomplishments. Engaging in such conversations may help learners acquire the language and a framework to characterize the skills and knowledge they are acquiring as STEM-relevant. This may improve a learner's ability to transport the skills and knowledge they've learned in one context and apply it to another.

While some badge system designers are advocating for learner participation in defining and awarding badges, others are integrating specific science learning standards and authentic STEM career practices into the architecture of the badge system. Though not mutually exclusive, these alternate approaches raise many questions around best practices for designing badge systems and the role of badges in helping learners (and those who support learners) to recognize, name and communicate the STEM-relevant learning occurring in environments such as games, free-choice learning environments and affinity spaces. Many approaches being tested within badging frameworks hold promise for promoting development of STEM learner identity and practical knowledge of STEM practices.

One might argue that the approaches that badge designers are using simply constitute good instructional design and practices, and thus raise the question, what do badges lend that could not be accomplished in other ways? Advocates cite a few technical affordances of badges that support visibility and accessibility of STEM career pathways: badge persistence, transportability and using badge tagging to make explicit the connections among badges and connections between badges and formal standards.

The Mozilla OBI and other systems render the badge and associated metadata persistent and transportable. Badges and badge constellations (stored within backpack systems) can theoretically be accumulated by learners from many different learning experiences and can be stored and presented in a common online space. These affordances could help individual learners to recognize and communicate the various skills and knowledge they have acquired in many locations, formats and contexts. Different systems propose different models for management of persistence and accessibility to the badges, but the potential for persistence exists. A large question that remains is what the "shelf life" of the badges would be. While the badges and associated metadata may be persistent, it is not clear that the skills and knowledge that they represent will persist as long as the badge. Some badges may mark characteristics of a learner that, once demonstrated, can be hypothesized to be persistent so that a badge, once earned, is good for life. Yet other badges that are proposed or in use, such as those used to mark computer programming languages, indicate skills and knowledge that must be maintained or renewed to keep pace with changing trends in the STEM workforce and marketplace. In such cases, badge designers have integrated "expiration dates" which can be attached to badges that should be maintained or renewed regularly. In such dynamic STEM fields, it is possible that the badges would provide entry into a STEM-related community of practice, and STEM interest would be signified (or possibly measured) by continuous participation in activities within the community, including badge maintenance and renewal.

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Many argue that for badges to reach their full potential, badging systems must provide extensive tagging or some other mechanism to rate the badges. Badges can be tagged or rated based on their relationship to formalized standards; to show connections among badges within a suite of possible badge earning opportunities; to illuminate STEM career pathways; and to highlight endorsements, which indicate the value that others have attributed to a badge. The Mozilla OBI provides the means to tag badges, but effective tagging usually occurs through extensive use and social feedback within a community. Thus, many learners must try a badge and rate or tag it before the tagging and ratings have meaning for others. Perhaps this phenomenon will occur organically over time, but lessons learned through other tagging and rating systems also highlight ways in which such a socially organized system may be corrupted by those who may have an interest in manipulating the system or seeing particular badges come out on top. Such threats raise questions about whether there must be some mechanisms to monitor badging systems and ensure that badge tagging and ratings signify the relationship between the badge and the learning values they claim to represent.

With these caveats in mind, tagged badges could lead to community-defined constellations of badges within a badge universe. Such tags could be used to recommend badges based on learner interests, and these recommendations may reveal pathways and connections among topics and experiences that a learner may not have recognized on their own. Connections among badges may help introduce learners to new real and virtual resources that match their interests and goals, and such mechanisms may be key to developing truly personalized learning trajectories toward STEM careers.

A well-curated tagging system could also provide data and feedback to program designers as they document pathways that users take through a particular suite of badge options. Over a longer term, badge analysts may be able to connect badge acquisition to learner characteristics to inform badge design, instructional design and design of interest-driven learning experiences. Further, patterns in badge acquisition and use may be connected to eventual STEM career pursuits, and highlighting pathways that STEM workforce participants have taken through a badging system is likely to highlight diverse pathways and experiences that can ultimately lead to STEM-related careers. Illuminating diverse pathways may help broaden the cadre of people pursuing STEM careers, and participating in a STEM-oriented badging community may encourage young learners to persist in STEM-related fields of study. While all of these are exciting hypothesized outcomes of a badging system, those projects that we reviewed are early in the process of developing communities around badging, which makes it difficult to assess the potential for these outcomes to come to fruition. There is exciting work in the field related to studying similar mechanisms currently in play in online communities. This work is likely to answer and unearth many questions around how badging systems operate in the "wild."

Support Selection Processes

The fourth purpose our research found for the use of badges is to support a variety of selection processes, from internships to postsecondary education to jobs. Related to the purpose of using badges to expand the kinds of skills and knowledge that are recognized, as well as the need for different grain sizes of information regarding an individual's competences, this application of badges would enable individuals to bring more salient information to selection processes, and would also provide more relevant and fine-tuned information to those making the decisions. Badge backpacks offer students a way to construct their academic identity outside of using only grades and transcripts. For this reason, the process of selecting which badges a person opts to present to a would-be

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employer is itself an indication of their understanding of the opportunity and of what they bring to it.

Precedent for the use of badges for selection processes can be found in examples from the tech industry. Stack Overflow is a peer-based technical support website for professionals and amateurs to pose and respond to questions about programming. As members post questions and solutions, they begin earning a reputation based on votes from peers. A badge system serves to promote certain behaviors (e.g., there is a badge for voting over 300 times on answers) and to signal expertise (e.g., the "good answer" badge is earned by approval votes from other members). Employers use Stack Overflow's Career 2.0 service to identify and hire programmers with specific qualifications. Those looking to hire can see examples of responses that potential candidates have posted to Stack Overflow, including how many times the responses were voted as "approved" by other programmers on the site. However, leveraging peer voting as part of a process to document learning and expertise poses many challenges, particularly in high-stakes contexts.

One reason for the use of badges to support selection processes is that current credentialing systems denote fairly large grain-size accomplishments, yet provide little detail regarding an individual's competency in job-specific skills that employers seek. Employers are looking for ways to distinguish among applicants for any limited resource (e.g., jobs, promotion, internships). Badges provide individuals an opportunity to make colleagues or future employees aware of their skills and competencies in an efficient way. Employers could also publicize the specific badges that they value in the hiring process, providing more fine-tuned information in the "qualifications" section of a job description.

