Envisioning the Future of Computational Media

The Final Report of the Media Systems Project

MEDIA SYSTEMS

Convening Partners

NSF

NATIONAL ENDOWMENT FOR THE Humanities

ART WORKS. National Endowment for the Arts arts.gov

Microsoft Studios

Microsoft Research

Convening Hosts

G+PM GAMES AND PLAYABLE MEDIA UC SANTA CRUZ

IHR INSTITUTE FOR HUMANITIES RESEARCH

For videos of talks and more, visit mediasystems.soe.ucsc.edu

Envisioning the Future of Computational Media

The Final Report of the Media Systems Project

Report Authors

NOAH WARDRIP-FRUIN
Associate Professor, Department of Computer Science
Co-Director, Expressive Intelligence Studio
Director, Digital Art and New Media MFA Program
University of California, Santa Cruz

MICHAEL MATEAS
Professor, Department of Computer Science
Co-Director, Expressive Intelligence Studio
Director, Center for Games and Playable Media
University of California, Santa Cruz

Design by Jacob Garbe in InDesign using Nexa Bold and Arial.

This material is based upon a workshop supported by the National Science Foundation (under Grant Number 1152217), the National Endowment for the Humanities' Office of Digital Humanities (under Grant Number HC-50011-12), the National Endowment for the Arts' Office of Program Innovation, Microsoft Studios, and Microsoft Research. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of these sponsors.

Table of Contents

Executive Summary

This is the final report of the Media Systems project, held at University of California, Santa Cruz in 2012. This gathering brought together field-leading participants from media-focused computer science, digital art, and digital humanities — located in and across universities, industry, federal agencies, publishers, and other stakeholders in the future of media. Different participants focused on diverse aspects of how new media forms are impacting culture, education, the economy, and other areas of national importance, using examples ranging from the World Wide Web to computer animation, and from video games to social media. Surprisingly — despite this diversity of background and focus — rather than struggling to explain our different fields to each other, we found ourselves engaged in deep conversation focused on a coherent set of shared activities. For the purposes of this report, the authors have chosen to name these activities *computational media*.

