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Change comes to schools from unexpected directions. As a society, we need our schools to help a new generation of learners acquire new sets of knowledge and skill as well as the ability to use what is already known to build a better world. Our schools will need to support learners who are creative and innovative, have the ability to consume and create information in new media environments, and who are flexible enough to develop new life and career skills (Partnership for 21st Century Learning, n.d.). Educators and policy makers are continuously involved in the ongoing work of regularly updating the practices, as well as the expectations of our schools. We spend millions on researching, purchasing, and implementing new tools and practices designed to influence student learning. Our intentional efforts to reform the practices of schooling often result in real change, but the actual nature of that change is as difficult to predict as it is to direct.

In the 21st century, a wave of new media technologies is redefining what we mean by learning environments in everyday life. We are in the midst of a revolution that provides unprecedented levels of access to knowledge, skills, and communities through digital media technologies. Digital media tools let us answer our questions whenever we have them and provide our own answers to questions that others pose. Video games invite us to experience historical and fantasy worlds, experiment with new identities and miraculous powers, and participate in social interaction at worldwide scale. These opportunities for digital participation all clearly involve learning—the exploration of new questions, the availability of synchronous and asynchronous mentoring, and in the use of demonstration and production as forms of assessing the quality of knowledge and skills.

Over the past 25 years, schools and new media environments have established an uneasy truce in the world of learning. Reform, particularly in the K-12 world, has focused on learning the same content and skills, regardless of students' interests. Schools insist on high-quality, standardized learning tools and environments that specify what counts as learning *for* students. Media spaces, on the other hand, flourish when tools and environments are transformed *by* users. New media tools generally rely on easy-to-use interfaces that spark user-generated, interest-based engagement; schools prefer tools that have common content linked to widely used standards and reliable assessments of performance. The gap between schools and new media becomes clear when schools are defined as serious places where real learning is supposed to happen, and mastery of new media environments, from video games to social media, is not a worthwhile activity if it does not "move the needle" on improving test scores.

This uneasy truce has led to an unfortunate situation where education reformers are driven to measure the quality of digital media learning tools in terms of pre-digital institutional outcomes (Young, Slota, & Cutter, 2012; Carr, 2008), while many digital media learning researchers write off schools as an impossible venue for real change (Gee, 2013). The impasse has resulted in an

unsettling split personality for students (and increasingly, for educators) who are expected to use cutting-edge tools for learning and communication outside of schools, and then revert to more primitive technologies for in-school learning (Halverson & Shapiro, 2013).

Eventually, in an ideal world, the barrier between practices of learning in and out of schools may simply erode. In the meantime, though, the *participation gap* between students will continue to grow (Jenkins, Purushotma, Clinton, Weigel, & Robison, 2007). We are beginning to see real differences between students who understand how to create learning environments from digital media tools to amplify their school learning experiences and students who use digital media primarily for entertainment and social communication (Pabilonia, 2015). Students who have mastered the ability to create their own learning environments have an advantage over students who rely on traditional environments to structure their learning. Students who understand how to use new tools for school learning typically do not pick up these skills at school—they learn from the habits of parents and peers who work in knowledge fields (Watkins, 2013). Widespread access to many innovations in the digital world has great promise in engaging all students in 21st century learning, but without the active role of schools to remediate the class distinctions, the participation gap will continue to widen in ways that reflect social inequalities.

This paper addresses the gap between the potential of new media tools for transforming learning in and out of schools and the school commitment to technologies that support testing and accountability. We argue that the gap between schools and digital worlds can be *intentionally bridged* if we match the affordances of widely used new media environments and tools, such as makerspaces, video games, citizen science, fantasy sports and youth media arts organizations, with needs that traditional schools often struggle to meet. Matching affordances with needs means that educators do not have to invent entirely new approaches to teaching and learning. Rather, they can leverage learning practices widely used outside schools to answer questions raised by teachers and learners in schools.

One obstacle to bridging this gap, though, is the different interpretation of what we mean by learning in and out of schools. When schools define learning in terms of achievement on standardized tests, they capture a singular perspective that provides a common reference for all schools engaged in reform. At the same time, a focus on student achievement alone can obscure a more comprehensive understanding of the social and material conditions for successful learning. We propose the idea of *participatory culture* as a robust model for how to think about the emerging practices of learning in digital media spaces. The participatory culture framework helps to make sense of learning in and out of schools, and points toward viable paths to integrate the best of new media experience into contemporary school design.

