SCRATCH-ED
Collaborating with Educators to Support the Cultivation of High-Level Learning Skills through Scratch-Based Design Experiences

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1. Program Overview

In 2003, our research group at the MIT Media Lab was awarded a four-year NSF grant (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 on the web. We publicly launched our Scratch software and website in May 2007. Since then, more than 600,000 people have downloaded the software, and they have produced an incredibly diverse range of creative projects: science simulations, virtual tours, design competitions, interactive tutorials, and many others (see screenshots below). Every day, more than 1000 new projects are shared on the Scratch website by young people, often "remixing" and building upon one another's work. Several ongoing ITEST programs, including CompuGirls (grant #0833773) and the IDEA Cooperative (grant #0737379), are involving youth in learning to program in Scratch.

As young people program and share Scratch projects, they have opportunities to learn important mathematical and computational concepts, while also learning to think creatively, reason systematically, and work collaboratively, essential skills for success in the STEM workforce of the 21st century. But we recognize that the educational benefits (and the broader dissemination) of Scratch will be limited if we do not provide better means of scaffolding and support, to help young people develop the high-level learning skills associated with Scratch activities.

Towards that end, we propose to develop, implement, and study new strategies for professional development and collaboration among educators, so that they are better able to support STEM learning in the context of Scratch. As part of this effort, we will develop and coordinate a new online community for educators, called Scratch-Ed. Just as the existing Scratch online community enables young people to share projects and ideas with one another, Scratch-Ed will serve a similar role for educators, enabling them to share learning experiences, access educational resources, and discuss strategies for introducing STEM concepts in the context of Scratch projects. We will collaborate with educators to develop a set of educational support materials and plans, to help educators make connections between Scratch-based design activities and the high-level learning skills fostered by those activities. In addition, we will organize a series of workshops and conferences, where Scratch educators will meet in person to share ideas, organize collaborations, and plan future directions.

2. Project Goals and Objectives

- Develop new strategies for supporting the cultivation of high-level learning skills through design-based activities

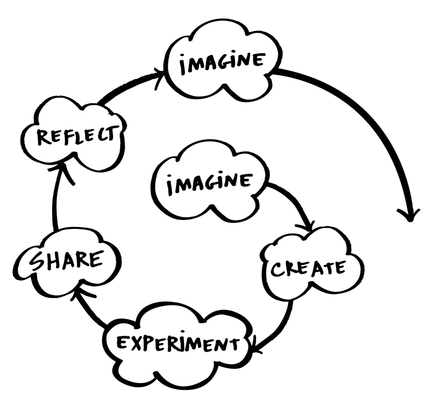
- Expand opportunities for young people to become fluent with new media technologies by scaffolding the process of learning to program with Scratch

- Empower educators as partners in development and sharing of resources to support STEM learning in classrooms and informal learning environments

- Contribute to the knowledge base about STEM education, by leveraging cyberinfrastructure technologies to foster collaboration among educators in online communities to support STEM learning

3. Guiding Principles

Our strategies and activities are guided by a design-based approach to learning (e.g., Kolodner et al., 2003; Vattam & Kolodner, 2006), informed especially by Papert's constructionist theories of learning and education (Papert, 2000). In our group's previous research (e.g., Resnick, 2002; Resnick, 2006; Resnick, Rusk, & Cooke, 1998; Rusk et al., 2008), we have found that design-based activities offer a particularly effective way to motivate youth with diverse interests to become engaged in exploring math, science, and engineering concepts.



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, *reflect* on their experiences – all of which leads them to *imagine* new ideas and new projects (Resnick, 2007a, 2007b). In developing Scratch and the Scratch website, we focused explicitly on how to support all phases of this learning spiral. Children *create* Scratch programs by snapping together graphical programming blocks. By avoiding the obscure syntax and punctuation of traditional programming languages, Scratch frees children to tinker and *experiment*, constantly trying out new possibilities. When children *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 children try out other projects on the website, they *imagine* ways that they could remix and extend them.

This learning-spiral process provides an effective context for developing a set of high-level learning skills that have become known as "21st century skills." As described in the report *Learning for the 21st Century*, these skills "are not new, but they are increasingly important in workplaces" (Partnership for 21st Century Skills, 2003). The report organizes these skills into three broad categories, all of which are cultivated in Scratch activities:

- ***Information & Communication Skills***. Effective communication in today's world requires more than the ability to read and write text. Scratch engages children in choosing, manipulating, and integrating a variety of media in order to express themselves creatively and persuasively. In this way, Scratch helps children become truly *fluent* with new technologies (International Technology Education Association, 2000; National Research Council, 1999; Resnick, 2001).

