Coding for All: Interest-Driven Trajectories to Computational Fluency

1. VISION AND GOALS

With strong support from the National Science Foundation, the Scratch programming language has emerged as the most popular way for young people around the world to learn to code. The National Science Foundation has supported the initial development of Scratch (ITR-0325828), the study of collaboration in the Scratch online community (OCI-1027848), the design of resources to support educators working with Scratch (DRL-1019396), the development of a cloud-based version of Scratch (IIS-1002713), and the development of a version of Scratch for children ages 5-7 (DRL-1118682).

Young people are using Scratch to program their own interactive stories, games, animations, and simulations – and participating in the Scratch online community to experiment with, comment on, and remix one another's projects. In the process, members of the Scratch community develop as computational thinkers and creators: they learn core computational and mathematical concepts, while also learning important strategies for designing, problem solving, and collaborating. Scratch is available free of charge and has been translated into more than 50 languages. More than 3 million projects have been shared on the Scratch website, with 4000 new projects added every day (roughly three new projects every minute).

One reason for the success of Scratch is its ability to support many different types of projects – and thus connect with the widely varying interests of young people. The Scratch website includes a diverse collection of projects, including virtual tours, interactive newsletters, math tutorials, adventure games, public service announcements, paint programs, and much more. Scratch has demonstrated the value of interest-driven trajectories into computer programming and computational fluency, attracting a more diverse range of young people than traditional computer-programming languages and courses.

In the proposed initiative, we build on the success of this interest-driven approach, aiming to expand the reach of Scratch in groups that have been traditionally underrepresented in computing. We see an opportunity to engage young people who have, in the past, felt alienated by or disinterested in traditional pathways into computational fluency. To reach them, we will integrate Scratch across a broader range of youth interests – designing ways for a more diverse range of young people to get engaged in Scratch by building on their existing interests and social identities. We will also integrate Scratch into libraries and other informal-learning settings that reach low-income and non-Asian minority youth.

This project integrates the work of three research groups uniquely qualified for this undertaking:

- The Lifelong Kindergarten Group at the MIT Media Lab, which has led the development of the Scratch programming language and online community (and will lead design and development efforts in this new initiative)
- The Digital Media and Learning Hub at University of California Irvine, which is recognized as an international leader in the study of interest-driven, social, and online learning (and will lead the research studies in this new initiative)
- The Berkman Center for Internet and Society at Harvard University, which has been a pioneer in the study of legal and policy implications of youth engagement in online activities (and will lead on the legal and policy-related aspects in this new initiative)

This interdisciplinary collaboration is ideally positioned to address resilient challenges in expanding pathways to computational fluency and STEM interests and careers. Issues of equity must be addressed through the multiple approaches represented by this team: the design of online tools and environments, social and cultural factors, as well as legal and policy dimensions. The project PIs and research organizations have all had longstanding commitments to path-breaking work in making the digital and online world more accessible, equitable, and responsive to the learning needs of youth and educational practitioners. The organizations and PIs also bring to this project a broad network of partners and dissemination vehicles that will extend the reach and impact of the deployment, including the robust community surrounding Scratch, online sites with large audiences, library and museum partners, community technology centers, and networks of both formal and informal educational practitioners.

1.1 The National Need

This research, integration, and deployment agenda speaks to important national priorities in workforce development, equity, and the need for a scientifically and technologically fluent public. With the growth of the high-tech economy and the influx of computational technologies in all sectors of society, the past decade has seen a growing recognition of the importance of computational fluency (Resnick 2013). With demand for technology-savvy workers on the rise, industry leaders are raising concerns about a growing talent gap in high-tech jobs, and advocating that "every student in every school should have the opportunity to learn to code" (http://code.org). These efforts dovetail with longstanding efforts of educators and policy makers to support a pipeline of STEM education that can prepare young people to be full participants in a high-tech society and pursue interests and careers in science and engineering. These efforts have raised awareness and increased opportunities for developing computational fluency (Computer Science Teachers Association 2005; Goode 2007).

In the same period of time, however, we have seen *declining* proportions of women and non-Asian minorities entering the high-tech workforce and continued under-representation in computer science classes and majors (Gal-Ezer & Stephenson 2009; Griffin & High 2011; Margolis et al. 2008; NCWIT 2012; Swift 2010). Burgeoning opportunities in computer science are being taken up by an increasingly homogeneous and disproportionately privileged population. This trend is in large part framed by issues of social networks and cultural identity that make underrepresented groups feel that they don't have shared interests or don't belong in the high-tech world (Ito 2013).

In addition to raising questions of equity and fairness, the lack of inclusiveness and diversity in the computing world contributes to a talent gap and hurts technological innovation. Many have argued that more diversity in a workplace fuels innovation, by bringing divergent perspectives to the table (Forbes Insight 2011; Griffin & High 2011; Lakhani & Panetta 2007). Only by diversifying the demographics of the computing world can we begin to address these problems. Open educational resources, tools, and communities like Scratch provide a wealth of opportunity for learning to code, but these spaces need to be more welcoming and relevant to more kids who don't identify with geek culture.

This initiative addresses these issues by deploying cyberlearning for computational fluency in ways that target groups underrepresented in the computational world. More specifically, it creates diversified pathways to the Scratch programming environment by integrating the interest areas and cultural referents of non-dominant youth. When we use the term "non-dominant" instead of the more common descriptors of race or minority status, we reference youth who are disconnected from power and opportunity by reasons of race, ethnicity, immigration status, and socioeconomic status (Gutierrez et al. 2009). The initiative disseminates Scratch coding activities in informal learning environments that serve the technology and educational needs of low-income youth, focusing particularly on public libraries. Through this approach to integration and deployment, the project will address this national need for a diversified high-tech workforce and a computationally fluent public, as well as providing robust research that can inform the design and deployment of related efforts in STEM education.

1.2 Background

1.2.1 Computational Fluency

Over the past few years, there has been a growing recognition among educators, researchers, and policy-makers that ideas from the field of computer science can be useful in understanding and solving problems in a wide range of disciplines and contexts. Jeannette Wing (2006) coined the term *computational thinking* and explained that "it represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use" (p. 33). A steady stream of workshops and research reports have examined how computational thinking could be integrated into educational practice (e.g., Grover & Pea 2013; Guzdial 2008; National Research Council 2010, 2011).

For this proposal, we use the term *computational fluency* rather than computational thinking, since we want to highlight the importance of young people developing as computational creators as well as computational thinkers. In our view, computational fluency involves not only an understanding of

computational concepts and problem-solving strategies, but also the ability to create and express oneself with digital technologies. We frame computational fluency along three dimensions (Brennan & Resnick 2012): concepts (e.g., conditionals and parallelism), practices (e.g., debugging and remixing), and perspectives (e.g., seeing oneself as a creator and collaborator).

