NEW YORK UNIVERSITY
GRAND CHALLENGE COMPETITION

Programming across the curriculum: Building a complete, open-source computationally rich learning environment for high school students

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Section I: Describe your idea/concept and the scientific basis for your idea and how it fits the concept of grand challenge. (1-2 pages)

Today's educational systems are geared, both in form and in scope of content, toward 19th century mass-produced learning; students are trained to learn existing facts, skills, and ideas in a list of subjects that has remained unchanged for more than a century: literature, mathematics, history, physics, chemistry, and so on. Yet most of today's college students face a job market that is undergoing incredibly rapid change, driven by technological innovation even in traditionally low-tech sectors, resulting in an ever growing gap between those who can code and those who can not. Programming ability will be an essential 21st century skill, but by postponing the teaching of programming until college, and then only in certain majors or fields, we diminish the competitiveness of our national workforce.

What if programming together was just as popular a collective activity among youth as Tweeting, FaceBooking, and passing around YouTube links? What if programming, both in and out of the classroom, was one of the most formative and powerful social and emotional experiences that high schoolers looked back on from this time in their lives? By "programming" in this context we mean a carefully graduated infusion of skills in applying principles of computational thinking [Wing], beginning with the sorts of "programming for kids" efforts that focus on middle or elementary school [Papert, Resnick], and progressing from there toward full command of programming.

Current State. The average young person in the United States possesses at least a basic level of written literacy, but cannot program a computer. Because of this disparity, vast opportunities for our society go unrealized, and many professions remain limited by the assumption that their practitioners lack the ability to program. There have been very good attempts to teach programming in middle school (grades 6-8) [Resnick]. Unfortunately, whatever gains are achieved in these programs are largely lost when students enter high school at around the age of fourteen. At this age, young persons will tend to reject activities or skills that are not well integrated into the social fabric of life. They discover fashion, social networking, music, and many other socially driven activities through which to define an emerging identity as young adults.

A Possible Future. If we can make computer programming socially and psychologically relevant between grades 9 through 12, then we will create a generation of young adults who can program. We propose to rethink the place of computer programming in these crucial grades. Rather than positioning computer programming as a stand-alone, primarily solitary skill-set, we propose to create programming activities that are fundamentally social in nature, and that integrate into emotionally and socially meaningful contexts for high schoolers, tapping into the desires of this age group, with an understanding of where their peer group influences interests and behaviors.

We envision programming as a part of all aspects of the high school years -- not just science and mathematics, but also English and social studies, as well as electives such as art and music, and social activities outside of school. We see programming in these contexts as a way to share powerful emotional and social reactions both in and out of the classroom to whatever is being discussed and analyzed. We plan to enable students to use these tools not just in class, but also as part of the everyday media fabric of their lives outside of the classroom, piggybacking on the well documented drive for high schoolers to participate in social media to define themselves [Ito].

Grand Challenge: Programming as Disruption. Consider the positive disruptive elements of a society in which all of the citizenry can program, with the same facility that most citizens now bring to reading and writing. The very nature of many professions will undergo a profound evolution. Economics, history, literature, government, and many other fields will be able to grow in new ways by empowering consumers of software to become software designers that can take full advantage of the ever-increasing power of computers.

Our grand challenge is to dramatically raise high school computational literacy, skills, and interest in continuing to program, by making programming ‘cool,’ and specifically by creating an online, editable tool for programmable media, and using it to create crowd-sourced, open source editable materials for all high school subjects as computational media within the next ten years.

The time is right to begin this process. Paper textbooks are now being replaced by eBooks, and the coming decade will provide a powerful opportunity to build a new kind of interactive textbook, and corresponding teacher supplemental material, to support a culture of procedural learning. Our end goal is to make these new eTexts as compelling as today's social media, so that learners enter a lifelong practice of using them, and thus of programming as well. We believe this will yield a world in which all citizens can program. This world will be intellectually richer in cultural possibility and economic growth in a fundamental way, just as Western society became intellectually enriched by the introduction of moveable type in the fifteenth century and the introduction of the practical hyperlink and image tag two decades ago.

In addition, as these techniques, implemented as low-cost solutions, expand into the Third World, the potential for improvement of the world's economy is profound. Information technology is the most rapidly growing sector of the global economy, and increasing the percentage of a society's procedurally literate citizens is a powerful way to improve economic and cultural opportunities within that society.

Section II: Describe the technical approach (your experimental plan/project design) and the implementation plan. Describe competitive approaches if any. (5-6 pages)

Our fundamental approach will be to reposition programming as a social skill, not merely as a solitary activity, and to integrate this skill on a fundamental level with other creative activities, such as the creation of text documents, and other "maker" practices. Our own research on the NSF funded project RAPUNSEL has shown the power of this approach for middle school youth [Plass]. If you have used Google Docs, you know that the creation of documents is highly amenable to real time collaboration and to social interaction. We propose to work with open education providers and computer science education initiatives to create integrated environments in which text and programming are both seen as aspects of a cohesive socially shareable activity. For example, consider social studies. Rather than merely read texts, students will also be able to process and cross-reference data from powerful databases, such as the CIA factbook, the U.S. Census, and various geographic and municipal databases, as well as the databases that will be made available by CUSP at NYU and parallel efforts. Students will be able to write procedural filters for such data, implement methods for visual display of results, and integrate the results into narrative reports. They will be able to use compelling and engaging visual and auditory effects to create emotionally resonant representations of the data at hand, more connected to interpersonal stories and reactions.

