Best of both worlds: Issues of structure and agency in computational creation, in and out of school

Executive Summary

Problem
We are surrounded by computational systems and interfaces, from social networks to banking infrastructure to entertainment platforms to transportation systems. But at present, most people do not fully participate in computational culture because they are unable to participate as *computational creators*. Constructionist learning environments that balance learner agency and structure are well suited to developing the capacities required for computational creation, and in this thesis, I explore two questions related to the activities and role of the learner in these environments:

> *How can constructionist learning environments be designed to support computational creators in the activities of designing, personalizing, sharing, and reflecting?*
>
> *Within these learning environments, how can structure be employed to enable, rather than constrain, the agency of computational creators?*

Approach
Scratch provides a rich context in which to examine the tension between structure and agency in constructionist learning environments, through both study and design. Hundreds of thousands of young people have created more than 2.4 million interactive digital media projects with Scratch and shared those projects with others through the Scratch online community. In this proposed thesis, I use a primarily qualitative approach (drawing on ethnographic, case study, and design-based research traditions) to describe how computational creation experiences take place in both the online community (characterized by low structure and high learner agency) and in schools (often characterized by high structure and low learner agency). Using a theoretical framework of agency and structure based on Giddens' notion of structuration, I analyze how the online community and school contexts enable – or do not enable – young people to develop as computational creators, and how this can inform the design of constructionist learning environments that support computational creators.

Contribution
The tension between structure and agency in learning environments lacks both theoretical and empirical attention in the research literature, particularly in the context of digital media learning and constructionist learning environment design. This thesis will address these gaps by providing: (1) rich descriptions of participation in computational creation in the Scratch online community and with Scratch in schools, (2) an analysis of how structure can support or undermine agency in constructionist learning environments, and (3) design principles for supporting computational creators, in and out of school.

Best of both worlds: Issues of structure and agency in computational creation, in and out of school

Thesis proposal submitted to the Program in Media Arts and Sciences
in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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Abstract

Hundreds of thousands of young people have created more than 2.4 million interactive digital media projects with Scratch and shared those projects with others through the Scratch online community. In this proposed thesis, I adopt a qualitative approach (drawing on ethnographic, case study, and design-based research traditions) to describe how experiences with computational creation take place in the online community (characterized by low structure and high learner agency) and in schools (often characterized by high structure and low learner agency). Using a theoretical framework of agency and structure, I analyze how the online community and school contexts enable – or do not enable – young people to develop as computational creators, and how this can inform the design of constructionist learning environments that support computational creators.

A Culture of Computation

In July 2011, I had the opportunity to visit Tokyo for several days. Unlike other places I had visited, I felt lost. I was unfamiliar with the language. I was unable to understand the landscape surrounding me. Although I was able to minimally interact with others and navigate the city, I was disconcertingly reliant on my host – mostly unable to express myself, to solve problems, to participate in the culture.

Many people face a similar experience in the culture of computation. We are surrounded by computational systems and interfaces, from social networks to banking infrastructure to entertainment platforms to transportation systems. This reality has given rise to a sense of urgency – expressed by a variety of sources from computer science education researchers (e.g. Guzdial & Forte, 2005) to literary theorists (e.g. Hayles, 2005) to government agencies (e.g. Chopra, 2012) – that everyone should be able to fully participate in computational culture. The urgency stems, in part, from a concern that unless we understand how to actively participate in computational culture, we risk being controlled by it:

> Everyday life is increasingly regulated by complex technologies that most people neither understand nor believe they can do much to influence. The very technologies they create to control their life environment paradoxically can become a constraining force that, in turn, controls how they think and behave. (Bandura, 2001, p.17)

As Appadurai (1996) observed (about the world of advertising, though it applies equally well to the culture of computation), we will find that we are no longer "actors", if we ever were, and that we will have become "choosers" instead (p. 42).

There is significant debate about what constitutes an acceptable standard of participation in computational culture. For example, does participation require only that one is able to use computational applications? Further, the name given to this participation and knowing has changed over time – "21st century skills", "IT fluency", "technological literacy", "digital literacy", and more recently "computational thinking" (Hargittai, 2009; ITEA, 2000; National Research Council, 1999; National Research Council, 2010; Partnership for 21st Century Skills, 2009; Wing, 2006).

