Title:CDI-Type II: Collaborative Research: Preparing the Next Generation of Computational Thinkers: Transforming Learning and Education Through Cooperation in Decentralized Networks

Institution: Massachusetts Institute of Technology

NSF Program:CDI Type II

Principal Investigator: Resnick, Mitchel

Rating: Fair

Review:

What is the intellectual merit of the proposed activity?

This work seems to mix quite a few ideas, as shown by the fact that almost half of the proposal's space is devoted to introducing all of the different ideas and concepts that will be researched, and the 11 research questions are only introduced on page 8. The PIs are to be congratulated on the impressive scope of their proposed project; however, at the same time this impressive scope has a significant cost in terms of coherence. While the proposal it is clearly multi-disciplinary,and highly broad, the proposed work does not seem to integrate clearly into a single coherent whole. In addition, the proposed research is also somewhat mismatched to the themes discussed in the introduction -- for instance, none of the three threads seemed to exactly link to the interesting discussion and repeated example of the importance of studying why people collaborate on large-scale collaborative projects like Wikipedia. (as Scratch and Wikipedia, though both fine systems, are different in very important ways)

In addition, the extremely large scope raises questions of whether the researchers will genuinely be able to address all of their research questions within their time and budget. While the proposed budget is large, several of their research questions û e.g. "What motivates people to want to cooperate?", "What computational-thinking competencies are needed to engage in different forms of cooperation?" could individually be a significant grant in themselves, and it is uncertain how well the research proposed will address these questions. The observational studies proposed are not given in sufficient detail to enable judgment on this, in many cases just giving a list of additional questions that will be addressed, but not giving detail on how, except for single keywords ("cluster analysis", "logfile analysis"). For instance, the section 'Comparisons Among Sub-Communities" lists 6 different research questions, any one of which could occupy a PhD student for several months if done thoughtfully. Which of these questions will actually be addressed? How will they be investigated? Studying whether learning trajectories are significantly different between two groups, for instance, is not a trivial problem to analyze at the statistical level û which of the many analytical

options will the PIs use?
The three examples of field experiments seem reasonable, however no detail is given on how the variations' impacts will be measured.

The team assembled is highly impressive, with prominent researchers. The organizational plan is thorough and clear.

What are the broader impacts of the proposed activity?

Given the wide distribution and usage of the Scratch environment, it seems likely that even incremental improvements to Scratch will have a broad impact. Many students' engagement may be enhanced, improving flow into the workforce pipeline.

Summary Statement

In terms of the additional criteria for CDI: the research agenda is certainly both bold and multidisciplinary. It is hard to see, however, how paradigms will be shifted through this research -- it largely seems to consist of research which will have incremental (though real) benefits for Scratch and Scratch-like environments. In addition, although the work involves methods from multiple disciplines, the benefits of the work seem to be focused solely in one discipline, collaborative learning through creation.

Overall, the proposed grant is likely to have positive impact, and has interesting ideas. The proposal is light on methodological detail; while the researchers are well-known for their skill, it would be useful to know in detail how they intend to address the large number of difficult research questions they propose to address -- with more detail on methods, instruments, measures, analytical techniques, etc. It also seems to be a project focused on a single discipline rather than the type of integrative work that benefits multiple disciplines that CDI is targeted towards.

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Principal Investigator: Resnick, Mitchel

Rating: Very Good

Review:

What is the intellectual merit of the proposed activity?

STRENGTHS

* Investigators are gathered from a broad, yet complementary, range of disciplines, including computer science, education, organizational science and economics and position themselves as having the capabilities to address complex problems in an interdisciplinary fashion;

* The proposed conceptual framework, covering design levers for cooperation, collaborative learning, computational thinking, and broader participation, appears to be well developed and thoughtfully integrated. The framework draws from the individual expertise of PIs while presenting a holistic perspective on the theoretical undertones of the proposal;

WEAKNESSES

* What could be spelled out in more detail is whether and how the online learning network, Scratch, can be re-designed to serve the goals of broadening participation and emphasizing computational thinking even more (than was specified in the original design). That is, are there design lever requirements that can be derived from extant research on the use of Scratch either for computer science undergraduates or young women?