Project Activities. Three activities will be needed to reach the goal of a computationally rich high school curriculum: First, we will extend our current research platform so that third parties can help us

develop computationally rich materials. Second, we will partner with computer science and open educational content providers to begin the process of crowd-sourcing materials development. Third, we will iteratively use and revise our engine for testing and refinement of this curriculum in practice, by working with partner schools such as the Academy for Software Engineering and the Bronx Academy of Software Engineering (two open-enrollment public high schools in New York). We intend to evolve these curricula on a practical scale by systematically instigating and aiding community-driven, crowd-sourced solutions, and doing 'agile development' not just for software but for the programmable eTexts, in which rapid iteration and partnership are emphasized as ways to converge quickly on workable solutions and then improving them.

The initial NYU funding for this grand challenge will be used to fund two major activities: First, we will begin the process of agile development by creating the earliest prototypes of the tools, materials, and activities that can be iterated and refined (beginning with assembling existing open-source materials). Second, this seed funding will help bootstrap the process of engaging targeted potential audiences, both to help drive iteration on our learning materials, and to begin raising the awareness and interest needed to grow to a complete, computationally rich, open source high school curriculum by 2023. We take our grand challenge to be developing a platform and materials that engage computational thinking and learning and having it reach 10% of all high-school aged youth in America.

Measuring Outcomes. We will measure outcomes by piloting our system in schools with which we have prior research relationships through our collaborative work across the NYU Games for Learning Institute, CREATE, Game Innovation Lab, and Media Research Lab, as well as the expanding NYU network of global sites. Given promising pilot results, we have access to national and international networks of teachers and schools through which we can broadly disseminate these tools, with the intent of taking them 'viral'. We will combine quantitative and qualitative strategies for assessment for both the pilot and full release. Our team has expertise in assessing both individual and group response to learning tools, and can examine both cognitive, affective/emotional, and metacognitive variables.

Work Plan. Our work plan for the first two years will consist of five thrusts: technology development; computer science literacy assessment development; partnership development and outreach planning; content development; and design-based research on the overall model. We now discuss each of these in turn.

Technology development within the computer science team will focus on two areas: (1) Creating a smooth set of creation/editing/sharing/annotation software tools for collaborating users. This will entail creating interactive "What you see is what you get" editing software for the combined text and code that support shared on-line procedural documents. Included in this editing software is support for the

creation and editing of "power-up" gestural programming tools, since such tools allow participants to rapidly iterate on their work together, without interrupting the flow of social interaction between collaborators. (2) Creating a set of instrumentation tools that track use of the software and create a database of statistical measures, which we will subsequently analyze in order to understand the effectiveness of various software features in support of social engagement.

One key focus of that software effort will be on design and implementation that maximize "discoverability". For example, we make it easy for kids who are interested in "looking under the hood" to examine and modify the underlying mark-up language. To that end, we optimize our design for mark-up that is clearly readable and directly editable. Another key feature of our implementation will be support for "conversational" widgets -- color editors, curve editors and so forth -- to support collaborators making changes to code in real time: As a user of the system, you are seeing actual code, but you are also using a structured editor that cannot make syntax errors, and which is allowing you to code gesturally.

We have also been working closely with Google to ensure that the shared server which allows participants to make use of our software is compatible with the continually expanding power of Google Drive (ie: synchronous cloud server support, features, and data types). This close coordination with Google will also help pave the way for an eventual funded partnership with Google for the project, as it expands in scope.

The tools will be developed using a series of iterations with frequent rounds of user testing and feedback, working with members of the target educational cohort as well as their teachers/ mentors. These user tests will include measures of emotional, social, cognitive, and behavioral engagement that are state-of-the-art for the Human Computer Interaction (HCI) field, toward achieving the project aims of strong social and emotional engagement of learners both in and outside of formal learning settings. The software is already being used by Perlin to teach the graduate computer graphics class in the Department of Computer Science at Courant, a course that will be repeated in the Fall 2013 semester. In that semester, support for synchronous sharing will be in place, which will allow us to begin assessing social engagement in students' collaborative use of the software. We will also leverage the user research facilities in the Game Innovation Lab at NYU-Poly and of the CREATE lab at NYU Steinhardt to conduct this series of user tests, and will also be able to make this project one of the core focus research opportunities in the graduate Introduction to HCI course taught in Fall 2013 and Fall 2014 at NYU-Poly. Isbister will lead the user research/interface development efforts on the technical development, supporting the core tool-building efforts of Perlin's group.

Computer science literacy assessment development will focus on creating measures of how

computational thinking is being developed in students. We know that computer science concepts and computational thinking can be assessed in traditional school settings using interviews and exams. However, because we hope to integrate computer science learning with multiple subjects across the curriculum, and even in non-curricular use of the computational media, we need to develop arm-length assessments that are tied to tool use. Tightly focused research involving direct observations and prior instruments for assessing computational thinking will be used to triangulate with emergent measures related to use of the programmable media tool (for example, identifying code examples that match particular algorithms, developing media with certain computational properties or complexity, etc.) to assess computational literacy. These measures will be informed by the literature on computer science curriculum development and assessment [e.g., College Board, 2012; ITEA, 2007; Committee for the Workshops on Computational Thinking; National Research Council, 2010, 2011]. By the end of year 1, we will have selected certain target concepts in computing, hypothesized traces that these concepts might leave in the online tool, and during year 2 will conduct a pilot study to see in what ways traditional measures of computer science concepts align with student use of the tool.