Participatory Cultures

Henry Jenkins and his colleagues have reframed how we understand the role of production and learning in popular media cultures. Their work encourages us to think of everyday media interaction as an active, social process that, enabled by the Internet, connects us with like-minded people around the world in collaborative work and learning. The development of participatory

cultures began in Jenkins' work on fan cultures which blurs the definition "between forms of cultural production and forms of social exchange" by inviting people to communicate, produce, and circulate content and ideas according to their interests (Jenkins, Ito, & boyd, 2015). The learning that takes place in fan cultures sparked Jenkins and his colleagues to build a *participatory culture* framework that defines the functions of innovative learning spaces.

> A participatory culture is a culture with relatively low barriers to artistic expression and civic engagement, strong support for creating and sharing one's creations, and some type of informal mentorship whereby the most experienced people pass along what they know to novices. A participatory culture is also one in which members believe their contributions matter, and feel some degree of social connection with one another (Jenkins et al., 2007).

Participatory cultures grow from interest-based interactions and establish norms for contributions and communication. They tend to grow in third spaces, around and outside of institutions, in which members bring together media-driven content in spaces that allow for the exchange of ideas. James Gee's (2006) concept of an *affinity space* as a place were people who share similar interests gather to play, learn and exchange information describes how social interaction comes together around interests. The learning model for participatory cultures is grounded in very old practices of apprenticeship and situated learning where learners come to understand how to think and act like experts through continuous cycles of discussion, production, critique, and refinement of work (Lave & Wenger, 1991). While new media technologies are not essential to the function of participatory cultures, access to interest-based communities is radically widened by Internet access. Massive multi-player games, for example, involve players from around the world in complex forms of play, making, advice-giving (and getting), and critique. Access to virtual worlds makes participatory cultures come alive as an accessible way to think about teaching and learning.

Jenkins and colleagues describe four key functions that define the operation of any participatory culture: *affiliations*, *expressions*, *collaborative problem solving*, and *circulations*.

- *Affiliations* express the *interest-driven* aspect of participatory cultures. Members elect to join and people can belong to multiple participatory cultures. One of the key affordances of affiliations is the ability to grow new interests based on the social connections made in the culture. Players of one game begin to play another; participants in one discussion forum join others together. Another affordance of affiliation is the social aspect of interacting with others who share interests. Affiliations include members with a range of ability levels whose collective expertise becomes a community resource.
- *Expressions* define the *production* aspect of participatory cultures. Members engage in cycles of conceiving, representing, and sharing ideas through a range of products including videos, games, and critiques (Halverson, 2012). The initial steps toward membership, described by Lave and Wenger (1991) as legitimate peripheral participation, invite new members to engage in tasks that are necessary to the community's functioning, but not yet central to its success. This apprentice-like approach means that newcomers do

a lot of watching and learning as their work. As members become more familiar with the culture, they begin to communicate like other members, discuss the work of others, and finally produce as full members. For example, participants in instructional video communities on YouTube begin by watching the work of others as a means of completing a task of interest, move to commenting on the instructional videos, and eventually end up making videos themselves. Full membership requires supporting new members along the way through critique and advice for new making.

- *Collaborative problem solving* is the *knowledge-building* aspect of participatory cultures. Members work together through communities such as Wikipedia and Reddit, to address questions whose answers are unknown. Questions range from "Who will be the most productive second-baseman in the American League?" to "What is the best way to teach computational literacy with simple machines?" Participatory cultures are organized to coordinate collaborative inquiry toward solving unknown questions, distributing knowledge across the community, then toward specifying the next set of questions on the horizon.
- *Circulations* describe the *networks* through which interactions and information flow. The networks of interaction that shape daily life are each governed by our interests in communicating and sharing knowledge. While place-based circulation networks reinforce existing practices and limit the abilities of members to benefit from loose connections to other networks, in virtual cultures social networks link across communities to draw in new members and interests, and to provide contrast to the everyday, taken-for-granted aspects of our cultures. Solutions from one community can address the problems of another. Widened circulation networks enable members to pursue new interests and to reflect on status quo practices.

The principles of participatory cultures do not map directly onto the cultures of schooling. For a start, schools are not organized around the interests of learners. What is in the student's interest is specified by curricular standards, not by the learner. Educators are pressed each year to get students to "buy in" to school, typically with the promise of rewards or punishments that will result from the effort put forth in school. Expressions typically take the form of homework and the circulation practices are limited almost exclusively to the teacher and occasionally to peers. Curricula are composed of problems already solved by others that students need to replicate; and circulations are suspiciously controlled because of the links to cheating. If anything, the features of participatory cultures seem to highlight, rather than bridge, the gap between learning inside and outside of schools.

