University of Colorado at Boulder

Center for LifeLong Learning & Design (L^3D)

Department of Computer Science

ECOT 717 Engineering Center
Campus Box 430
Boulder, Colorado 80309-0430
(303) 492-1592, FAX: (303) 492-2844

Learner-Centered System Design: HCI Perspective for the Future

Panel Organizer & Moderator
Mark Guzdial, Georgia Institute of Technology, guzdial@cc.gatech.edu
Yasmin B. Kafai, University of California, Los Angeles, CA, kafai@gse.ucla.edu

Panelists
John B. Carroll, Virginia Polytechnic Institute
Gerhard Fischer, University of Colorado at Boulder
Roger Schank, Institute for the Learning Sciences, Northwestern University
Elliot Soloway, University of Michigan

Discussant
Ben Shneiderman, University Maryland at College Park

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Mark Guzdial • Graphics, Visualization, & Usability Center • Georgia Institute of Technology
College of Computing • Atlanta, GA 30332-0280 • *guzdial@cc.gatech.edu*
Yasmin B. Kafai • Graduate School of Education & Information Studies • University of California, Los Angeles • Los Angeles, CA 90095-1521• *kafai@gse.ucla.edu*

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ABSTRACT

User-centered system design (Norman & Draper, 1986) taught the HCI community to address users and their needs, but the community has learned that the needs of users are not a constant. Learner-centered design draws attention to the changing needs of users (both students and professionals) as they gain expertise and how these changes need to be reflected in the interface. The panelists will help in defining how interface design must be tailored to support users as learners with case studies of their experiences in designing adaptive and adaptable interfaces for learners.

KEYWORDS: user-centered system design, learner-centered design, diversity, education, software-realized scaffolding

INTRODUCTION

User-centered system design (Norman & Draper, 1986) focused on the needs of the user and meeting those needs in the interface. In the ten years since Norman & Draper's influential book, the community has learned that *the user* is a moving target: Diverse users have diverse needs (Leventhal, Teasley, & Stone, 1994).

Moreover, even an individual user can represent a range of changing needs when that user is changing due to

- learning a new domain,
- learning to perform a different task, and
- learning to use different tools and interfaces to those tools.

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We refer to this focus on the changing user needs due to learning as *learner-centered system design* (Soloway, Guzdial, & Hay, 1994). While traditional students are clearly the beneficiaries of this approach, business researchers and professionals (e.g., Senge, 1992) are claiming that all organizations in our fast-paced economy should be considered *learning organizations*. Professionals also need to be supported in developing expertise in their work as they develop richer and deeper understandings of (often newly invented) contents and practices.

Learner-centered design offers a new perspective in which HCI interaction principles are combined with educational interaction support. This approach draws upon research in several different domains:

- Research in the HCI community has provided examples how interaction structures can guide users through complicated tasks such as menu structures, screen layout, and effective help systems.
- Research in education has sought to characterize how learning can be facilitated. For example, teachers often use scaffolding to support students in learning new skills. Learner-centered design needs to define software-realized scaffolding to capitalize on this research.
- Research in the design of educational technologies has provided many examples how computational interaction structures such as fading interfaces, the use of multiple media, and intelligent guides or coaches can support learners in the process of successfully achieving complex tasks and learning through this experience.
- Research in psychology and sociology help in understanding how learners gain expertise and how

their needs change with the development of expertise.

DISCUSSION

This panel brings together experts who are known for their research both in HCI and educational technology to provide examples of (1) computational support mechanisms for users-as-learners and (2) design processes for these support mechanisms. In particular, the following issues will be addressed:

- Needs of learners as their expertise changes;
- Different definitions for interface scaffolding;
- Design issues of adaptable tools and interfaces;
- Design cases of learner-centered tools.

FORMAT OF PANEL

- Introductory and framing remarks by the moderators. (5 minutes)
- Panelists offer controversial opinions on the state of the art. Though each of these panelists works in educational technology, each brings different perspectives to bear on needs, approaches, and meaning of learner-centered design. (8-10 minutes)
- Discussant (Ben Shneiderman) compares and contrasts the learner-centered design approach with the established user-centered design approach. (10 minutes)
- Questions from the audience. (35 minutes)

This format offers (1) a review of the issues in learner-centered design from experts with different perspectives, (2) a comparison of the issues with the user-centered design perspective, and (3) ample opportunity for audience participation.

