ScratchEd: Working with teachers to develop design-based approaches to the cultivation of computational thinking

In this Full Research and Development project, we address the third DR K-12 program challenge – *How can we enhance the ability of teachers to provide STEM education?* Through the use of Scratch, a graphical programming environment developed under a previous NSF grant (ITR-0325828), we will work with K-12 teachers to directly address information and communication technology education, as well as indirectly address mathematics and engineering education. In particular, we will design, develop, and test an online teacher community, gatherings (workshops, webinars, and conferences), and resources (curriculum guides and workshop guides).

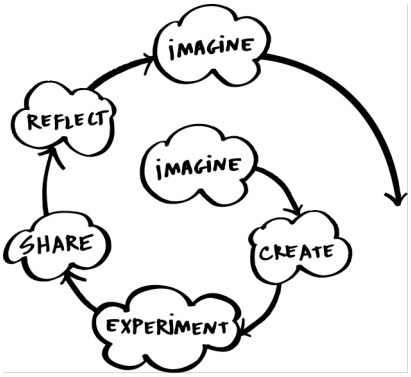
1. Background

In 2003, our research group at the MIT Media Lab was awarded a four-year grant from the National Science Foundation (ITR-0325828) to develop a new programming environment, called Scratch, that enables young people to create their own interactive stories, games, animations, and simulations – and share their creations with one another online. The Scratch website (http://scratch.mit.edu), launched in May 2007, has become a vibrant online community, with more than 400,000 registered members sharing, discussing, and remixing one another's Scratch projects (Resnick et al., 2009). The Scratch software, which is available for free, has been downloaded more than 1,000,000 times, and each day members of the Scratch community (mostly ages 8 to 16) upload approximately 1500 new Scratch projects to the website – on average, a new project every minute. The collection of projects is incredibly diverse: interactive newsletters, science simulations, virtual tours, animated dance contests, interactive tutorials, and many others, all programmed with Scratch's graphical programming blocks (illustrated below).

Scratch supports the cultivation of *computational thinking*, a set of strategies, skills, and capacities that draw on ideas from the world of computing (e.g., abstraction, debugging, and problem decomposition). In the past few years, there has been a growing recognition of the importance of computational thinking for understanding and solving problems in a wide range of contexts, not only in the field of computer science (Guzdial, 2008; Wing, 2006; Wing, 2008). As young people program and share Scratch projects, they begin to develop as computational thinkers: they learn core computational and mathematical concepts, while also learning important strategies for designing, problem solving, and collaborating. At the same time, young people begin to see themselves as computational creators, confident and capable of designing, creating, and expressing themselves with computational media, not merely interacting with it.

In our research, we take an explicitly *design-based approach* to the development of computational thinking (Papert, 2000; Kolodner et al., 2003). We have found that design-based activities, such as creating interactive stories and games, offer a particularly effective way for youth with diverse interests to become engaged in exploring computational ideas (Resnick, 2002; Resnick, 2006; Resnick, Rusk, & Cooke, 1998; Rusk, Resnick, Berg, & Pezalla-Granlund, 2008). As youth work on design projects, computational ideas are situated within meaningful activities, rather than presented as decontextualized concepts, as happens too often in computer science classes. We have found that design activities are most effective when connected to personally meaningful issues and topics, and situated within environments that offer the potential for productive collaborations and reflective waypoints. Thus, we see four elements serving as a foundation for the design-based approach: (1) engaging in design activities, (2) exploring personally meaningful topics, (3) collaborating with others, and (4) deepening understanding through reflection.

In communicating our design-based approach to educators, we often describe the process in terms of a *learning spiral*. In this process, learners *imagine* what they want to do, *create* a project based on their ideas, *experiment* with their creations, *share* their ideas and creations with others, and *reflect* on their experiences – all of which leads them to *imagine* new ideas and new projects (Resnick, 2007a; Resnick, 2007b). In developing Scratch and the Scratch website, we focused explicitly on how to support all phases of this learning spiral. Young people *create* Scratch programs by snapping together graphical programming blocks. By avoiding the obscure syntax and punctuation of traditional programming languages, Scratch frees young people to tinker and *experiment*, constantly trying out new possibilities. When young people *share* their projects on the Scratch website, they receive comments and feedback from other members of the Scratch community, leading them to *reflect* on their experiences. As young people try out other projects on the website, they *imagine* ways that they could remix and extend them.