In developing Scratch (http://scratch.mit.edu), we have aimed to engage young people with diverse interests and backgrounds on pathways towards computational fluency. We take a constructionist, design-based approach to the development of computational fluency (Kolodner et al. 2003; Papert 1980), providing young people with opportunities to create projects related to their interests. We have found that design-based activities offer a particularly effective way for youth with diverse interests to become engaged in exploring computational ideas (Resnick 2006; Rusk et al. 2008; Rusk, Resnick, & Cooke 2009). 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. Scratch also emphasizes the social side of learning: we launched a collaborative online community at the same time we introduced the programming language (Brennan, Resnick, & Monroy-Hernandez 2010).

Research studies have documented how Scratch can support the development of computational fluency, with special focus on members of groups underrepresented in the computational world. For example, Maloney and colleagues (2008) analyzed 536 Scratch projects created by low-income youth, ages 8-18, at an after-school center and found evidence of the learning of key programming concepts over an 18-month period. Ericson and McKlin (2012) found significant increase in pre-post test scores for recognizing and understanding computational concepts in Scratch in an 8-week computer summer camp for youth, primarily from underrepresented minority groups. Peppler and Warschauer (2012) present a case study of a nine-year-old girl with cognitive disabilities who experienced a transformation, in both her skills and identity, as a result of learning to create interactive multimedia projects in Scratch within an informal after-school environment serving low-income youth.

Although we designed Scratch especially for ages 8 to 16, it has also been adopted in university computer-science curricula as a way to engage students with no prior programming experience. For example, Rizvi and colleagues (2012) found that use of Scratch in a pre-introductory computer science course (CS0) resulted in significantly higher retention rates for students initially identified as at-risk for dropping out of computer science, as well as higher performance in the subsequent computer science courses (CS1 and CS2) than other students. Similarly, Malan and colleagues (Malan 2008; Malan & Leitner 2007) found that introducing Scratch as the first unit in an introductory computer science course increased retention rates and particularly helped students who did not have previous experience or confidence with programming.

In short, the Scratch programming language and community have been designed in order to lower barriers in acquiring robust computational fluency, and a growing body of research documents successes in building pathways for children and youth otherwise underrepresented in the computational world.

1.2.2 Interest-Driven Learning Pathways

The research and design approach of Scratch can be situated within a body of research documenting the importance of interest-driven, informal, and culturally relevant teaching in STEM-related learning (Dabney et al. 2011; Gay 2010; Goldman 2006; Maltese & Tai 2010; National Research Council 2009; Palmquist & Crowley 2007; Steinkuehler & Chmiel 2006). Whether it is cooking or tinkering at home or engaging in a robotics club, informal learning in everyday life experiences is central to sparking and sustaining scientific interests and learning (Fender & Crowley 2007; Goldman 2006; Goldman et al. 2010; Leinhardt, Crowley, & Knutson 2002; Melchior et al. 2005; Michalchik et al. 2007; Michalchik et al. 2008). Attending to interest in out-of-school settings is arguably even more critical for computational fluency, which is often fostered through informal peer interaction and online exploration, and generally has few supports within formal education (Ito et al., 2010).

In a related vein, sociocultural learning research describes how learning grows out of the social relations and identities that young people are immersed in as part of family, peer, and community life

(Greenfield 2004; Lave 1988; Rogoff 2003; Scribner & Cole, 1973). The knowledge and skills they acquire in these settings have a highly positive value because they are linked to meaningful practices, valued relationships, and shared interests. "Interest-driven learning" refers to learning embedded in these shared interests, relationships, and practices rather than a purely individual passion. Jim Gee (2004) has described how informal learning and literacy develops in affinity spaces of shared interests. Online communities like those that surround Scratch can help young people connect with others who share their interests and provide productive peer mentorship and expertise. Ito's studies describes how online technologies lower barriers to social connection, information access, sharing, and feedback in ways that that can fuel self-directed, social, and interest-driven learning (Ito et al. 2008, 2010, 2013; Ito, Okabe, & Tsuji 2012). In contrast to more adult-driven and formal learning environments, these peer-based settings can foster greater engagement as well as deep expertise because they center on learner choice, problem solving, and specialization.

Research on interest-driven and informal learning sees the affinity spaces as important sites of engagement and learning, but also recognizes that they can be disconnected from the learning that matters in school and future opportunity. Further, not all interests are equally valued or connected to pathways to educational and economic opportunity. Annette Lareau's (2003) ethnographic research suggests that the parenting styles of lower-income and middle-class families differ in their emphasis on organized out-of-school enrichment activities. More recent research has suggested a growing disparity in investments that poor and wealthy families make on enrichment expenditures (Duncan & Murnane 2011). These enrichment activities help connect interests fostered in home and unstructured settings to more academic and formal educational opportunities. For this reason, researchers have argued for the importance of out-of-school and interest-driven science and engineering programs that foster student interest and engagement among diverse youth (Dabney et al. 2011).

In summary, research has documented how STEM learning and expertise grows out of interests and out-of-school settings, but needs to be effectively connected to educational pathways, especially for less privileged youth. These findings have led us towards design interventions keyed specifically to connecting informal learning and interests of non-dominant youth to pathways to computational fluency.

1.2.3 Connected Learning: Building Pathways from Interest to Opportunity

A model for how to build connections between diverse interests and learning opportunity is the "connected learning" approach that has emerged from the Digital Media and Learning Initiative (http://www.connectedlearning.tv), supported by the MacArthur Foundation. Connected learning is realized "when a young person is able to pursue a personal interest or passion with the support of friends and caring adults, and is in turn able to link this learning and interest to academic achievement, career success, or civic engagement" (Ito et al. 2013). This approach to learning builds on the research on interest-driven and informal learning, developing a design model for how to create environments and programs, like we see with Scratch, that can effectively support learning pathways between interests and opportunity, particularly for non-dominant youth. It is about creating learning materials, programs, and environments that connect, hybridize, and sit between three often disconnected spheres of learning: peer culture, interests, and academic subjects.

Connecting in-school and out-of-school learning is a foundational educational goal, and yet transfer across settings has been a persistent challenge. A recent report by the National Academies concluded that "Over a century of research on transfer has yielded little evidence that teaching can develop general cognitive competencies that are transferable to any new discipline, problem or context, in or out of school" (National Research Council 2012). The connected learning model takes on this challenge by focusing on concrete and "consequential transitions," pathways, and connections between interests and opportunity and between different disciplines and interests (Beach 1999; Bransford & Schwartz 2001; Dyson 1999; Lave 2011; Pacheco 2012). This approach builds on educational research with non-dominant youth that leverages their linguistic and cultural repertoires across learning environments (Gonzalez, Moll, & Amanti 2005; Lee 2007; Moll et al 1992; Morell, 2007; Soep & Chávez, 2005; Vasquez, 2002). When learning

grows out of existing interests and identities, it helps young people build connections between otherwise unfamiliar disciplines and home cultures and practices (Aikenhead & Michell 2011; McIntyre, Rosebery & Gonzalez 2001; Orellana 2009; Pacheco 2012).