With increases in opportunities for individuals to assemble their own set of educational experiences and acquire personalized competency sets, there is a need for alternatives to traditional credentials earned in one place, such as a college degree. This process has been referred to as the "unbundling" of schools (e.g., Hess, 2012). As opportunities open for individuals to drive their own educational paths, and to accrue their competencies from a variety of places, badges could serve as an individual's central repository, in which they assemble evidence of their mastery and accomplishment, and then present these badges in appropriate combinations to various audiences. The unbundling of school surfaces a need for more flexible approaches for recognizing and certifying accomplishments.

A major challenge identified in our research is the recognition of badges as valid to those engaged in the selection processes. Traditional credentials have currency only to the extent that consumers of those credentials consider them valuable, valid and reliable. While badges could broaden the range of entities that certify learning, the influx of badge-issuing entities means that those who would make use of the badge for selection purposes now have a larger set of credentialing entities with which to establish trust. Related to this concern is the challenge of developing descriptions of the reliability and validity of assessment and credentialing processes that are accessible to would-be badge earners and consumers.

Similar to digital portfolios, the inclusion of additional information in the digital badge translates to an exponential increase in the volume of information that any one applicant would bring to the process. This in turn translates to substantially greater time investment on the part of hirers and admissions officers, who are already stretched thin. For badges to play a meaningful role in large-

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scale selection processes, this challenge will need to be addressed. One approach that is being built into the OBI is the ability for badges to be endorsed by external organizations. In this way, smaller badge-issuing entities gain credibility by 'borrowing' the credibility of more established institutions. While some see this as a promising solution, particularly in local arenas (e.g., a company endorsing badges issued by the local school district), others expressed concerns that the process of endorsement would result in the same situation in which we currently find ourselves, in which large testing organizations have the final say on which badges gain credibility and currency.

Finally, some scholars we consulted expressed concern about the prospect of badge value being determined by those badges that "rise to the top". The concern is that those badges are likely to be those that have significant backing and marketing and are issued by entities that can forge partnerships and endorsements. In other words, in such a system, the badges that are valued may not coincide with those that have the best assessment methods behind them or are based on the best research.

EXAMPLES FROM THE FIELD

The purposes described above are implemented in a broad range of ways, and in various combinations, by the badge initiatives. This section presents four examples of how these purposes work in concert in diverse contexts.

New York City Department of Education, Office of Postsecondary Readiness

The New York City Department of Education's badges project is focused on students in transfer high schools – small, personalized environments for students who have been disengaged, failed to make progress, and are returning to high school. These transfer schools are set up to be student-centered environments. The badges project at the New York City Department of Education is led by Dr. Michael Preston, who came on in 2011 as director of blended learning strategy within the Office of Postsecondary Readiness. Their badging efforts are serving a curricular system focused on competency-based digital literacy learning activities, which satisfy the requirements for high school credit recovery.

Preston's position was created through a federal grant[3] that funded a program to give away 5,000 computers to students, and give them reasons to be online. Thus they found themselves in the position of needing to set the table so that students would feel academically ready and have a sense of digital literacy skills that are broad-based and framed as a key component of postsecondary readiness. In response, they set about creating a digital literacy course called DIG/IT ("dig it") for students with a broad range of academic needs. The course needed to be fun and engaging, but also lead to acquisition of knowledge and skills. In collaboration with LearningTimes, they set out to create a new context for learning that could offer manageable and engaging student-facing curriculum, with the ability to submit work, receive feedback and publish. In the process, the LearningTimes team developed BadgeStack, a web-based platform for delivering curriculum, submitting and assessing student work, and recognizing achievements in the form of digital badges. Each day in DIG/IT, students choose among tasks to perform in the service of earning a badge that signified a specific outcome. This unique course structure, supported by badges, was a way to shift the focus toward competency-based learning. Prior to the badge-based approach, students' exposure

[3] Connected Foundations was funded by the U.S. Department of Commerce's Broadband Technology Opportunities Program (BTOP) and managed by the New York City Department of Education and the New York City Department of Information Technology and Telecommunications.

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to digital learning was mostly in the form of credit recovery courses or various homegrown courses in platforms like Google Apps and Wikispaces. The badge-enhanced digital literacy course has been taught in more than 60 high schools in New York City, the majority of which are transfer schools. The course has proven an effective strategy for introducing teachers and students to a blended learning model. Teachers were able to see the benefit of letting students make progress independently and have clear indicators of accomplishments and outcomes. So far roughly 10,000 students have enrolled in the course, and upwards of 80,000 badges have been awarded through the platform. By June 2013, the Connected Foundations team, in partnership with Computers for Youth, will have given away 5,000 computers.

After the first year of the program, the team worked closely with a select group of teachers to develop 11 additional courses in the core subject areas of English language arts, math, science and social studies. These courses have allowed teachers across the program to extend the blended, badge-based approach. In contrast to the majority of badge initiatives we reviewed, this project applies badges within formal academic courses. It is a way of taking a course like algebra or social studies and breaking down the content into more discernable and recognizable outcomes whether content-related or skill building. For instance, students can earn a badge for writing an essay that involves a good critical argument. Badges and tokens help students see how individual tasks and accomplishments relate to a specific goal, and show their progress toward the goal of course completion. Units of study are akin to levels. Students complete a certain number of badges to pass each level, which translates to 3-6 tasks. In other words, badges are a way to provide clear guidance toward the goal, which is the completion of the course, while providing some choice to students, who can choose the badge they want to work on a given day.

In this initiative, there are two kinds of badges. "Quest badges" are tied to content and domain-specific skills. They map roughly to outcomes in a given course and provide specific goals that students can work toward as they engage with the curriculum. They can also signify specific knowledge or skills. "Reward badges," on the other hand, are tied to 'soft' skills and community participation, including valued non-cognitive behaviors such as persistence, being a good peer, and self-regulated learning. The reward badges were designed to express the values of the learning community and also to make the experience of taking these courses more fun, to increase motivation, and encourage students to engage productively with their learning. There are roughly 100 reward badges that can be earned, and the two types of badges are not mutually exclusive of one another. For instance, a student can earn a reward badge for presentation skills while working on an English language arts unit. Badges are awarded for actions as well as assessments of task outcomes. The level of rigor is set by the teacher in his or her classroom, including how many times a submission will be reviewed before it is deemed finished. To date, students enrolled in these courses have earned more than 80,000 badges.

The New York City Department of Education application of badges is similar to those implemented in other online learning communities. For instance, Khan Academy has established a tiered badge system. Each tier is defined in terms of the amount of effort required to earn a badge. Within each tier, the focus could be use of the site (watch five videos for five consecutive days); completing several modules on a single topic; mentoring others; or solving a certain number of problems in a row correctly.

