

Prof. Andrew Lippman
Chair, Departmental Committee on Graduate Students
Program in Media Arts and Sciences
Massachusetts Institute of Technology
Cambridge, MA 02139
November 2005

RE: General Exam Proposal: Revised Submission.

Dear Professor Lippman,

This is to inform you that Hayes Raffle intends to take a general examination in the field of human computer interaction, with focus on emerging interaction techniques for informal educational tools. The proposed examining committee members are:

Main Area:

Interaction Design with Tangible Interfaces

Hiroshi Ishii

Associate Professor of Media Arts and Sciences

Massachusetts Institute of Technology

Technical Area:

Technological Frameworks for Learning

Mitchel Resnick

LEGO Papert Associate Professor of Learning Research

Massachusetts Institute of Technology

Contextual Area:

Design and the Interpretation of Interactive Media

John Maeda

Associate Professor of Media Arts and Sciences

Massachusetts Institute of Technology

An introduction to the research areas is provided with a description of each topic including its importance, requirements for written examination, and the corresponding reading list.

In response to feedback from DCGS, and specific discussions with Judith Donath, the contextual area includes a revised, expanded reading list.

Sincerely,

Hiroshi Ishii
Associate Professor of Media Arts and Sciences
MIT

Proposal for Ph.D. General Examination

Hayes Raffle
November 2005

Introduction

What would a school look like in which the technology disappeared seamlessly into the everyday objects and artefacts of the classroom?

Recent efforts in the design of “tangible user interfaces” (TUIs) and “digital manipulatives” have sought to bring together interaction models like direct manipulation and pedagogical frameworks like constructivism to make new, often complex, ideas salient for young children. This general exam is concerned with developing a comprehensive framework to extend the breadth of interaction techniques for tangible interfaces for young children. Although there is value in a variety of computational media for children (both screen-based and tangible), research has suggested several areas where TUIs may provide advantages over screen-based (GUI) computational educational media:

- in colocated, collaborative learning exercises
- for tasks emphasizing motor skills and kinesthetic development
- in situations involving spatial problem solving
- in situations where a GUI may be overly complex, distracting or aesthetically inappropriate
- in applications where the user controls many things simultaneously

This examination will cover three interrelated areas underlying the design of tangible interfaces for education. The main area, **Interaction Design with Tangible Interfaces**, will survey related work in physical interaction techniques and educational media and look for common threads.

The technical area, **Technological Frameworks for Learning**, will correlate technical approaches and theoretical foundations to designing interactive educational interfaces. This will include constructivist and constructionist theories of learning as well as broader epistemological theories from the fields of education, psychology and cognitive science.

The contextual area, **Design and the Interpretation of Interactive Media**, deals with form, aesthetics and communication issues relevant to the development of TUIs for education. It draws from work in industrial and product design, graphic design, fine art and addresses the convergence of technology and the arts.

Main Area

Interaction Design with Tangible Interfaces

Hiroshi Ishii

Associate Professor of Media Arts and Sciences

Massachusetts Institute of Technology

Description

This area focuses on foundations in the design of tangible interfaces, with a specific focus on interactive tools designed for learning. This will include an overview of historical pedagogical arguments for tangible interfaces, specific design approaches to tangibles for learnings, as well as evaluation procedures for novel interface designs. This area will also include analysis of a variety of interfaces for 3d problem solving and simulation and overview the history of TUI construction kits.

Written Requirement

The written requirement for this area will be satisfied with a paper suitable for journal publication, to be administered and evaluated by Professor Ishii. This paper will discuss theoretical frameworks for tangible interfaces for education.

Signature _____ Date: _____

Foundation texts in tangible interfaces and interaction design

Ackerman, D. (1990) *A Natural History of the Senses*, Random House, Inc.

Bødker, Susanne (1991) *Through the Interface: a human activity approach to user interface design*. New Jersey: Lawrence Erlbaum Associates.

Crampton Smith, G. (1995). "The Hand That Rocks the Cradle." *I.D.*, May/June 1995, , 60-65.

Flores, Fernando and Winograd, Terry (1986) *Understanding Computers and Cognition: A New Foundation for Design*. Norwood, N.J.: Ablex Publishing.

Thackara, J., "The Design Challenge of Pervasive Computing." In *Interactions*, May-June 2001, pp. 46-52.