Partnerships and outreach will focus on convening meetings of relevant open education and computing/programming literacy organizations such as Girls Who Code, the Digital Media and Learning Research Hub, the National Center for Women in IT, MOUSE Squad, and so on. We will also seek partners currently providing substantive coverage of high school curriculum in open formats who are interested in porting their content to this computationally richer medium, such as the CK-12 Foundation. As a result of these meetings, by the end of year 1 we will have produced a plan for specific ways computation could enhance subject matter representation in the online textbooks and additional ways to consider seeding computationally rich content in non-school settings.

Content development will focus on building or adapting existing open-source curricula to a computationally rich environment. We will use the framework developed by Kirch to accomplish this:

1. Curricula should be structured around big ideas and questions. These should be interesting to children and can often be matched to children's big ideas and questions (see also, Principle #3, below).
2. Curricula should ensure that students will discover its relevance to the past, present and future. The origins of an idea (e.g., the needs, the wonder questions) should be an integral part of the learning and discovery process structured by instruction.
3. Curricula should relate knowledge and knowing to students' pursuits and goals.
4. Curricula should use abstract models as an aspect of learning. Such abstractions provide workable models that simplify learning.
5. Students should play an active role in their own learning (e.g., as researcher)
6. Curricula should be structured to help students organize their thoughts for successful

communication including the creation and use of verbal, written, graphic and symbolic forms.

7. Curricula should allow for flexibility especially with respect to the teacher's role. Sometimes the teacher will be providing information, sometimes he will be guiding student investigation, but she will always be structuring instruction for success.
8. Curricula should motivate and empower students by inspiring curiosity, supporting investigation, and generating open-ended questions.
9. Differentiate instruction for all learners including those with disability(ies). Use Universal Design principles for all materials, interactions, and delivery whenever possible.
10. Be cognizant of the role and identities of women, minorities and people with disabilities in STEM fields and in society. The ancient and renaissance periods of the history of science are dominated by male stories, but the faces in the recent past, present, and future story of science are multicultural and gender-balanced.How are the scientists, people (including children) portrayed in the curriculum under development? How can the design demonstrate or support the notion that anyone can become a scientist?

This framework will help us engage not only the computer science concepts that the software can support, but also using the computational medium to enrich curriculum of other subjects. Over the next 10 years, we plan to develop or assemble, test, and deploy a full suite of open-source curricula and open ended challenges around several integrated STEME content areas.

Design-based research on the model will examine a wide variety of variables to inform the overall concept. Viewing these first two years as a discrete part of the ten year trajectory, the primary goal will be to get the platform operable to the point where partnerships and crowd-sourcing can begin, and to test the key hypothesis: That computationally rich, sharable media can get programming skills into the hands of students across school subjects. In design-based research, interventions are iterated in context, and a wide variety of measures are collected not only to improve the intervention but also to document the impact of successive changes to the model and implementation. We will work with a number of field sites for design-based research, working with centers at NYU, NYU-Poly, and with educational institutions in New York City that have affiliations with NYU. The Jumke Basu STEME Education and Research Center at Steinhart (http://steinhardt.nyu.edu/portal/steme), the NYU-Steinhardt Young Investigators Program (an after-school science/engineering program for 4th grade students that is part of Steinhart's teacher preparation program for elementary school teachers - grades 1-6) and the NYU-Poly Center for K-12 STEM Education (http://www.poly.edu/k12stem) will serve as our primary in-house sites for testing and working with educators; we will work extensively with both programs to augment their curricular programming with our work; these partnerships will focus primarily on testing with youth in informal learning settings. The Center for K-12 STEM at NYU-Poly have made incredible strides in developing extracurricular programming in mechanical engineering and robotics (e.g.

their CREST program); our research will provide important offerings in software development to complement these existing programs. In addition, we will partner with the Academy For Software Engineering (AFSE) and Bronx Academy for Software Engineering (BASE), two computing-oriented public high schools in New York.

Variables we will document include attitudes toward computing, usability and interface design, teacher and student adoption ease, contextual information about the school contexts in which the tool might be used, and after school contexts in which we hypothesize the tool will also prove useful. By the end of year 2, we expect to report (1) empirical data assessing the core premise that computational media will yield computational literacy; (2) which features (collaborative or otherwise) are necessary to allow students to learn the system with a suitably gentle learning curve; and (3) market data on what partner organizations would find necessary to use such a platform to help crowd-source the entirety of the high-school curriculum.

Section III: List milestones and metrics of success. What quantifiable success criteria will be used to assess progress? (2 pages)

Milestones and metrics for the software design and implementation will be as follows:

- Successful implementation and deployment of creation/editing/sharing/annotation software tools for collaborating users.
- Support for the creation and editing of "power-up" gestural programming tools to allow participants to rapidly iterate on their work together in a social context.
- Successful implementation and deployment of the suit of instrumentation tools that track use of the software and create a database of statistical measures.
- Implementation and utilization of tools to analyze the gathered statistical measures, to drive our model assessing the effectiveness of various software features in support of social engagement.
- Successful design and implementation of features to maximize "discoverability" in the mark-up language and power-level editor.
- Integration with the Google Drive shared server to allow participants to make use of our software in a way that is compatible with the evolving power of Google Drive (ie: synchronous cloud server support, features, and data types).