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Digital Youth Network

The Digital Youth Network (DYN) first started discussing the possibility of using badges in their program over three years ago, prior to support from the Digital Media and Learning Competition badges program. From the start, the DYN have used badges to support already existing programs centered on role-driven, artifact-based learning goals. Akili Lee, who is co-founder and Director of Digital Strategy and Development at DYN, describes the two fronts to their work as badge design and operationalization via technology. The badge design process has entailed defining the criteria, carefully considering the motivational aspects, assessment and integration with their mission and programs, as well as critically examining the operationalization of the badge framework within the iRemix platform. The DYN team emphasizes that they are building a social-learning system in which they are exploring the role that badges can play in meeting their overarching organizational goals.

The badges offered by DYN are the result of a year of work to map badge design onto their existing conceptual framework. Central to their mission is media arts programming under the umbrella of digital literacy; under this umbrella, DYN centers its programming on artifacts and roles. If producing a public service announcement video is the goal, the learner must consider audience and the roles that go into production such as editor, scriptwriter or actor. DYN made sure the design of the badge system aligned with their artifact-based model and mission by 1.) integrating assessment based on rubrics, 2.) designing a leveling of badges that matched program learning goals, and 3.) matching the level of granularity of badges with the roles and practices of digital media production.

From this process, DYN has come to offer three types of badges within iRemix, which they designate as: manual badges, submission badges and automatic badges. "Manual" are badges for which the requirements and expectations are clearly outlined ahead of time. The learner can decide when and where to complete the requirements, but once they have done so, the badge is issued. "Submission" badges can be defined, to a certain degree, by the user. A user completes a media project and decides that it may qualify them for a particular kind of badge. They must put together the materials and submit them for consideration of a particular kind of badge, and the submission is submitted to a queue. Then a mentor or system administrator reviews the submission and decides whether it meets the requirements for the badge; mentors can accept or reject with feedback for the user. Finally, "automated" badges can be automatically awarded to learners based on activities within the iRemix social networking environment. Such badges may be awarded for participation in the community, or may be used to automatically award "meta" badges representing user achievement of a customized set of smaller badges.

Current DYN badge efforts are centered on operationalizing the badge design. Their strategic plan includes implementing professional development for mentors within the network that is also supported by badges. These mentor badges are supporting an expansion of their mentor training plan, but map onto trajectories that they observed among past mentors within their programs. The expanded system will integrate face-to-face and online training allowing them to increase their training capacity, while using a social networking environment to maintain a personal connection with the mentors. They are exploring how integrating badges into this system can support a hybrid professional development approach.

DYN has carefully considered how badges fit within existing frameworks they use for capturing evidence of learning. DYN has focused on making learner actions transparent, and have relied on portfolio approaches for assessing learning. Badges are supporting these efforts in that the badges

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earned can map onto different roles within a given project. Whereas their previous system allowed them to recognize that a student contributed to production of a video, using badges can help them understand the specific role of each user related to the overall project team and goals. DYN leaders see potential for badges adding granularity to their assessment and documentation of learning, and serving as a mechanism for learners to target more specific skill sets and roles. This assists DYN program managers see and understand learning that is occurring, and DYN also propose that this helps the youngsters recognize and value their own learning. Further, they see opportunities for teachers to use the information represented in badges to understand the skills and background knowledge of students in a class, which would allow a teacher to build upon these skills and knowledge in the classroom.

MOUSE, Inc.

MOUSE has a long history of supporting youth in building computational, digital and workplace literacies that are essential for innovation. MOUSE was founded in 1997 and began implementing a program in 2001 to train urban high school students to establish and manage technology support desks at their own schools. This program has grown to serve over 350 schools nationally, through the leadership efforts of over 4500 students. The MOUSE project is currently examining the utility of badges to support this innovative and empowering youth network.

The MOUSE Squad program is currently working to integrate badges into an existing blended (online and offline) social networking and support community. Starting in 2007, MOUSE began efforts to develop a web platform that would serve as a hub for the increasingly distributed student network participating in MOUSE projects. The site was built as a digital ecosystem, with content and student profiles, that would support community-driven representations of the MOUSE experience. Designers viewed it as critical that youth could share skills and experiences with peers in the program, and grow the identity that lead them to participate in the MOUSE program in the first place. Incorporating badges into the online system aligns with the goal of helping students evolve their design and technology skills through programs like the NYC MOUSE Corps.

MOUSE aims to build literacy and dispositions toward making and designing with technology. Badges serve two purposes toward these goals: marking student achievements toward different "certifications," and encouraging students to participate in the learning environment by rewarding online contributions and feedback to peers. The badge system involves microbadges, which are called "Wins!." Wins! can be aggregated to align with MOUSE certifications in areas like circuitry, programming or prototyping. Students are also rewarded for participating, communicating and collaborating across this national network of youth technology leaders, mirroring modern fields of practice in technology and other industries. Thus, the MOUSE badging system recognizes both hard and soft skill needed by a STEM-literate workforce.

Prior to February, all badges issued within the MOUSE framework were awarded by adult educators and mentors, but in February they began a pilot project to explore the effect of offering peer-awarded badges within the online community. This approach raises significant research questions about how students operate in online communities and around the utility and validity of peer-issued badges. Using processes and tools that mirror those used on popular social networking sites (e.g. the "like" button on Facebook), MOUSE is studying how students issue "Wins!" for inspiration, creativity and tech-savvy. These soft skills can be hard to capture using other forms of assessment, and the peer-to-peer model mirrors the organic process by which these

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soft skills take on meaning and have impact within collaborative groups. Yet, it remains to be determined whether badges awarded by youth can be valid and reliable. A number of other badging systems we examined proposed using peer-to-peer assessment as a means to issue badges, yet MOUSE is unique in its efforts to explicitly study the process and impact of peer-to-peer badging within their online community.

MOUSE has also been designing systems that will allow their organization to learn from log file and metadata information that is generated and shared via the badging system. Leaders at MOUSE view this data as critical to their organization, which has a core staff of 12 people, but supports a distributed network of youth development programs that often must be monitored and managed remotely. MOUSE organizers envision that data generated from badges may help illuminate pathways students are choosing to follow through their online and in-person training and mentoring programs. This data will also provide data useful in program evaluation and revision. The organization has just begun efforts to harness the rich data streams that can be generated through student use of online badging systems.