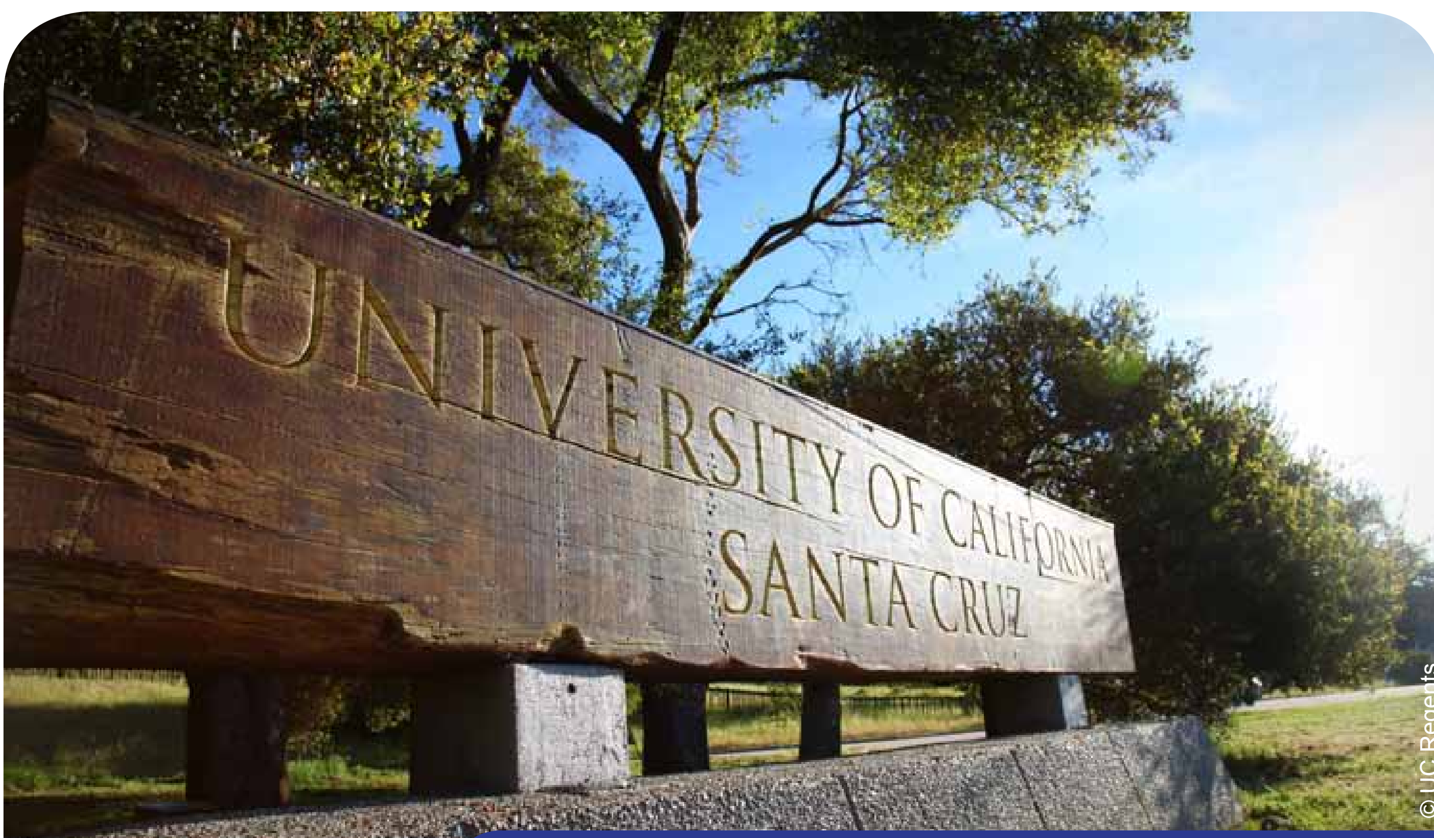
Computational media involves four types of work and develops four types of knowledge and skills — generally combining two or more of these categories simultaneously:

- **Technical** — computational media work requires and develops deep technical engagement, from the invention of new algorithms to the use of specialized tools for purposes such as 3D animation or examining code archives.
- **Creative** — computational media practitioners must exercise creative skills, from the creation of new genres of digital art and scholarship to the imagining and prototyping of new technology and tool possibilities for media.
- **Interpretive** — the creation and understanding of computational media requires being able to interpret particular examples and place them in broader contexts, from situating media forms historically to interpreting new kinds of human learning behavior enabled by computational artifacts.
- **Collaborative** — computational media work is most often carried out by interdisciplinary groups, exercising and developing 21st Century skills in communication, teamwork, and problem solving.

Looking at the same activities through a different lens, we could say that computational media work produces four kinds of outcomes — often with outcomes in multiple categories from the same project:

- **Artifacts** — the outcome of making novel computationally-driven media.
- **Capabilities** — the outcome of developing computational, representational, and design approaches that enable new forms of media.
- **Insights** — the outcome of studying the technical, historical, and cultural creation and function of computationally-driven forms of media, both old and new.
- **Educated Practitioners** — the outcome of interdisciplinary education and training in computational media.

During the discussions at the three-day Media Systems gathering (together with more than a year of followup conversation and writing) we identified a core set of opportunities and challenges facing computational media work. Examining these resulted in the development of 12 recommendations for specific constituencies, which are summarized here and discussed in greater detail at the end of this report.