The position I adopt is that to fully participate in computational culture, one needs to develop as a *computational creator*, and that *learning how to program* is a particularly rich activity for supporting this development and ensuing participation. Computational creators are familiar with certain computational concepts, such as sequences, loops, and variables. Computational creators are also familiar with computational practices, such as being able to remix and reuse others' code, or being able to abstract and modularize ideas. Furthermore, and perhaps most importantly, computational creators develop new perspectives on computation, "certain ways of understanding the world, … kinds of knowing that derive from a computer culture" (Papert, 1993, p. 51). With new perspectives on computation, a computational creator can see how computation can be used to express ideas and solve problems, how computation enables new connections to be made between people, and how understanding computation can empower one to question computation itself.

Knowing how to program empowers people to participate as creators – not just consumers – in computational culture. We take computational culture for granted at the Media Lab, a place where people are able to participate as sophisticated readers and writers of computation. But most people do not participate as writers in computational culture (or even understand what that might imply) and often even struggle as readers. Understanding programming and understanding code is a critical layer of modern culture – and should not "remain the exclusive concern of computer programmers and engineers" (Hayles, 2005, p. 61). As Rushkoff (2010) argued, if we leave programming to a select group, "we risk being programmed ourselves" (p. 133).

What can we do, then, to enable more people to develop as computational creators through programming, thereby enabling them to participate as writers and creators in computational culture? First, people need *tools* that make it easy to get started. Programming languages have historically been difficult to use, involving specialized syntax that is unforgiving of even the smallest error, such as a missing semicolon (Kelleher & Pausch, 2005). Second, people need meaningful *activities* that make it worthwhile to participate. Computer science education has long been criticized for developing learning environments and activities that are disconnected from the passions and interests of young people, or only appealing to a very narrow subset of young people (Resnick & Silverman, 2005; Turkle & Papert, 1990). Finally, people need access to *others* to support their learning. Despite increased awareness of computational creation (from events like Maker Faire, movies like The Social Network, and initiatives like Codecademy's Code Year), programming generally has an unflattering public image – something that is done by socially awkward people, often men, who are uninterested in interacting and working with others (Klawe, 2009; WGBH & ACM, 2009). Even the design of the personal computer, with its single keyboard and single mouse interface, suggests computing as a solitary activity. Along all three of these dimensions – tools, activities, others – computer science and programming have a bad reputation, so it is unsurprising that there is a cultural devaluing of these activities and declining participation (Carter, 2006; CSTA, 2006; Foster, 2005; Maillet & Porta, 2010).

Scratch is the Lifelong Kindergarten research group's vision for supporting development as a computational creator through programming. Scratch was designed to provide a tool, a context for personally meaningful activities, and a setting for interacting with others, enabling young people to engage in computational creation. It is a computational authoring environment that enables young people to design interactive media – stories, games, music, art, animation – and share their designs with other computational creators.

As a *tool*, Scratch was designed to be much easier to use than traditional programming languages. Instead of a text-based interface, Scratch uses graphical programming elements, which make it as easy to program a sequence of instructions as it is to snap puzzle pieces together. This freedom from exacting syntax enables computational creators to focus on other aspects of their designs, such as interface and behavior. As a context for *activities*, Scratch was designed to be used by a wide variety of young people, with a wide variety of interests. Unlike tools that focus on a specific genre (e.g. games, stories, or simulations), Scratch can be used to design almost any type of project that a computational creator can imagine, and can include a wide variety of media, such as favorite images or audio clips. As a context for interacting with *others*, Scratch was designed to go beyond the individual experience of the authoring environment by connecting to an online community of creators.

Agency and Structure: An Approach to Learning

Scratch follows in the constructionist tradition – an approach to learning that emphasizes the importance of constructing, building, making, and designing as ways of knowing, "that knowledge is not simply transmitted from teacher to student, but actively constructed by the mind of the learner. Children don't get ideas; they make ideas" (Kafai & Resnick, 1996, p. 1). This builds on constructivist assumptions that learning does not happen through a process of transfer or acquisition; learners construct new models and understandings that are connected to the learner's existing structures and models (Duffy & Cunningham, 1996; Scardamalia & Bereiter, 1991).