- ***Thinking and Problem-Solving Skills***. To create Scratch projects, children need to think creatively as well as systematically, to find problems as well as solve them. As they create external representations of problem-solving processes (in the form of computer programs), children have opportunities to reflect on their own thinking (Papert, 1980).

- ***Interpersonal & Self-Directional Skills***. The Scratch website supports collaboration and sharing, and the visual objects and modular code of Scratch make it easy for children to build on one another's work – in a type of open-source learning community (Monroy-Hernandez & Resnick, 2008). Children also learn patience and persistence as they start with a tentative idea and work to turn it into a functioning computer program.

There is a strong consensus among educational researchers and policy-makers that these types of high-level learning skills will be essential to success in tomorrow's STEM workforce (National Academy of Sciences, 2007).

What is the best way to help young people develop high-level learning skills and true fluency with new technologies? While there exists some sentiment that technology-proficient students can self-manage with respect to technology, with minimal support from educators, educational research suggests that this approach is not sufficient and that support should begin with the educator (Fuller, 2000; Ouzts & Palombo, 2004). Fuller demonstrated that additional technology support and learning opportunities directed to educators resulted in greater technology integration in their educational practice. Cook-Sather (2001) provided an explanation, emphasizing that educators 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 educator attitude toward technology increases the likelihood of technology uptake by students, which further emphasizes the need for initiatives to make educators comfortable with technology.

Based on this research, we focus our efforts in this project on professional development of educators. While many models have been proposed to support educators in the use of technology, collaboration among educators (in both online and offline interactions) has proven to be particularly effective (Dexter, Anderson, & Ronnkvist, 2002; Dexter, Seashore, & Anderson, 2002; Fuller, 2000; Schlager & Fusco, 2003). Thus, our strategy revolves around new opportunities for educators to collaborate and share ideas in the use of technology to support STEM learning.

4. Project Description

Our strategy involves three strands:

- creating and cultivating an online community of educators called Scratch-Ed
- developing resources that support the high-level learning skills promoted by Scratch and that make connections to STEM areas
- organizing face-to-face professional development gatherings, both in the form of smaller workshops and larger conferences

4.1 Cultivating online community

There has been great interest in Scratch since its public launch in May 2007. Educators recognize the enormous potential of Scratch, but there is a disconnect between what educators want to do (in both formal and informal settings) and the tools and support materials that are presently available to them. Part of the challenge is that the main Scratch website is designed for people (primarily youth ages 8-16) who create Scratch projects, not for those who are *supporting* people who create Scratch projects.

In response, we are designing a separate online site dedicated to the practices of educators. Called Scratch-Ed, this site is composed of four main areas of potential engagement: accessing and exchanging resources, sharing stories, facilitating discussions, and establishing connections with other members.

- *Resources*. All communities need tools, materials, and practices to achieve their goals. Scratch-Ed members will be able to share and access many kinds of resources – for example, posters advertising STEM careers, Scratch unit plans for an ICT classroom, and mathematics-focused Scratch projects. The resources will be 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. Members can provide feedback on resources through comments and ratings.

Our team will seed the site with initial resources, then support and guide educators as they share their own.

- *Stories*. The site will provide scaffolding to support educators in documenting their Scratch experiences and stories. Documenting the stories of a community serves multiple purposes. First, it strengthens connections among individuals in the community, as they get to know one another through their stories. Second, the stories serve as a history of the community, allowing members to learn from and build upon one another's experiences. Members can share stories through text, audio, video, and Scratch projects – and then receive feedback from others through comments.
- *Discussions*. The discussions area provides a space where all members can seek advice or guidance from 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 the virtual and physical world. This area offers mapping features that enable members to locate other Scratch educators who are nearby geographically, facilitating collaboration and local events.