Summary of Opportunities

The major opportunities can be organized into three groups. First, opportunities for economic and cultural impact. These are already significant, though computational media are among the youngest forms of media. On a cultural level, innovations in computational media shape the expression of ideas and modes of communication in a wide variety of contexts. For example, video games are becoming culturally pervasive: played in 67% of U.S. households, with 70% of U.S. companies using games to train their employees — as well as becoming recognized for their unique expressive powers (and now exhibited by venues such as the Smithsonian and the Museum of Modern Art). Economically, the video game business is now estimated at $66 billion a year and the even-younger mobile app business is estimated at $25 billion. Other forms of computational media — from computer animated films to World Wide Web pages — are at least as economically significant and culturally widespread. Computational media have reached this level of impact through innovation in new forms, providing new experiences to broadening audiences. A major focus of our recommendations is creating the conditions needed for continuing this kind of trajectory in innovation and impact.

Another area of opportunity is in addressing national priorities. President Obama's Strategy for American Innovation identifies a number of national priorities, ranging from broad-based emphases on fundamental research and 21st Century skills to highlighting very specific Grand Challenges. Computational media have important roles to play in a number of these areas. For example, they can be highly intrinsically motivating, as recognized by the administration's ARPA-ED initiative, which includes as a key goal making "Educational software as compelling as the best videogame." They can also be deeply customized, as seen in cutting edge work on intelligent educational media. They have demonstrated potential in areas ranging from health interventions to formal software verification. They are also particularly powerful for representing how systems shape our world — from civic engagement to climate change. And their creation has proven a successful focus for interdisciplinary education efforts. The powerful cultural and economic effects of the development of fundamental technologies and approaches for representing three-dimensional spaces and objects on a screen serves as

Seymour Marine Discovery Center © UC Regents

Computational media have reached this level of impact through innovation in new forms, providing new experiences to broadening audiences.

Summary of Opportunities

an exemplar of the dividends that computational media research can pay. Significant research will be required to deliver on the promise of the many other areas of computational representation that are currently underdeveloped or unexplored.

Finally, the growing importance of computational media has led to another opportunity — in education and research. Many colleges and universities have now founded one or more programs or centers in areas connected to computational media — often under umbrellas such as digital arts, video games, new media, or digital humanities. For example, nearly 300 colleges and universities are members of the New Media Consortium. Some of these are already deeply interdisciplinary centers for computational media research and/or education. Many more of them have the potential to fulfill this role, helping address the significant challenges that face the field, if the right conditions for this growth can be established.

Summary of Challenges

A key challenge facing the field is the need for sustained basic and applied computational media research. Currently, computational media work in industry is often highly interdisciplinary, but the work is generally focused on the results needed for a specific product. Teams dedicated to basic research — tackling the high-risk, high-payoff questions — are rare. On the other hand, organizations in which basic research is the norm, such as research universities, have a hard time assembling and maintaining interdisciplinary teams. This is for a variety of reasons, including: their institutions and institutional success criteria are often strongly disciplinary, their funding sources may provide no appropriate programs or mechanisms for such work, and their opportunities for publication and other research impact are generally determined by peer reviewers who may apply inappropriate metrics to judging their success.

This is related to another challenge facing the field — a lack of balance between basic and applied research. For example, in games research by far the largest investments are in applied research: games for training, games for health, games for education, games for crowdsourcing knowledge, and so on. Applied research helps define questions and creates impact, but basic research provides the foundational understandings and capabilities that allow applied research to make major strides. While it is appropriate to make these investments, applied research needs to be in better balance with basic research for the field to move forward. Media Systems participants particularly

Organizations in which basic research is the norm, such as research universities, have a hard time assembling and maintaining interdisciplinary teams,

Summary of Challenges

discussed the need for basic research in enabling new forms of media (e.g., deeply interactive narrative, radically adaptive and generative games) and in improving research and dissemination (e.g., innovative approaches to evaluation, new forms and genres for scholarly communication, education, and cultural heritage).