Wilson F. (1999). *The Hand : How Its Use Shapes the Brain, Language, and Human Culture*. Vintage.

Foundation papers in tangible interfaces

Cooperstock, J., et al. "Evolution of a Reactive Environment." In *Proceedings of CHI'95*, pp. 170-177.

Eisenberg, Michael, Nishioka, Ann and Schreiner M.E. (1998) "Helping Users Think in Three Dimensions: Steps Toward Incorporating Spatial Cognition in User Modeling," Department of Computer Science and Institute of cognitive Science, University of Colorado, Boulder.

Fitzmaurice, G., Ishii, H., Buxton, W. (1995). Bricks: Laying the Foundations for Graspable User Interfaces, *Proceedings of Conference on Human Factors in Computing Systems (CHI '95)*, ACM, Denver, May 1995, pp. 442-449.

Frazer, J. "Three-Dimensional Data Input Devices. "In *Computers/Graphics in the Building Process*, Washington, 1982.

Ishii, H. and Ullmer, B. (1997) *Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms*, in *Proceedings of Conference on Human Factors in Computing Systems (CHI '97)*, (Atlanta, March 1997), ACM Press, pp. 234-241.

O'Malley, C. Fraser, D. "Literature Review in Learning with Tangible Technologies." Nesta Futurelab series. Report 12, 2005. http://www.nestafuturelab.org/research/reviews/reviews_11_and12/12_01.htm

Weiser, M. "The Computer for the 21st Century." In *Scientific American*, 265(3), pp. 94-104.

Projects involving tangible interfaces for education

Africano D., Berg S., Lindbergh K., Lundholm P., Nilbrink F., Persson A. (2004). *Designing tangible interfaces for children's collaboration*. Extended abstracts of CHI 04.

Alborzi, H., Druin, A., Montemayor, J., Platner, M., Porteous, J., Sherman, L., Boltman, A., Tax'En, G., Best, J., Hammer, J., Kruskal, A., Lal, A., Plaisant-Schwenn, T., Sumida, L., Wagner, R., and Hendler, J. (2000) *Designing StoryRooms: Interactive storytelling spaces for children*. In *Proceedings of Designing Interactive Systems (DIS-2000)*, ACM Press, 95–104.

- Blauvelt, G., Wensch, T., and Eisenberg, M. "Integrating Craft Materials and Computation," C&C '99, Proceedings of the third conference on Creativity and Cognition, Loughborough, England, October 1999, pp. 50-56
- Cassell, J. and Ryokai, K. (2001) "Making space for voice: Technologies to support children's fantasy and storytelling." *Personal technologies* 5(3): 203-224.
- Cohen, J., Withgott, M., Piernot, P. "Logjam: A Tangible Multi-Person Interface for Video Logging." In Proceedings of CHI'99, pp. 442-449.
- Collela, V. (1998) Participatory Simulations: Using Computational Objects to Learn about Dynamic Systems Proceedings of the CHI'98 conference, Los Angeles, April 1998.
- Druin, A. "Cooperative Inquiry: Developing New Technologies for Children with Children." Proc. CHI 99.
- Frei, Phil. (2000). curlybot: Designing a new class of computational toys. Master's thesis, Massachusetts Institute of Technology.
- Gorbet, M., Orth, M. and Ishii, H. (1998) Triangles: Tangible Interface for Manipulation and Exploration of Digital Information Topography, in Proceedings of Conference on Human Factors in Computing Systems (CHI '98), ACM Press, pp. 49-56.
- Greenberg, S., and Fitchett, C., "Phidgets: Easy Development of Physical Interfaces through Physical Widgets." In Proceedings of UIST 2001, p209-218.
- Ichida H., Itoh Y., Kitamura Y., Kishino F. (2004). ActiveCube and its 3D Applications, IEEE VR 2004, Chicago, IL, USA.
- Ishii, H. (2004) Bottles: A Transparent Interface as a Tribute to Mark Weiser, in IEICE Transactions on Information and Systems, Vol. E87-D, No. 6, pp. 1299-1311.
- Itoh Y., Akinobu S., Ichida H., Watanabe R., Kitamura Y., Kishino F. (2004). TSU.MI.KI: Stimulating Children's Creativity and Imagination with Interactive Blocks, In proceeding to the Second International Conference on Creating, Connecting and Collaborating through Computing (C5'04) January 29 - 30, 2004.
- Luckin, R, Connolly, D, Plowman, L and Airey, S (2003). Children's interactions with interactive toy technology. *Journal of Computer Assisted Learning*, 19, 165-176
- Marshall, P., Price, S., and Rogers, Y. Conceptualising tangibles to support learning. Proceedings of Interaction Design and Children, Preston, England, July 1-3, pages 101-110. 2003
- Montemayor, J., Druin, A., Farber, A., Simms, S., Churaman, W., and D'Armour, A. (September 2001) Physical Programming: Designing Tools for Children to Create Physical Interactive Environments CHI 2002, ACM Conference on Human Factors in Computing Systems, CHI Letters, 4(1), 299-306.
- Newton-Dunn H., Nakano H., Gibson J. (2003). Block Jam: A Tangible Interface for Interactive Music. Proceeding of the 2003 Conference on New Interfaces for Musical Expression (NIME-03), Montreal, Canada
- Resnick M. et al. (1998) Digital manipulatives: New toys to think with. Proceeding of CHI 1998.