Planet Stewards
The National Oceanic and Atmospheric Administration (NOAA) is collaborating with GoGoLabs, a game-inspired learning technology lab, with the goal of promoting learning of Earth science concepts and awareness of NOAA careers. Together they developed a teacher-managed curriculum tool that uses quest-based learning modules combined with badges. NOAA had previously developed learning materials and curricula related to a wide variety of Earth science topic areas, but were lacking capacity to effectively distribute this rich content in engaging and sustainable ways. GoGoLabs had an established quest-based learning platform that has been successfully used in 10 countries and with thousands of students. GoGoLab's team of instructional and game designers worked with NOAA content experts to merge Earth science content with quest-based curriculum supported by badges.

The project focuses on solidifying the connection between badges criteria and formal learning standards. Through the Planet Stewards system, students earn badges by completing game-like quests as part of their classroom science work. Based on a backward design process and formal mapping performed by a standards correlation service (EdGate), quests and badges are linked with specific state learning standards. The badges are designed to incorporate redundancy in the standards addressed, and as students work within the system they can choose which badge to pursue in order to meet a certain learning goal or standard.

In addition to being linked to science learning standards, 15 badges are organized within five NOAA science areas: freshwater, climate, oceans and coasts, marine life, or weather. As students work within this system they earn successive badges toward a cumulative badge representing expertise in one of these five NOAA science areas. The skills and knowledge represented by the quests and badges have been reviewed and critiqued by current practitioners in the NOAA science fields of interest. For example, the climate modeling quest is based on input from a climate modeler, who assisted with selecting and framing the content. Thus, efforts have been made to ensure that the skills and knowledge represented by the badge are tied to science learning standards and also representative of the practices of active participants in STEM fields.

The Next Generation Science Standards pose new challenges for teachers to incorporate scientific practices into their curriculum and instruction. The Planet Stewards project may provide an engaging

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way for teachers to meet this goal. This may be particularly useful to teachers who feel underprepared to deliver experiences that reflect authentic scientific practices. It also provides a venue through which NOAA can distribute content that delves deeper into important Earth science concepts, like impacts of climate change, sea level rise or ocean acidification, than a teacher may typically be able to cover in a general science curriculum. A pilot group of teachers implemented these curricular pieces in their classrooms during the spring of 2013.

Planet Steward badges represent stepping stones along a trajectory of learning within a specific and authentic Earth science domain. By setting the badges as markers of achievement along a pathway related to a specific scientific career or role, students can begin to understand the specific skills, knowledge and habits of mind used by current practitioners in the STEM field. This ability to take on roles, try out different pathways, and connect the concepts and activities to a real world science career holds promise for students developing a grounded sense of identity related to potential STEM career opportunities.

Many science agencies, like NOAA, find it difficult to effectively connect federally funded science research to classroom instruction. The Plant Stewards project demonstrates the partnerships and process used to build a technologically facilitated instructional context that combines cutting edge content and scientific practices with promising methods of engaging students in deep STEM learning; badges are just one part of this innovative system.

TOWARD AN AGENDA FOR RESEARCH AND DEVELOPMENT

Through extensive interviews, the available literature and feedback gathered from over 100 national experts in fields related to STEM badges, we identified six primary directions for future research and development.

Assessment

A frequently voiced concern pertained to the quality of assessment practices in badge implementations, and the extent to which badges indicate that the learner has actually achieved competence in the stated knowledge or skill. Though existing forms of assessment, including grading practices, performance assessments and large-scale tests have shortcomings as well as strengths, there is no guarantee that badges represent an improvement. Though badges could potentially be used to promote stronger forms of assessment, this is entirely at the discretion of the badge issuer. Currently there are no uniform criteria or standards of practice regarding forms of assessment used in badge issuing systems.

A related consideration raised by the advisory board is the need to develop a common language of skills, and ways to display them that would truly attain the goal of transparency. Put another way, what information is lacking in current approaches to representing assessment and credentialing outcomes, and how might that information be effectively communicated to various stakeholders?

Research is needed in order to document the kinds of assessment practices in use, and to identify effective processes for implementing valid and reliable badge-based assessments. A related question is whether the adoption of badges prompts learning communities to reexamine and refine their assessment practices. In terms of programs, supports for developing assessments may be in order, particularly for organizations that have not focused on assessing learning and knowledge, such as informal or after school groups.

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Credibility

Credibility of badges emerged as a pivotal issue, particularly for the use of badges across contexts and for high-stakes decisions. As with traditional credentials, the value of any given badge, and the extent to which it carries currency both within and beyond a community, will determine its value. Though this is true of traditional credentials as well, the novelty of badges as the "new kid on the block" provokes a myriad questions from would-be consumers. Research questions to be addressed in relation to credibility include: How do organizations establish credibility of their badges within their community? What is the impact of endorsement techniques on the uptake of badges, and to what extent is credibility aligned with valid assessment? What are the implications for credibility when badges can be awarded by "just anyone," including peers?

Motivation

Many badge systems are being implemented with the aim of fostering motivation among learners; however, as a field, we have yet to discover which characteristics support intrinsic motivation, and which practices redirect learners' attention from the STEM content and practices to the accumulation of badges for their own sake. This concern has a basis in research by scholars like Edward Deci, who found that young learners lost their intrinsic motivation for activities when extrinsic rewards were introduced. A related concern, echoing Resnick and Resnick (1992), is "what you badge is what you get." Simply transitioning from grades to badges does not indicate that deeper learning or authentic engagement is taking place. Just like test criteria, badges serve as value signals and as such are likely to drive engagement in specific directions. This was evidenced in a recent TED talk by Salman Khan and Bill Gates, in which they reported seeing that students flocked to wherever the rewards were positioned within the online environment. Research that examines and experimentally tests conditions under which badges best support intrinsic motivation would inform best practices and implementation designs.

Privacy

Particularly of those under age 14, privacy is another challenge raised in relation to the widespread adoption of badges. Under the Children's Online Privacy Protection Act, organizations are limited in the extent to which information about young learners can be made public. For New York City Department of Education, all badges remain private within a specific course; the Digital Youth Network created their own social network, iRemix, so that badges and interactions would remain safely within a closed system. Additional work is needed to develop models for effectively addressing privacy issues.

Process and Product

In this report we organized our findings around the purposes that badge initiatives are being created to address. However, there is also a branch of thought around the value of badges as a "process". From this perspective, an organization's efforts to implement badges is hypothesized to be transformational. The organization can come to a collective, cohesive, tangible and transparent vision for how they assign value to learning outcomes within their system. The badges themselves may be of secondary importance to the organizational outcomes that accrue through the process of grappling with badge design and implementation. This product-process tension also has relevance for badge earners. Supporting learners in reflecting on the process may pose a challenge if the accumulation of badges is considered more appealing. Research can examine what happens to

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organizations or programs as they take up the challenge of adopting badge systems, as well as the ways that badge initiatives effectively foster reflection and thoughtfulness in learners.