DISCUSSANT

Ben Shneiderman is a Professor in the Department of Computer Science, Head of the Human-Computer Interaction Laboratory, and Member of the Institute for Systems Research, all at the University of Maryland at College Park. His technical interests include user interface design, information visualization, and applying educational technology. He has written over 150 technical research papers and several books including *Designing the User Interface: Strategies for Effective Human-Computer Interaction* which was published first by Addison-Wesley in 1987. He has consulted and lectured for IBM, Apple, GE, Honeywell, AT&T, Bell Labs, Citicorp, and university research groups.

PANELISTS POSITIONS

John M. Carroll is Professor of Computer Science and Psychology, and Head of the Computer Science Department at Virginia Tech (Virginia Polytechnic Institute and State University). His research is in the analysis of human learning and problem-solving in human-computer interaction contexts, and in the design of methods, tools, and environments for instruction and design. His most recent books are *The Nurnberg Funnel: Designing minimalist instruction for practical computer skill* (MIT Press, 1990), *Designing Interaction: Psychology at the Human-Computer Interface* (Cambridge University Press, 1991), and *Scenario-Based Design: Envisioning work and technology in system design* (John Wiley, 1995).

Position Statement: **No documentation without education!**

Documentation design can seem prosaic indeed. One does not have to write with sparkle; one merely has to describe what is there: clearly, systematically, thoroughly. It would seem that much of the documentation we read has been created under such ground rules. The implicit assumption is that people use documentation for routine reference tasks: the user is pursuing a specific goal but does not know or cannot fully recall the method to accomplish it. The standard example would be checking the syntax for an advanced or infrequently-used option.

This view of documentation needs to be elaborated. Documentation is often used in exceptional circumstances: The user opportunistically notices something and wants to understand it, perhaps even interrupting the pursuit of a current goal to do so, the user makes an error and needs to diagnose and recover in order to proceed, and so forth.. Such documentation situations are also paradigmatic learning situations: People learn most effctively when they are seeking and using information in the pursuit of immediate and personally meaningful goals.

A learning-centered view of documentation suggests design requirements beyond — and to some extent in conflict with — being systematic and thorough. To support learning, documentation must support task-oriented concerns; it must help people learning while doing. Thus, it must provide information coordinated with or embedded in people's activities. It must provide information in the "language" of tasks and activities: example applications, annotated demonstrations, contextual help. Using documentation should be a creative endeavor; it should encourage people to reason about the information, to reflect on what they are doing and on the information they are using, to get more out of the documentation than its literal content, perhaps even to add their own information to the documentation.

In several projects, we have developed and explored this view of documentation. For example, the View Matcher (Carroll, Singer, Bellamy, & Alpert, 1990) documents Smalltalk applications by providing coordinated run-time views: interface graphics, a method execution stack, an object inspector, and a commentary couched in functional goals, as well as

access to object and class definitions. This tool allows the user to dynamically explore an application, to see what it does and how. In this way, it provides scaffolding for generalized learning about the Smalltalk language and environment, and about object-oriented design (Carroll & Rosson, 1995).

We subsequently extended this approach in the Reuse View Matcher, which provided dynamic and explorable documentation for reusable classes (Rosson, Carroll, & Sweeney, 1991). This tool supported a style of reuse in which the behaviors of candidate objects can be easily auditioned, and their protocols easily accessed. We found that programmers want to quickly learn about the uses of objects, not read class definitions (Rosson & Carroll, 1993).

In other work, we have explored styles of documentation that explicitly construct the tradeoffs in rationale through the course of system development. In this approach, a system is not documented merely as a static set of features, but as a concretization of an intermediate point in an open-ended design argument, pushing onward to other results. In particular, we documented systems as constituted by the set of user scenarios they enable, and the social, behavioral and system rationales that explain those scenarios (Rosson & Carroll, 1995). One of our chief goals was to support more explicit learning and reasoning about the psychological and system claims implicit in design decisions and outcomes. We showed how such documentation can support reasoning from a given design to its successor, for example, from the View Matcher to the Reuse View Matcher (Carroll & Rosson, 1991).