Milestones for the empirical assessment of impact after 2 years will be as follows:

Outcome measures

- Greater than 50% increase in the number of individuals actively engaged in programming and in software design with our system;
- Additional greater than 30% increase in the number of individuals actively engaged in programming and in software design in a social context with our system;
- Computational literacy increases of at least 20-40% beyond what current tools deliver for this age group

Contextual/Implementation Knowledge

- Establish usability of the system based on multiple iterations of user research and system redesign;
- List of features (collaborative or otherwise) that are necessary to allow students to learn the system with a suitably gentle learning curve;
- Market data on what partner organizations would find necessary to use such a platform to help crowd-source the entirety of the high-school curriculum

Section IV: Define the needed external partners and how the external community will be mobilized? (1 page)

Our strategy for engagement will be fourfold. First, we will engage *testbed partners*, to help us refine the concept and the tools. Secondly, we will engage *content partners,* to help us adapt or create learning materials in the online tool. Third, we will engage *learning dissemination partners*, who either have a vested interest in education or youth development who might guide the overall dissemination plans. Fourth, we will engage *technology partners,* who will help us make sure the tool is maximally relevant to users' everyday lives and technically robust and expandable.

Because of its huge potential impact on society, this initiative is also highly fundable by government and foundations, as well as by for-profit corporations such as Microsoft and Google, which share a strong vested interest in increasing the number of programmers in society. Once we have used the seed funds from this grant to deploy prototypes that demonstrate the potential impact of this approach, we will be able to attract far greater funds to invest in the necessary research into content, design and distribution which will enable widespread adoption.

Both Microsoft and Google have expressed interest in this initiative. For example, at the request of Peter Norvig (Google Director of Research), we have delivered to him a copy of our current research software, so that he can personally play with it, provide constructive feedback, and assess its utility for MOOC authoring and instruction (Dr. Norvig co-created a highly successful online A.I. course at Stanford in 2011, with Stanford professor and Google VP Sebastian Thrun, who then went on to found

Udacity).

Also, Jaron Lanier at Microsoft Research has expressed strong interest in using this software and approach to create interactive explorations of the commerce of data mining, as described in his new book "Who Owns the Future" (see NY Times review, May 6, 2013).

In addition, Alan Kay and his company Viewpoint Technologies have expressed interest in conducting joint educational projects for teaching programming to young people that will use our software as a core component.

We already have connections to several learning dissemination partners, including the NYC Department of Education, afterschool providers such as GlobalKids and MouseInc, cultural institutions such as the New York Hall of Science and the American Museum of Natural History, and other providers of informal learning opportunities, such as the HIVE NYC learning network.

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Papert, "A Learning Environment for Children", Computers and Communications Implications for Education, 1977.

Plass, J.L., Goldman, R., Flanagan, M., & Perlin, K. (2009). *RAPUNSEL: Improving self-efficacy and self-esteem with an educational computer game.* Paper presented at DIGITEL 2009, December 5-9, 2009 in Hong Kong.

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Wing, J., *A Vision for the 21st Century: Computational Thinking*, CACM vol. 49, no. 3, March 2006, pp. 33-35.

Appendix material - i) Management & staffing plan (1-2 pages)

Ken Perlin, professor of Computer Science at Courant, directs the NYU Games For Learning Institute, was founding director of the Media Research Lab, directed the NYU Center for Advanced Technology, researches graphics, animation, augmented/mixed reality, user interfaces, science education, multimedia, received an Academy Award for Technical Achievement, the 2008 ACM/SIGGRAPH Computer Graphics Achievement Award, the TrapCode award for achievement in computer graphics research, NYC Mayor's award for excellence in Science and Technology, Sokol award for outstanding Science faculty at NYU, and NSF Presidential Young Investigator Award, is on the program committee of the AAAS, was general chair of the UIST2010 conference, a featured artist at the Whitney Museum of American Art, and is on the Advisory Board for the Centre for Digital Media at GNWC. *Perlin will be lead PI, overseeing development of project software, including the instrument to assess the software's effectiveness. His team will also interface with commercial partners, such as the Google Drive team, that will be providing complementary capabilities, and will also be responsible for interfacing with all external technology partners, such as Microsoft Research, SAP and Viewpoint Technologies.*

Chris Hoadley, associate professor in the Educational Communication and Technology Program, has over 35 years experience designing and building educational technology, and has conducted research on technology, learning, and collaboration for 25 years. Research focus: collaborative technologies, computer support for cooperative learning (CSCL), and design-based research methods (a term he coined), directs dolcelab, the Laboratory for Design Of Learning, Collaboration & Experience, is affiliate scholar for the National Academy of Engineering's Center for the Advancement of Scholarship in Engineering Education (CASEE), received a Fulbright for 2008-2009 in the South Asia Regional program. Interests: research on/through design, systems for supporting social capital and distributed intelligence, the role of informatics and digital libraries in education, science and engineering education. *Hoadley will oversee design-based research and contribute to design of the proposed system and to outreach.*