The design of Scratch-Ed was motivated and informed by requests from educators in the Scratch community, as well as analysis of other sites designed for educators, including initiatives such as NSF-funded KNOW (Knowledge Networks on the Web). We presented preliminary ideas for Scratch-Ed to educators at the 2008 Scratch@MIT conference in a design charrette session, and received feedback that resulted in design refinements. Despite minimal promotion of the site, more than 200 educators – from both formal (K-12) and informal (museum, library, community center, homeschooling) learning environments – have already volunteered to be beta testers of the site once it has been developed. Given that more than 600,000 people downloaded Scratch software, and more than 200,000 people registered on the Scratch website, in the first 18 months after its public launch, we expect that tens of thousands of educators will participate on Scratch-Ed in a similar time frame, impacting hundreds of thousands of students.

In summary, we propose to:

- develop an initial implementation of the Scratch-Ed website, based on the four main areas described above
- recruit and invite Scratch-using STEM educators to participate in the community
- scaffold educators to support sharing of stories and resources on the site
- iteratively refine the website and online community, based on feedback and suggestions from the community

4.2 Developing resources

The development of online infrastructure is not enough. We also need compelling, practice-useful content. Much as the design and implementation of Scratch-Ed will be a participatory process in collaboration with the community of educators, we plan to work closely with Scratch-Ed community members on the development of resources, so that resources on the site are context-appropriate and field-tested.

Most of the resources will take the form of *annotated activity guides* – that is, descriptions of specific Scratch projects or activities, with supplementary comments to highlight important educational ideas and concepts. We envision three main types of annotations in these guides:

- *High-level learning skills annotations*. Some activity guides will highlight the high-level learning skills associated with a project or activity. For example, one annotation might point out the problem-solving strategy of decomposing a problem into simpler sub-problems. Another annotation might describe how a learner persisted and explored alternative paths when feeling stuck in the course of a Scratch project. Another annotation might discuss the collaborative strategies used by a group of students who worked on a Scratch project together.

- *STEM-content annotations*. Some Scratch projects are based specifically on STEM-related themes. For example, the Scratch website currently features projects on the topics of global warming, cell division, ballistic trajectories, and mercury poisoning, among others. These projects could be annotated with deeper discussions of the scientific concepts and connections to curriculum standards. We expect that most of these annotated projects will come from educators in the Scratch community, who bring a wealth of expertise on how to connect STEM concepts to educational activities and practices.

- *Scratch-programming annotations*. There are many STEM concepts inherent in the activity of Scratch programming itself. In the process of programming Scratch projects, students naturally make use of variables, random numbers, logic operations, and other mathematical concepts. Some annotations will highlight these concepts, showing how math, computer-science, and engineering concepts can be learned in the process of creating interactive animations, games, and other Scratch projects.

In summary, we will:

- develop documents that describe the high-level learning skills supported by Scratch
- develop a collection of sample activity guides with annotations, focusing especially on high-level learning skills
- develop templates for annotating Scratch activity guides
- support educators in the development and annotation of activity guides, drawing on their STEM expertise
- partner with participating educators to test, refine, and iterate the annotated guides

4.3 Organizing face-to-face gatherings

While the nation's cyberinfrastructure has radically altered the ways we communicate and fostered new forms of connections and community, we believe that face-to-face interactions remain essential to ensure the accessibility and sustainability of endeavors such as Scratch. In-person 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, as part of our strategy, we will organize two types of in-person gatherings:

- *Workshops*. We will organize a series of annual workshops that involve key participants on Scratch-Ed, so that we can collectively explore the connections between Scratch, high-level learning skills, and STEM-specific content. Inspired by lesson-study tradition and design-charrette practices, the workshops will bring together educators from a wide variety of contexts and STEM backgrounds to participate in refining Scratch-Ed. Workshop participants will collaborate on development of resources, explore connections to high-level learning skills, and share practice-related experiences, so that our work remains continuously grounded in the lived experiences of educators. The exact format of the two-day workshops will vary from year to year, in response to the development process and participant needs.

- *Conferences*. While workshops will enable key participants on Scratch-Ed to have in-depth interactions around practices and resources, we also plan to organize a yearly conference that reaches a broader audience. 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 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 annual Scratch conference will offer opportunities to present resources developed through Scratch-Ed participation, and share STEM-classroom experiences.