Programming can serve as a core component of the design-based approach – and a valuable context for developing as a computational thinker. A report from the National Research Council (1999) argued that the algorithmic thinking inherent in programming "is essential to comprehending how and why information technology systems work as they do." In addition, the report argued that "the continual use of abstract thinking in programming can guide and discipline one's approach to problems in a way that has value well beyond the information technology-programming setting. In essence, programming becomes a laboratory for discussing and developing valuable life skills, as well as one element of the foundation for learning about other subjects."

Many previous initiatives to introduce programming to youth have not lived up to their promise, in part because programming languages have been too difficult to use and programming activities haven't resonated with youth interests. Scratch reduces those barriers, with its graphical approach to programming and its emphasis on media-manipulation activities that are part of today's youth culture. When presented with the opportunity to program with Scratch, a wide range of young people become actively engaged. In the process, they learn core computational concepts such as iteration, conditionals, event handling, parallelism, and synchronization. More broadly, they learn important design, problem-solving, and project-management strategies. These aspects of computational thinking are essential for full participation in 21st century society – for all students, not only those planning to major in computer science and become computer professionals.

2. Purpose and Goals

Much of the early use of Scratch, following its launch in 2007, took place in homes and after-school settings, and many of the initial participants came from home environments that encourage and support creative explorations with technology. But in the past year, a growing number of schools have begun to use Scratch in classroom activities – and, looking forward, we want to support and accelerate this trend. We see the adoption of Scratch in schools as essential for broadening and diversifying the community of young people who are using Scratch, moving beyond early adopters and connecting opportunities for learning across informal and formal settings.

Our aim is not simply to proliferate the use of Scratch, but to support and encourage a design-based approach to teaching and learning. While some of the initial teachers using Scratch have adopted design-based approaches for introducing Scratch, many others have adopted more traditional "instructionist" strategies due to various pressures, such as insufficient support, lack of resources, or challenges in accommodating standards. We believe a design-based approach is important for connecting to the interests of a broader range of students, creating a space for deeper understanding of computational ideas through reflection, expanding possibilities for collaboration, and providing opportunities for experiencing and learning about the process of design – an important component of computational thinking.

How can we best support a design-based approach to learning Scratch and cultivating computational thinking? While some people believe that technology-proficient students can self-manage with respect to technology, with minimal support from teachers, educational research suggests that this approach is not sufficient and that support should begin with the teacher (Fuller, 2000; Ouzts & Palombo, 2004). Fuller demonstrated that additional technology support and learning opportunities directed to teachers resulted in greater technology integration in their teaching practice. Cook–Sather (2001) provided an explanation, emphasizing that teachers have the pedagogical experience necessary for meaningful integration, which may be lacking in students. Bahr, Shaha, Farnsworth, Lewis, and Benson (2004) demonstrated that a favorable teacher attitude toward technology increases the likelihood of technology uptake by students, which further emphasizes the need for initiatives to make teachers comfortable with technology.

While many models have been proposed to support teachers in the 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). In particular, a *community of practice* model – in which teachers have access to peers, shared goals, and resources – is key for enabling teachers' learning (Wenger, 1998; Barab, Barnett, & Squire, 2002). 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, we focus our efforts on the professional development of teachers to reach new audiences and to implement design-based approaches to computational thinking. Our project responds to the third DR K-12 program challenge: **How can we enhance the ability of teachers to provide STEM education?** More specifically, our project development, design, and evaluation activities are framed by the following overarching research question: **How can the design of communities, gatherings, and resources enable teachers to understand and employ design-based approaches to the cultivation of computational thinking?**

To respond to this research question, we have identified two primary project goals:

- Develop technologies, models, and resources to support design-based approaches to learning with Scratch in formal learning environments

- Rigorously document the ways in which Scratch is used in formal learning environments

In pursuit of these goals, we will develop and study:

- An online community, called ScratchEd, for teachers working with or interested in Scratch
- Face-to-face and online gatherings where teachers can gain a deeper understanding of Scratch, computational thinking, and design-based approaches to learning
- Guides for teachers to use when introducing Scratch to students and when conducting workshops for their colleagues

3. Research and Development Design

In this section, we describe the core components of our project – the technologies, models, and resources that we will be developing in order to enable teachers to understand and employ design-based approaches to the cultivation of computational thinking with Scratch. We then present the project timeline, which outlines our iterative approach to developing and documenting these core components.