We do not suggest replacing the culture of traditional schooling with participatory cultures, or even to estimate whether participatory cultures could thrive in schools. Instead, our goal is to determine where the functions of the compelling success stories of participatory cultures map onto some chronic needs that educators in many schools seek to address. We propose to match the features of several flourishing participatory cultures with these identified school needs in

order to open a design space for educators to integrate the best of participatory cultures into the everyday practices of schooling.

- **Affiliations: Makerspaces**
  Inviting multi-ability members to share expertise around emerging and common interests
- **Production: Youth media arts organizations**
  Preparing youth to make and share multimedia stories of their lives and communities as an expression of new literacies
- **Collaborative problem-solving: Citizen science**
  Creating collaborative communities to engage learners in real inquiry
- **Circulations: Pinterest**
  Leveraging open networking platforms to transform professional interaction through resource sharing

We offer these four examples of participatory cultures to highlight each of their features, and to describe how schools might adopt participatory cultural practices through the affordances of these successful learning environments.

Affiliations: Makerspaces

Inviting multi-ability members to share expertise around emerging and common interests

Participatory cultures invite members to affiliate with groups in social spaces that encourage learners to pursue their interests. Makerspaces "are informal sites for creative production in art, science, and engineering where people of all ages blend digital and physical technologies to explore ideas, learn technical skills, and create new products" (Sheridan et al., 2014). Makerspaces have repurposed activities that had become consigned to garages and basements into shared, public spaces for people to come together, build stuff, and exchange ideas. A typical makerspace is an affinity space that contains a variety of construction and fabrication tools for welding, knitting, circuitry, digital printing, and woodworking. Some spaces offer free access for users to explore and to engage in projects; others require a membership fee or a commitment to serve as a mentor for new makers. Spaces usually include makers of different ability levels who engage in a variety of projects where veterans are expected to help novices use tools and think through projects. Over time, a successful makerspace develops a culture that both encourages new participants to learn to make and provides expert makers a shared space for working on long-term projects.

Making and makerspaces have become an international movement. Almost 1,500 makerspaces operate around the world, and libraries, museums, schools, and community centers are adding sites every month (Lou & Peek, 2016). Some makerspaces are housed in public institutions such as libraries and schools or fee-based institutions such as museums; others are standalone spaces dedicated to various forms of making independent of institutional affiliation. They often include digital making as well as a wider range of tools in conventional, physical media. FabLabs, one of the earliest organized forms of makerspaces for digital fabrication, were

sparked by Neil Gershenfeld's work at the Massachusetts Institute of Technology in the early 2000s. They are environments dedicated to allowing everyday people to build solutions to their own problems using a package of tools and plans to teach engineering, robotics, design, and programming (Gershenfeld, 2005). Nearly 500 FabLabs operate around the world (Fab Foundation, 2016), and they have adapted this model for K-12 schools worldwide (Transformative Learning Technologies Lab, 2013).

Many maker communities originated in the open-source world that formed around creating and patching software. The maker movement is now bringing these activities back into the physical world, integrating electronics and thus programming into everything, including knitting, welding, and carpentry. A key affordance of makerspaces is access to an open, user-generated network of blueprints (on sites such as thingiverse.com or instructables.com) to design anything from furniture to power generators. Maker Media also provides access to blueprints through websites and conventional publications (*Make* magazine), and national user communities through maker faires—more than 120,000 people attended the 2016 11th annual Maker Faire Bay Area (Conlan, 2016). Making has also has shaped a wide range of distribution communities for peer-to-peer selling and funding. For example, Etsy, a shopping website that specializes in peer-to-peer selling, had $2.39 billion gross merchandise sales in 2015 and 54 million members in 83 countries (Smith, 2016). From free public makerspaces to user-generated market places, making has emerged as a popular form of participatory culture based on affiliation, production, and exchange that include virtual and face-to-face participation.

Makerspaces provide a viable model for schools to integrate interest-based learning communities into the sites and curricula of public education. Mimi Ito and colleagues (2010) describe the kinds of learning that unfold in places like makerspaces in terms of hanging out, messing around, and geeking out. Learners "hang out" with like-minded peers as a way to become familiar with community practices. They "mess around" with tools to informally explore what can be done in a given media and to acquire new forms of technical skill. Once inducted into the basic moves of the art form, learners can begin to "geek out" by creating in terms of the standards and practices of the medium, by innovating on these standards and practices, and through helping others in the emergent community of practice.

Educators can tap into makerspaces as places for students to hang out, mess around, and geek out by building affordances of makerspaces into day-to-day practices of teaching and learning through:

- repurposing common use spaces to support making; and
- using maker activities to support bridges to disciplinary learning.