Our most recent work has addressed developing the concept of "design history": documenting a system by recording views of the process of its development, not merely the official views, not merely the after-the-fact reconstructions, but the informal motivations and concerns that inspired the technical decisions, and the collaborative dynamics of the design team itself that made it possible to achieve the technical objectives. Our first project of this type was a video information system consisting of brief clips in which design team members described current episodes and issues at various points through the course of a project (Carroll, Alpert, Karat, Deusen, & Rosson, 1994). Our current project is a web-based information system documenting the history of the Blacksburg Electronic Village through the documents and reflections of members of the Blacksburg community (Carroll, Rosson, Cohill, & Schorger, 1995).

People want to learn from documentation, and documentation can be a rich resource for discovery and reflection. We need to take a learning-centered approach to documentation design to fully exploit these opportunities.

Gerhard Fischer is Professor in the Computer Science Department and a Member of the Institute of Cognitive Science at the University of Colorado, Boulder. He is the director of CU Boulder's center for "Lifelong Learning and Design". His research interests include human-computer communication, use of computers in education, artificial intelligence, cognitive science, and software design. His research has led to the development of new conceptual frameworks and to the design and implementation of a number of innovative systems in the areas of cooperative problem solving, integrated domain-oriented design environments, intelligent support systems and end-user modifiability.

Position Statement: **Rethinking and Reinventing Education and Computing Environments from a Lifelong Learning Perspective**

We must reconceptualize our educational system by acknowledging that coverage is impossible and obsolescence is unavoidable. Learning cannot stop with a high school diploma or an undergraduate degree. The world is constantly evolving creating the challenge for skilled workers to deal with change and for universities to prepare for change.

In our research, we (1) explore conceptual frameworks (including: learning on demand, reflection-in-action, breakdowns as sources of creativity, telecollaboration), (2) create computational environments (including: domain-oriented design environments, critiquing systems, end-user modifiability), and (3) assess our approach in naturalistic environments (including: realistic use situations with skilled domain workers).

Technology will not fix education. The major argument driving current business reengineering efforts is that investments in information technology have delivered disappointing results because companies tend to use technologies to mechanize *old ways of doing business.* I claim that a similar argument can be made for education: we use technology as an add-on to existing practices, instead of fundamentally rethinking what education should be about in the next century. Old educational frameworks and practices such as instructionism, fixed curricula, memorization, decontextualized learning, solving given problems, working in isolation from knowledge in the world will not turn into more promising ways to educate the knowledge workers of the future by applying technology to them — whether this technology is computer-based training, intelligent tutoring systems, multimedia, or computer networks. What is needed instead are new educational frameworks such as lifelong learning, the integration of working and learning,

allowing learners to engage in authentic problems, supporting learning on demand and (intrinsic) motivation, and transcending the focus on the individual by emphasizing collaborative and organizational learning.

Lifelong Learning. Our focus on lifelong learning is more than "adult education". It postulates that learning cannot stop with a high school diploma or an undergraduate degree. It is an approach to education that is applicable to learners of all ages by bringing the child's experience closer to meaningful and personalized work and the adult's experience closer to one of continued growth and exploration. By emphasizing learning as a new form of labor and by acknowledging that coverage is impossible and obsolescence is unavoidable, new educational strategies such as learning on demand and the integration of working and learning become necessities rather than remaining options. Current school and university education does little to prepare students to become lifelong learners: (1) by being lecture dominated, it emphasizes knowledge transmission rather than knowledge construction, (2) by being curriculum dominated, it gives little room for authentic, self-directed learning activities, (3) by asking students to solve given problems, problem framing is not practiced, (4) by giving closed book exams, it ignores the importance of distributed cognition, and (5) it puts little emphasis on collaborative learning and communication skills.