3.1 Core project components

Our approach to addressing the key research question involves three core components: an online community, gatherings, and guides.

3.1.1 ScratchEd: An online community to support Scratch educators

There has been great interest in Scratch since its public launch in May 2007. Educators recognize the potential of Scratch, but there has been a disconnect between what educators want to do and the tools and resources available to them. Part of the challenge is that the main Scratch website is designed for young people who are *creating* Scratch projects, rather than the educators who are *supporting* these Scratch creators.

In response, we are developing a separate online site dedicated to the practices of educators. Called ScratchEd, the site supports four main types of interactions: sharing stories, accessing and exchanging resources, participating in discussions, and establishing connections with other members.

- *Stories* – The site provides scaffolding for educators to document their Scratch experiences and stories. Documenting the stories of the Scratch teacher community serves multiple purposes. Stories serve as a history of the community, allowing members to learn from and build upon one another's experiences. Stories also strengthen connections among individuals in the community, as they get to know one another through their stories. Members can share stories through text, audio, video, and Scratch projects – and receive feedback from others through comments.

- *Resources* – All communities need tools, materials, and practices to achieve their goals. ScratchEd members are able to share and access many kinds of resources – for example, Scratch programming video tutorials, lesson plans for creating games with Scratch, or collections of mathematics-focused Scratch projects. The resources are organized by a site-defined taxonomy as well as member-defined keywords. To simplify the process of finding appropriate and relevant content, the taxonomy specifies three dimensions for the resources: content type, age/grade, and curricular area. Our team seeded the site with initial resources, and encourages educators as they share their own.

- *Discussions* – The discussions area provides a space where members can seek advice, provide guidance to others, and make announcements to the community.

- *Members* – In addition to providing a space for members to share information about themselves, the members area serves as a bridge between virtual and physical worlds. Featuring a map with members' locations, this area enables members to locate other Scratch educators who are geographically proximate, which supports face-to-face collaboration and local events.

The design of ScratchEd is motivated and informed by requests from educators in the Scratch community and by analysis of other sites designed for educators, including initiatives such as NSF-funded KNOW (Knowledge Networks on the Web). We presented preliminary ideas and interface mockups for ScratchEd to educators at the 2008 Scratch@MIT conference in a design charrette session. Based on this feedback, we refined the design and developed an initial version of the site, which we launched in summer 2009. Since then, more than 900 educators – from both formal (K-12) and informal (museum, library, community center, homeschooling) learning environments – have joined the community and contributed stories, resources, and discussions.

While we are encouraged by early interest in the site, we recognize that a better understanding of the community and further design of the ScratchEd site are needed in order for the site to become an effective vehicle for the dissemination of design-based approaches to the cultivation of computational thinking. The proposed project activities will enable us to go beyond this initial version, beyond anecdotal accounts of use to systematic study. More specifically, we will study the community to cultivate deeper understandings of: (1) who is participating (using site registration information and surveys), (2) how they are participating (using analytics and usability testing), and (3) how the community is supporting (or not) design-based approaches to learning with Scratch (using site artifact analysis and interviews).

Using this collected data about early engagement and participation, we will respond to community members' needs by engaging in design-develop-test cycles – iteratively refining the design and implementation of the site to better enhance the abilities of teachers to support design-based approaches to learning with Scratch in formal learning environments.

3.1.2 Gatherings: Models for introducing Scratch and design-based learning

The ScratchEd online community serves as an ongoing record of activity and connectivity between members, but it provides an inherently asynchronous form of communication. Synchronous, real-time interactions – workshops, webinars, and conferences – remain essential to ensuring the accessibility and sustainability of endeavors such as Scratch. Real-time interactions enable rapid exchange between individuals and iteration of ideas, and provide a deeper sense of belonging and participation in a community. To this end, we will organize three types of gatherings:

- *Workshops* – Teachers who want to employ design-based approaches to the cultivation of computational thinking in their teaching practice should have opportunities to experience those design-based approaches as learners. Each year we will organize six 30-person, day-long, hands-on, free workshops for teachers, for both those who are new to Scratch and those who are further along in their investigations with Scratch. The workshops will be an opportunity to explore the connections between Scratch, computational thinking, design-based approaches, and practice-specific content.