In summary, we propose to:

- organize yearly workshops that include key participants in the Scratch-Ed online community
- use workshops as an opportunity for concept exploration, resource development, and community building
- organize yearly conferences that reach a broad range of Scratch-using educators
- use conferences as an opportunity for presentation of resources, discussion of core learning concepts, interdisciplinary interactions, and community building

5. Participation Scenarios

We anticipate that our project will attract and support a wide range of STEM-focused educators. We expect that the participation of these educators will vary along several dimensions – *extent of involvement* (those who participate more centrally or more peripherally), *mode of interaction* (those who participate more online or more offline), and *situation of practice* (those who participate in more formal or more informal settings). Here, we present three short scenarios that describe the ways in which educators may participate in our project:

- A 7th grade technology-studies teacher reads about Scratch in a news article, and isn't sure how to get started. She visits the Scratch website and learns about Scratch-Ed. After reading about the high-level learning skills associated with Scratch and exploring several sample projects with STEM connections, she decides to start an after-school Scratch programming club. In organizing sessions for the club, she tries out different activities that she found on Scratch-Ed. At the end of the year, she attends the annual Scratch conference. There she meets other STEM-focused educators and they talk about approaches for integrating Scratch into their classroom practices. To connect with curriculum standards, she designs a unit plan that uses Scratch to model behavior in a robotics unit, highlighting the computational ideas (such as iteration and conditionals) involved in the activity. On Scratch-Ed, she shares her unit plan and posts a story about her experience.

- A science-museum educator has been involved with Scratch since it first launched, and has been looking for ways to share his experiences. He joins Scratch-Ed and quickly becomes a key member of the community, providing feedback on materials being developed by MIT researchers. He is happy to join the small group of educators who have been invited to participate in a Scratch-Ed workshop at MIT. At the workshop, he refines his own STEM-specific resources for Scratch, integrating ideas from other workshop participants.

- A 5th grade mathematics teacher learns about Scratch and Scratch-Ed at a national mathematics education conference. On Scratch-Ed, she finds mathematics-specific resources contributed by community members, and wonders how they could be better connected to the high-level learning skills she heard about at the math education conference. She writes a teacher guide describing these connections and shares it on Scratch-Ed. She organizes a professional development workshop around Scratch for other educators in her district (as well as other nearby educators invited through Scratch-Ed). At the annual Scratch conference, she makes a presentation in which she shares her approach to professional development for math educators.

6. Timeline

Year One
• develop an initial implementation of the Scratch-Ed online community • invite Scratch-using STEM educators to participate in the community • develop documents that describe the high-level learning skills supported by Scratch • develop a collection of sample activity guides with annotations, focusing especially on high-level learning skills • organize initial workshop, focused on MIT-developed resources • encourage educators to post their STEM-specific stories and resources • organize Scratch conference, with special focus on highlighting the possible modes of participation on Scratch-Ed

Year Two
• develop templates for annotating Scratch activity guides • support educators in the development and annotation of activity guides • second workshop – focusing on community-created resources • encourage feedback about resources from educators in the Scratch-Ed community • Scratch conference – sharing collaboratively-developed STEM resources with the broader Scratch educator community and soliciting feedback through hands-on sessions with the resources
Year Three
• partner with participating educators to test, refine, and iterate the annotated guides • final workshop – organizing collections of resources, documenting key participants' experiences throughout the three-year process, planning future directions • re-launch Scratch-Ed site based on feedback from community • Scratch conference – presenting the site re-launch, reflecting on key participants' experiences, discussing future directions

7. Anticipated Results

- Establishment of a new online community of educators, with tens of thousands of educators expected to participate over the course of this grant
- Development of a collection of annotated resources to support the use of Scratch in STEM-related activities
- Organization of annual conferences and workshops to bring together educators engaged in the use of Scratch to support STEM learning
- Documentation of new strategies to cultivate high-level learning skills through design-based activities, providing insights into how to prepare today's students for participation in the STEM workforce

8. Evaluation Plan

We are pleased to be working with the Education Development Center's Center for Children and Technology (EDC/CCT) to conduct the evaluation of our project. EDC/CCT brings a wealth of expertise in rigorous program evaluation, and they are well-acquainted with ITEST initiatives, having developed the ITEST Learning Resource Center. 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 do both formative and summative evaluation reports.

Our evaluation is guided by several key questions about the strategy's activities: questions related to the cultivation of *online community*, questions related to the development of *resources*, and questions related to the organization of *in-person gatherings*. Our 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.

8.1 Online community

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

  Using quantitative measures, we will conduct an ongoing analysis over the three-year period of site usage to determine how features are being used (or not) by community members. By collecting data about how the site is being used, we will be able to identify 10 community members to participate in the Scratch-Ed workshops. In addition to these quantitative measures, we will conduct content analysis of contributed stories, discussions, and comments to develop common themes to STEM educators, as evidenced by their contributions.