Definitions and Assumptions

Unsurprisingly, we found substantial variation in badge definitions and assumptions. Though there is core agreement, especially on the part of the main drivers of badge efforts (e.g., Mozilla, MacArthur Foundation, BadgeStack) that badges serve as markers or signals of accomplishment, we found that there is a tendency to assume that badges are themselves a new form of assessment, and moreover that they are inherently better forms of assessment relative to traditional measures such as grades. We also found evidence that badges are sometimes assumed to provide more information than do existing credentialing systems. Though badges issued through the OBI may well contain more information, there is no guarantee that this will be the case. Related to these observations, we also noted assumptions in the literature and in conversations that badges are necessarily more valid and reliable than are traditional credentialing systems and assessment practices. Finally, the term "digital badges" for some has led to the expectation that badges are earned in an online or digital setting. However the criteria for digital badges could actually reside entirely offline. Finding ways to inform the larger public about these issues is likely to increase the possibility that badge implementations are successful and meet their intended goals. In order to build a valid and reliable evidence base, research on badges needs to be based on clear definitions and well-specified assumptions.

THE FUTURE OF STEM BADGES

The new opportunities for transparency and portability that badges carry have the potential to make a positive impact on STEM learning and engagement. However these possibilities hinge on crafting effective solutions to several critical issues.

Rigorous Scientific Content

Fostering long-term STEM engagement, learning and careers in larger numbers will require new approaches to sharing authentic science content and practices with a broader public. For STEM badges to serve this function, the scientific content they target must be accurate, current, relevant, linked to careers and connected to the overall STEM terrain. Moreover, STEM badges would need to provide windows onto the ways that science, engineering, technology and mathematics are practiced in communities, and across a wide range of topics and applications. The assurance that content is current, together with the creation of opportunities to see and experience the ways that STEM practices are carried out in industry and academia, is all the more important given the documented shortcomings of typical classroom experiences in introducing young people to authentic scientific practices (Quellmalz, Timms, Silberglitt, & Buckley, 2012). Research shows that classroom science instruction too often focuses on terms rather than concepts and process. As a result, students have limited opportunities to experience what a lifelong pursuit of STEM careers might be like (Shymansky, Yore, & Good, 1991; Stern & Roseman, 2004; Weiss & Pasley 2004). STEM badges could provide opportunities to expand the breadth and depth of content coverage that students experience in formal classroom settings.

The accessibility of accurate and current STEM content is also important for educators, whose preparation often emphasizes pedagogical strategies over content expertise, and who are frequently assigned to teach classes on topics in which they do not have formal training (e.g., Ingersoll, 1999; Shulman, 1986). According to data collected from teachers for the US Department of Education's

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2007-08 Schools and Staffing Survey, 15.6 percent of secondary core academic classes are taught by a teacher with neither certification nor a major in the subject area taught. In high-poverty schools, one in four math classes are taught by teachers with neither a mathematics certification nor degree major; for low-poverty schools the figure is one in 10. In schools where more than half the student population is from a low-SES household, 10 percent of secondary students receive instruction from a teacher with elementary education training (U.S. Department of Education, 2010). Even for teachers with STEM degrees and certifications, the many demands of classroom teaching leave little time for keeping abreast of the latest advances in the STEM community, much less translate those advances into effective and engaging instructional experiences for young people.

In addition to targeting current and accurate content, STEM badges would need to highlight the interdisciplinary nature of STEM practices, and the linkages between and among topics, phenomena and trends. Targeted content and practices would also need to be aligned with the practices set forth in the Next Generation Science Standards, as well as the Common Core State Standards in Mathematics.

Engaging and Effective Learning Experiences

A key to the success of STEM badges for fostering broader participation is the translation of current STEM content into rich learning experiences. It is widely established that expertise in a content area is not the same as expertise in the teaching of that content (Ericcson & Smith, 1991; Pellegrino, Chudowsky, & Glaser, 2001). Creating effective STEM learning experiences requires the close collaboration of content experts and learning scientists to ensure that the instruction, component activities and content are appropriately structured and scaffolded for learners at all development stages.

In addition to fostering deep understanding of STEM domains, there is a need for young people to experience STEM in ways that spark and sustain their excitement, curiosity and engagement. Well designed STEM badge experiences could serve as portals into long-term interest in engaging with STEM learning and careers. Repeatedly supporting learners' situational interest can promote the development of individual interest, which is marked by value, knowledge and a tendency to define and pursue projects of increasing complexity and expertise (Hidi & Renninger, 2006; Riconscente, 2010).

There are multiple strategies for integrating content with instruction (Shavelson, 2009). A curriculum-to-instruction, or standards-based, approach starts from analysis of the content domain, and through logical analysis of the content creates a scope and sequence that carries learners from simple through complex understanding. Alternatively, a cognition-to-instruction, or learning progressions, approach works from empirical insights into how people grow from novice to expert in a domain over the developmental continuum. While the former has been characterized as additive in its conception, in the latter, knowledge evolves to more closely align with normative understandings and practices over time. Some scholars suggest that the latter is more conducive to the creation of successful learning experiences (Heritage, 2007, 2008); however others caution that additional research is needed to validate the prioritization of learning progressions over standards-driven approaches (Corcoran, Mosher, & Rogat, 2009).

Evidence-centered design also offers helpful principles for the design of instruction that leads to intended learning growth and development (Mislevy & Haertel, 2006). Particularly in the area of technology-supported instruction, such as simulations and games, evidence-centered design can

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inform processes for collaboration among diverse experts, ensuring innovative learning experiences that do not compromise on content accuracy or depth of knowledge (Riconscente & Vattel, 2013).

Finally, some scholars have suggested that knowledge of how to teach specific content is a particular kind of knowledge (Ball, Hill, & Bass, 2005). In addition to embodying principles of topic-specific effective instruction, the STEM badges ideally would include supporting materials related to effective instruction of the target content.

Attracting Diverse Audiences

The content, criteria, and learning experiences must be accessible to broad audiences, particularly those underrepresented in STEM. In discussions among participants at the working meeting, a common point of discussion regarded the conditions that would be necessary for badge systems to increase, rather than undermine, equity in STEM education and career opportunities. STEM badges could increase participation if they are easy to access, include an array of entry points to rigorous content, support individual learning, and provide content and instructional resources for educators, mentors and parents to facilitate young people's learning and engagement. As Penuel and O'Connor (2010) have noted, both the practice and study of learning are influenced by social values and priorities. STEM badges offer an opportunity to focus learning opportunities on human agency, values and engagement with social practices.