Constructionism is grounded in the belief that the most effective learning experiences grow out of the active construction of all types of things, particularly things that are personally or socially meaningful (Bruckman, 2006; Papert, 1980), that are developed through interactions with others (Papert, 1980; Rogoff, 1994), and that support thinking about one's own thinking (Kolodner, 2003; Papert, 1980). These four aspects of constructionism – which I define here as learning through the activities of *designing*, *personalizing*, *sharing*, and *reflecting* – are key activities of young people participating as designers of interactive media with Scratch, just as they were for Scratch's main predecessor, Logo.

Beyond suggesting a certain set of activities for learning, constructionism, like constructivism, suggests that learners should have *agency* within those activities. Agency is multiply defined, and has been associated with a wide variety of ideas, including "self-hood, motivation, will, purposiveness, intentionality, choice, initiative, freedom, and creativity" (Emirbayer & Mische, 1998). Despite its multiplicity of meanings and definitions, learner agency is a theme that recurs throughout the constructivist/constructionist literature, and is seen as an essential element of constructivist/constructionist learning environments. Here, following Bandura (2001) and Martin (2004), my working definition of learner agency is a learner's ability to define and pursue learning goals, which enables him or her "to play a part in their self-development, adaptation, and self-renewal with changing times" (Bandura, 2001, p. 2).

We are entering an era in which learner agency is of particular importance. For the past hundred years, school has been assumed to be the primary site of learning, and has often been characterized by low learner agency. But increasingly, school is not the *only* place of learning, a trend particularly supported by the use of computer networks (Collins & Halverson, 2009; Ito et al., 2009). Learners have new control and new responsibilities in these new places of learning:

> We grew up with the idea that learning means taking courses in school. … [T]he identification of education with schooling is slowly unraveling, as new technologies move learning outside of school's walls. In some sense, the divorce of schooling and learning may take us back to an era where individuals negotiate their own learning experiences. (Collins & Halverson, 2009, p. 129)

Learning – whether it happens in school, at work, at home, with friends, family, colleagues, or strangers – needs to have the learner at the center of the learning process, actively involved in defining and pursuing their learning goals.

One challenge faced in designing learning environments that support learner agency (as in constructivist and constructionist approaches) is establishing the role of *structure*. Like agency, structure is a word that eludes crisp definition despite its pervasiveness, appearing "in social scientific discourse as a powerful metonymic device, identifying some part of a complex social reality as explaining the whole" (Sewell, 1992, p. 2). Following Sewell's (1992) theorization (based on the work of Giddens and Bourdieu), structure is manifested through rules and resources, both explicit and assumed. In a classroom, for example, a lesson plan is a resource that serves as explicit structure and the role of the teacher as expert is an often-enacted assumed rule.

The tension between agency and structure – and the implications for the design of learning environments – has been an ongoing discussion in educational research (e.g. Craig, 1956; Anthony, 1973; Perkins, 1991). One extreme reaction to the history of learning environments with low learner agency has been to completely remove any structure, as it might unduly impinge on the agency of the learner (Kafai, 2006).

Minimizing structure may not ideally support learning, however, as learners are not as successful without structure in some of the activities that are important for their development as individuals who can define and pursue learning goals. Scardamalia and Bereiter (1991), while fully supporting environments of high learner agency, highlighted the value provided by the structure of other learners and of tools for identifying what is known and not known, and cautioned against "romanticizing the idea of the child as independent knowledge builder" (p. 40). Kirschner, Sweller, and Clark (2006) discouraged a lack of structure or guidance from others in learning, as it further disadvantaged novice learners, who benefit from "direct, strong instructional guidance" in defining and achieving their learning goals (p. 83). Mayer (2004), in examining the particular context of how young people learn programming, argued that a review of the youth computer programming literature of the mid-80s (mostly connected to the low-structure aspirations of the Logo movement) illustrated "the failure of pure discovery as an effective instructional method" (p. 17).