  For participants who are new to Scratch, *starter* workshops will provide some background and motivation for computational thinking and design-based learning, include a series of hands-on activities, provide opportunities to share creations, introduce ScratchEd as a means for ongoing support and conversation, and provide recommendations for next steps and further exploration. For participants who have some experience with Scratch, *intermediate* workshops will focus on deeper discussions about design-based approaches to cultivating computational thinking, and sharing of practice-related experiences. The workshops will support our research goals by ensuring that our work remains continuously grounded in the lived experiences of educators, and by serving as a

testbed for the development of the curricular and workshop resource guides (described in the next section).

- *Webinars* – To reach a broader audience than those who are able to attend a face-to-face workshop, we will also organize six two-hour, free webinars each year. Inspired by lesson-study tradition, the webinars will provide an opportunity for extended presentation and discussion of design-based approaches to computational thinking with Scratch, and for teachers from a wide variety of contexts and backgrounds to share their experiences.

  For participants who are new to Scratch, *starter* webinars will provide background and motivation for Scratch, computational thinking, and design-based learning, include stories of and ideas for best-practices from teachers already working with Scratch, introduce ScratchEd as a means for ongoing support and conversation, and provide recommendations for next steps and further exploration. For participants who have some experience with Scratch, *intermediate* webinars will focus on sharing practice-related experiences and feature various guest speakers with expertise in Scratch, design-based approaches to learning, and computational thinking. Like the workshops, the webinars will also serve as a testbed, supporting the development of the curricular and workshop resource guides (described in the next section).

- *Conferences* – In addition to the workshops and webinars, we will organize a biennial conference that enables participants to have an extended series of in-depth, face-to-face interactions around practices and resources for Scratch, computational thinking, and design-based approaches to learning. We hosted the first Scratch conference (Scratch@MIT) in July 2008. More than 300 educators attended – sharing stories of how Scratch is being used in a variety of contexts, participating in hands-on workshops, and discussing research about learning with Scratch. In feedback forms, many educators said that they appreciated the opportunities to connect with like-minded individuals, as well as benefits derived from interdisciplinary interactions. For example, mathematics teachers were able to connect with art teachers, and subsequently found new ways of enriching their practices to enhance student learning and motivation for studying STEM-related topics.

  The biennial Scratch conference will offer opportunities to present project findings – the development of ScratchEd, workshops, webinars, and resources – as well as to share classroom practices and experiences. Scratch@MIT 2010 will focus on formally announcing the project and its core components, as well as presenting ways for members of the community to participate in the project work. The conference will also be a time for extensive documentation and data collection about current practices within the Scratch educator community. Scratch@MIT 2012 will be an opportunity to share major findings of the project from the previous years. The 2012 conference gathering will focus on computational thinking as a major theme, with activities and speakers emerging from project activities.

As with the online community, we will study the Scratch workshops, webinars, and conferences to develop deeper understandings of: (1) who is participating (using registration information and surveys), (2) how they are participating (using video recording and artifact analysis), and (3) how the gatherings are supporting (or not) design-based approaches to learning with Scratch (using artifact analysis and interviews). Using this collected data, we will iteratively refine the design and implementation of the Scratch gatherings, as well as the development of resource guides (as described in the next section).

3.1.3 Guides: Supporting the introduction of Scratch, computational thinking, and design-based approaches to learning

The development of online infrastructure and gatherings is not enough. We also need compelling, practice-useful content and documentation that will enable teachers to get started with Scratch or to

rethink and reimagine their approach to working with Scratch, computational thinking, and design-based learning. Much as the design and implementation of ScratchEd will be a participatory process in collaboration with the community of educators, we will work closely with ScratchEd community members and Scratch gathering participants throughout the development of resources, to ensure that generated resources are context-appropriate and field-tested.

Through this project, we will develop two main guides:

- *Curriculum guide* – Although our research group has created introductory resources for Scratch, such as a guide to creating an initial Scratch project and a set of programming flash cards, we do not currently have a curriculum guide that supports teachers' integration of Scratch into their teaching practices. In this project, we will develop a guide that introduces Scratch through a series of design-based activities. The guide will highlight the computational thinking associated with each project or activity. For example, an annotation might point out the problem-solving strategy of decomposing a problem into simpler sub-problems. The guide will also highlight the many engineering and mathematical concepts inherent in the activity of Scratch programming itself. For instance, an annotation might describe how students make use of variables, random numbers, logic operations, and other mathematical concepts in the process of programming Scratch projects.