By highlighting issues with local relevance, STEM badges could foster the engagement of a more diverse set of learners. In addition, exhibits and programs at science museums could include indications of related STEM badges that individuals could pursue on their own, following their museum visit, to continue learning about a particular topic, or to discover additional topics related to those that piqued their interest at the museum. Similarly, school instruction on core topics could include suggestions of STEM badges that students could pursue to learn more about topics they have found interesting in class.

Valid and Reliable Assessments

The criteria and processes established for assessing the way learners engage with and work toward mastery of the content must be valid and reliable (Mislevy & Haertel, 2006). This entails transforming the way assessment is conducted so that the processes used are appropriate for the kinds of knowledge, skills and abilities that elude single-sitting multiple-choice tests (Pellegrino et al., 2001; Quellmalz et al., 2012). STEM badges could foster valid assessment practices by explicitly linking evidence to claims about learning, and by providing materials to support the application of specific criteria to a particular student's work. The assessments included in STEM badges could span a wide spectrum vis-à-vis scoring methods, from fully automated, computer-scored tasks (e.g., Khan Academy math questions) to fully analog, long-term performance assessments scored by a trained panel of experts (e.g., AP Studio Art portfolios). This would enable a number of entities—such as scouts, museums, schools, after-school programs, youth organizations—to carry out the assessments defined within each badge.

Effective Implementation

The previous four issues all pertain to the creation of a robust library of STEM badges. The final step is the implementation of those badges with broad audiences. The process for earning badges—i.e., establishing that a particular learner has indeed met the stated criteria—must be credible and practically feasible. From a practical standpoint, trusted and credible agencies must take up the role of badge issuer.

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Clearly, addressing these central issues will require a multifaceted solution and the contributions of experts from diverse domains, including science, learning, instruction, policy and assessment. The scientific community has long had a commitment to disseminating the results of scientific work to the broader population. However there is room for improvement in the extent to which these efforts attain their desired impacts of broadening participation and communicating newly discovered scientific insights to the general public. Translating the highly specialized nature of today's scientific research efforts into instructional opportunities for young people demands the close collaboration of scientists, educators and learning scientists.

In a recent editorial, Alberts (2010) suggests that a national system of badges could make it possible for young people follow the specific interests that are born in the course of everyday life. "What does a kid who loves lightning do next?" asks Alberts (p. 11). Badges can serve a role in motivating continued, lifelong STEM engagement, by using learners' existing interests as entry points to the vast variety of topics and professions in the STEM arena, particularly specialized topics that are not included in formal curricular sequences.

Imagine if there were a national initiative or broad-based initiative designed to tap the expertise of the scientific community in collaboration with learning scientists to utilize the content and expertise of both communities to design learning resources that span the learning K–16 continuum and beyond. We envision a variety of ways that badge ecosystems could increase the quality and extent of participation in STEM fields. For instance, scientists and learning experts could collaborate on a rich, interconnected ecosystem of STEM badges that make scientific advances accessible to learners. These badges would target relevant scientific content, including developmentally appropriate learning experiences with vertical continuity, and describe assessment criteria and processes that are grounded in appropriate evidence. The badges would offer guideposts and enrichment opportunities for STEM educators in classrooms and informal settings. Badges could be awarded by informal and formal institutions with the internal expertise to determine whether learners have met the criteria. These institutions could also support the process of badge earning through program development, and by connecting learners to local opportunities to engage with educators, content experts and programs. This work could be embedded in places like scouts, after-school organizations, university programs, and STEM-focused museums—entities that already serve large numbers of young people and are capable of working with STEM-focused content.

The Planet Stewards project described in this report provides an illustration of effective collaboration between a science-driven agency and cutting-edge learning scientists. In this project, badges are leveraged to address the common goals of these organizations – to instill STEM learning opportunities with engaging activities that represent the creativity and diversity of the STEM enterprise. Unfortunately, all too often researchers and educators find it difficult to collaborate, despite complementarities in their goals. Badges may represent an opportunity to create a principled infrastructure for NSF science research awardees to collaborate with learning scientists, and simultaneously address the broader impacts criteria for their grant.

A badge architecture that is built on a fundamentally sound framework for linking badges to attendant assessment criteria may provide a modular system for co-development of learning materials by science researchers, educators and technology designers. Envision a new suite of badges that is released in conjunction with the most recent publication in a STEM field; if carefully crafted, badge designs could incorporate niche science concepts, derived from the bleeding edge of scientific

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discovery, into a larger constellation of science learning objectives and standards. In order to do this, both scientists and learning specialists would need to be involved in the design of badges and badging systems.

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APPENDIX A: ADVISORY BOARD

Chris Dede, Harvard Graduate School of Education
Barry Fishman, University of Michigan
Louis Gomez, University of California, Los Angeles
Dan Hickey, Indiana University
Dan Schwartz, Stanford University
Connie Yowell, MacArthur Foundation

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APPENDIX B: SEMI-STRUCTURED INTERVIEW PROTOCOL

WHO

- What is your role in your organization? What does your organization do?

WHAT

- There are a variety of perspectives out there on badges. How do you/your organization answer: What is a badge?

WHY

- What challenge or problem do you see badges solving? And/or what opportunities to badges offer?
- What is driving your (others') interest in badges?
- What do you find most exciting about work being done in the field of badges today? Why do you think badges are being advocated so strongly right now?
- What is the utility of badges? What is unique about badges? Are there other approaches that are similar to badges or might be used instead (or in complement to) of badges?
- Would it take a unified/centralized badge repository or infrastructure for badges to serve the needs you identified? (support your work?)
- How about the usefulness of badges specifically in the STEM arena? Why uniquely useful here?
- Who do you see as:
    - badge earners?
    - badge issuers?
    - badge consumers?

CHALLENGES/ASSUMPTIONS/CONSIDERATIONS

- What would need to happen (technically? culturally?) in order to see broad implementation and use of badges?
- Where do you see challenges to wide adoption at various levels?
- What are some common assumptions being made about badges? Do you feel they are accurate?
- What are some 'devil's advocate' concerns you have heard about badges?
- What do you see as the big challenges in creating badge systems? Implementing them? Getting them recognized/respected?
- How will we ensure the validity of badges? How will we be sure that a badge truly indicates learning/competence/? What will it take for you to <u>trust</u> a badge?
- Do we need a credentialing entity to issue "stamps of approval" to badge issuers?
    - Will "the people decide"?
    - Leave it to the badge consumer to review the available evidence?
    - Do you see a professional organization in your field serving the role of monitoring badges?