Further, computational media production (in industry and non-profits), research, and education are all made significantly more challenging by a lack of computational media practitioners with deeply interdisciplinary training. Industry has created special job categories for such individuals, such as “technical artist” (connecting visual art and computer science) and “gameplay programmer” (connecting experience design and computer science). But these jobs are exceptionally difficult to fill. Universities have run into the same issues when attempting to hire interdisciplinary faculty to lead computational media research and education initiatives. It is not only necessary to begin training many more truly interdisciplinary computational media practitioners, but also necessary to focus on increasing the diversity of enrolled students, the diversity of faculty, and the diversity of the fields in which students are eventually hired.

Finally, computational media lacks many of the pieces of infrastructure that help fields continue to grow and innovate. The lack of sophisticated tools and platforms in many areas of the field raises costs for all creators and results in high barriers to entry, reducing diversity in both what is created and who creates it. A lack of accessible collections of computational media works means that designers, artists, scholars, and technologists cannot gain insights from experience of the field’s history. The application of innapropriate evaluation criteria — and the lack of established, more appropriate alternatives — makes cutting edge work hard to fund and publish. And a lack of well-documented models for successful interdisciplinary work creates challenges in everything from organizing small project teams to developing major educational initiatives.

Summary of Recommendations

1 Support the Creation of New Works and Design Approaches

ADDRESSED TO: Industry; independent and non-profit creators; universities and colleges; federal and private funding agencies.

IMPLEMENTATION: Support interdisciplinary design research that results in high-risk computational media creation efforts — integrating arts, humanities, and computer science — on three scales: demonstration, project, and product.

EXAMPLE: Computational media works that attempt to translate knowledge from the history of rhetoric into new interactive forms.

2 Invest in Developing New Computational Models and Genres

ADDRESSED TO: Industry; universities and colleges; federal and private funding agencies.

IMPLEMENTATION: Support interdisciplinary basic research toward developing new technological possibilities for computational media, integrating efforts across multiple areas of computer science, the arts, and the humanities.

EXAMPLE: New technology and design approaches to enable compelling, highly-interactive dramatic characters.

Summary of Recommendations

3 Encourage New Forms of Scholarship

ADDRESSED TO: Publishers; universities and colleges; federal and private funding agencies.

IMPLEMENTATION: Invest in new publishing venues that will provide a high-quality outlet for experimentation with new forms of scholarship; revise funding programs and review procedures to support these new forms; and seek ways to recognize a broader range of scholarly activity in computational media.

EXAMPLE: Prototyping new scholarly forms that require computational media for their argument structure.

4 Cultivate Rigorous Dissemination Venues and Evaluation Approaches

ADDRESSED TO: Professional societies; publishers; conference organizers; journal and series editors; universities and colleges; federal and private funding agencies.

IMPLEMENTATION: Support computational media communities in: identifying exemplars of strong projects and research contributions; describing current best practices in computational media evaluation; developing new interdisciplinary evaluation approaches, which may combine methods formerly seen as in tension with or in contradiction with one another; and disseminating these for use in existing field-defining contexts (from journal review to tenure evaluation) and in the establishment of new dissemination venues.

EXAMPLE: A computational media track of a rigorous, high-impact conference, with distinct, publicized evaluation criteria and knowledgeable peer reviewers.

5 Build Interdisciplinary Education and Student Diversity

ADDRESSED TO: Industry; universities and colleges; federal and private funding agencies.

IMPLEMENTATION: Design degrees and student support programs to enable student-led interdisciplinary pathways; create degrees (and modify existing degrees) with interdisciplinary cores (and foundation courses) engaging the methods, languages, and problems of more than one discipline; hold workshops and summer institutes for working computational media practitioners (and those looking to transition into computational media); and use resources to recruit and support diverse faculty and students.

EXAMPLE: Transitioning a relatively disciplinary “game engineering” degree into a deeply interdisciplinary computational media degree.

6 Foster the Next Generation of Leaders

ADDRESSED TO: Industry; professional societies; conference organizers; universities and colleges; federal and private funding agencies.