- *Workshop guide* – In addition to the curriculum guide, we will develop a guide for teachers to introduce colleagues to Scratch, computational thinking, and design-based learning. The development of this guide will be supported through the Scratch gatherings and through ScratchEd. The guide will support the sustainability of the project, enabling teachers to conduct their own professional development workshops, as well as supporting educators beyond K-12 with workshop design.

We will study: (1) development of the guides (using journaling and artifact analysis) and (2) use of the guides (using analytics, surveys, and interviews). Using this collected data, we will iteratively refine the design of the guides.

3.2 Project plan and timeline

As with the design-based approach we advocate for cultivating computational thinking, the development of core project components – the ScratchEd online community, gatherings, and resources – is based on an iterative design-develop-test model, in which feedback and evidence from each iteration inform subsequent iterations. The project timeline below outlines our development plan, with external evaluation tasks described in section 4.

	Major Tasks	Year 1				Year 2				Year 3	
		Q1 Jul-Sep 2010	**Q2** Oct-Dec 2010	**Q3** Jan-Mar 2011	**Q4** Apr-Jun 2011	**Q1** Jul-Sep 2011	**Q2** Oct-Dec 2011	**Q3** Jan-Mar 2012	**Q4** Apr-Jun 2012	**Q1** Jul-Sep 2012	**Q2** Oct-Dec 2012
Project-Wide	Meet with advisory board members										
	Make formal project announcement										
	Write up findings for confs, etc.										
	Share formative findings at confs										
	Share summative project findings										
	Document development processes										
ScratchEd	Collect participation data										
	Analyze participation data										
	Design features										
	Implement features										
	Deploy and test features										
Gatherings	*Workshops*										
	Plan starter workshop										
	Host/document starter workshop										
	Analyze starter workshop data										
	Plan int. workshop										
	Host/document int. workshop										
	Analyze int. workshop data										
	Webinars										
	Plan starter webinar										
	Host/document starter webinar										
	Analyze starter webinar data										
	Plan int. webinar										
	Host/document int. webinar										
	Analyze int. webinar data										
	Conferences										
	Host conference										
	Analyze conference data										
	Plan conference										
Guides	*Curriculum Guide*										
	Research curriculum guides										
	Design guide										
	Release guide										
	Collect/analyze feedback, use data										
	Workshop Guide										
	Research practices, guides										
	Design guide										
	Release guide										
	Test guide in workshops										
	Collect/analyze feedback, use data										

4. Evaluation

We are pleased to be working with the Education Development Center's Center for Children and Technology (EDC/CCT) to conduct the external evaluation of our project. EDC/CCT brings a wealth of expertise in rigorous program evaluation, and they are well-acquainted with NSF initiatives. EDC has done extensive work in researching and operating online communities for educators, both at CCT and in their Center for Online Professional Education. They will be able to leverage previously validated focus group protocols, web and email surveys, and message-analysis techniques to generate both formative and summative evaluation reports.

The evaluation is guided by several aspects of the project's overarching research question: the *core components* (cultivation of online community, organization of gatherings, development of guides) and *desired outcomes* (teachers' understanding and use of design-based approaches to cultivating computational thinking with Scratch). The approach to evaluation is both formative and summative, relying on both quantitative and qualitative strategies, and involving the community in data collection where appropriate and meaningful to community members.

4.1 ScratchEd online community

- *How are teachers using the various structures and content (e.g. stories, resources, discussions, members, comments) of the ScratchEd online community?*

  Using quantitative measures, we will conduct an ongoing analysis of site usage to determine how features are being used (or not) by community members. In addition to these quantitative measures, we will conduct content analysis of contributed stories, discussions, and comments to develop common themes, as evidenced by their contributions.

- *What are teachers' experiences of participating in the ScratchEd online community?*

  We will conduct quarterly surveys with the entire ScratchEd community to collect usability feedback. Based on the quantitative analysis of usage patterns and this survey data, we will conduct in-depth interviews with a select sample of community members, constructing the sample based on the dimensions of *extent of involvement* (more centrally or more peripherally), *mode of interaction* (more online or more offline), and *situation of practice* (more formal or more informal settings). Experiences with ScratchEd will also be explored through group interviews. The survey data, individual in-depth interviews, and group interviews will be coded and analyzed to provide insights into how educators experience the site as a way of supporting their understandings and use of design-based approaches to the cultivation of computational thinking, and the ways in which the site could be improved, either from social or technical perspectives.