More important, however, than understanding that learners do not necessarily thrive in an environment devoid of structure, is understanding the relationship between agency and structure. A "structureless" environment was never actually an option because it does not exist – agency and structure are not in opposition, they mutually constitute each other (Bandura, 2001; Buckingham & Sefton-Green, 2003; Emirbayer & Mische, 1998; Freeman, 1972; Giddens, 1984; Schwartz & Okita, 2009). The connections between agency and structure are elaborated in Giddens' (1984) structuration theory. We have agency through structure, and we have structure through agency:

> Theorizing about human agency and collectivities is replete with contentious dualisms that social cognitive theory rejects. These dualities include personal agency versus social structure, self-centered agency versus communality, and individualism versus collectivism. The agency-sociostructural duality pits psychological theories and sociostructural theories as rival conceptions of human behavior or as representing different levels and temporal proximity of causation. Human functioning is rooted in social systems. Therefore, personal agency operates within a broad network of sociostructural influences. For the most part, social structures represent authorized systems of rules, social practices, and sanctions designed to regulate human affairs. These sociostructural functions are carried out by human beings occupying authorized roles. (Bandura, 2001, p. 14)

In applying structuration theory to the design of learning environments, we see again that structure is not in opposition to agency. With careful design, structure can be used to amplify learner agency, as structure "is always both constraining and enabling" (Giddens, 1984, p.25). Further, different structures will constrain and enable in different ways, and different settings have different structures. Designers of constructivist/constructionist learning environments need to consider the affordances of the settings in which they work and how to design for learner agency in relationship to structure.

Research Questions and Plan

The tension between structure and learner agency is a central one in the design of all learning environments – and has preoccupied me as a designer of constructionist learning environments and as a researcher. This tension lacks both theoretical and empirical attention in the research literature, particularly in the context of digital media learning and constructionist learning environment design. As Emirbayer and Mische (1998) observed, there is a need for work that is grounded in experience, "the empirical challenge becomes that of locating, comparing, and predicting the relationship between different kinds of agentic processes and particular structuring contexts of action" (p. 1005) – a need that has also been more recently echoed (Damsa, 2010; Martin, 2004; Pea, 2004).

In my thesis, I explore two central research questions:

> *How can constructionist learning environments be designed to support computational creators in the activities of designing, personalizing, sharing, and reflecting?*
>
> *Within these learning environments, how can structure be employed to enable, rather than constrain, the agency of computational creators?*

Scratch has served as a particularly rich context in which to examine the tension between structure and agency in constructionist learning environments, through both design and study. I explore these questions in two settings: (1) the Scratch online community, in which young people design computational media and which is characterized by low structure and high learner agency, and (2) K-12 classrooms, in which educators design learning environments for young people to engage in computational creation with Scratch and which are often characterized by high structure and low learner agency.

My methodological approach is primarily qualitative, as a way of attending to the culture, community, and context of these learning environments, as well as the lived experiences of individual young people and teachers. Stake (2010) described this dual focus – and process/representation – of qualitative research:

> It is common for people to suppose that qualitative research is marked by rich description of personal action and complex environment, and it is, but the qualitative approach is equally distinguished for the integrity of its thinking. There is no one way of qualitative thinking, but a grand collection of ways: It is interpretive, experience based, situational, and personalistic. Each researcher will do it differently, but almost all of them will work hard at interpretation. They will try to convey some of the story in experiential terms. They will show the complexity of the background, and they will treat individuals as unique, yet in ways similar to other individuals. (p. 31)

I draw on three research traditions: ethnography (LeCompte &Schensul, 1999; Van Maanen, 1988), case study (Yin, 2009), and design-based (Anderson & Shattuck, 2012; The Design-Based Research Collective, 2003). All three traditions acknowledge the importance of real-world (as opposed to controlled, laboratory) experiences – and the corresponding complexity of these settings and processes, which cannot be reduced to a simple set of variables or factors and require detailed descriptions. Detailed descriptions invite dense data collection (including observation, interview, artifact analysis, and survey), and the use of multiple types and instances of data serves to minimize bias in interpretation during analysis.

My analytical approach is to thematize collected data using the constructionist principles of designing, personalizing, sharing, reflecting, and the themes of structure and agency (Kvale, 1996; Miles & Huberman, 1994). The data collection and analysis processes will support developing rich descriptions of the settings, and (following the design-based research tradition) a set of design principles that suggest how to support agency via structure in constructionist learning environments, here, in the context of Scratch. As Anderson and Shattuck (2012) argued, "[t]hese principles are not designed to create decontextualized principles or grand theories that function with equal effect in all contexts. Rather, design principles reflect the conditions in which they operate" (p. 17).