Requirements for Computational Environments in Support of Lifelong Learning. The engagement in authentic problems requires that the choice of tasks and goals must be under the control of the user/learner, resulting in the requirement that systems are *simultaneously* learner-controlled and supportive. This requirement illustrates the limitation of general purpose programming environments (such as Logo, Scheme, Smalltalk) which fail on the supportive end and intelligent tutoring systems which fail on the learner-controlled end.

The limitation of the individual human mind and the necessity to rely on distributed cognition (either as things which make us smart or as other human beings who engage with us in collaborative work practices) requires that in order to avoid information overload these agents help us with information which is relevant to "the task at hand" by saying the "right" thing at the "right" time in the "right" way.

Emphasizing active knowledge construction rather than passive knowledge absorption leads to the requirement to support learning by doing (based on conceptual frameworks such as "reflection-in-action" and "argumentation serving design"). Because artifacts and actions do often not speak for themselves, we need processes which identify breakdowns and contextualized information spaces which allow us to reflect upon these breakdowns.

Domain-Oriented Design Environments. Over the last decade, we have developed domain-oriented design environments as prototypes of systems supporting these educational goals and the requirements derived from them. By bringing tasks to the forefront, these environments support "human problem-domain communication" (and not just human computer interaction). They serve as artifact memories allowing stakeholder to engage in long-term, indirect collaboration. By providing mechanisms such as specification of components and embedded annotations, they have an understanding of the task at hand. Critiquing is used to increase the "back-talk" of the situation and to provide learning on demand opportunities. Support for end-user modifiability allow the evolutionary development of these environments by allowing users (depending on the context) to act either as learner or as teacher.

Roger Schank directs the Institute for the Learning Sciences and is John Evans Professor of Electrical Engineering and Computer Science, Professor of Psychology, and Professor of Education at Northwestern University. Schank is the author of over a dozen books, is widely published in journals, and is invited regularly to speak in this country and abroad on artificial intelligence, learning, and improving schools.

Position Statement: Let's face it, when it comes to learning the schools have failed miserably. After years of education we become good at test taking, proficient at memorization, okay at writing book reports or accounts of our summer vacation, capable of asking where the pen of our aunt has gone to in French, and competent at citing the main products of Venezuela. What happens when we want to know something in our adult lives? What happens when we need to learn something new? We can only resort to what we know about how to learn, and this means reading, memorizing, preparing for tests, all the stuff we learned how to do in school. In so doing we replicate the problems of the educational system in our own lives, and we don't learn. When businesses decide that their employees should know something new, they make the same mistake. They send employees to training courses that look an awful lot like school, full of workbooks, tests, lots of stuff to read, and worst of all — endless lectures. We have employees memorize the seven principles of this or the five best methods of that. This isn't learning, but as a society enmeshed in an outdated educational system, we can't hardly tell the difference any more.

What is the answer? Computers.

Why? Because they allow for doing. The trick is to find ways for doing and teaching to be intertwined electronically.

Elliot Soloway is Professor in the Electrical Engineering and Computer Science Department and in the School of Education at the University of Michigan. His column, *Log On Education*, in *Communications of the ACM* addresses educational technology issues. His research interests include highly-interactive computing environments, facilitating students engaged in complex learning activities, and learning through programming-like activities.

Position Statement: Ease of use is not enough; while it has served the HCI community well for a number of years, we must move beyond ease of use as the driving objective. Learners have unique needs that must be addressed if computers are truly to become ubiquitous and productive agents. Motivation, diversity, growth – and ease of use – all must be addressed. And, learners are not just short users; we are all learners, all the time. Computers can do more to support learning; we in the HCI community need to step up to the challenge.

ORGANIZERS

Mark Guzdial is an assistant professor in the College of Computing at Georgia Institute of Technology. He is a member of the Graphics, Visualization, and Usability Center and of the Cognitive Sciences Program. His research interests include contextualized programming and learning environments.

Yasmin Kafai is an assistant professor in the Graduate School of Education & Information Studies at the University of California, Los Angeles. Her research interests include computational learning environments in mathematics and science for children and the design of software tools for young software and game designers.

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