Repurposing public spaces to support making. Schools have traditionally maintained libraries as the spaces where students can pursue interests through access to knowledge resources. In recent years, as the media that control access to knowledge have expanded from books to digital resources, libraries have begun to transform from quiet places of research and

study to spaces that support active learning with online tools (Barack, 2015). Many school and public libraries are integrating making in the library learning ecology (Weisgrau, 2015). A maker mentality extends the "library as resource" metaphor from the consumption to the production of ideas, by inviting learners to mess around with media, such as circuit boards and Legos, to sparking creativity and to inviting learners to act on their interests. Moderating the space, however, is different from being a librarian and from being a teacher. Moderators (often called facilitators, maker educators, or mentors) should be skilled enough to spark interest through modeling; to guide learners in attempts at making; to sustain engagement; to provide constructive critique for both the aesthetic (i.e., does it reflect the makers vision?) and functional (i.e. does it work?) aspects of making; and to make connections among other makers with similar skills and interests (Bevan, Gutwill, Petrich, & Wilkinson, 2014; Sheridan et al., 2014). Repurposing school libraries into makerspaces can create a safe environment to reengage traditionally disengaged learners through opportunities to mess around with media and participate in emergent making cultures.

Using maker activities to support bridges to disciplinary learning. The maker movement has experienced particularly strong support as a pathway to deeper participation in science, technology, engineering, and mathematics (STEM) fields. In schools, science, and math education are content-heavy disciplines that require students to memorize facts and algorithms in order to advance. Many STEM educators argue that play that leads to interest and inquiry is a helpful prerequisite for the heavy lifting of science and math content learning. Lee Martin (2015) argues that makerspaces provide ideal learning environments for students to become interested in engineering. Martin describes how fabrication and programming make it possible for students to acquire the technical skills necessary to understand basic processes in electronics, physics, and computer science.

The community that develops around making demonstrates how STEM inquiry is a collective process, and students who successfully engage in the community can develop a "maker mindset" that supports play and modeling as a condition for complex learning. A maker mindset invites students to engage in learning based on their personal interests, which increases engagement and leads to exploration of and experience in careers.

Researchers in the maker world have explored how these kinds of communities can provide bridges to other forms of learning as well. Matthew Berland (2016) shows how video game and board game design introduce learners to the basic principles of programming. Yasmin Kafai and colleagues (2014) discuss making with digital textiles as a pathway from sewing and clothes making to electronic design. Kim Sheridan and colleagues (2014) demonstrate the link between arts-based learning activities and engineering through making environments. This research describes a new form of literacy as the ability to produce something that peers in one's affinity space would value. Once spaces are built to support making, educators have a rich variety of resources to guide in curriculum development that links student interests to disciplinary learning in schools.

Production: Youth media arts organizations

Preparing youth to make and share multimedia stories of their lives and communities as an expression of new literacies

Participatory cultures guide members to produce works that are informed by the standards of the culture and serve as the markers of successful participation in the group. Youth media arts organizations (YMAOs) are informal learning environments where youth learn to use new media tools to produce digital art such as movies, music, and podcasts about their lives and their world. The aims and purposes of these organizations focus on creating arts-driven spaces for collaborative expression, youth voice, and media literacy.

YMAOs typically flourish in afterschool and out-of-school contexts where production and performance artists can work with youth in a collaborative design environment. The organizations typically include virtual channels that allow for the distribution of products where authentic audiences can provide critique and promotion (Halverson, Lowenhaupt, Gibbons, & Bass, 2009). The Chicago Digital Youth Network is an example of the design and durability of an YMAO. Started in 2005, the network grew from an afterschool program to a MacArthur Foundation funded partnership with Chicago Public Libraries to create a space for urban youth to engage in media arts. A digital youth network has five main components:

- an *artifact-driven curriculum* that defines membership through making products that can be exchanged in the community;
- *modes of digital media communication* that facilitate peer mentoring, and learning-resource and artifact sharing;
- *integrated learning spaces* that bridge in-person participation in media studios with virtual mentoring and resource networks;
- *skilled mentors* in the form of a practicing artist community, both within a digital youth network and across the city, that guide and critique novice contributions; and
- *showcased opportunities* that allow members to share products with authentic audiences (Barron, Gomez, Pinkard, & Martin, 2014).