* Along the lines of the point above, how amendable is Scratch to re-design so that cooperation or collaboration will be a more integral part of the online learning network experience? Concern lies in the adaptability or flexibility of the current platform that might be perceived as radical in terms of initial design. It might help to see the progression and iterations of changes that are anticipated based on initial and projected research and design.

What are the broader impacts of the proposed activity?

STRENGTHS

* Investigators are drawing from a broad range of studies, fields, and technologies to validate the assumption that Scratch 2.0 (an enhanced version of the original platform that incorporated requirements including sharing, co-creating, remixing, and data mining) will be adopted broadly. It is reported that approximately 1500 new Scratch projects are initiated daily and that nearly 1 million projects have been initiated to date.

WEAKNESSES
* It was unclear as to what the specific definition of a _Scratch project_ was and what attributes of these projects would lead investigators to anticipate influences on computational learning and broader participation;

* It is not entirely clear what the features of cooperative activity are and how Scratch 2.0 will stimulate or support this type learning.

Summary Statement

The intent of the proposal is to study the nature and patterns of cooperation in decentralized learning environments, in this case the NSF-sponsored Scratch platform (an online graphic programming environment for users 8 and up). From this research, the goals are to establish design principles to guide the development of systems that foster cooperative attitudes and behaviors, and develop strategies to cultivate the computational-thinking capacities that are critical for productive cooperation and problem solving in virtual organizations. Outcomes are anticipated to be applicable broadly to the understanding and design of future virtual organizations. Overall, this is a very strong proposal in terms of conceptual framework, research and methodology. Investigators and senior personnel contribute requisite expertise and are supported by an impressive advisory panel.

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NSF Program:CDI Type II

Principal Investigator: Resnick, Mitchel

Rating: Excellent

Review:

What is the intellectual merit of the proposed activity?

This application proposes to explore how cooperation in decentralized networks can be the basis for fundamental changes in learning and education. It will be based on the NSF-funded Scratch learning network, which uses a specially-designed graphical programming language. The proposers will study how young people cooperate in such a virtual organization, what attitudes and motivations are related to their cooperation and what computational thinking skills and capacities are necessary for productive cooperation. It claims its Broader Impact to be design principles for cooperation in decentralized networks that can be used in a variety of other contexts. More directly, millions of young people in the Scratch learning network will have enhanced experiences in acquiring computation thinking skills.

Intellectual merit:
This proposal describes a well-designed set of studies for understanding cooperation in decentralized networks in the context of the Scratch learning network. Cooperation can be hard to define, but one of the PI's has developed a set of 'design levers' that could influence the dynamics of cooperation within a system. They also point out ways in which researchers have tried to infuse classrooms with cooperative activities, often with little result. The research they propose, moreover, looks at cooperation at a different scale, involving many thousands of young people. While they are interested in studying the current structure of the Scratch network, they are also interested in thinking about to re-structure a network so that they can leverage the availability of more knowledgeable peers rather than a totally unstructured network. This seems like an important question about this particular VO.

The proposers have a good taxonomy for cooperation and ways that they can support and track how each of these happens in the Scratch network. I have one question about the mining category û analyzing the kind of data they describe may be beyond the capabilities of the Scratch networkers, at least without significant support.

How much effect will the changes in Scratch 2.0 have?

There is a good mix of studies of the network as it currently is and a set of design interventions. I would have liked more specificity about the qualitative and quantitative measures they plan to use. Other measures are also under-specified in the description of observational studies.

What are the broader impacts of the proposed activity?

Broader Impact:
The proposers point out that there has been a significant drop in women in computer science over the past decade, and there is some evidence that computer science education using something akin to Scratch software in a cooperative environment can support increased participation by women and other populations sometimes 'turned off' by traditional approaches to computer science education.