The online world offers a new set of affordances for building these connections, pathways, and transitions. New media provide ready access to information and communities of interest, and to tools for self-expression, publication, and mobilization that radically expand opportunities for learning and civic engagement. Young people are taking to the online world to connect their interests to a range of learning, civic, and economic opportunities that would not have otherwise been available to them (Cohen & Kahne 2012; Gee & Hayes 2010; Ito et al 2008; Jenkins et al. 2009; Palfrey & Gasser 2008; Thomas and Brown 2011). Ito's Digital Youth study described many young people taking advantage of learning online, but also found that it was only highly motivated or privileged kids growing up in progressive and technology-rich homes who are taking to the Internet for truly connected learning (Ito et al. 2008). Most young people lack the motivation for completely self-directed learning, and need supports from parents and educators in connecting their interests to opportunity (Ito et al. 2008; Junco 2013a, 2013b).

While educators, parents, and learning institutions have a critical role to play in leveraging new media in connecting interests to opportunity, this potential is largely unrealized. Ito's study found that unlike youth, adults generally see these same engagements as a distraction from learning rather than an enabler (Ito et al. 2008). Many parents and educators also have concerns about online safety and privacy, steering young people away from reaching out to others online (Levy et al. 2012; Livingstone et al. 2012; Madden et al. 2013), even when those relationships could constitute valuable forms of peer connection, coaching, and mentorship. COPPA regulations have created a confusing set of policies that inhibit online educational providers from connecting with children under the age of 13, further undermining their ability to engage in social and interest-driven learning online (boyd, Gasser, & Palfrey 2010).

As institutions dedicated to interest-driven learning and the technology needs of low-income families, libraries provide an ideal site for bridging some of these divides (Miller et al. 2013), and a growing number are reinventing themselves through new programs that engage youth in creative online activities, including Scratch (Myers 2008; Nelson & Braafladt 2011). Many libraries, however, are stymied in these efforts by policies against social and mobile media use (Ahn et al. 2011; Bosco 2013; YALSA 2011).

This project will deploy and integrate the online-learning resources of Scratch in ways that provide more pathways and connections for non-dominant youth by building on their authentic interests and enabling informal educators (at libraries and elsewhere) to guide them to these opportunities. This means highlighting pathways that grow out of existing youth interests, knowledge, and communities, as well as removing policy and legal barriers for informal educators.

1.3 Project Goals and Research Questions

Design goal: Identify design principles and develop technological infrastructure for supporting interest-driven trajectories into computational fluency.

Deployment goal: Provide more pathways from interest to computational fluency for populations of youth underrepresented in the computing world.

Research goal: Contribute to a deeper understanding of trajectories that youth follow from their interests into computational fluency through a focus on the following ***research questions***:

- What are the barriers that non-dominant youth face in connecting their interests and identities to computational activities and interests?
- How can online environments be designed to remove these barriers and increase pathways to computational fluency by building on young people's existing interests?
- In following interest-based trajectories, how do young people develop as computational thinkers, establish identities as computational creators, and nurture relationships that support these identities?

2. PROJECT PLAN

2.1 Design Plan

2.1.1 Introduction

We will develop a collection of activities and environments that provide *interest-based pathways* into coding and computational fluency – opening opportunities for young people to use their interests (for example, in music, art, sports, or games) as a starting point for getting engaged in creative computational activities. In designing these interest-based pathways, we will focus explicitly on connecting with young people who otherwise would be unlikely to become engaged in coding.

In the current Scratch community, there are already many young people who are creating projects based on their interests. For example, there are thousands of Scratch projects based on the game Minecraft and thousands of projects based on the popular Warrior Cats book series. But many young people aren't even aware that coding can provide opportunities for them to further develop, explore, and share their interests. And even if they are aware, they are not good resources or support mechanisms to help them connect coding with their interests. New tools, activities, and environments are needed to help young people understand how their interests might be extended and enriched by integrating coding, how to get started coding in the context of their interests, and how to connect with peers and mentors with similar interests who could help support the process.

To support these interest-based pathways into coding, we plan to develop a collection of interest-based microworlds and online gatherings, as described below.

2.1.2 Interest-Based Microworlds

Although Scratch is much easier to learn than traditional programming languages, it can still be intimidating to someone without any previous experience with coding. To ease the transition into coding, we plan to develop a series of interest-based microworlds – simplified programming environments that are customized to particular youth interest areas, such as sports and music. Each microworld will include a subset of the Scratch programming blocks that are most relevant and useful for the particular interest area, along with specialized graphical assets related to the interest area. Each microworld will provide a simpler and more contextualized entry point for getting started with coding.

For young people who are interested in sports, for example, we will produce a microworld that enables them to experiment with and modify the code for a soccer video game. The microworld will come with basic objects for a soccer game (players, ball, goal posts) and some sample Scratch scripts for controlling the movements and interactions of the objects. It will also include new programming blocks that use the computer's webcam, so that people can interact with the game with body movements similar to Microsoft's Kinect technology, but youth can program the technology, not just interact with it. (See Figure 1, based on an existing project by a teen in the Scratch online community.)

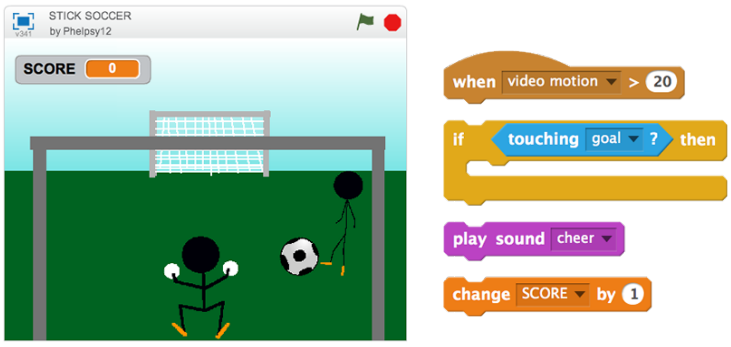

Figure 1: Soccer microworld screenshot, with sample programming blocks

In addition to aligning with a particular interest area, each microworld will highlight specific computational concepts and ideas, providing a starting point on the trajectory towards computational fluency. For example, the soccer microworld will introduce concepts of sensing (for detecting body movements) and variables (for keeping score). We will design each microworld to capture the interest of a particular sub-community of young people, quickly engage them in coding, and help them learn some basic concepts. After experience with the microworld, young people will be ready to transition to the main Scratch website, where they can see what other people have created and start working on more advanced projects of their own.

We plan to create about 20 microworlds, representing a range of youth interests. The collection will include microworlds that center on interests such as hip hop, cartoons, pro wrestling, spoken word, and dance, which go against stereotypes of what is typically associated with geek or coding culture. These microworlds will be highlighted on the Scratch website, and also embedded in library websites and youth-media sites, to reach youth who don't know about the Scratch website – or wouldn't think of going there.