Network members create music, videos, and stories inspired by their experiences and by ideas generated in workshops with peers and mentors. Each member uses the online environment ReMix World (remixlearning.com) to access learning resources and mentorship. ReMix World tools require members to provide feedback on each other's work in order to unlock new tools and projects to continue their own work. The focus on production guided by mentors in real-world arts communities shapes social interaction around making into a genuine participatory culture. YMAOs such as YouthRadio (youthradio.org), AppalShop (appalshop.org), ReelWorks

(reelworks.org) and InProgress (in-progress.org) share similar structures to guide young people in making sophisticated media about their lives and communities.[1]

YMAOs provide a physical space and access to resources that organize and support the development of new literacies through production. Lankshear and Knobel (2006) discuss the new literacies as transforming the traditional definition of literacy from reading (e.g., decoding, vocabulary, and phonics) to a productive activity aimed at communication. Accountability measures in public schools narrowed the curriculum to focus almost exclusively on reading and math. In limiting literacy to "encoding and decoding print," students lose the sense that literacy is a meaning-making act that requires them to understand and contribute. Outside of school, learning to participate in a discourse is the mark of a literate person; the ability to engage across multiple discourses is the characteristic of a 21st century learner. YMAOs are participatory cultures organized around media production where learners acquire the foundational skills of traditional literacy in the context of producing works designed to communicate sophisticated messages to real audiences (Halverson, 2012).

YMAO design has important implications for educators, who acknowledge the importance of the new literacy skills but may struggle to teach these practices in traditional school environments. We suggest three pathways for educators to connect the affordances of YMAO activities into the contexts of real schools:

- replace a traditional research project with a digital media reporting project;
- use YMAO models to connect with practicing media artists in the community; and
- seek authentic audiences for student work

Replace a traditional research project with a digital media reporting project. The five-paragraph essay and the PowerPoint presentation continue to serve as the introduction to research training for most K-12 students. These structures help learners organize reasons into warrants for making arguments, and they induct novice writers into the norms of non-fiction and the use of evidence in expression. YMAO projects can bring the conceptual organization of these types of projects into the world of new media and participatory cultures. The ubiquity of digital recording and editing tools, for example, makes a no-cost contribution for each student to create a dynamic representation of thinking. By creating alternative viable pathways that are grounded in collaboration with familiar media tools, these kinds of practices would benefit special education students, English language learners, and other students who struggle with traditional approaches to engage in sophisticated literacy practices.

The practice of YMAOs clearly show that media production is more than simply giving students cameras and setting them free. The process of pitching an idea, storyboarding, editing,

[1] Communities such as FanFiction and YouTube game tutorial makers operate in similar networks of mentoring, production, feedback, and sharing with real audiences. These communities typically lack the in-person mentoring YMAOs provide and rely more on the virtual environment to mediate interpersonal interaction. (Black, 2008; Chau, 2010).

receiving and incorporating critical feedback, and sharing reinforces the underlying, traditional structures of research training while pressing makers to communicate their message to real audiences (Halverson & Gibbons, 2010). Organizations such as YouthRadio, for example, invite youth artists to contribute audio pieces to compete for public broadcast time. As a media-sharing platform, YouTube has generated an extraordinary range of communities that support fan communities and information sharing hubs for nearly every topic. Reframing classroom research activities into production cycles where students build and refine messages for publication provides a viable model for taking traditional school activities into 21st century participatory cultures.

Use YMAO models to connect with practicing media artists in the community. Supports for arts education in public schools has suffered in the era of test-score accountability (Metia, 2015; Urist, 2014). While arts courses are being eliminated, the time of arts educators is stretched thin across the classes that remain, often across schools. As a result, the expertise available for long-term projects that integrate arts-based production into traditional classroom practices is often limited to educators who develop these kinds of skills on their own. YMAOs offer a path toward a solution that can bring arts-based expertise back into the school. In communities with active YMAO communities, the process would be as direct as inviting a group of educators to meet and plan with YMAO leaders about collaborative projects. Even without the organizational structure of an YMAO, communities typically include new media artists who work as reporters, bloggers, web-developers or videographers. Identifying public-spirited artists willing to work on projects with schools can create stronger bonds with the local creative community and can provide powerful role models for young people interested in learning about how to translate creative skills into meaningful work. The Bubbler @ Madison Public Library in Madison, Wisconsin, for example, hires local artists to serve as artists in residence for several months; this time frame includes an in-library residency as well as time in library outreach programs to community partners. Bringing artists into schools can provide the expertise associated with pedagogies of tinkering, producing, and sharing that teachers might lack. Artists and teachers working together can create successful participatory cultures of distributed expertise.