Summary Statement

Summary: this is a very good proposal with a clear research agenda, a relevant body of prior work, and the appropriate team to do the work. It has the potential to be transformative in understanding better the role of decentralized networks so that they can be leveraged in other settings. It appropriately proposes to study how different design choices can support the growth and structure of the VO.

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Rating: Very Good

Review:

What is the intellectual merit of the proposed activity?

Scratch is a programming language for creating animations, music, games, art, etc. and a way to share them on the web. According to the authors, Scratch is used primarily by elementary and secondary age students. The authors propose to develop a new infrastructure for the Scratch learning network and to use the enhancements to study different forms of cooperation/collaboration (e.g., remixing, crowd sourcing). Currently, users must conduct their programming in a separate application and upload the results or download a project they wish to work with. Through this proposal, they aim to make it possible for users to author programs directly on the web. They state that this will make it possible for them to add features to Scratch to support means to share a broader range of artifacts (not just full projects but also scripts, images, sounds, etc.); tools for group decision-making and version control; visualizations of the provenance of projects; match-making mechanisms; and data mining tools. They propose to address research questions related to motivations to cooperate, skills needed to engage in different forms of cooperation, and decentralized learning networks. The project would employ several methods, including field experiments, observations, and design interventions.

The intellectual merit is high. Data collection in virtual communities is challenging. Because some of the PIs developed Scratch, they can easily introduce new features and then study them. The findings would contribute to a better understanding of the design of virtual organizations, particularly large virtual communities. For example, the tone of notification messages and their influence on attitudes and behaviors are applicable outside the Scratch environment. In addition, the results would provide insights into online environments for youth such as the ways in which they support learning and factors that motivate young people to participate in a resource such as Scratch.

The authors lay out an ambitious research agenda, and I am largely convinced that they can carry it off given the experience of the PIs and of the graduate students named in the proposal, plus a postdoc and other students to be hired. The personnel for the project and the coordination are well thought out. There are enough people to accomplish the work, and the PIs are located in close proximity, which is a benefit to collaboartion. The potential field experiments are well-described and seem feasible.

That said, the proposal is short on detail regarding how some of the work will be carried out, particularly how the team will assess progress toward "computational thinking." Further, it is not always clear how the PIs plan to gather the data to answer address particular research questions. For example, the authors propose to study learning trajectories of individual community members by analyzing Scratch

members of different ages and background. How will they come by the data necessary to do this? Are Scratch members required to provide "background" information in order to use Scartch? If so, what kind of information is available? Will the PIs have access to data that makes it possible for them to identify the sequence in which people do things (remixing, crowd-sourcing, etc.)? A short description of ways they addressed these challenges in other studies would have been useful in confirming that they could get the data needed to address the questions they pose. Finally, given the nature of the population of Scratch users (i.e. minor children) and the desire to include participants from other countries, how will the team handle IRB issues when conducting experiments that involve individuals from other countries? The coordination plan mentions IRB, but does not address these specific issues. These are critical to the proposed work, although I recognize that they are not mandatory to discuss in a proposal.

What are the broader impacts of the proposed activity?

The project has the potential for broad impact on based on findings related to youth participation in large virtual communities and to virtual organizations more generally. I believe the broad impact stands to be significant.

The authors discuss the need to address declines in student enrollment in computer science (CS) and to increase the number of women and minorities in CS. They point to research showing that the design and testing of applications such as games can improve participation by underrepresented groups. They also present some preliminary evidence that Scratch can help to attract a broader range of students to CS. However, they do not describe how they will specifically address issues relevant to women or minorities in the proposed project.

Summary Statement

The intellectual merit and broader impacts are very good, although one might wish for more detail regarding the specifics of the proposed work and plans to achieve broader impact. This is a strong team with the experience to conduct research on several interesting questions regarding distributed learning environments.

The postdoc mentoring plan is adequate.