2.1.3 Interest-Based Online Gatherings

Too often, coding is seen as an isolating activity, with a solitary coder sitting at a keyboard. Our work with Scratch has demonstrated that social interaction can play a very important role in engaging and supporting young people as they learn to code. On the Scratch website, community members experiment with, comment on, and remix one another projects. Many community members point to this social interaction as one of the main reason for their sustained participation creating and sharing projects on the website (Brennan et al. 2010). As we scale-up Scratch in this initiative, we will continue to emphasize the social dimension, making use of the existing social features on the Scratch website, but also adding several new features:

- *Interest-based portals*. For each interest area, we will create a separate portal on the Scratch website. The portal will include links to microworlds, sample projects, and discussion forums related to the interest area. Our goal is to support the development of a subcommunity around each interest area, so that young people can find not only projects and ideas related to their interests, but also other people who share their interests. This support for interest-based subcommunities is particularly important as the overall Scratch community continues to grow, to make it easier for people to meet one another and share ideas (like a gathering place within a larger city). We anticipate that many young people will have their first experience with Scratch through a microworld related to their interest, after which they will come to the interest-based portal on the Scratch website, to learn more and meet other people with shared interests.

- *Interest-based hangouts*. On the current Scratch website, we have prohibited real-time communication among community members (such as chat or instant messaging) because of privacy and safety concerns. But we believe that real-time communication (especially with video and audio) could play an important role in broadening participation in Scratch, since it will provide a more immediate and welcoming way to become engaged with the Scratch community, particularly for youth who have not had previous experience with computer programming.

We plan to organize a regularly-scheduled series of real-time hangouts (live video conversations with up to ten participants), each focused around common interests, with support from a mentor or facilitator. The hangouts will support youth in sharing projects, forming collaborations, and learning new techniques. Researchers from the Berkman Center will investigate privacy and safety issues around real-time communication among youth, and will develop guidelines and protocols for the hangouts based on current regulations and best practices. Ito's team at UCI has already been piloting interest-based hangouts in areas such as gaming and web development, and we will build on initial designs and findings from that work.

The interest-based hangouts will be based on Google Hangout technology but we will add new features to facilitate scheduling, archiving, and conducting of hangouts with youth. The hangouts will be organized in a variety of different formats, for example: a skill-share session in which an experienced mentor demonstrates advanced ways of using Scratch; a project showcase in which youth share their

projects with each other and give and receive feedback; a live debugging session that introduces youth to the practice of identifying problems in their code and fixing them.

- *Interest-based unconferences*. While hangouts are intended for relatively small groups of people (up to 10 or so), there are also benefits to larger online gatherings. Towards that end, we will organize a series of online unconferences to bring together larger numbers of people with shared interests.

The unconferences will serve as gatherings for interest-based subcommunities. Each unconference will start with a plenary session, to present ideas and plans to all participants. But the core of the unconference will consist of smaller breakout sessions, allowing more active participation by all members. Anyone can propose and facilitate a breakout session. Formats will be flexible and adaptive: while some breakout sessions will be scheduled ahead of time, others will be created on the fly during the course of the unconference. We will develop resources and technological supports to help with management and facilitation of sessions. As with the hangouts, Berkman researchers will investigate policies and best practices for dealing with privacy and safety issues in the unconferences.

2.1.4 Iterative Design Process

We will use a design-based research approach to develop and refine the design of the interest-based pathways into Scratch. This process is characterized by iterative cycles of "design, enactment, analysis, and redesign" (Design-Based Research Collective 2003, p. 5; see also Kaplan et al. 2012). The MIT Media Lab researchers, in collaboration with other colleagues, have applied design-based research methods to design and refine the Scratch programming language and Scratch website (Maloney et al. 2010), to identify design principles (Resnick & Rosenbaum 2013), and refine constructionist learning theory (Burke & Kafai, 2012; Resnick 2012).

For the current project, we plan to engage in iterative phases of design, deployment, analysis, and revision of the microworlds and interest-based portals on the Scratch site. This iterative process will be informed by observations and feedback from youth participating at the partner library sites, as well as analysis of log files and participation patterns of youth participating online. The structure, content, and functionality of the interest-based hangouts and unconferences will also be analyzed and refined based on feedback from librarians and youth participating in these gatherings and observation of their use within the library partner sites.

2.2 Deployment Plan

2.2.1 Library-based programs

The library-based programs will initially be deployed in three libraries in Chicago, Los Angeles, and the Boston area. Letters of commitment from Chicago Public Library and Los Angeles Public Library are included in this proposal, and we will identify one additional partner in Boston or Cambridge. These library systems were selected because they are in urban areas with large populations of lower-income and non-Asian minority youth, and for their proximity to the design and research teams. In Chicago, Ito's team has an existing research presence due to her ongoing involvement in the research and design of the YOUMedia Learning Lab in the Harold Washington main library in downtown Chicago.

In partnership with library leadership, we will identify one or more librarians and libraries in each library system to be part of the design and deployment team and function as testbeds for the initial deployments. We expect to work specifically with teen librarians in libraries serving high numbers of lower income and non-Asian minority youth. In the first two years of the project, we will bring the partner librarians into our design meetings so their perspectives can inform our approach to design, policy, and deployment. They will facilitate their teen patrons' participation in the microworlds, hangouts, and unconferences. In addition, we will work with our library partners in developing programs for their libraries that center on bringing together the interests of their teen patrons and engagement with the Scratch programming environment. This could take the form of add-ons to existing programs like book-reading campaigns, gaming tournaments, and makerspace activities, or standalone programs specifically

devoted to programming in Scratch. We expect that the librarians and participants in these focal deployments will become core evangelists and spokespeople in bringing other librarians and youth into the programs as we move into large-scale dissemination.

Researchers from UCI and MIT will be present in these library testbeds, will observe the uptake of the deployments, and recruit participants for the focal interviews and surveys as detailed in the research plan to follow. This ongoing research will enable iterative improvements to the design and deployments, as well as evaluation of learning outcomes and deployment effectiveness.

2.2.2 Dashboard for Librarians and Informal Educators

UCI will take the lead in the development of a website that will curate and feature resources deployed in this project, organized in a way that is easily accessible and usable for librarians and other informal educators. This site will function as a dashboard including easy points of access to the microworlds, hangouts, and unconferences, as well as a toolkit of resources developed by the Berkman team with guidelines, best practices, and FAQs regarding privacy, safety, and copyright issues tailored to informal educators. It will also highlight relevant policies, end-user licenses, and other legal vehicles that can facilitate the use of open and social resources in the sites hosted by libraries and other informal learning institutions.

The dashboard will initially serve primarily as a way of making this project's resources usable and accessible to librarians and informal educators. As we bring our library partners on board to the project, we expect that they will develop and curate their own resources, extending those that we have developed and deployed. The site initially will be developed and hosted at UCI, but before the end of the project, will be transitioned to sites maintained by our library partners. Letters of support from the Digital Public Library of America and the Young Adult Library Services Association of the American Library Association are included in this proposal, indicating their commitment to sustaining and maintaining this online resource beyond the life of this grant.