Seek authentic audiences for student work. A central problem with production in traditional schools is that consequential products have no authentic audience. Teachers, students, and parents all know that homework is, at best, a check for understanding, and at worst, a time-filling busy work proxy for real production. YMAOs carefully organize production toward communicating with real audiences and providing students with an opportunity to feel valued for their knowledge and representation of learning. New York City's ReelWorks, for example, provides a six-month documentary filmmaking internship to urban youth to tell the stories of their lives and their communities. Youth make these films for legitimate external audiences to see through ReelWorks' own film festival and through national festivals such as Media That Matters. In addition, producers often post their work on open platforms like YouTube and Vimeo. YMAOs rely on the review of internal and external audiences. The voices of fellow participants and the wider external audience serve as channels for formative and summative

feedback for learning. The community of makers engages in formative assessment through peer review and critique to develop better work and to use their emerging expertise to guide each other's work. External audiences, such as panels of experts or a wider YouTube or radio community, provide summative critique about the aesthetic quality of the work and degree to which the message was successfully communicated (Halverson, 2012).

Of course, building these types of authentic audience feedback structures into typical homework practice has challenges, but thinking about the daily work of students as organized into comprehensive goals invites educators to move toward consequential products. Further, inviting students to write or produce work about their interests would be more likely to spark a community of peer editors who may share similar interests. Organizing smaller communities around media topics like Minecraft, Shopkins, or the Unified Pixar Theory[2] can spark affinities among younger writers who can learn the skills of new literacies in interest-based groups. Older students can be motivated by working through emerging issues of identity, group membership, or community issues. The discussion boards and collaborative writing and media editing tools of Google classrooms can serve as a free, accessible context, like ReMix World, for budding producers to share and critique work. The same group of community artists and media producers mentioned above can serve as judges for the summative quality of the work. Explicit attention to audience in formal learning settings both acknowledges the new media landscape of participatory cultures and takes seriously the idea that new literacies learning is about consuming, producing, and communicating ideas (Magnifico, 2010).

Collaborative problem solving: Citizen science

Creating collaborative communities to engage learners in real inquiry

A key problem with school science is authenticity of inquiry. In a classroom, an inquiry project typically walks students through a series of steps to the solution of a problem unknown to the student, but well known to the teacher. Scientific inquiry in the real world, though, is an organized social activity around open questions with unknown solutions.[3] Even when schools teach science as science (and not as literacy), and even when educators engage in inquiry-based curriculum, learners may not experience the anticipation that comes with exploring the unknown through disciplined investigation.

Participatory cultures thrive when organized as opportunities for collaborative problem solving around questions that are not yet answered. Clay Shirky's (2008, 2010) work on

[2] Unified Pixar Theory argues all Pixar movies take place in the same universe and that clues in each movie reveal the connections among the films. An online fan culture maintains the theory. See http://www.pixartheory.com.

[3] Most ordinary science inquiry rests on a wide and deep context of what is already known in order to investigate the unknown. Science education is, in part, designed to prepare young scientists to acquire this rich variety of skills and knowledge so they can participate in authentic science inquiry. Still, the absence of true unknowns from the traditional science curriculum can give learners the sense that science is about memorizing facts and replicating procedures, rather than exploring open questions (Dean & Kuhn, 2007; Chinn & Malhotra, 2002; Berland, Schwarz, Krist, Kenyon, & Reiser, 2015).

crowdsourcing describes how cultures can form around open questions in which participants propose and test possible solutions with one another. Often the problems that draw the attention of collaborative problem solving at scale come from the world of entertainment and pop culture. Fantasy sports, for example, involves millions of players in competitive leagues that seek to predict the performance of professional sports players. Online prediction markets, such as the Iowa Electronic Market, allow members to buy shares in the outcomes of future events—such as presidential elections—and are often more accurate than traditional polls. And, of course, stock and commodity trading markets are the best examples of participatory cultures at scale.

Citizen science communities are organized to coordinate non-specialist engagement in addressing unsolved problems in science research. The participation by the general population in scientific projects is not a new phenomenon; science was started through amateur inquiry (Bonney, Phillips, Enck, Shirk, & Trautmann, 2014). Citizen science provides hub-and-wheel structure to connect experts who set the terms of the inquiry with amateurs who collect, and sometimes analyze, data to address the question. With citizen science, the "cognitive surplus" that Clay Shirky describes is transformed into a method for leveraging underutilized human resources toward a specific project goal, often through breaking down complex data tasks that introduce amateurs to science inquiry without requiring technical expertise. Education researchers suggest that participation in projects like citizen science can increase the public understanding of science (Feinstein, Allen, & Jenkins, 2013).