- *How does the design and function of the ScratchEd online community change over time based on feedback from community members?*

  We will document the development process of ScratchEd by adopting ethnographic techniques of observation and detailed notes. The process will be regularly recorded through an evolving design document that is annotated with journal entries that describe the perceived role of community members in the process.

4.2 Gatherings

- *What are teachers' experiences of participating in Scratch workshops and webinars?*

For the duration of the project, we will conduct surveys with participants before and after workshops and webinars. The data will be coded and analyzed to identify themes focused on experiences of participation. We will use a video ethnographic approach of participant observation to document the sessions, and use the themes from the interviews to organize narratives about the events as a means for supporting teachers' understandings and use of design-based approaches to cultivate computational thinking.

- *What are teachers' experiences of participating in the Scratch conferences?*

  Following each conference, we will conduct surveys of all participants to collect data about their experiences at the conference – questions will include issues related to content, audience, and relevance. In addition to surveying, we will conduct one-on-one interviews with selected conference participants. As with the data collection and analytical approach for the workshops, the interview data will be coded and analyzed to identify themes focused on experiences of participation. We will again use an ethnographic approach of participant observation to document the conference (including autoethnographic contributions from selected participants), and use the themes from the interviews to organize narratives about the events as a means for supporting teachers' understandings and use of design-based approaches to cultivate computational thinking.

- *How do real-time gatherings impact participation in the ScratchEd online community?*

  We will conduct a quantitative analysis of site participation (through the sharing of stories, contribution of resources, etc.) as related to real-time gatherings to identify any changes in participation. We will solicit feedback from individuals when they sign up for a ScratchEd account to determine how they heard about the site.

4.3 Guides

- *How can Scratch curriculum and workshops be communicated through guides?*

  Using the iterative guide versions, we will document the process of developing the Scratch curriculum and workshop guides. The analysis of the process will involve identifying general principles for developing this type of guide, and will be accompanied by the guides as evidence artifacts.

- *How are educators accessing these guides?*

  Using quantitative measures, we will conduct an ongoing analysis of site usage over the project period to determine how these resources are being used by community members. We will analyze viewing, downloading, commenting, and bookmarking trends, in conjunction with community member demographic information, to determine the relevance of the resources.

- *What are teachers' experiences of understanding, using, and contributing to these resources, both online and offline?*

  On an ongoing basis, we will collect and analyze the comments left on resources and discussions about resources to identify themes related to teachers' experiences with the resources. We will conduct quarterly surveys with the entire ScratchEd community to get feedback on the resources. The collected data will be coded and analyzed to provide understandings of how educators contribute to and use the resources, with an emphasis on how the resources support teachers' understandings and use of design-based approaches to cultivate computational thinking.

4.4 Summary of EDC/CCT evaluation timeline and deliverables

Data collection and deliverables	Year 1				Year 2				Year 3	
	Q1 Jul-Sep 2010	**Q2** Oct-Dec 2010	**Q3** Jan-Mar 2011	**Q4** Apr-Jun 2011	**Q1** Jul-Sep 2011	**Q2** Oct-Dec 2011	**Q3** Jan-Mar 2012	**Q4** Apr-Jun 2012	**Q1** Jul-Sep 2012	**Q2** Oct-Dec 2012
Online data and survey collection	◆	◆	◆	◆	◆	◆	◆	◆	◆	
Observations of Scratch conference	◆								◆	
Observations of workshops/webinars	Two sessions of each/year				Two sessions of each/year					
Interviews with users	◆		◆		◆		◆		◆	
Interim memos to MIT team		◆		◆		◆		◆		
Ongoing communication with MIT team	◆	◆	◆	◆	◆	◆	◆	◆	◆	
End-of year report				◆				◆		
Final project report										◆

5. Anticipated Results

We anticipate the following results from this project to enhance the ability of teachers to provide STEM education through understanding and employing design-based approaches to the cultivation of computational thinking:

- Expansion of the Scratch teacher community beyond early adopters
- Rigorous documentation of teachers' attitudes and approaches to using Scratch in formal learning environments
- Documentation of new strategies for understanding and employing design-based approaches to STEM learning
- Documentation of new approaches to understanding, introducing, and supporting the cultivation of computational thinking
- Development of a new online community of educators, with thousands of educators expected to participate over the course of this grant
- Hosting of gatherings for teachers, with 360 teachers participating in workshops, hundreds of teachers participating in webinars, and 800 teachers participating in conferences
- Models for gatherings – workshops, webinars, biennial conferences – that can be used beyond this grant to bring together educators engaged in (or interested in) the use of Scratch
- Design of Scratch curriculum and workshop guides that emphasize design-based approaches to learning and computational thinking that can be used by teachers nationwide