- Resnick, M., and Ocko, S. (1991). LEGO/Logo: Learning Through and About Design. In Constructionism, edited by I. Harel & S. Papert. Norwood, NJ: Ablex Publishing.
- Resnick, M., Bruckman, A., and Martin, F. (1996). Pianos Not Stereos: Creating Computational Construction Kits. Interactions, vol. 3, no. 6 (September/October 1996).
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- Price, S and Rogers, Y. (2004) Let's get physical: the learning benefits of interacting in digitally augmented physical spaces. Journal of Computers and Education. 15(2), 169-185.
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- Suzuki, H., and Kato, H. "AlgoBlock: A Tangible Programming Language." In Proceedings of the 4th European Logo Conference, August 1993. pp. 297-303.
- Ullmer, B., and Ishii, H. (1999) MediaBlocks: Tangible interfaces for online media (video). In Extended Abstracts of Conference on Human Factors in Computing Systems (CHI1999). 31-32. ACM Press
- Weinberg, Gili, Fletcher, R, Gan, S. 1998. "The baby sense environment: enriching and monitoring infants' experiences and communication." Conference summary on Human factors in computing systems (CHI) '98, 325-326. ACM Press.
- Wyeth, P., Purchase, H. (2002) Tangible Programming Elements for Young Children. In Proceedings of Conference on Human Factors in Computing Systems (CHI2002). 774-775. ACM Press.
- Zuckerman O., Arida, S., and Resnick M. (2005). Extending Tangible Interfaces for Education: Digital Montessori-inspired Manipulatives. Proceedings of CHI 2005.

Technical Area

Technological Frameworks for Learning

Mitchel Resnick

LEGO Papert Associate Professor of Learning Research

Massachusetts Institute of Technology

Description

This area will correlate technical approaches and theoretical foundations for designing interactive educational interfaces. It will focus on the influence of pedagogical and epistemological methods on interface design. This will include constructivist and constructionist theories of learning as well as broader epistemological theories from the fields of education, psychology and cognitive science. One goal of this area is to understand how different approaches to designing interactive media can be relevant to children at different stages of their development. Children progress through different developmental stages over time, and their mental models about the world may change. Since interaction and programming models are intuitive when they are reflections of our thinking, different programming and interaction models may be more or less meaningful to children at different times in their lives.

Written Requirement

The written requirement for this area will be satisfied with a 24-hour take home exam to be administered and evaluated by Professor Resnick.