2.2.3 Large-Scale Dissemination

The three partner groups (at MIT Media Lab, UCI, and Harvard) all have strong track records for broadly disseminating their ideas, activities, and technologies. For example, the Lifelong Kindergarten group at the MIT Media Lab has developed technologies (including Scratch and LEGO Mindstorms robotics kits) that are now used by millions of young people around the world. We expect that the new tools and activities developed in this project will experience similar success in widespread dissemination – but they will reach a higher proportion of groups generally underrepresented in computational fields, due to our targeted efforts in this project. To support large-scale dissemination, we will leverage a collection of networks and partnerships, in many cases building on already-existing relationships and collaborations:

- *Library networks*. We have received commitments from three important library networks to collaborate on various aspects on this project: (a) Young Adult Library Services Association (YALSA) has agreed to publicize the project among its 5000 members and host project resources on its website; (b) The Learning Lab network of digital media centers in libraries and museums, coordinated by the Urban Library Council, with support from the MacArthur Foundation and the Institute of Museum and Library Services, has agreed to support the introduction of our new tools and activities at its sites – including the 30 centers initially and more sites as the network expands; (c) the Digital Public Library of America, an aggregation of digital resources from libraries, museums, and archives around the country, has agreed to host resources from the project and to aid in dissemination and outreach.
- *Informal technology-learning networks*. Three networks focused on informal learning with new technologies have already agreed to integrate our new tools and activities into their programs: (a) the Computer Clubhouse network of 100+ after-school learning centers, co-founded by two of the project PIs (Rusk and Resnick) in collaboration with the Boston Museum of Science, with support from the

Intel Foundation, focusing exclusively on youth from low-income communities; (b) Black Girls Code, which organizes programming workshops for girls of color across the country; (c) the Hive Learning Networks in Chicago, New York, and Pittsburgh, which link together multiple sites within a city to support anytime-anywhere connected learning (funded by the MacArthur Foundation). As the project moves forward, we will add other similar networks.

- *Educator networks*. Over the past several years, the PIs on this project have helped launch several major educator networks, and they will use these networks to disseminate ideas and resources from the project. These networks include: (a) the Connected Learning community at connectedlearning.tv, organized by the Digital Media and Learning Hub at UC Irvine, which supports weekly webinars and other events for educators; (b) Learning Creative Learning, an online course (MOOC) developed at the MIT Media Lab (http://learn.media.mit.edu), which has attracted thousands of educators; (c) the ScratchEd online community, with more than 8000 educators who support young people learning with Scratch. In addition, the PIs regularly participate in major educator conferences, and they will disseminate resources and results of this project at those venues. Our goal is to help both formal and informal educators engage youth in computational fluency across settings.
- *Online media partnerships*. We plan to collaborate with major media companies to integrate microworlds-related coding activities on their websites, as a way of reaching larger numbers of children, parents, and educators. We have already received letters of support expressing interest in collaboration from two major media organizations, each of which reaches millions of people through their websites: PBS Kids (the children's website associated with the Public Broadcasting Service) and the Mozilla Foundation (which hosts and promotes "webmaking" activities on its website).

We expect that these dissemination efforts, taken together, will significantly increase the number of young people engaged in coding with Scratch – and the number of institutions and educators supporting coding with Scratch. The networks of libraries, museums, Computer Clubhouses, and digital media programs that have offered direct support for this project number well over a thousand, and networks such as YALSA, Scratch Educators, DPLA, and the Hive Learning Networks represent educational practitioners in the tens of thousands. We expect that that a significant proportion of these organizations and practitioners will adopt the new tools, resources, and activities described in this proposal, reaching hundreds of thousands of youth. By integrating microworlds into the websites of partner media organizations, we expect many more young people to become engaged with coding – at least hundreds of thousands (and potentially millions).

Through our dissemination efforts, we expect a substantial boost in new enrollments to the Scratch online community. The community is currently growing at roughly 1 million new members per year. We expect our dissemination efforts could lead to a 25% increase in the new membership rate, which would translate to 250,000 additional new members each year. Because of the targeted nature of our dissemination efforts, we expect that a significant proportion of these additional members (at least 50%) will come from groups underrepresented in the computing world.

2.3 Research Plan

The research for this project will involve a mixed-methods approach that includes ethnographic study, survey research, data mining and learning analytics, and legal and policy research.

2.3.1 Ethnographic Study

Ethnographic research will be conducted prior to the deployment to establish a baseline case study, and continue through the deployment to provide formative and summative evaluation of deployment effectiveness.

In the first year of the project, in parallel with the development of the new interest-based pathways, the UCI team will conduct an ethnographic case study of interest-driven and connected learning in the

existing Scratch community. This case study will adopt the methods and protocols developed in Ito's Leveling Up study of the Connected Learning Research Network, a project currently in its third year, conducting case studies of a variety of online interest-driven groups (such as pro wrestling online fandom and fashion design programs) that support connections to academic, career, and civic outcomes.

The case study will provide a baseline of the existing social and cultural learning context of the Scratch community. The ethnographic material will be analyzed based on codes developed by the Leveling Up project of significant supports and barriers to interest-driven and connected learning. This will enable comparative analysis with the other online interest groups in the Leveling Up study for factors such as demographic features, and their instantiation of interest-driven pathways and supports. Building on an existing set of measures, analysis, and collaborative research infrastructure will ensure a quick and lean ramp-up for robust research. Data collection will include:

- 20-30 baseline interviews with participants in diverse roles in the existing community to understand the learning supports and outcomes of participation
- 2-5 interviews with community organizers and developers to understand the values and intended learning approach of the community

After becoming embedded in the community and developing the baseline ethnographic case in the first year, the ethnographer will participate for two years in the design-based research in order to provide formative and iterative feedback to the designers and program deployers. The ethnographer will follow a cohort of participants who were enrolled specifically through the proposed deployment, in order to track trajectories of learning and participation and seek feedback on the deployments. They will also continue to observe the online Scratch programs for more holistic measures of how the new interest areas and programs are being taken up by the community, and whether they are resulting in a greater diversity of interest areas and pathways being represented. Data collection will include:

- Ongoing online and offline observations of key community discussions and events that provide evidence of collective identity, goals, and purpose
- 30-50 interviews with participants enrolled through the proposed deployments in Year 2, with a follow-up interview with at least half of these participants in Year 3.
- 5-10 interviews with librarians and online facilitators of hangouts and unconferences to understand their orientation to and experience of the deployments

2.3.2 Surveys

A survey with a target enrollment of 400-600 will be fielded among new and existing participants in the Scratch community in order to capture a broader sample of participants in the deployment, and to compare with the existing community members. The survey will capture baseline demographic data, skills background in technology and programming, as well including items designed to evaluate whether participant experience aligns with the design model of the deployment. This survey will be fielded after the round of deployments in the second year.