In the following sections, I describe the two settings of study and the particular data collection methods that I have been using for each.

Setting #1: The Scratch Online Community

Learning and creativity are enhanced through interaction with others because they are social processes (Csikszentmihalyi, 1997; Sawyer, 2006). Theories about communities of practice and situated learning give us ways of thinking about how community settings can support learning by providing the learner access to other learners and artifacts (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; Rogoff, 1994). More recent research has described the ways in which the social nature of young people's online participation serves as essential motivation and support for developing fluency of participation (Buckingham & Willett, 2006; Ito et al. 2009; Jenkins, Purushotma, Weigel, Clinton, & Robison, 2006). Whether hanging out with friends or playing games or remixing media, having access to others makes for better participation, as young people are able to support each other in understanding practices and norms. Bruckman's (1998, 2006) work described the cognitive, social, and psychological benefits that an online community provided for individual learners in constructionist activities. From technical support to emotional support, having access to others bolstered individuals' capacities for creative work. Based on these theories and inspired by Papert's (1980) model of the samba school, the Lifelong Kindergarten research group created an accompanying website for Scratch, *the Scratch online community*, where people of all ages come together to share their design work and support each other's learning.

The Scratch online community, launched in May 2007, has become very active, with hundreds of thousands of members sharing, discussing, and remixing one another's Scratch projects (Resnick et al., 2009). Each day, members (mostly ages 8 to 16) upload more than 2500 new Scratch projects to the website – on average, two new projects every minute – with more than 2.4 million projects available. The collection of projects uploaded is incredibly diverse and includes interactive newsletters, science simulations, virtual tours, animated dance contests, interactive tutorials, and many others, all programmed with the Scratch environment and its graphical programming blocks.

In addition to enabling people to upload their projects, the site was designed with features typical of community-based content-creation sites, such as Flickr and YouTube.

Members can leave comments on projects, annotate projects with tags, indicate admiration of projects by clicking the *Love It* link, and bookmark projects in a list of favorites. Members can also download each other's projects to learn how they were made and then build on each other's work by remixing projects. Members can mark other members as friends, create galleries or collections of projects with others, and participate in discussion forums. Each member has a profile page that displays their alias and country, as well as their contributions and interactions, such as lists of projects, favorites, friends, and galleries.

I joined the Lifelong Kindergarten research group shortly after the Scratch online community was launched in 2007. It was a fortuitous time to arrive; it has afforded me the opportunity to study participation in the online community as the community has grown from tens of members to hundreds of thousands of members. I have particularly attended to the ways in which the structures of the online community support the constructionist learning principles of *designing, personalizing, sharing*, and *reflecting.*

First, *designing* and *personalizing*. The depth and breadth of creation by young Scratchers is astounding – and even more astounding given that, from many perspectives (e.g. Mayer, 2004; Pea & Kurland, 1986), it should not have been possible, or at least highly unlikely. This led me to wonder how young people were able to engage in this sophisticated creation, how they were able to move from a blank authoring environment to a completed project. What experiences with computational creation had these young people already had? What resources did they have access to? How did they deal with the challenges of open-ended design activities? How did their creations connect to their interests and passions?

Next, *sharing*. With millions of projects that Scratchers can download, study, and remix, the Scratch online community serves as a large library of examples to find inspiration in and to build upon. But even from the early days of the online community, young people have gone beyond Scratch as repository of examples to a location of meaningful connections and collaborations, often in spite of the technical limitations of the website to support those deeper forms of sharing. This led me to wonder how other people serve the needs of individual creators. What were the different types of connections that young Scratchers were making with each other in (or beyond) the community? How were these connections being established? What were the challenges of connecting with others? What was the significance of these connections to young Scratchers' development as computational creators?