IMPLEMENTATION: Develop appropriate tenure and promotion guidelines; mentoring and career development workshops; support for post-doctoral researchers (and potentially early-stage faculty) to be embedded in successful interdisciplinary computational media contexts; and support for cross-training of disciplinary researchers seeking to move into computational media.

EXAMPLE: “Hydra” post-doctoral grants, bringing together early-stage researchers from multiple disciplinary perspectives to create a multi-year computational media project under the guidance of a researcher experienced in organizing, supporting, and communicating the value of such work.

7 Support for Tool and Platform Development

ADDRESSED TO: Industry; universities and colleges; federal and private funding agencies.

IMPLEMENTATION: Provide support for tools and platforms that address needs already demonstrated by patterns of media making practice; strongly consider open source strategies, especially before putting more resources into a tool project that has thus far failed to find or create a community.

EXAMPLE: Tools that represent and can reason about the system components and play aesthetics of simulation and strategy games, enabling a dramatic broadening of creators and applications.

8 Support for Collections and Archives

ADDRESSED TO: Industry; independent and non-profit creators; libraries, archives, and museums; universities and colleges; federal and private funding agencies.

IMPLEMENTATION: Industry, independent and non-profit creators, collecting organizations, and research organizations collaborate to develop strategies for collecting and making accessible final works, the resources from which these works were created, records of the development process of works, records of reaction and contribution by audiences, and records of marketing and reception. Supporting basic and applied research in fundamental questions ranging from information organization (e.g., ontologies and metadata) to preservation and access (e.g., emulation and migration).

EXAMPLE: Developing industry best practices around archiving current “closing kit” materials with third parties, expanding to include records of the development process.

9 Promote Collaboration

ADDRESSED TO: Industry; universities and colleges; federal and private funding agencies.

IMPLEMENTATION: Supporting co-teaching and other interdisciplinary education efforts; hiring individuals who can translate across research and media-creation groups within an organization; promoting organizational structures and best practices for collaborations between computational media researchers and media creators who are in different organizations; experimenting with artist/humanist/computer scientist-in-residence programs and decentralized, partially-volunteer efforts (including with open source developers); and not assuming members of collaborations will be drawn from disciplinary backgrounds (computational media collaborations are strongest between interdisciplinary practitioners).

EXAMPLE: Create best practice intellectual property and collaboration models for computational media projects spanning industry and universities, based on studies of successful partnerships; incentivize their adoption through startup funding for centers that use them.

10 Develop Better Field Understanding

ADDRESSED TO: Professional societies; universities and colleges; federal and private funding agencies.

IMPLEMENTATION: Resources for both broad and detailed studies of computational media, resulting in specific, strongly-supported recommendations and rich, particular case studies.

EXAMPLE: An extensive research and writing project on computational media, in the vein of *Beyond Productivity* or *Our Cultural Commonwealth*, including public information gathering meetings, testimony from field experts, and analysis of available empirical data.

11 Build on Existing, Local Strengths

ADDRESSED TO: Industry; universities and colleges.

IMPLEMENTATION: Identifying nascent computational media strengths and differentiators (which may already be organized in development groups, research centers, and/or educational programs) as starting points for building computational media focus areas.

EXAMPLE: Building on local strengths in software studies, natural language processing, and human-computer interaction to develop a computational media focus area around tools for analyzing computational media authoring strategies and artifacts.

12 Establish National Centers of Excellence

ADDRESSED TO: Industry; universities and colleges; federal and private funding agencies.

IMPLEMENTATION: Found centers that engage in fundamental field-development work (from developing best practice recommendations to hosting mentoring workshops); provide loci of expertise for particular research and/or application areas; and build the national research and education infrastructure for computational media.

EXAMPLE: A center linking three North Carolina universities, and local computational media industry partners, with a research focus on operationalizing interdisciplinary models (working with experts in cognitive science, psychology, design studies, creative writing, and narrative theory) to enable new kinds of interactive media and media design tools for learning and entertainment.