The items intended to evaluate the effectiveness of the deployment will be adapted from the connected learning survey developed by Bill Penuel at the University of Colorado Boulder to measure the experience and outcomes of connected learning as a multidimensional construct defined by six core qualities: (1) powered by youth interest, (2) peer-supported, (3) academically oriented, (4) characterized by collaboration, (5) production-centered, and (6) designed around networks that link people and institutions. The survey team identified or developed items to elicit youth's experience of each of these qualities, with the intention of developing evidence related to the first claim above. With assistance from SRI colleagues, CU researchers conducted pilot tests and cognitive interviews with youth in the target population and iteratively refined the measures over a period of 8 months. These measures will indicate the effectiveness of this project's deployments in creating environments for interest-driven experiences, connected learning, and building pathways from interests to opportunity.

The current version of the survey was field-tested in spring 2013 with 497 youth aged 12-17 from 19 different program sites that provide opportunities for youth to pursue activities that reflect many of the features of the current model of connected learning. Preliminary scales indicate good reliabilities for measures of each of the six qualities of connected learning ($0.68 \leq \alpha \leq 0.84$). The outcome scales had similar reliability estimates ($0.72 \leq \alpha \leq 0.84$). At present, the CU team is fitting Rasch models to the survey data to test hypotheses regarding which survey items best indicate deeper forms of connected learning and examining validity evidence related to links between qualities of connected learning and the outcomes measured.

2.3.3 Data Mining and Learning Analytics

In order to understand the rates, patterns, and trajectories of participation and learning along the interest-based pathways, we will conduct quantitative analyses of data collected on the Scratch website. We will have an extraordinary large and rich collection of data at our disposal, since the new cloud-based version of Scratch (launched in May 2013) automatically stores detailed logs and project version history of each individual's process of creating, coding, sharing, and remixing computational artifacts.

In our data analysis, we will focus particularly on two target groups: (a) all participants entering the Scratch site from interest-based microworlds, and (b) the subsample of participants at library partner sites. For each of these groups, we will analyze data both from the interest-based microworlds (which will be hosted on the Scratch site and embedded in a variety of different sites) and from the main Scratch website (for participants who progress to the Scratch website after initial activity in a microworld).

To study participation and learning trajectories to computational fluency, we will analyze data along four dimensions:

- *Overall participation.* We will examine the levels and patterns of participation in order to understand and improve youth engagement in the tools and activities. Question include: How much time do youth spend on each microworld? How much time on the main Scratch website? How many and what types of projects do they create? In particular, we will analyze the number of projects in interest areas of non-dominant youth and the number of participants entering through public library programs as indicators as to whether the deployment is diversifying pathways to the Scratch community.
- *Code*. We will examine the code in youth projects for evidence of learning particular computational concepts (for example, use of multiple scripts with "green flag" trigger blocks can serve as an indicator of learning parallelism). We will examine the structure and complexity of participants' code using several different metrics (e.g., number of scripts, levels of nesting of code). We will examine how these metrics change over time to understand individual trajectories of learning.
- *Media*. We will examine how participants use images and sounds in their projects, and whether they create or import these media objects. The types and diversity of media will be analyzed to help identify different pathways to engagement.
- *Social*. We will examine how participants use different social components of the Scratch website, including: commenting on other people's projects, following other people, joining collaborative studios, participating in discussion forums, remixing other people's projects. This analysis will serve as evidence for certain aspects of computational fluency (e.g., remixing), while also providing insight into pathways to engagement.

In order to understand how these dimensions support the development of computational fluency over time, we will also do analyses across dimensions, examining (for example) how social trajectories interact with coding trajectories on the Scratch website, and how engagement in media creation relates to coding concepts. We will examine this data in the aggregate (e.g., comparing participants coming to the website from libraries versus those coming from other venues) and also for selected individuals (to get a better understanding of specific learning trajectories).

2.3.4 Cyberlaw and Youth Research

The Harvard team will conduct ongoing policy and legal research, examining existing barriers, precedents, and practices to inform the design and deployment for this project as well as to inform the field of cyberlaw in the area of online privacy for young people. The research for this project will build on the existing body of research in the Berkman Youth and New Media project, led by John Palfrey and Urs Gasser, which encompasses an array of research, advocacy, and development initiatives around youth and technology. This research will tie into concrete legal vehicles, policies, and toolkits for this project, as well as white papers and other public-facing publications designed to inform informal educators as well as the broader public about legal and policy issues in young people's online learning and participation.

3. TIMELINE

Year 1: Initial Ethnographic Case Study; Design and Pilot of Interest-Based Pathways ***February 2014 - January 2015***
- Ethnographic study of Scratch online community members, including interviews, observations, surveys - Design and pilot initial set of microworlds, hangouts, and unconferences - Onsite research and co-design with youth and librarians at L.A., Chicago, and Boston area libraries - Background research on safety and privacy issues and best practices
Year 2: Revision and Deployment of Interest-Based Pathways ***February 2015 - January 2016***
- Revise and design additional microworlds and interest-based gatherings based on Year 1 studies - Deploy in larger library networks and other informal learning networks - Interviews and baseline surveys with 30-50 focal participants in deployments - Initial analysis of log files and projects for youth from interest-based pathways and partner libraries - Dashboard development
Year 3: Broader Dissemination, Learning Analysis, Deployment Effectiveness Survey ***February 2016 - January 2017***
- Dissemination of tools and activities through dashboard, learning networks, and partner media sites - In-depth analysis of log files and projects for youth from target groups - Follow-up interviews and surveys with focal participants in deployments - Deployment effectiveness survey with 400-600 new and existing youth - Design, formative research, and iteration on dashboard for librarians - Refine design principles for interest-based pathways - Initial dissemination of research results through publications and conference presentations
Year 4: Summative Analysis, Publication, and Wide-Scale Promotion ***February 2017 - January 2018***
- Widespread publication of findings in journals, websites, blogs, and social media - Presentations of findings at educational, learning, and computing conferences - Wide-scale promotion of interest-based pathways

4. EXPECTED OUTCOMES

4.1 Broader Impacts

This project responds to the Cyberlearning challenge to "draw in and promote learning among those in populations not served well by current educational practices," and addresses important national priorities in workforce development, equity, and the need for a technologically fluent public. The project's tools and activities will provide alternative pathways into coding, increasing opportunities for young people in non-

dominant communities to develop computational fluency. The project will also build capacity among informal educators by providing them with educational resources and policy frameworks for leveraging the power of online networks and communities. The focus on public libraries supports public educational institutions most geared towards serving the technology needs and diverse interests of non-dominant communities in taking advantage of new online learning opportunities. The three project partners all have strong track records for broadly disseminating their ideas and technologies, and they expect the proposed project to reach tens of thousands of informal-learning organizations and engage at least hundreds of thousands of youth (and potentially millions).

4.2 Intellectual Merit

This project will advance the current state of research in the learning sciences, technology design, and policy research through interdisciplinary analysis of a rich mixed-methods corpus of data. In the area of learning research, this project will contribute to a deeper understanding of the supports, pathways, and outcomes related to computational fluency, and will develop a new set of frameworks for understanding how these processes operate for non-dominant youth. By bringing together equity-oriented research on connected learning with design-oriented research on computational fluency, this work represents an important interdisciplinary synthesis. Further, the integration of policy and legal research will develop new frameworks for understanding barriers to youth participation in online networks. The findings from this research will inform researchers and practitioners concerned with STEM-related learning, online educational resources, equity in education, and cyberlaw.