Finally, *reflecting*. Even in the early days of Scratch, it was apparent that some young people were not only thinking about individual projects, but were thinking deeply about what it means to make projects and to participate in the online community. Some young people were reflecting on the processes of project development, by helping others through the development of tutorials. Others were leading conversations about the benefits of (and strategies for attaining) visibility within the online community. Still others were organizing debates about the challenges and opportunities of the site's remixing policies. These reflective activities have increased over time as the community has developed, providing community members with opportunities to think about their longitudinal participation and the evolution of the community. These observations led me to wonder about the extent to which young people were thinking about their own learning with Scratch. What were their motivations to engage in an activity like Scratch? How did young people think about defining learning goals? How did young people assess their development and progress?

Methods

To develop understandings and descriptions of how these principles of constructionist learning environments are supported (or not) by the structure of the Scratch online community, and how structure enables (or constrains) the agency of young computational creators using Scratch, my main sources of data are observation and interviews.

Observing interactions in the online community
For the past five years, I have been observing young people's participation in the Scratch online community. Based on this observation work, I have been writing field notes and memos about Scratchers' activities, and saving artifacts of their work – primarily Scratch projects, but also other electronic artifacts (such as forum posts, emails, and blog entries).

Talking with young Scratchers
Observation helps make sense of *what people do*, but provides limited insight into *how people think* about their actions and behavior. As such, I have also been conducting (with support from ScratchEd research team members) in-depth interviews with young Scratchers, as a way "to understand the world from the subjects' points of view, to unfold the meaning of peoples' experiences, to uncover their lived world" (Kvale, 1996, p. 1). This approach – trying to understand the culture of computational creators through the perspective of computational creators – is particularly important, as a way of supporting learner agency through learner voice.

35 interviews were conducted between November 2007 and January 2012 with Scratch online community members, who were selected based on quantitative analysis of participation in the online community. The interviewees represent a range of ages (7-16), geographic locations (mostly U.S., but including England, Belgium, Russia, and Canada), durations of participation (3 weeks to more than 4 years), and technical/aesthetic sophistication (from beginners to sophisticated programmers and designers). 40% of the interviews were conducted with female Scratchers, which reflects the proportion of female participation in the online community.

The interviews, which were semi-structured and were approximately 60-120 minutes in duration, were organized into four major sections:

1. Background
    a. Introduction to Scratch: *How did you find out about Scratch? What is Scratch?*
    b. Current practices: *Where do you use Scratch? What do you do with it? Do*

other people help you? Do you help other people?

2. Project creation
    a. Project framing: *How did you get the idea for your project (one of several projects that are discussed)?*
    b. Project process: *How did you get started making your project? What happened when you got stuck?*
3. Online community
    a. Introduction to the online community: *What do you do in the online community? What is the Scratch online community?*
    b. Other people, other projects: *How do you find interesting people and interesting projects? How do you interact with other Scratchers?*
4. Looking forward
    a. Scratch: *What do you dis/like about Scratch? What would you keep, add, change?*
    b. Technology: *What are other tech-related things you like to do?*
    c. Beyond technology: *What are other non-tech-related things you like to do?*

Setting #2: K-12 Classrooms

Much of the early use of Scratch took place in homes and after-school settings, and many of the initial participants came from home environments that encouraged and supported creative explorations with technology. But a growing number of schools have started to include Scratch in classroom activities. Scratch is used in a variety of settings – across disciplines, from computing studies to language arts to science to visual arts, and across ages, from kindergarten to college – and by educators who have varying levels of familiarity with Scratch and computational creation. The adoption of Scratch in schools is essential for broadening and diversifying the community of young people who are participating as computational creators, moving beyond early adopters and connecting opportunities for learning across informal and formal settings.

Although the Scratch online community is a vibrant, active community, it was not designed to support educators – it was designed for people who want to create and share projects, while educators are primarily concerned with helping *other* people create projects. The disparity between the design and teachers' requirements came increasingly into focus when, shortly after joining the group in 2007, I began to receive numerous emails from teachers. In these messages, teachers were sharing stories about their experiences with Scratch. They were requesting curricular resources – or offering to contribute resources that they had created. They were asking questions and offering to respond to others' questions. They were looking for ways to connect with other educators working with Scratch who were nearby or had similar interests.