Katherine Isbister is Research Director of the Game Innovation Lab at NYU-Poly, where she conducts research with support from NSF, Microsoft, Yahoo, and Bell Labs. Isbister is jointly appointed between the NYU-Poly Computer Science Department and the NYU Tisch Game Center. Her expertise is in Human Computer Interaction, with a focus on broadening the social and emotional palette of everyday experience with technology. Isbister will work closely with Perlin to shape the interface to the core programming toolkit based on user-centered design principles, and making use of the latest research thinking about how to stimulate emotional engagement and social connection through design of interface. Isbister and Perlin have prior experience collaborating in this way from their work

within the Games for Learning Institute. *Isbister will oversee user testing at NYU Poly and contribute to software design and to outreach.*

Susan Kirch is an Associate Professor in the Department of Teaching and Learning. Kirch is a science educator and a biologist. Research includes: investigations of teaching and learning science in urban elementary schools and studies of teacher learning in the areas of science and inclusion, has participated in a variety of initiatives designed to bring teachers, K-12 students, educational researchers and scientists together to study access to science and the nature of scientific inquiry and she has published chapters and articles on school funding, inclusion, feminist pedagogy, co-teaching, and discourse in elementary school classrooms in journals such as *Science Education, School Science and Mathematics, Cultural Studies of Science Education,* and the *Journal of Science Teacher Education* among others. Dr. Kirch currently studies how elementary school children learn the nature of scientific evidence through activities that feature contemporary questions and issues in science. *Kirch will oversee the curricular development efforts and contribute to outreach.*

R. Luke DuBois, a composer, artist, and performer, explores temporal, verbal, and visual structures of cultural and personal ephemera, holds a doctorate in music composition from Columbia University, has lectured and taught worldwide on interactive sound and video performance, collaborated on interactive performance, installation, and music production work with many artists and organizations including Toni Dove, Matthew Ritchie, Todd Reynolds, Michael Joaquin Grey, Elliott Sharp, Michael Gordon, Maya Lin, Bang on a Can, Engine27, Harvestworks, and LEMUR, directed the Princeton Laptop Orchestra for its 2007 season, co-authored Jitter, a software suite for the real-time manipulation of matrix data developed by San Francisco-based software company Cycling'74. *DuBois will oversee the interdisciplinary aspects of the content development -- in particular how the software can be used in ways that extend beyond STEM topics to include the arts and humanities, and will be responsible for crowd-sourcing research.*

Jan L. Plass, Paulette Goddard Professor of Digital Media and Learning Sciences, Founding Director of CREATE in the Steinhardt School of Culture, Education, and Human Development, has directed a broad range of projects of developing digital learning materials and conducting related empirical studies since 2001, co-directs the Games for Learning Institute in collaboration with Ken Perlin, focusing on social, cognitive, and emotional aspects of design of simulations and games for learning, and game-based assessment of learning. His research intersects learning science, cognitive sciences, and design, with the goal to enhance the effectiveness of digital media for learning and to develop new approaches to assessment with digital tools. *Plass will will oversee user testing at CREATE, analysis of learning analytics (user logs) and contribute to the design of the system and outreach.*

Biosketch for Ken Perlin

Professor of Computer Science Director, Games for Learning Institute 715 Broadway, Rm 1224, NY, NY 10003 (212) 998-3386, perlin@cs.nyu.edu

Educational experience: Harvard University, Theoretical Mathematics, B.A. 1979. New York University, Computer Science, M.S. 1984. New York University, Computer Science, Ph.D. 1986.

Employment:

7/87 Professor,CourantInstituteofMathematicalSciences,NewYorkUniversity (tenured 1993). 9/86-6/87 Research Scientist, Courant Institute of Mathematical Sciences, New York University. 10/84- 8/87 Head of Software Development, R/GREENBERG Associates, NY, NY. 7/79-9/84 Research Scientist, Mathematical Applications Group, Inc., Elmsford, NY. After 9/81 was System Architect of SynthaVision system for computer generated animation.

Five Relevant Publications:

RAPUNSEL: How a computer game designed based on educational theory can improve girls. self-efficacy and self-esteem. Plass, J. L, Goldman, R., Flanagan, M., Diamond, J., Dong, C., Looui, S., Hyuksoon Song, H., Rosalia, C. & Perlin, K. Proceedings of the American Educational Research Association , Chicago, April 2007.

Growing up programming: democratizing the creation of dynamic, interactive media. Mitchel Resnick, Mary Flanagan, Caitlin Kelleher, Matthew MacLaurin, Yoshiki Ohshima, Ken Perlin, Robert Torres: CHI Extended Abstracts 2009: 3293-3296.

The Rapunsel Project. Ken Perlin, Mary Flanagan, Andrea Hollingshead: International Conference on Virtual Storytelling 2005: 251-259.

Physical Objects as Bidirectional User Interface Elements, Dan Rosenfeld, Michael Zawadzki, Jeremi Sudol, Ken Perlin, IEEE Computer Graphics and Applications; Vol. 24 No. 1 2004.

Immersive environments: a physical approach to the computer interface. Allison Druin, Ken Perlin: CHI Conference Companion 1994: 325-328 1994.