Convening Participants

ANNE BALSAMO
Dean, School of Media Studies
New School for Public Engagement

BRETT BOBLEY
Chief Information Officer
Director, Office of Digital Humanities
National Endowment for the Humanities

IAN BOGOST
Distinguished Chair, Media Studies
Professor, Interactive Computing
Georgia Institute of Technology
Founding Partner, Persuasive Games

DONALD BRINKMAN
Program Manager
Bing Ranking and Relevance
Microsoft Corporation
At time of Media Systems:
Program Manager
Microsoft Research

ALAN CHRISTY
Associate Professor, History
Director, East Asian Studies
Co-Director, Center for the Study of Pacific War Memories
University of California, Santa Cruz

WENDY CHUN
Professor, Modern Culture and Media
Brown University

BETH COLEMAN
Professor, English Language and Literature
Director, City as Platform Lab at the Games Institute
University of Waterloo

GERHARD FISCHER
Professor, Computer Science
Fellow, Institute of Cognitive Science
Director, Center for Lifelong Learning and Design
University of Colorado at Boulder

KENT FOSTER
Director, University Talent Development and Outreach
Microsoft Studios

BILL GAVER
Professor of Design
Director, Interaction Research Studio
Goldsmiths University of London

CHAD GREENE
Art Director
Microsoft Studios

KIRSTEN SILVA GRUESZ
Professor, Literature
University of California, Santa Cruz
Co-PI, Latino Cultures Network, University of California

D. FOX HARRELL
Associate Professor, Digital Media
Comparative Media Studies Program
Computer Science and Artificial Intelligence Laboratory
Massachusetts Institute of Technology

IAN HORSWILL
Associate Professor, Computer Science
Northwestern University
Director of Integrative Arts, Robert S. McCormick School of Engineering and Applied Sciences
Director, Division of Graphics and Interactive Media, Department of EECS

KATHERINE ISBISTER
Associate Professor
Computer Science and Engineering, Polytechnic Institute
NYU Game Center, Tisch School of the Arts
Research Director, Game Innovation Lab
New York University

Convening Participants

PAMELA L. JENNINGS
CEO
CONSTRUKTS, Inc
Former National Science Foundation Program Officer
CreativeIT and Human Centered Computing Programs
At time of Media Systems:
Director, Earl and Brenda Shapiro Centers for Research and Collaboration
School of the Art Institute of Chicago

ARNAV JHALA
Assistant Professor, Computer Science
Director, Computational Cinematics Studio
University of California, Santa Cruz

JANET KOLODNER
Regent's Professor, School of Interactive Computing
Georgia Institute of Technology
Program Officer, Cyberlearning
National Science Foundation

JENNIFER LANGDON
Independent Writer
At time of Media Systems:
Associate Director, University of California Humanities Research Institute

BRENDA LAUREL
Adjunct Professor, Computer Science
University of California, Santa Cruz
At time of Media Systems:
Independent Designer

GEOFFREY LONG
Technical Director and Research Fellow
Annenberg Innovation Lab
University of Southern California
At time of Media Systems:
Lead Narrative Producer, Narrative Design Team
Microsoft Studios

MARY LOU MAHER
Professor and Chair
Software and Information Systems Department
University of North Carolina Charlotte

ALEX MCDOWELL
Visiting Professor, Production and Interactive Media
School of Cinematic Arts
University of Southern California
Co-founder and Creative Director, 5D | Institute

TARA MCPHERSON
Associate Professor, Critical Studies
University of Southern California
Founding Editor, *Vectors*

NICK MONTFORT
Associate Professor, Digital Media
Massachusetts Institute of Technology

KATHERINE MORIWAKI
Assistant Professor, Media Design
School of Art, Media, and Technology
Parsons School of Design

STUART MOULTHROP
Professor, Digital Humanities
University of Wisconsin, Milwaukee