Signature_____ Date:_____

Theoretical foundations in learning and education

- Bruner, J. (2004) *Towards a Theory of Instruction*. Belknap Press.
- Chi, M. Why is self explaining an effective domain general learning activity? in *Glaser, R. ed. Advances in Instructional Psychology*, Lawrence Erlbaum Associates, 1997.
- Cole, M., and Cole, S. (2001) *The Development of Children*, Fourth Edition. New York, NY : Worth Publishers.
- Dewey J. (1997) *Experience And Education*. Free Press; Reprint edition.
- Duckworth E. (1996) *The Having of Wonderful Ideas & Other Essays on Teaching & Learning*. Teachers College Press; 2nd edition.
- Furth, H. & Wachs, H. (1974). *Thinking goes to school; Piaget's theory in practice*. New York: Oxford University Press.
- Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.
- Gopnik, Alison et al. (2001) *The Scientist In the Crib: What Early Learning Tells Us About The Mind*. Harper Paperbacks.
- Holt, John. (1995) *How Children Learn*. Perseus Publishing; Revised edition.
- Lave, Jane and Wenger, Etienne (1993). *Situated Learning: Legitimate Peripheral Participation*. New Montessori, M. (1912). *The montessori method*. New York: Frederick Stokes Co.
- Piaget, J. (1976). *The grasp of consciousness*. Cambridge: Harvard University Press.
- Rogoff, Barbara. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.
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Relationships between technology and learning

- Ackermann, E. Enactive Representations in Learning: Pretense, Models, and Machines, in Bliss, J., Light, P. and Saljo, R. eds. *Learning Sites: Social and technological Contexts for learning*, Elsevier, 1999, 144-154.
- Ackermann, E. Perspective-taking and object construction: two keys to learning, in Kafai, Y. and Resnick, M. eds. *Constructionism in practice: designing, thinking, and learning in a digital world*, Lawrence Erlbaum, Mahwah, NJ, 1996, 25-35.
- Klopfer, E., T. Um. (2002). *Young adventurers - modeling of complex dynamic systems with elementary and middle school students*. International Conference on the Learning Sciences. York: Cambridge University Press.
- McNerney T. (2004). From turtles to Tangible Programming Bricks: explorations in physical language design. In *Personal and Ubiquitous Computing*, Volume 8, Issue 5 (September 2004), Pages: 326 – 337.
- Papert, S. (1980). *Mindstorms: Children, computers and powerful ideas*. Cambridge, Massachusetts:

Perseus Publishing.National Research Council, How People Learn: Brain, Mind , Experience and School.

Papert, S. (2000). "What's the big idea? Toward a Pedagogy of idea power." IBM Systems Journal Volume 39, No. 3 & 4.

Plowman, L. and Luckin, R. "Digital Childhoods, The Future of Learning for the Under-10s." Summary of Research 5 March 2003, Robinson College, Cambridge.

Resnick, M. "Behavior Construction Kits." In Communications of the ACM, July 1993, pp. 64-71. July 1993, pp. 64-71. ACM

Resnick, M. (1999). Decentralized modeling and decentralized thinking. In Feurzeig, W. and Roberts, N. (Eds). *Modeling and simulation in precollege science and mathematics* (114-137). Springer: New York.

Turkle, S., and Papert, S. (1990) *Epistemological Pluralism*. Signs 16, 1, 128-157.

Kinesthetic learning

Johnson, M. 1987. *The body in the mind: The bodily basis of meaning, imagination, and reason*. Chicago: The University of Chicago Press.

Kestenberg, J. S., Marcus, H., Robbins, E., Berlowe, J., & Buelte, A. 1972. "Development of the young child as expressed through bodily movement." *Journal of the American Psychoanalytic Association*, 19: 746-764. New York: APA.

Magill, R. A. 1989. *Motor learning: Concepts and applications*. Dubuque, Iowa: Wm C. Brown.

Seitz, J. A. 1992. "The development of bodily-kinesthetic intelligence in Children: Implications for Education and Artistry." *Holistic Education Review*, 35-39. Vermont: Holistic Education Press.

Physical materials for education

Brosterman N. (2002). *Inventing Kindergarten*. Harry N Abrams.

Chattin-McNichols J. (1991). *The Montessori Controversy*. Delmar Thomson Learning.

Giulio C., Zini M., (eds.) (1998). *Reggio Children – Children, Spaces, Relations*.

Liebschner J. (2002). *A Child's Work: Freedom and Play in Froebel's Educational Theory and Practice*. Lutterworth Press

Montessori M. (1982) *Secret of Childhood*. Ballantine Books; Reissue edition.