Five Additional Publications:

The UnMousePad: an interpolating multi-touch force-sensing input pad. Ilya D. Rosenberg, Ken Perlin: ACM Trans. Graph. 28(3): 2009.

Measuring Bidirectional Texture Reflectance With a Kaleidoscope, Jefferson Y. Han, Ken Perlin, Computer Graphics; Vol. 36 No. 3, 2004.

Improv: A System for Scripting Interactive Actors in Virtual Worlds with Athomas Goldberg, Computer Graphics; Vol. 29 No. 3, 1996.

Real Time Responsive Animation with Personality. Ken Perlin: IEEE Trans. Vis. Comput. Graph.

1(1): 5-15 1995.
Pad: an alternative approach to the computer interface. Ken Perlin, David Fox: SIGGRAPH 1993: 57-64.

Synergistic Activities: Director of the multi-institutional Games for Learning Institute. Extensive collection of educational on-line java applets, which are widely used for informal science education, both by children and adults. A sample of this collection was featured by the Whitney Museum of American Art in January 2004. Developed *Emotive Face* software which is widely used by children with autism as a self-learning tool for recognizing facial expressions, and is currently used a research tool at the NYU School of Medicine to assess childrens' emotional development. *Quikwriting* text entry system is used by children with physical disabilities. Other user interaction interfaces are being used by the Computer Clubhouse project. Recipient of: SIGGRAPH Achievement Award, Academy Award for Technical Achievement, Trapcode Award for contributions of computer graphics, NYU Sokol Award for Outstanding Science Faculty, the NYU Mayor's Award for Excellence in Science and Technology, National Science Foundation Presidential Young Investigator Award. Developed computer graphics techniques widely used in many feature films (the first was TRON).

Collaborators and Other Affiliations: Winslow Burleson (ASU), David Ebert (U Maryland), Mary Flanagan (Dartmouth), Athomas Goldberg (Electronic Arts), Bruce Homer (CUNY), Katherine Isbister (NYU- Poly), Joel Kollin (NYU), Aaron Hertzmann (U. Toronto), Daniel Kristjannsen (NYU), Jon Meyer (NYU), Ken Musgrave (Fractal Worlds, Inc.), Fabrice Neyret (INRIA), Salvatore Paxia (NYU), Rosalind Picard(MIT), Jan Plass (NYU, Dan Rosenfeld (Microsoft), Luiz Velho (IMPA), Jeol Wein (NYU-Poly), Denis Zorin (NYU).

Graduate Advisor: David Lowe, NYU (currently at University of British Columbia)

Thesis Advisor and Postgraduate-Scholar Sponsor: Hubert Chang, Yotam Gingold, Aaron Hertzmann, Daniel Howe, Andruid Kerne, Daniel Kristjannsen, Xin Li, Christopher Robbins, Ilya Rosenberg, Murphy Stein, Jonathan Tompson, Adam Gashlin

Biosketch for Jan L. Plass, Ph.D.

Paulette Goddard Professor of Digital Media and Learning Sciences
New York University, 196 Mercer St., Suite 800, New York, NY 10012

Professional Preparation

Ph.D., Educational Psychology; Computer Science, 1994, Erfurt University (PH), Germany; M.A., Mathematics and Physics Education, 1990, Erfurt University (PH), Germany

Academic and Professional Appointments

2011–present	Paulette Goddard Professor of Digital Media and Learning Sciences; NYU
2010–2011	Professor of Educational Communication and Technology; NYU
2008–present	Co-Director, Institute for Games for Learning
2003–2010	Associate Professor of Educational Communication and Technology; NYU
2001–present	Director, CREATE, NYU
2000–2003	Assistant Professor of Educational Communication and Technology; NYU
1996–2000	Assistant Professor of Multimedia/Instructional Technology, University of New Mexico

Publications closely related to Proposal

Plass, J.L., O'Keefe, P., Homer, B.D., Hayward, E.O., Stein, M, & Perlin, K. (in press). Motivational and Cognitive Outcomes Associated with Individual, Competitive, and Collaborative Game Play. Special Issue on Advanced Learning Technologies. *Journal of Educational Psychology*.

Homer, B.D., Hayward, E.O., Frye, J., & Plass, J.L. (2012). Gender and Player Characteristics in Video Game Play of Preadolescents. *Computers in Human Behavior*. DOI: 10.1016/j.chb.2012.04.018

Plass, J.L. (2009, October). Simulations and Games for Science Learning: Design Patterns. Invited Panel Presentation to the National Research Council's (NRC) Board on Science Education's Committee on Learning Science: Gaming, Simulation, and Education, October 7, 2009. National Academy of Sciences, Washington, DC.

Plass, J.L., Goldman, R., Flanagan, M., Diamond, J., Song, H., Rosalia, C., & Perlin, K. (2007). RAPUNSEL: How a computer game designed based on educational theory can improve girls' self-efficacy and self-esteem. Paper presented at the 2007 Annual Meeting for the American Educational Research Association (AERA), Division C-5: Learning Environments, in Chicago.

Kröner, S., Plass, J.L., & Leutner, D. (2004). Intelligence assessment with computer simulations. *Intelligence, 33*, 347–368.