A wide range of citizen science projects is available on the Internet (*Scientific American*, 2016; Citizen Science Alliance, n.d.a). One group of projects invites participation in population census taking. For example, eBird, launched in 2002 through the Cornell Lab of Ornithology and the National Audubon Society, asks users to "record the birds you see, keep track of your bird lists, explore dynamic maps and graphs, share your sightings and join the eBird community, and contribute to science and conservation" (eBird, 2016). The project supports mobile platforms for use in the field, has monthly challenges, and recognizes an "eBirder of the Month," and in May 2015, participants made more than 9.5 million bird observations in North America (eBird, 2016). Data from eBird have been used in more than 90 peer-reviewed articles and book chapters (Bonney et al., 2014). The Invasive Mosquito Project (Citizen Science Alliance, n.d.b) uses a similar approach to incidence tracking to trace the development and symptoms of Zika virus cases across the world.

Other projects use Shirky's concept of cognitive surplus to involve amateurs in identifying patterns in big data sets. *Planet Hunters*, for example, invites participants to look for simple dips in the light curve of stars to identify transiting planets from Kepler satellite images. Astronomers only step in when multiple users tag the same image. Overall, users see patterns that computer programs miss, and their planetary identification work contributes to the field of astronomy. *Foldit* is a crowdsourcing video game where players fold proteins to minimize the spaces in the structure of molecules while preserving the interaction rules that allow proteins to function. Players who master the basic game can participate in science puzzles and grand challenges that predict the structures of proteins in amino acid sequences. Players can fold proteins in ways not

predicted by computer simulations and, in some cases, make contributions to understanding viral diseases (Cooper et al., 2010).

We propose educators integrate citizen science projects into school activities at two levels:

- include at least one citizen science project per year for all students; and
- ground citizen science inquiry in local communities.

Include at least one citizen science experience per year for all students. The wide availability of citizen science projects across most areas of natural, applied, and social sciences means that educators can select activities that fit grade levels and interests of students. Even casual participants can gain basic literacy in the discourse of the space, understand the tasks their peers are completing, and be able to complete the tasks at hand and contribute to the field in a meaningful and innovative way. Contributing to citizen science projects represents an authentic experience of inquiry in a way that most schools are not accustomed to asking or evaluating. These experiences can challenges the fundamental message schools give students about what it means to "do science."

Ground citizen science inquiry in local communities. Many of the pressing problems in science inquiry are framed in response to local environmental and health concerns. For example, a number of limnology and water quality projects invite amateurs to measure water pH levels and gather data on water clarity (Hinterthuer, 2014). Projects such as California's West Oakland Environmental Indicators Project engage local learners in community maintenance and empowerment by documenting air quality and health indicators in high poverty neighborhoods (woeip.org). These kinds of place-based citizen science projects can be replicated in most communities with tools such as ARIS (arisgames.org) that allow users to create virtual worlds for situating local inquiry projects and adding information to large scale collection projects. Situating science inquiry in terms of civic engagement and place-based education helps students to make connections between classroom activities and the world outside of schools.

Circulations: Pinterest

Leveraging open networking platforms to transform professional interaction through resource sharing

Circulations are networks where members can use product sharing, critique, and mentoring to widen access to new colleagues. In prior examples, we have considered leverage points to integrate participatory cultures to enhance student learning. Pinterest provides an opportunity to show how circulations can transform professional learning in schools.

Pinterest first appeared in 2010 as an open, web-based, social networking platform that allowed users to share (or "pin") media and links in interest-based groups, or "boards." Six years later, there are over 75 million users around the world, 85% of whom are female, including 42% of adult women in the United States (DMR, 2016). The "pins" are visually appealing to scroll through, making an individual's selected content quick to scan. Each pin includes space for a

short comment, tags, and a link to the original website. Pins are added from anywhere on the web or uploaded from a device, by entering the link directly on the website or using a browser extension.

The power of Pinterest is the development of social networks and knowledge exchange. Pinners follow one another, often "repinning" content to their own boards and tagging the content in terms of user interest. This form of developing a user-generated tagging scheme is a "folksonomy" that, when aggregated, comes to fit the conceptual framing users create for a specific content type (Vander Wal, 2007). Folksonomic tagging is powerful for linking categories of content to the terms users find familiar to guide their searches. Pinners vote for or affirm ideas by following or repinning.

Although Pinterest was not designed specifically for teaching, teachers immediately perceived the benefit of the site as a way to share lesson ideas. For years, schools, districts, and professional organizations have labored to create "portals" or content sites that would distribute high quality content and engage users to develop online professional learning communities. The design priority of districts and state agencies to curate sites *for* teachers to ensure quality parallels the perspective of schooling *for* students. When organizations such as districts or schools make these kinds of decisions for learners—whether the learners are teachers or students—the governing organization acts on a deficit model as if learners are incapable (or unwilling) to make the right decisions about their own learning. Participatory cultures invite members to identify interests and design their own learning spaces. Self-policing and self-evaluating communities like Pinterest rely on the discretion of members to select the good resources and to guide community members toward valued products. In the case of schools, teachers who feel de-professionalized by accountability policies and standardized curriculum can begin to exercise agency as professional learners in participatory cultures like Pinterest to reaffirm their status as professionals.