Based on these educator interests and motivated by the *community of practice* literature – a model in which teachers as learners have access to peers, shared goals, and resources (Wenger, 1998; Barab, Barnett, & Squire, 2002), I developed a separate space for Scratch educators, creating a companion site to the main Scratch site, where teachers interested in or already actively working with Scratch could share stories, exchange resources, ask and answer questions, and find other educators. This separate space, called ScratchEd, made its public debut in August 2009. Since then, more than 4800 educators from around the world have joined the community, and have contributed more than 150 stories, 400 resources, and 2,200 discussion posts. Over the past year, the site has had an average of 55,000 page views from 9,200 unique visitors per month, predominantly from educators in the United States.

Although some of the initial teachers working with Scratch employed constructionist approaches in their teaching, many others adopted more traditional “instructionist” strategies due to various pressures, such as insufficient support, lack of resources, expectations about roles, or challenges in accommodating standards (Rainio, 2008; Sawyer, 2004). With these constraints, there is a concern that the structure of school operates in opposition to a constructionist, learner-agency-based approach, undermining the goals of designing, personalizing, sharing, and reflecting by, for example, enforcing a homogeneity in activity or relying on models of learning as an individual activity.

But teachers have a crucial role to play in supporting a constructionist approach to learning and in supporting learner agency within those constructionist learning environments. As described earlier, supporting learner agency does not imply removing all structure and support. Teachers can provide much-needed meta-cognitive support, helping students define problems, persist through challenges, and reflect on experiences – with the teacher modeling to the learners what being a learner can look like (Brown, 1994; Duffy & Cunningham, 1996; Hmelo-Silver, 2004; Scardamalia & Bereiter, 1991).

While many models have been proposed to support teachers, particularly in supporting teachers’ experimentation with new pedagogical strategies and with use of technology, collaboration among teachers has proven to be particularly effective (Dexter, Anderson, & Ronnkvist, 2002; Dexter, Seashore, & Anderson, 2002; Fuller, 2000; Schlager & Fusco, 2003). A blend of online and face-to-face interactions best supports a community of practice, with online interactions and face-to-face interactions mutually reinforcing the development of relationships, understanding of practice, and building of capacity among teachers (De Souza & Preece, 2004; Goodfellow, 2005; Hew & Hara, 2007; Kirschner & Lai, 2007; Vaughan, 2004).

Based on this research, it was evident that, although the ScratchEd online community provided some support for teachers’ understandings of constructionist approaches to designing learning environments and their understandings of Scratch, additional support was needed. Additional support was also needed to better accommodate all of the settings in which Scratch is being used. To broaden support, I wrote a proposal with my advisor, Mitchel Resnick, for the National Science Foundation Discovery Research K-12 program. We received $2.2 million in funding from the NSF in September 2010 (http://bit.ly/drk12-scratched), and I have been leading this NSF ScratchEd initiative.

The expanded ScratchEd professional development model involves several components. First, we are featuring stories, resources, and discussions in the ScratchEd online community that highlight constructionist approaches to the design of learning environments. Then, to accompany the ScratchEd online community activities, we are organizing face-to-face and online gatherings where teachers can develop deeper understandings of Scratch and constructionist approaches to learning, including quarterly introductory workshops for educators new to Scratch, monthly meetups for educators with some Scratch experiences, and monthly webinars that are recorded and shared on ScratchEd. Finally, we are developing resources for teachers to use when introducing Scratch to students and when conducting workshops for their colleagues. For example, I wrote a curriculum guide for Scratch that was released in September 2011 and was downloaded more than 21,000 times in the five months following its release. Accessing and exploring these resources is made as easy as possible by connecting announcements to other channels, such as email, Twitter, and Facebook.

These spaces have helped me to explore several key issues related to school-based constructionist learning environments that use Scratch. What roles do teachers play in these learning environments? How do teachers think about constructionist approaches to learning with Scratch? In particular, how do teachers negotiate the open-ended nature of computational design, the relationship between students' interests and constraints of curriculum, the role of sharing in a culture that privileges individual achievement, and the opportunities to support students reflecting on their experiences with Scratch?

Methods

To develop understandings and descriptions of how these principles of constructionist learning environments are supported (or not) by the structure of teachers and K-12 classrooms, and how structure enables (or constrains) the agency of young computational creators using Scratch in classrooms, my main sources of data are interviews, artifact analysis, and observation.