6. Dissemination Plan

Our research group at the MIT Media Lab has a strong track record for broadly disseminating our ideas, activities, technologies, and strategies. Millions of young people are currently using technologies based on our group's research (including Scratch and LEGO MindStorms robotics kits). We have also developed educational programs that have had a major impact in broadening participation in computing: the Computer Clubhouse network of after-school learning centers, co-founded by our research group, has expanded to more than 100 sites, reaching more than 20,000 young people in low-income communities (Resnick, Rusk, & Cooke, 1998). This program was awarded the Peter F. Drucker Award for nonprofit innovation.

We have had great success in attracting educators to participate in our projects. Our initial Scratch@MIT conference in 2008, intended primarily for educators, reached its registration maximum (300 people) a full month before the conference and included several NSF-funded Scratch project presentations. In May 2009, we coordinated a distributed event called Scratch Day (http://day.scratch.mit.edu), during which educators around the world conducted their own Scratch-related workshops and activities on the same day. 120 events were hosted on Scratch Day and were attended by thousands of teachers and students.

In addition to sharing our research and development designs, findings, and overall project information with the DR K-12 Resource Network and reporting annually via the NSF online data system, this project has two major dissemination components: attracting educators and sharing research results.

6.1 Attracting educators to participate in the ScratchEd online community and gatherings

Given that, in the first 30 months after its public launch, more than 1,000,000 people downloaded the Scratch software and more than 400,000 people registered on the Scratch website, we anticipate that thousands of educators nationwide will participate on ScratchEd in a similar time frame, impacting hundreds of thousands of students. We will continue to promote the online community and gatherings through presentations at education conferences, mailing lists, and blogs. The Scratch project has already received considerable press coverage; we expect that future press coverage will report on ScratchEd and increase traffic to the site. An increasing number of NSF-funded projects (including some with DR K-12 funding) involve Scratch and we will reach out to those groups to encourage them to share their work via ScratchEd.

6.2 Sharing our research results with practitioners, researchers, and policymakers

In addition to sharing research results via ScratchEd and the Scratch conference, we will share our strategies and results through multiple other channels:

- *Papers and publications* – Our team regularly publishes in educational magazines and research journals, reaching a broad and diverse audience. Recently, an article about Scratch written by our research group was featured as the cover story of *Communications of the ACM* (Resnick et al., 2009) and an article about Scratch and the creative learning spiral was prominently featured in *Learning and Leading with Technology* (Resnick, 2007a). Resnick's work is frequently discussed and linked on educator websites, as well as major newspapers, magazines, and other media outlets.

- *Hands-on workshops* – Our team regularly runs professional-development workshops for educators. For example, in the past year, we organized workshops as part of the Building Learning Communities, CSCL (Computer Supported Collaborative Learning), and NECC conferences, as well as hosting our own Google-sponsored three-day CS4HS workshop.

- *Professional conferences* – Members of our team are frequently featured as keynote presenters at major educational conferences. In the past two years, for example, Resnick has been invited to make major presentations at NECC, BETT, the International Conference on Teaching and Learning with Technology, and the Australian Computers in Education Conference, among others.

7. Sustainability Plan

The NSF funding (ITR-0325828) that supported the development of our Scratch software and website ended in summer 2008. Fortunately, we have been successful in attracting funding from corporations and private foundations to continue development and support of the software and website. Current sponsors include Google, Microsoft, Intel, Nokia, Telmex, and Portugal Telecom – all of whom are supporting Scratch because they see it as an effective vehicle for stimulating youth interest in science and technology. We expect a similar path towards sustainability for the ScratchEd online community and gatherings.

8. Expertise

The expertise of teachers will be an integral part of the process, and will be continuously folded into the work in a variety of ways – through the different settings (the online community and gatherings) and at different scales (one-on-one conversations and interviews, focus groups, and surveys).

The MIT Media Lab, and our Lifelong Kindergarten research group in particular, are inherently interdisciplinary, combining a wide variety of disciplines, such as computer science, engineering, education, psychology. The success of this project depends on expertise from all of these areas.