Other Significant Publications

Plass, J.L., Milne, C., Homer, B.D., Jordan, T., Schwartz, R.N., Hayward, E.O., Verkuilen, J., Ng, F., Wang, Y., & Barrientos, J. (2012). Investigating the Effectiveness of Computer Simulations for Chemistry Learning. Special

Issue on Large-Scale Interventions in Science Education for Diverse Student Groups in Varied Educational Settings. *Journal of Research in Science Teaching, 49*(3), 394–419. DOI: 10.1002/tea.21008

Plass, J.L., Moreno, R., & Brünken, R. (Eds.) (2010). *Cognitive Load Theory*. Cambridge University Press.

Plass, J.L., Kalyuga, S. & Leutner, D. (2010). Individual Differences and Cognitive Load Theory. In J. L. Plass, R. Moreno, & R. Brünken (Eds.), *Cognitive Load Theory*. New York: Cambridge University Press.

Plass, J.L., Homer, B.D., & Hayward, E. (2009). Design Factors for Educationally Effective Animations and Simulations. *Journal of Computing in Higher Education, 21*(1), 31–61.

Plass, J.L., Homer, B.D., Milne, C., Jordan, T., Kalyuga, S., Kim, M., & Lee, H.J. (2009). Design Factors for Effective Science Simulations: Representation of Information. *International Journal of Gaming and Computer-Mediated Simulations, 1(1)*, 16–35.

Synergistic Activities

Co-Director, Games for Learning Institute, NYU. Consortium of 13 faculty members from 9 universities to conduct research on the use of games for learning. Responsible for Education/Assessment part of research on design patterns for effective educational games.

Director of CREATE – Consortium for Research and Evaluation of Advanced Technologies in Education at New York University. Research lab with 5 faculty members, 4 post doctoral scholars, and approx. 12 doctoral research assistants, conducting research on a variety of topics related to the use of simulations and games in early literacy, STEM, and health education.

Service on editorial boards of Educational Psychology Review (since 2011), Journal of Computing in Higher Education (since 2008); Computers in Human Behavior (since 2005); Journal of Educational Psychology (since 2002), and others

Collaborators, Co-Editors, Graduate Students, Examinations

Collaborators/Co-Editors: Roland Brünken, University of the Saarland, Germany; Roxana Moreno, University of New Mexico, John Sweller, University of New South Wales, Australia, Bruce Homer, CUNY Graduate Center, Eric Wallen, University of New Mexico, Stephan Kröner, Univ of Erlangen, Germany, Ken Perlin, New York University, Adina Kalet, New York University, Steffi Domagk (Heidig), Erfurt University.

Graduate and Postdoctoral Advisors: Detlev Leutner, Essen University, Germany; Dorothy Chun, University of California Santa Barbara

Doctoral Thesis Advisor: John C. Chadwick, Linda C. Jones, Erik S. Wallen, Teresa A. Griffin, Heather Hamilton, Sylvia Hernandez, Hyunjeong Lee, Janet Zydney-Mannheimer, Scott Angarola, Robert Whelan, Chaoyan Dong, Eunjoon Um, Ian Aronson, Ruth Schwartz, Huyk Soon Song, Yoo Kyung Chang, Chris Allen, Jon Frye, Melissa Biles, Tsu-Ting Huang, Dixie Ching, Meagan Bromley

Postgraduate-Scholar Sponsor: Yan Wang, Florrie Ng, Elizabeth Hayward, Ruth Schwartz, Suzy Letourneau

SUSAN A. KIRCH, Ph.D.

Associate Professor, K-12 Science Education
New York University; Steinhardt School of Culture, Education and Human Development

(a) Professional Preparation

Mount Holyoke College	Biochemistry, cum laude	B.A., 1989
Harvard University	Cellular and Developmental Biology	Ph.D., 1996

(b) Professional Appointments

Associate Professor, Department of Teaching & Learning, New York University, 2007 – present
Senior Research Associate, Equity Studies Research Center, Queens College of CUNY, 2006-2007
Interim Assoc. Supervisor, Science and Math Education Centre, Curtin University of Tech., Australia, 2006
Assistant Professor, Urban Education, The Graduate Center of CUNY, 2005-2007
Assistant Professor, Early and Elementary Childhood Education, Queens College of CUNY, 2003-2007
Assistant Professor, Department of Biological Sciences and Teacher Education (dual appointment) Wright State University, 2001-2003
Post Doctoral Fellow, Developmental neurogenetics, University of California, San Francisco (NIH and HHMI Fellowships), 1997-2001
Research Associate, Department of Molecular Biology, Massachusetts General Hospital and Harvard University Medical School, 1996-1997

(i) Publications Most Closely Related to the Project (in Science Education).

Kirch, S.A. and Amoroso, M. (under contract). Teaching elementary school science. Rotterdam: Sense Publishers.

Kirch, S.A. (in review). Contradictory epistemic norms for setting criteria for truth reveal the consequences of unexamined epistemic practices in the elementary classroom. *Science Education*. (Based on work from DRL #0918533; 2009-2011)

Kirch, S.A. (2013). Instructional design that leads to the development of young scientists. In D.R. Reutzel (Ed.) *Handbook of research-based practice in early education*. New York: Guilford Press. (Based on work from DRL #0918533; 2009-2011)

Kirch, S.A. and Stetsenko, A. (Summer 2012). Studying scientific knowledge: Third grade students research using claims and evidence in science. *Science and Children,* p 44-49. (Based on work from DRL #0918533; 2009-2011)

Kirch, S.A. and Siry, C. (2010) "Maybe the algae was from the filter": 'Maybe' and similar modifiers as mediational tools and indicators of uncertainty and possibility in children's science talk. *Research in Science Education*

Kirch, S.A. (2010). Identifying and resolving uncertainty as a cultural tool in science: A comparative analysis of scientists and elementary science students at work. *Science Education*, 94, 308-335.