4.3 Project Deliverables

4.3.1 Design and Technology Deliverables

- A collection of interest-based microworlds (which can be embedded on any website)
- Portals for interest-based subcommunities on the Scratch website
- Technological infrastructure for online hangouts and unconferences
- Design principles for developing interest-driven pathways to computational fluency

4.3.2 Deployment Deliverables

- Initial deployments at libraries in Los Angeles, Chicago, and Boston/Cambridge
- Librarian dashboard integrating resources, events, and policy/legal toolkit addressing issues of privacy, safety, and copyright
- Large-scale dissemination through informal-learning networks, reaching tens of thousands of informal-learning sites and engaging hundreds of thousands of youth, with special focus on youth from groups underrepresented in the computing world
- Partnerships with major media organizations, who will host microworlds and other resources on their sites, reaching at least hundreds of thousands of youth (and potentially millions)

4.3.3 Research Deliverables

- A deeper understanding of trajectories that youth follow from their interests into computational fluency through analysis of mixed-methods data
- A rich corpus of data, including youth interviews, educator interviews, surveys, observational fieldnotes, and extensive log files of participation and interactions on the Scratch online community
- Publications based on research results, including: research articles for learning-sciences and HCI journals; ethnographic case study based on connected-learning framework; legal/policy research paper and associated publication for practitioners

4.4 Outcomes and Effectiveness Measures

The effectiveness of the designs and deployments will be evaluated through a suite of indicators that will be fed back into the design and deployment for ongoing refinement.

- *Measures of deployment effectiveness.* We will collect a range of data for formative and summative evaluation. Data will include: ethnographic interviews and observations, both before and during deployment; surveys of new and existing Scratch community members; analysis of online data for participation patterns of youth in target groups. Together, these indicators will enable evaluation of the overall reach of the deployments; whether the deployments build pathways from interests to opportunity; whether the deployment has enrolled greater numbers of youth in populations underrepresented in programming and high tech fields.
- *Individual pathways and learning outcomes.* We will conduct an in-depth mixed-methods longitudinal study of a subgroup of 30-50 participants from focal deployments, to gain insights into individual pathways and outcomes. Data will include ethnographic interviews, surveys, and analysis of products created and social interactions in the Scratch online community. Together, this data will enable us to determine whether the new deployments are succeeding in providing interest-driven pathways to computational fluency for participating youth.

5. PRIOR SUPPORT

Resnick and Rusk at the MIT Media Lab have served as PIs (individually or collectively) on five NSF-funded projects to support development, dissemination, and study of Scratch:

Developing a Media-Rich Networked Programming Environment for Community Technology Centers in Economically Disadvantaged Communities (ITR-0325828: $1,999,435, 9/15/03 - 8/31/07)
Intellectual Merit: Advanced the understanding of the design of programming languages for youth
Broader Impacts: Created online community where youth share and collaborate on programming projects
Publications: Maloney et al. 2008; Monroy-Hernández & Resnick 2008; Resnick et al. 2009; Maloney et al. 2010

Scratch 2.0: Cultivating Creativity and Collaboration in the Cloud (IIS-1002713: $798,204, 7/01/10 - 6/30/13)
Intellectual Merit: Developed a new model for integrating a programming language into the cloud
Broader Impacts: Expanded opportunities for youth creativity and collaboration in programming activities
Publications: Dasgupta 2012; Monroy-Hernandez 2012; Resnick 2013

Preparing the Next Generation of Computational Thinkers: Transforming Learning and Education Through Cooperation in Decentralized Networks (OCI-1027848: $1,179,020, 10/01/10 - 9/30/14)
Intellectual Merit: Designed strategies for supporting cooperation in large-scale decentralized communities
Broader Impacts: Broadened participation in computing by using cooperation as a motivating context for learning
Publications: Resnick 2012; Roque 2012; Roque, Rusk, & Blanton 2013

ScratchEd: Working with Teachers to Develop Design-Based Approaches to the Cultivation of Computational Thinking (DRL-1019396: $2,158,587, 8/15/10 - 7/31/14)
Intellectual Merit: Developed strategies to support and assess design-based approaches to coding
Broader Impacts: Supported development of active community of educators helping students learn to code
Publications: Brennan et al. 2010; Brennan 2012; Brennan & Resnick 2012

ScratchJr: Computer programming in early childhood education as a pathway to academic readiness and success (DRL-1118682: $531,278, 8/01/11 - 7/31/14)
Intellectual Merit: Created new framework for educational technologies in early childhood
Broader Impacts: Developed programming language accessible to younger children, ages 5-7
Publications: Flannery et al. 2013

COLLABORATION AND MANAGEMENT PLAN

1. Project Management: Senior Personnel

Mitchel Resnick, Professor of Learning Research at the MIT Media Lab, specializes in the development and study of new technologies that expand the range of what young people can design, create, and learn. 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 and the NSF-funded PIE Network of museums. Resnick earned a B.S. in physics from Princeton and a Ph.D. in computer science from MIT. He was awarded an NSF Young Investigator Award in 1993 and the McGraw Prize in Education in 2011.

Mizuko Ito is Professor in Residence and MacArthur Foundation Chair of Digital Media and Learning at the University of California Irvine Humanities Research Institute, Department of Anthropology, Department of Informatics, and School of Education, and acts as Research Director of the Digital Media and Learning Hub and the chair of the MacArthur Connected Learning Research Network. She is an ethnographic researcher who specializes in sociocultural studies of young people's learning with new media, including electronic games, social media, and digital media production. She has conducted research in a wide range of settings in Japan and the US, and has led large-scale collaborative and mixed methods research projects, including the Digital Youth project, conducted and analyzed over 20 different ethnographic case studies of youth new media engagement in the book *Hanging Out, Messing Around, and Geeking Out: Youth Living and Learning With New Media.* Ito earned an M.A. in Anthropology, a Ph.D. in Education, and a Ph.D. in Anthropology from Stanford University.

Urs Gasser is the Executive Director of the Berkman Center for Internet & Society at Harvard University and a Professor of Practice at Harvard Law School. Urs Gasser's research and teaching activities focus on information law, policy, and society issues. Dr. Gasser has written and edited several books, and published over 100 articles in professional journals. He is the co-author of "Born Digital: Understanding the First Generation of Digital Natives" (Basic Books, 2008, with John Palfrey) that has been translated into 10 languages (including Chinese), and co-author of "Interop: The Promise and Perils of Highly Interconnected Systems" (Basic Books, 2012, with John Palfrey). Gasser is a graduate of University of St. Gallen (S.J.D. 2001, J.D. 1997) and Harvard Law School (LL.M. '03). He is a member of the International Advisory Board of the Alexander von Humboldt Institute for Internet and Society in Berlin and a Fellow at the Gruter Institute for Law and Behavioral Research.