JANET MURRAY
Associate Dean for Research and Faculty Affairs
IAC College Professor, Graduate Program in Digital Media
Director, eTV Lab
Ivan Allen College for the Liberal Arts
Georgia Institute of Technology

BILL O'BRIEN
Senior Advisor for Program Innovation
National Endowment for the Arts

SIMON PENNY
Professor, Art
University of California, Irvine

Convening Participants

KEN PERLIN
Professor, Computer Science
Founding Director, Media Research Lab
Director, Games for Learning Institute
New York University

STEPHEN RAMSAY
Associate Professor, English
Fellow, Center for Digital Research in the Humanities
University of Nebraska, Lincoln

JASON RHODY
Senior Program Officer
Office of Digital Humanities
National Endowment for the Humanities

DOUG SERY
Senior Acquisitions Editor for New Media, Game Studies, Design, and Digital Humanities
The MIT Press

JOHN SHARP
Associate Professor, Games and Learning
School of Art, Media and Technology
Co-director, PETLab (Prototyping, Education and Technology Lab)
Parsons The New School for Design

JOAN SHIGEKAWA
Acting Chairman
National Endowment for the Arts
At time of Media Systems:
Senior Deputy Chairman

JOEL SLAYTON
Executive Director, ZERO1
Professor, Art and Design
Director Emeritus, CADRE Laboratory for New Media
San Jose State University

ELAINE SULLIVAN
Assistant Professor, History
University of California, Santa Cruz
At time of Media Systems:
Visiting Assistant Professor, Department of Near Eastern Languages and Cultures
University of California, Los Angeles

MARILYN WALKER
Professor, Computer Science
Director, Natural Language and Dialogue Systems Lab
University of California, Santa Cruz

JIM WHITEHEAD
Professor and Chair, Computer Science
Director, Augmented Design Lab
Director, Software Introspection Lab
University of California, Santa Cruz
President, Society for the Advancement of the Science of Digital Games

R. MICHAEL YOUNG
Professor, Computer Science
Founder and Executive Director, NC State Digital Games Research Initiative
Director, Liquid Narrative Research Group
North Carolina State University

Convening Organizers

KATE COMPTON
PhD Student
University of California, Santa Cruz

ROBIN CROUGH
Project Manager
Montana State University
At time of Media Systems:
Operations Manager
Center for Games and Playable Media
University of California, Santa Cruz

CHAIM GINGOLD
PhD Student
University of California, Santa Cruz

APRIL GROW
PhD Student
University of California, Santa Cruz

ERIC KALTMAN
PhD Student
University of California, Santa Cruz

COURTNEY MAHANEY
Program Coordinator
Institute for Humanities Research
University of California, Santa Cruz

MICHAEL MATEAS
Professor, Department of Computer Science
Co-Director, Expressive Intelligence Studio
Director, Center for Games and Playable Media
University of California, Santa Cruz

JANE PINCKARD
Founder
GameGirlAdvance
At time of Media Systems:
Associate Director
Center for Games and Playable Media
University of California, Santa Cruz

IRENA POLIC
Associate Director
Institute for Humanities Research
University of California, Santa Cruz

MICHAEL TREANOR
Assistant Professor, Computer Science
American University
At time of Media Systems:
PhD Student
University of California, Santa Cruz

NOAH WARDRIP-FRUIN
Associate Professor, Department of Computer Science
Co-Director, Expressive Intelligence Studio
Director, Digital Art and New Media MFA Program
University of California, Santa Cruz

Communication and Design

JACOB GARBE
PhD Student
University of California, Santa Cruz
Document Design

BEN SAMUEL
PhD Student
University of California, Santa Cruz
Communication

NSF

NATIONAL ENDOWMENT FOR THE
Humanities

ART WORKS.
National Endowment for the Arts
arts.gov

Microsoft Studios

Microsoft Research

GAMES AND PLAYABLE MEDIA
UC SANTA CRUZ

IHR INSTITUTE FOR HUMANITIES RESEARCH