MORE

- What other types of badges are out there?
- What groups/project using badges are you familiar with?
- Who else is doing good work or thinking/writing in this area?

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Implementers

1. Describe your project

- What are you creating?
- How is it being used?
- What criteria do you use to issue badges?
- What validity challenges are you encountering?
- How are you dealing with them?

2. How is it going?

- Challenges
- Successes
- # badge earners, # badges issued
- What tool/infrastructure are you using for issuing/managing?
- What advice would you give to others who want to start implementing badges?

Policy Makers

"From a policy perspective specifically..."

- What do you see as the potential benefits of badge systems?
- Potential downsides?
- Challenges to adoption etc from policy perspective?

Funders

"From the perspective of a funder...."

- What do you see as the role for badges in the future?
- What do you find most troublesome about the push for badges?
- How might funding decisions be supported by development of badge infrastructure?
- Why do you think foundations may (may not) be interested in badges?
- What characteristics (partnerships?) do you see as key to a successful badge initiative - who would need to 'be at the table' for it to work well?

Tech Infrastructure Makers

- What are the challenges? (Are they technical challenges, or organizational?)
- How difficult will it be to manage privacy/data security?
- What partnerships (alliances/agreements) do you see as necessary for making badge implementation successful?
- What needs to happen to support persistence of badges across platforms over time?

Assessment/Credentialing Experts

- How would you describe the relationship between badges and assessment? (What is it currently? What should it be?)
- Are there particular assessment contexts or approaches that you see as synergistic with (complementary to) badges?
- Are there ways that badges could help support assessment that currently can't be done in another way?
- Are there historical analogues (e.g. scouts) we should be thinking about? (How does current effort compare?)
- Are there any misconceptions about badges that you think need to be clarified?

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APPENDIX C: INTERVIEWEES *(as of May 12, 2013)*

Sam Abramovich, University of Pittsburgh
Judd Antin, Facebook
Jodi Asbell-Clarke, EdGE at TERC
Jonathan Bergmann, Flipped Classroom
Lucas Blair, Little Bird Games/Badge Forge
Rick Bonney, Cornell Lab of Ornithology
Rebecca Bray, Smithsonian National Museum of Natural History
Malcolm Brown, EDUCAUSE Learning Initiative
Carla Casilli, Mozilla Foundation
Meri Cummings, Wheeling Jesuit University
Cathy Davidson, HASTAC
Katie Davis, University of Washington
Lisa Dawley, GoGo Labs
Chris Dede, Harvard Graduate School of Education
Jim Diamond, Education Development Center
Sean Duncan, Indiana University
Liz Fagen, Douglas County School District (CO)
Jonathan Finkelstein, Credly
Barry Fishman, University of Michigan
Kumar Garg, White House Office of Science and Technology Policy
Vanessa Gennarelli, P2P University
Drew Gitomer, Rutgers University
Louis Gomez, UCLA
Sheryl Grant, HASTAC
Monica Harriss, Cooper Hewitt
Michael Hibbard, North Salem (NY) Central School District
Dan Hickey, Indiana University
Cindy Hmelo-Silver, Rutgers University
Eric Klopfer, MIT
Pat Kyllonen, ETS
Daniel Laughlin, NASA
Chris Lawrence, HIVE Learning Network/Mozilla
Akili Lee, Digital Youth Network
Marc Lesser, MOUSE, Inc.
Amy McQuigge, SUNY Empire State College
Syna Morgan, Douglas County (Colo.) School District
William Penuel, University of Colorado Boulder
Michael Preston, New York City Department of Education, Office of Post-Secondary Readiness
Dennis Ramirez , University of Wisconsin Madison
Tim Riches, NEALE Overseas Programs
Dan Schwartz, Stanford University
Marsha Semmel, Institute of Museum and Library Services
Sally Goetz Shuler, Informal Science Education Consortium
Robert Starr, NASA
Martin Storksdieck, BOSE Board on Science Education NRC

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Maya Thompson, Cornell Lab of Ornithology
Cathy Tran, University of California, Irvine
Nancy Valentine, 4-H National Headquarters, NIFA, USDA
Michelle Viotti, NASA Jet Propulsion Lab
Jacey Wilkins, The Manufacturing Institute
Connie Yowell, MacArthur Foundation

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APPENDIX D: MEETING AGENDA

STEM BADGES: CURRENT TERRAIN AND THE ROAD AHEAD

8–9 am	Registration and Breakfast
9–9:15 am	Welcome Janice Earle, National Science Foundation Margaret Honey, New York Hall of Science Susan Singer, National Science Foundation
9:15–9:30 am	Framing the Day Michelle Riconscente, New York Hall of Science
9:30–10:30 am	Implications of Technology for Digital STEM Badges *Mozilla's Open Badges Infrastructure (OBI) has created technological possibilities that previously were unavailable for credentialing initiatives. In this session, Mozilla's Erin Knight will present an overview of the OBI. Prof. Fishman will then offer considerations more broadly about the affordances of technology for supporting STEM badge initiatives.* Erin Knight, Mozilla OBI Barry Fishman, University of Michigan
10:30–10:45 am	*Coffee Break*
10:45 am–12:15 pm	The Value Proposition: Examples from the Field *To ground the afternoon's breakout sessions in real examples of badge projects, we have invited representatives from four badge initiatives to respond to four questions about their work.* *1) How is your organization or program using badges?* *2) What specific challenge(s) are you addressing through badges, and why did you choose badges as the solution over other options?* *3) What have you learned so far?* *4) What do we need to know more about, and what do we need to build, to realize the potential of STEM badges?* Akili Lee, Digital Youth Network Alejandro Molina, Providence After School Alliance Michael Preston, NYC Dept of Education Peg Steffen, National Oceanic and Atmospheric Administration Moderator: Michelle Riconscente, NYSCI
12:15–1:15 pm	*Lunch*