Natalie Rusk, Research Scientist at the MIT Media Lab, develops technology-based programs that build on young people's interests and researches youth motivation in informal learning environments. She is a core research and developer of Scratch, and leads the development of educational materials for the Scratch network. She collaborates on the Pathways study of youth development in community-based youth programs, based at the University of Illinois at Urbana-Champaign. She co-founded the Computer Clubhouse after-school program and established the Learning Technologies Center at the Science Museum of Minnesota. She served as Network Director of the NSF-funded PIE Network, a collaboration with six museums to develop a new generation of hands-on science activities. She served on the National Academies' Oversight Group on Learning Science in Informal Environments. She earned a Ed.M. from Harvard Graduate School of Education and a Ph.D. in Child Development from Tufts University.

Philipp Schmidt, Research Scientist at the MIT Media Lab, is Executive Director and co-founder of Peer 2 Peer University (P2PU), the grassroots community for social open learning. An open education activist, he co-authored the Cape Town Open Education Declaration, served as a founding board member for the OpenCourseWare Consortium, and has been awarded Shuttleworth and Ashoka fellowships.

2. Project Roles

PIs Resnick, Ito, and Gasser will be responsible for the overall direction of design, research, and deployment activities described in the proposal, with the following specific responsibilities: Resnick will direct the development and deployment of the microworlds and interest-based gatherings. Ito will direct the ethnographic studies, the deployment effectiveness survey, development of the dashboard, and the research and deployment in the Chicago and Los Angeles library sites. Gasser will direct the Berkman Center's research efforts in policy and legal research and coordination with the Berkman Cyberlaw Clinic. Co-PI Rusk will lead the design of the microworlds and interest-based portals, manage the data analysis on the Scratch website, and coordinate the research and deployment in the Boston area library site. Schmidt will manage the development and deployment of the interest-based hangouts and unconferences.

The project coordinators, postdocs, and graduate student researchers will contribute to each aspect of the project—from technological development to data collection, analysis, documentation, and dissemination—with supervision from their advising faculty. Each site has budgeted for a staff member to coordinate project meetings, provide project updates, and organize document sharing across sites: Rusk at MIT Media Lab, the project coordinator at UCI, and the project coordinator at Berkman. The postdoc at UCI will perform ethnographic research on interest-driven learning in the Scratch community and will collaborate with the MIT Media Lab team on the design of the microworlds, informed by the ethnographic research findings. The postdoc at Berkman will conduct legal and policy research to address the privacy, security, and policy issues related to youth online participation and sharing.

3. **Project Management and Coordination Plan**

Each of the sections below provides more details on the project management and coordination.

Management of Technological Development: PI Resnick will oversee the technological development, including the microworlds, hangouts, and unconferences. Rusk will manage the development of the microworlds and interest-based activities on the Scratch site. Schmidt will manage the development of the hangouts and unconferences. Each will host weekly team meetings with the staff and graduate students contributing to the design and development. The project teams will make use of feature and bug tracking systems, which have been effective in managing and tracking the design iterations of the Scratch 2.0 environment. The system administrator from the MIT Media Lab will manage the technological infrastructure for the project, ensuring the availability, continuity, and security of data on the site.

***Coordination of Data Collection and Analyses*:** Resnick and Ito, along with Rusk, will be responsible for designing and implementing research activities together with graduate student researchers. Ito will lead the survey and ethnographic studies. Rusk will manage the analysis of log files and project artifacts from Scratch web site on the MIT server. Ito will be responsible for the data collection in the Los Angeles and Chicago library sites, and Resnick and Rusk will be responsible for the data collection in a Boston area library site. All of this data will be shared project-wide, in accordance with procedures established for the protection of human subjects (as described in the Data Management Plan). Collaborative analysis will be conducted using a shared codes wiki and the cloud-based mixed methods data analysis software, Dedoose, based on already-established practices and infrastructures already in place at the UCI Digital Media and Learning Hub. The PIs will work on establishing priorities for deliverables to NSF (see also below), conference presentations, and journal publications.

Coordination of Deployment: PI Resnick and co-PI Rusk will oversee the deployment of the interest-based online gatherings and in the Boston area library, coordinating with Ito and her team in the deployment with the Los Angeles and Chicago libraries. PI Ito will oversee the deployment in the Los

Angeles and Chicago library, and the development of the dashboard, incorporating resources from all three teams and library partners. In the broader dissemination in years 2, 3 and 4, Ito will lead in dissemination to library and museum networks, Rusk to other informal learning networks, and each PI will take responsibility for dissemination to specific online media partners.

Legal and Policy Mechanisms: The Berkman Center team will be on call to respond to specific research and related legal needs of projects partners as they arise (including, for example, preparation of website terms, privacy policies, and EULA and related documentation for sites or software applications developed as part of the project.

Communication Mechanisms: Research team meetings (include the 3 PIs) will be scheduled on a monthly basis with conference calls. In addition, we will organize in-person project team meetings once a year to discuss research plans and findings. The research team will use a combination of traditional and new social media for communication. For communication within the project team, we will primarily make use of email and web and phone conferencing. We will make use of online document sharing (as we have done for collaborative preparation of the grant proposal).

Reporting Mechanisms: To communicate findings with other interested researchers and educators, we will present at conferences, share publications and reports on our respective websites, and post updates to blogs and social media accounts associated with our groups. PIs Resnick, Ito, and Gasser will be responsible for filing annual progress reports to NSF and for working on the final report once the grant activities have been completed.

Capacity Building**:** We will involve graduate students in all aspects of research from software development and design to data collection and analyses. Our graduate students bring substantial professional experience to this project from diverse fields, such as computer science, human-computer interaction, education, learning sciences, law, and cultural anthropology. Graduate students will review pertinent research, conduct observations, implement surveys, and analyze online data and design artifacts. They will work closely together with their advisors in preparing conference presentations and publications. They will also participate in other related project activities such as arranging workshop activities at annual conferences. The postdoctoral researcher at UCI will be an ethnographer in the field of learning sciences or technology studies, and will be provided opportunities for full participation in research and publication activities (as described in more depth in the Postdoctoral Researcher Mentoring plan). The postdoctoral fellow at the Berkman Center will conduct research, write findings, and connect this project with the historical and ongoing efforts of the Center's Youth and Media project.

Institutional Review Board**.** The PIs and all research personnel associated with the project work will have completed training and received certification in conducting research with human subjects; the certificates will be submitted to their institutions' Institutional Review Board (IRB). Each PI will submit an application to their university's IRB and receive approval of concept, procedures, and consent and assent forms. In order to avoid conflict between different consent and assent (for minor) forms, the PIs will work collaboratively on generating these materials. The protocols, any associated materials, and approval notices will be on file at each university's IRB office.

Project Administration**:** Since the proposal is submitted as a collaborative proposal, the Grants & Contracts and business offices at MIT, UC Irvine, and Harvard, respectively will handle all grant administration in terms of personnel, travel, and other research expenditures for each PI. Office space and furniture will be provided by the university administrations.