Talking with educators
21 interviews with Scratch educators were conducted between October 2009 and March 2012. The educators represent a range of grades (from K to 12), teaching experience (from a year to more than 40 years), settings (required courses, elective courses, in-school, after-school), and subject areas (cross-curricular, IT studies, computer science). The interview protocol has evolved over time to highlight different areas of focus, but has been generally organized into three major sections: previous teaching and technology experiences, approach to including Scratch in the classroom, and motivations and reflections on using Scratch in teaching practice.

Studying teacher artifacts
Designing the ScratchEd professional development model over the past five years has provided opportunities to study how teachers make sense of computational creation (in the context of Scratch) and of constructionist approaches to designing learning environments. In particular, the stories, resources, and discussions that educators have posted to the ScratchEd online community have been rich sources of data about teaching practice.

Observing educators' practices
A limitation of interviews and many artifacts (particularly planning artifacts, such as lesson and activity descriptions) is that they do not necessarily reflect the details of what actually happens in practice. Our professional development offerings (such as the monthly meetups and workshops) and site visits have provided another source of data for understanding educators' approaches to teaching.

Timeline

As of March 2012, I have iterated the ScratchEd professional development model over several years, conducted 61 in-depth interviews with young Scratchers and educators, and collected observation and participation data for both the Scratch and ScratchEd online communities. Based on my ongoing data analysis, I have collected sufficient data to present rich descriptions of Scratch in the online community and in K-12 classrooms, using structure/agency in constructionist practice as a central analytic framework.

Date	**Activity**
March 2012	Ongoing analysis of collected data Writing
April 2012	Ongoing analysis of collected data Writing
May 2012	Ongoing analysis of collected data Writing
June 2012	First draft of thesis to committee
July 2012	Revisions
August 2012	Second draft of thesis to committee
September 2012	Dissertation defense
October 2012	Submit final thesis

Outline of Chapters

The thesis will be organized into eight chapters, as follows:

Chapter 1 Introduction: A culture of computation

Chapter 2 Background: Constructionism and agency

Chapter 3 Settings/Methods: Scratch and ScratchEd

Chapter 4 Designing
- What are young people's computational design practices and strategies?
- How do teachers support open-ended computational design activities?

Chapter 5 Personalizing
- How are young people connecting their computational design practice to their interests?
- How do teachers make connections between young people's interests and school curriculum?

Chapter 6 Sharing
- How do others impact young people as computational designers?
- How do teachers support young designers in connecting with others?

Chapter 7 Reflecting
- How are young people thinking about their participation as computational creators?
- How are teachers thinking about including computational design in their teaching practice?

Chapter 8 Conclusion

Contributions

This work will contribute to the empirical needs described earlier, and to the digital media and learning, computer science education, and teacher professional development research literatures, by providing:

- rich descriptions of participation in computational creation in the Scratch online community and with Scratch in schools
- analysis of how structure supports and undermines agency in constructionist

learning environments
- design principles for supporting computational creators, in and out of school

Resources Required

All of the data collection (including interviews, event design, online community development) and a significant portion of the data analysis have already been conducted. This research has been supported by numerous research interns – including Harvard Graduate School of Education Master's students (Jeanne Wellings, Robyn Bykofsky, Michelle Chung, Ashley Lee, Amanda Valverde, Joe Prempeh, Linda Qian, Anushka Paul, Krista Shapton, Mydhili Bayyapunedi, Gracie Elqura, Mylo Lam, Aaron Morris, Vanessa Gennarelli, Jen Lavalle, Alex Schoenfeld, Vanity Gee) and MIT (Crystal Noel, Laura Wacker, Monica Oliver) and Yale (Jane Long) undergraduate students – and by research staff (Michelle Chung).

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Biography

Karen Brennan is a PhD candidate at the MIT Media Lab, a member of the Scratch Team, and leads the ScratchEd project. Her research is primarily concerned with the ways in which learning communities support computational creators. More concretely, her work focuses on Scratch and the Scratch educator community, studying how participation in the Scratch online community and how professional development for educators can support young people as creators of computational media. She has a BSc in computer science and mathematics, a BEd in the same areas, and an MA in curriculum studies – all from the University of British Columbia.

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