1:15–2:15 pm	Research, Development, and Assessment *This panel will offer an illustration and overview of research and assessment issues related to STEM badge efforts. Marc Lesser will describe how their badge initiative is addressing these topics concretely. Professor Hickey will describe current research underway in this area, and offer considerations for future research on STEM badges. Professor Penuel will then share observations related to STEM badges from an assessment and validity perspective.* Marc Lesser, MOUSE, Inc. Dan Hickey, Indiana University Bill Penuel, University of Colorado Moderator: Amy Kamarainen, NYSCI/Harvard GSE
2:15–3:30 pm	Working Groups: Defining Research and Development Priorities for STEM Badges *Please see the meeting packet to find out which working group you belong to, and which room you are meeting in. *The goal of the working groups will be to apply the draft report framework to develop agendas for research and development related to digital STEM badges. Each of the five badges projects presented earlier in the day will serve as a springboard for these discussions.* *The report describes four overarching purposes characteristic of badge initiatives.* *1. Motivating learning and participation.* *2. Expanding the range of skills that are recognized, in a broader range of contexts.* *3. Promoting STEM engagement by making pathways visible and accessible.* *4. Supporting selection processes related to college and career.11* *The report also highlights the role that new technologies such as the OBI are playing, and could play, in advancing STEM badge efforts.* In light of this framework, your experience, and what you've learned today, please create an agenda for: a. Additional tools, programs, and other supports needed to realize the potential of STEM badges. b. Research questions or programs that would inform the effective implementation of STEM badges.
3:30–3:45 pm	*Coffee break*
3:45–4:45 pm	Toward an Agenda for Research and Development *In this interactive session, we will integrate outcomes of the working groups into coherent frameworks and gather additional feedback on the STEM Badges report. We'll also award badges to the working group presentations!*
4:45–5 pm	Closing Remarks

APPENDIX E: MEETING PARTICIPANTS

Sam Abramovich, University of Pittsburgh
Jodi Asbell-Clarke, EdGE at TERC
Eva Baker, UCLA/CRESST
Stephen Bartlett, National Science Foundation
Kathleen Bergin, National Science Foundation
Lucas Blair, Little Bird Games/Badge Forge
Matt Blakely, Motorola Solutions Foundation
Paulo Blikstein, Stanford University
Rick Bonney, Cornell Lab of Ornithology
Kyle Bowen, Purdue University
Rebecca Bray, Smithsonian National Museum of Natural History
Al Byers, National Science Teachers Association
Darren Cambridge, American Institutes for Research
Vikram Surya Chiruvolu, Society for Science & the Public
Janet Coffey, Gordon & Betty Moore Foundation
Allan Collins, Northwestern University
Michael Cosaboom, New York Hall of Science
Catherine Cramer, New York Hall of Science
Meri Cummings, Wheeling Jesuit University
Katie Davis, University of Washington
Lisa Dawley, GoGo Labs
Arlene de Strulle, National Science Foundation
James Diamond, Education Development Center
Ed Dieterle, Bill & Melinda Gates Foundation
Katie Dowd, White House Office of Science and Technology Policy
Sean Duncan, Indiana University
Richard Duschl, National Science Foundation
Janice Earle, National Science Foundation
Michael Evans, Virginia Tech
Jonathan Finkelstein, Credly
Barry Fishman, University of Michigan
Andy Forest, MakerKids
Matthew Garcia, AAAS DOE
Kumar Garg, White House Office of Science and Technology Policy
Louis Gomez, University of California, Los Angeles
Sheryl Grant, HASTAC
Alexander Halavais, Arizona State University
Eric Hamilton, Pepperdine University
Jim Hamos, National Science Foundation
Darcy Hardy, UT San Antonio/US Department of Education
Susan Harris, USC Joint Educational Project
Susan Henderson, EDUCAUSE
Kenneth Hibbard, North Salem Central School District (NY)
Daniel Hickey, Indiana University
Ross Higashi, Carnegie Mellon Robotics Academy
Caitlin Holman, University of Michigan

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Margaret Honey, New York Hall of Science
Jennifer Humke, MacArthur Foundation
Rebecca Itow, Indiana University
Barry Joseph, American Museum of Natural History
Amy Kamarainen, New York Hall of Science
Avi Kaplan, Temple University
Eric Klopfer, Massachusetts Institute of Technology
Erin Knight, Mozilla Foundation
Janet Kolodner, National Science Foundation
Anita Krishnamurthi, Afterschool Alliance
Michael Lach, The University of Chicago
Richard Laine, National Governors Association
Sherry Lassiter, MIT Center for Bits & Atoms, Fab Foundation
Daniel Laughlin, NASA
Akili Lee, Digital Youth Network
Marc Lesser, MOUSE, Inc.
Andrew Lincoln, Virginia Tech
Jerome Lucido, University of Southern California
Mike Lydon, TopCoder
Anne Mackinnon, Carnegie Corporation of New York
Jack Martin, Global Kids / Hive Fashion
Marina Martin, White House Office of Science and Technology Policy
Camsie McAdams, US Department of Education
Amy McQuigge, SUNY Empire State College
Vera Michalchik, SRI International
Kevin Miklasz, Iridescent
Amon Millner, Olin College of Engineering
Danielle Mirliss, Seton Hall University
Ariam Mogos, American Museum of Natural History
Alex Molina, Providence After School Alliance
Peggy Monahan, New York Hall of Science
Caroline Payson, Cooper-Hewitt Museum
Kyle Peck, Penn State University
James Pellegrino, University of Illinois at Chicago
William R Penuel, University of Colorado Boulder
Jan L Plass, New York University
Megan Powell, National Science Foundation
Michael Preston, NYC Department of Education, Office of Postsecondary Readiness
Alex Reeves, Clinton Global Initiative
Michelle Riconscente, New York Hall of Science
Steven Ruthford, National Science Foundation
Rose Schapiro, Carnegie Corporation of New York
Dennis Schatz, National Science Foundation
Katerina Schenke, University of California, Irvine
Marsha Semmel, Institute of Museum and Library Services
Erika Shugart, Koshland Science Museum
Sally Goetz Shuler, Informal Science Education Consortium
Tanya Shuy, U.S. Department of Education

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Susan Singer, National Science Foundation
Michael Soupios, Seton Hall University
Robert Starr, NASA
Peg Steffen, NOAA National Ocean Service
Reed Stevens, Northwestern University
Sandra Toro, Institute of Museum and Library Services
Cathy Tran, University of California, Irvine
Nancy Trautmann, Cornell Lab of Ornithology
Nancy Valentine, 4-H National Headquarters, NIFA, USDA
Lucien Vattel, GameDesk
Peter Wardrip, University of Pittsburgh
William Watson, Purdue University
David Wells, New York Hall of Science
Jacey Wilkins, The Manufacturing Institute
Diego Zapata-Rivera, Educational Testing Service

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