Pinterest belongs to a larger family of user-generated content and exchange tools that also serve as occasions for participatory cultural practices in teacher communities. An emerging body of research on the role of Twitter in teachers' professional practices suggests that educators use Twitter for a range of purposes including acquiring resources and ideas from colleagues and for community-generated professional development (Carpenter & Krutka, 2014). Like Pinterest, Twitter allows teachers to organically generate topics of interest via hashtags (#). For example, #MTBoS (MathTwitterBlogosphere) refers to a self-described "community of math teachers on the Internet [who] communicate via Twitter and blogs" (*Exploring the MathTwitterBlogosphere*, 2016). Their activities include resource development and sharing, synchronous and asynchronous professional development opportunities, and a face-to-face conference they call "Twitter Math Camp." Social media platforms including Twitter and Pinterest afford the kinds of circulations that participatory cultures require, and have the potential to extend and transform teachers' professional networks.

We suggest that schools consider using user-curated content and exchange tools like Pinterest to cultivate extended, virtual professional learning communities. In particular, we suggest that schools:

- complement district and school resource portals with online, member curated resource networks; and
- engage in online sharing platforms to develop extended professional networks that lead to further learning

Complement district and school resource portals with online, member curated resource networks. Sites like Pinterest invite members to share interests of what they would like to learn and what they have expertise in. Members then provide a variety of resources that other users can identify as relevant to their interests. Content is often sourced from blogs, but pins and boards are curated from content already published on the web. Thus the creative part of Pinterest is the reappropriation of content as a form of production. Pinterest is a place where personal and professional lives can coexist in a creative space where members shape their worlds according to their interests. Sites like Pinterest revive self-driven professional learning by inviting educators to share questions and products in affinity spaces that support their interests.

Engage in online sharing platforms to develop extended professional networks that lead to further learning. Pinterest boards and Twitter hashtags provide a public display of valued learning resources and helps educators learn what they want to know. Educators might share boards in school with their colleagues, but more likely they will develop new professional networks of educators who curate valued resources and share interests outside their school community. Users who like pins on the board of another long-time user can make a new connection by following that board. Likewise, a new teacher may get more advice from a response to the tweet "#MTBoS teaching middle school for the first time next year. Recommendations??" than if that teacher asked that same question of school building colleagues and leaders. Districts and schools that proactively encourage the use of tools like Pinterest give the message that participation in extended networks is an encouraged aspect of professional learning. Teachers can then build on the features of professional judgment that aids other educators in classifying and finding valued resources, identifying collections and curators that align with interests, and evaluating the trustworthiness of the source. Pinterest and Twitter communities can provide for educators what participatory cultures provide for learners outside of schools.

Conclusion

Schools can look to the technologies and practices identified in this paper to shift the schooling experience to be more relevant, immersive, and authentic for teachers and students. The goal of the incorporation of participatory cultures into schools is to bring together the successful practices of everyday learning into the specialized world of schooling. The promise is to help increase school capacity to support new modes of learning and collaborating with the

hope that the practices of schooling will be seamlessly integrated into advances in learning technologies.

In *Participatory Cultures in a Networked Era*, Henry Jenkins, Mimi Ito, and danah boyd (2015) discuss the impact of new media on the evolution of participatory cultures. Even as learning outside of schools now includes experiences sparked by Twitter, *Minecraft*, and Google Docs, the relation of participatory cultures and schools remains in tension. The authors explain:

> Schools often give this message that what matters to young people doesn't matter in school. As they do so, they also signal the opposite—that what matters in school doesn't have any meaning in the rest of your life. (117)

The contrast between the kinds of disciplinary learning that thrive in many schools and the new media that shape learning in the rest of the world is a core design challenge of 21st century schooling. However, as we know from our experiences working with schools, there are educators and students leading the way in creating pathways for participatory cultures to live in schools. Innovations such as personalized learning (Halverson et al., 2015) and connected learning (Ito et al., 2013) are mapping new spaces where digital media can transform conventional practices in teaching and learning. We hope this effort to frame the challenge in terms of participatory cultures can provide educators, policy makers, and researchers with new ideas to experiment with the affordances of learning with new approaches to redefine what we mean by learning in schools.

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