(ii) Other Significant Publications (in Science).

Zallen, J.A., Kirch, S.A., Bargmann, C.I. (1999). Genes required for axon pathfinding and extension in the *C. elegans* nerve ring. *Development, 126*, 3679-3692.

Kirch, S.A., Rathbun, G.A., Oettinger, M.A. (1998). Dual role for RAG2 in V(D)J recombination: catalysis and regulation of ordered Ig gene assembly. *European Molecular Biology Organization (EMBO) Journal*, *17*(16), 4881-4886.

Kirch, S.A., Sudarsanam, P., Oettinger, M.A. (1996). Regions of RAG1 protein critical for V(D)J recombination. *European Journal of Immunology, 26*, 886-891.

Liu, Z., Kirch, S.A., Ambros, V.A. (1995). The *Caenorhabditis elegans* heterochronic gene pathway controls stage-specific transcription of collagen genes. *Development, 121*, 2471-2478.

Hsu T., Gogos, J.A., Kirch, S.A., Kafatos, F.C. (1992). Multiple zinc finger forms resulting from developmentally regulated alternative splicing of a transcription factor gene. *Science, 257*(5078), 1946-50.

(d) Current Synergistic Activities

1. Jhumki Basu STEME Education and Research Center at NYU-Steinhardt (faculty co-founder)
2. Director, Young Investigators Program @ NYU-Steinhardt (after-school program in science and engineering for 4th grade students; part of elementary teacher preparation program) (2010-present)
3. Director of NYU-Steinhardt Doctoral Program in Science Education (2008-present)
4. Editorial board member for the Journal of Science Teacher Education (2009-present)
5. Past Principal Investigator of the NSF-DRK12 *Scientific Thinker Project: A study of teaching and learning concepts of evidence and nature of scientific evidence in elementary school.* Amount: $450,000. Duration: 2009-2011. Currently in data analysis and publication phase.

(e) Collaborators & Other Affiliations (past four years).

e1. Recent Collaborators and Co-Editors: Pamela Fraser Abder (NYU); Andre Adler (NYU): Michele Amoroso (New York City Department of Education); Mary Ellen Bargerhuff (Wright State University); David Grier (NYU); Jane Buter Kahle (MU); Okhee Lee (NYU); Mary Leou (NYU); Lorena Llosa (NYU); Sonya Martin (Drexel University) Catherine Milne (NYU); Katheryn Scantlebury (University of Delaware); Christina Siry (University of Luxembourg); Anna Stetsenko (Graduate Center-CUNY); Kenneth Tobin (Graduate Center-CUNY); Heidi Turner (Wright State University); Michael Ward (NYU); Michele Wheatly (Wright State University)

e2. Graduate Advisor Marjorie A. Oettinger, MGH and Harvard University Medical School
Postdoctoral Sponsor: Cornelia I. Bargmann, Rockefeller University

e3. Thesis (Doctoral) Advisory Committees (14 to date, 12 in last 5 years)

Gillian Bayne (Hunter College/CUNY); Christine Coughlin (NYU); Christopher Emdin (Teachers College/Columbia); Sanaz Farhangi (NYU); Tim Fredrick (NYU); Heather Howell (NYU); Edward Lehner (College of Staten Island/CUNY); Kara Naidoo (NYU); Wesley Pitts (Hunter College/CUNY); Ashraf Shady (CUNY Graduate Center); Christina Siry (Manhattanville College & CUNY Graduate Center); Trevor Spoonis (NYU).

iii) Budget – including salaries, supplies, travel and other costs. (1 page)

	Year 1	Year 2	Total
Personnel			
Project Manager	$60,000	$60,000	$120,000
Research Assistant (programming)	$25,000	$25,000	$50,000
Research Assistant (learning sciences)	$25,000	$25,000	$50,000
OTPS			
Workshop (travel, materials, catering)	$12,500	$12,500	$25,000
Outreach activities (hosting local meetings)	$2,000	$2,000	$4,000
Research Supplies	$500	$500	$1000
TOTAL	$125,000	$125,000	**$250,000**

iv) Budget narrative – describe and justify the requested cost elements. (1 page)

Personnel. Funds in the amount of $120k over two years (60k a year) are requested for a postdoc or Master's level project manager. This person could be primarily responsible for outreach, fundraising, and coordination of all research and development activities and will manage the overall collaboration.

Funds in the amount of $100k ($50k a year) are requested for two research assistants. One RA will focus on curriculum development and empirical studies (requiring learning sciences expertise), one will focus on programming and helps port curriculum to the online platform (requires computer science/engineering expertise).

OTPS. Funds in the amount of $25k are requested for two workshops, one each year, in which we will solicit input for our development plans (year 1) and feedback on our implementation (year 2). Additional funds in the amount of $2k per year are requested for outreach activities such as hosting meetings of local partners. Funds in the amount of $500 annually are requested for research supplies.