Muller T., Schneider R. (2002). *Montessori: Educational Material for Early Childhood and Schools*. Prestel; Bilingual edition.Contextual Area:

Contextual Area

Design and the Interpretation of Interactive Media

John Maeda

Associate Professor of Media Arts and Sciences

Massachusetts Institute of Technology

Description

This area deals with form, aesthetics and communication issues relevant to the development of TUIs for education. The basis of inquiry in this area is the observation that children will spend more time working with objects and interfaces that are emotionally and aesthetically engaging. Since the arts and design fields make emotional and aesthetic communication two focuses of inquiry, readings in this area will draw from the fields of industrial and product design, graphic design, fine art, and the influence of technology on art and design. A particular emphasis will be placed on work that has addressed people's relationships to machines-with-behavior.

Written Requirement

The written requirement for this area will be satisfied with a 24-hour take home exam to be administered and evaluated by Professor Maeda.

Signature _____ Date: _____

- Banham, Reyner. *Theory and Design in the First Machine Age*. The MIT Press; 2nd edition (July 25, 1980).
- Burnham, J. *Beyond modern sculpture; the effects of science and technology on the sculpture of this century*. New York: Braziller, 1968.
- Hulten, K. G. Pontus, *The Machine As Seen at the End of the Mechanical Age*, New York, The Museum of Modern Art, 1968
- Jensen, Jacob. *Design for Sound by Jacob Jensen*. 1978 MoMA Exhibition celebrating Jacob Jensen's association with Bang & Olufsen.
- Krauss, R. E. *Passages in Modern Sculpture*, Thames & Hudson, 1977.
- Lin, M. Y. *Boundaries*, Simon and Schuster, 2002.
- Lupton, Ellen. *Thinking With Type: A Critical Guide for Designers, Writers, Editors, & Students*. (Design Briefs) Princeton Architectural Press (October 31, 2004)
- Miyake, I, Fujiwara, D. Kries, M. *A-Poc Making: Issey Miyake and Dai Fujiwara*. Itra Design Stiftung; Bilingual edition (November, 2001)
- Mount, C. Bartolucci, M. (Editor), Cabra, R. (Editor). *Arne Jacobsen: Compact Design Portfolio*. Chronicle Books (June, 2004)
- Mumford, L. *Technics and Civilization*, Harvest Books, 1990.
- Naef. Naef Design. <http://www.naefspiele.ch/>
- Rand, P. *Thoughts on design*. New York: Van Nostrand Reinhold, 1970.
- Shankin, E. A. (2002). "Art in the information age: Technology and conceptual art." In Michael Corris, ed., *Invisible College: Reconsidering "Conceptual Art."* Cambridge: Cambridge University Press.
- Thompson, D. (1942). *On Growth and Form: The Complete Revised Edition*. New York: Dover Publications Inc, 1992. Reprinted from the original Cambridge University Press publication, 1942.
- Tufte, E. *Envisioning Information*. Graphics Press (May, 1990).
- Wingler, H. *The Bauhaus: Weimar, Dessau, Berlin, Chicago*. Cambridge, MA: MIT Press, 1969.

=> additional readings, included in response to DCGS feedback

Ascott, R., *Behaviourist Art and the Cybernetic Vision*

Benjamin, W., *The Work of Art in the Age of Mechanical Reproduction* (1936)

Burnham, J., *The Art of Intelligent Systems* (1969)

Burnham, J., *Real Time Systems*. Reprinted from *Artforum* (September, 1968).

Burnham, J., *The Future of Responsive Systems in Art* (1968)

Burnham, J. "Systems Esthetics." Reprinted from *Artforum* (September, 1968).

Bush, V., *As We May Think* (1945)

Goldberg, K. *The Robot in the Garden. Telerobotics and Telepistemology in the Age of the Internet*. MIT Press (2000).

Huhtamo, E. *Trouble at the Interface, or the Identity Crisis of Interactive Art*. <http://www.mediaarthistory.org/Programmatic%20key%20texts/pdfs/Huhtamo.pdf>

Interfacing reality (panel): exploring emerging trends between humans and machines. <http://doi.acm.org/10.1145/258734.258904>

Kac, E. "Interactive Art on the Internet", *Wired World, Proceedings of the Ars Electronica Symposium*, Peter Weibel, 1995.

Kac, E. http://www.ekac.org/Telepresence.art._94.html

McCarter, R. *Building Machines*. Princeton Architectural Press (1997).

Survival Research Laboratories <http://www.srl.org>

Tuchman, Maurice. *Exhibition Catalog for Art and Technology* (LACMA, 1970).

Winner, L. *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought*. MIT Press (1978).