Mitchel Resnick, Professor of Learning Research at the MIT Media Lab, specializes in the development and study of new technologies that engage children in creative learning experiences. His research group developed (with NSF support) the "programmable bricks" that were the basis for the LEGO MindStorms robotics kits, and the Scratch software and website that are the basis for this proposed project. He co-founded the Computer Clubhouse network of after-school learning centers for youth from low-income communities, as well as the NSF-funded PIE Network of museums. Resnick earned a BS in physics from Princeton in 1978, and an MS and PhD in computer science from MIT in 1992. He was awarded an NSF Young Investigator Award in 1993. In the proposed project, Resnick will serve as Principal Investigator and Project Director.

Karen Brennan is a research assistant and PhD student in the Lifelong Kindergarten group at MIT Media Lab. Prior to joining the Media Lab, she completed a Combined Honors BSc in Computer Science and Mathematics, a BEd in Computer Science and Mathematics, and an MA in Curriculum Studies with a specialization in Technology Studies Education from University of British Columbia. She has 10 years of teaching experience, in secondary and post-secondary computer science and mathematics, and post-secondary teacher education, including curriculum, instructional, and qualitative research methods. As an educational researcher, she has been involved in large-scale and small-scale qualitative, quantitative, and mixed-methods research projects – from data collection and analysis to complete research design – with a focus on technology and mathematics education research. Since joining the research group in August 2007, Brennan has led the design and development of the ScratchEd and Scratch Day projects, and has been co-chair of the Scratch conferences. In the proposed project, Brennan will lead the development of the online community, gatherings, and resources.

Other graduate students in our research group will provide support for the development and implementation of workshops, webinars, and conferences.

We will also hire two half-time staff people: one person to support resource development and event organization, and another person to support educational research activities, including the data collection and analysis processes.

In addition, we will employ undergraduate and graduate interns, and external consultants. MIT undergraduate interns will support technical development and assist with workshops and conferences. Harvard graduate interns from the School of Education will support educational research activities, including conducting literature reviews, performing data collection tasks, and assisting with data analysis. External consultant **EDC** will be responsible for external evaluation (as described in section 4). An as-yet-unspecified consultant will support the graphic design of the curriculum and workshop resource guides, and another as-yet-unspecified consultant will support development tasks for the ScratchEd online community.

To provide further guidance regarding educational research activities, we are very pleased to have assembled an exceptional Advisory Board, with extensive backgrounds in educational research, online teacher communities, and design-based learning. We will meet with the full Advisory Board each year of the project and with members individually or in subgroups each quarter, to get their input and suggestions on aspects of the project most relevant to their interests and expertise. Board members include: **Barry Fishman** (Associate Professor of Learning Technologies at The University of Michigan School of Education), **Yasmin Kafai** (Professor of Learning Sciences at the University of Pennsylvania Graduate School of Education), **Marlene Scardamalia** (Presidents' Chair in Education & Knowledge Technologies and Director, Institute for Knowledge Innovation and Technology, at OISE University of Toronto), **Judith Fusco** (Research Social Scientist, Center for Technology in Learning, SRI International), **Sasha Barab** (Professor of Learning Sciences, IST and Cognitive Science, and Director of the Center for Research on Learning and Technology at Indiana University), **Nancy Baym** (Associate Professor of Communication Studies, University of Kansas), **Kylie Peppler** (Assistant Professor of Learning Sciences at Indiana University).

9. Results from Prior NSF Support

This proposed project builds directly on the results of our NSF-ITR grant (ITR-0325828) that funded the initial development and study of the Scratch programming environment and website. The project, which ran from 2003-2008 with a total budget of $1,957,000, has received recognition from the educational research, computer science, and design communities. In 2008, Scratch was awarded the Eliot Pearson Award for Excellence in Children's Media, and also an Honorable Mention in the Digital Communities category of Prix Ars Electronica.

Research studies based on the original NSF grant have provided insights into how young people learn important computational concepts while programming with Scratch, both at Computer Clubhouse after-school learning centers and through the Scratch online community (Maloney et al., 2008; Monroy-Hernandez & Resnick, 2008; Resnick et al., 2009). Our research identified three core design principles contributing to the success of Scratch. Compared with other programming environments, Scratch is: (1) more *tinkerable*, enabling an easier entry path to programming through a novice-friendly user interface (2) more *meaningful*, supporting a wide diversity of projects and greater personalization through media, and (3) more *social*, emphasizing sharing and collaboration as paths to greater creative potential.