- *What are STEM educators' experiences of participating in the Scratch-Ed online community?*

  Twice-yearly, we will conduct surveys with the entire Scratch-Ed community to get 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 9 community members, whose participation varies along the dimensions of involvement, interaction, and situatedness (as described earlier). Experiences with Scratch-Ed will also be explored through group interviews with the Scratch-Ed workshop participants. The survey data, individual in-depth interviews, and group interviews will be coded and analyzed to provide understandings of how educators experience the site, and the ways in which the site could be improved, either from social or technical perspectives.

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

  We will document the development process of Scratch-Ed by adopting ethnographic techniques of (self-)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.

8.2 Resources

- *How can high-level learning skills, STEM content, and STEM processes be communicated through the annotation of Scratch activity guides?*

  Using a journaling approach to data collection, we will document the process of developing annotated Scratch activity guides. The analysis of the process will involve identifying general principles for developing this type of guide, and will be accompanied by a collection of the activity guides as evidence artifacts.

- *How are STEM educators accessing these resources?*

  Using quantitative measures, we will conduct an ongoing analysis over the three-year period of site usage 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 STEM educators' experiences of contributing to and using 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 educators' experiences with the resources. Twice-yearly, we will conduct surveys with the entire Scratch-Ed community to get feedback on the resources. We will also conduct one-on-one and group interviews with Scratch-Ed workshop participants. The survey data, individual in-depth interviews, and group interviews will be coded and analyzed to provide understandings of how educators contribute to and use the resources.

8.3 In-person gatherings

- *What are STEM educators' experiences of participating in the Scratch-Ed workshops?*

  For the duration of the project, we will conduct one-on-one interviews with the 10 key participants from Scratch-Ed following each workshop. The interview data will be coded and analyzed to identify themes focused on experiences of participation. We will use an ethnographic approach of participant observation to document the sessions, and use the themes from the interviews to organize narratives about the events.

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

  Following each conference, we will conduct surveys of all self-identifying STEM educators 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.

- *How do in-person gatherings impact participation in the Scratch-Ed online community?*

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

9. Dissemination Plan

Our research team has a strong track record for getting our ideas, activities, technologies, and strategies disseminated nationally and internationally. Millions of young people are currently using technologies based on our research (including Scratch and LEGO MindStorms robotics kits). We have also developed educational programs with a broad impact: the Computer Clubhouse network of after-school learning centers, founded by two members of our team, has expanded to more than 100 sites in 20 countries, reaching more than 20,000 young people in low-income communities (Resnick, Rusk, & Cooke, 1998).

The Scratch-Ed project has two dissemination components:

Attracting educators to participate in the Scratch-Ed online community

As described earlier, we have already started to talk with educators about Scratch-Ed through discussion forums on the Scratch website and presentations at education conferences, and hundreds have expressed interest in participating. When we publicly launch Scratch-Ed, we will spread the word through mailing lists, blogs, and conferences reaching STEM-focused educators. The Scratch project has already received considerable press coverage; we expect that future press coverage will report on Scratch-Ed and increase traffic to the site.

Sharing our research results with educators, researchers, and policy-makers

We will share our strategies and results through multiple channels:

- *Papers and publications*. Our team regularly publishes in educational magazines and research journals, reaching a broad and diverse audience. For example, Resnick's article on "Sowing the Seeds for a More Creative Society" was prominently featured in *Learning and Leading with Technology* (Resnick, 2007a), and his 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, we organize workshops each year for the Building Learning Communities educator conference.
- *Professional conferences*. Members of our team are frequently featured as keynote presenters at major educational conferences. In the past year, for example, Resnick has been invited to make major presentations at the National Educational Computing Conference, BETT, the International Conference on Teaching and Learning with Technology, and the Australian Computers in Education Conference, among others.

10. 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 Microsoft, Intel, Nokia, Portugal Telecom, and Intel Foundation – all of whom are supporting Scratch since they see it as an effective vehicle for stimulating youth interest in science and technology.

We expect a similar path towards sustainability for the Scratch-Ed website and online community. If we are able to develop the Scratch-Ed website and attract a core community of STEM-focused educators through this proposed NSF project, we are confident that corporations and private foundations will be interested to be associated with the continuation of Scratch-Ed.