**Human-Computer Interaction and the Learning Sciences†**

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**Abstract:** Human–Computer Interaction (HCI) research has been highly influential in understanding the potential of new technologies to support human activities. Research in the Learning Sciences (LS) draws on multiple fields to improve learning and education. Both are active research communities with well-established practices, core values and a substantial body of literature. As both concentrate on utilizing computing technologies to better support people, there is a natural overlap; however, the Learning Sciences are not simply HCI applied to the domain of learning. The practices, traditions, and values are substantially different leading to tensions are keenly felt by researchers who actively participate in both fields. They also make it harder for researchers in either field to move towards the other. To explore and improve the relationship between these fields, we organized the workshop “Human-Computer Interaction and the Learning Sciences.” This workshop was meant for both interdisciplinary researchers (i.e., active participants in both communities) and researchers from either discipline interested in the other field. In this paper, we support these audiences by providing introductions to the two fields: their histories, values and practices.

**Introduction**

There has been recent interest in the Learning Sciences (LS) to build on the tools, methods, and knowledge of Human-Computer Interaction (HCI). Many of the problems of technology-supported learning and education are not primarily addressed through innovations in learning theory (a particular emphasis in LS) but by addressing problems through usable and innovative designs (an emphasis in HCI). At the same time, work in HCI that focuses on learning and education could benefit from the methods and theoretical focus of the learning sciences. There are some questions that may need an answer from the intersection between HCI and LS, for example: how to make sure that usability issues in the user interface do not affect students’ learning outcomes? Which design principles should be considered when designing learning tools? Are usability tests enough to evaluate a learning application?

Much research in the field of HCI studies how people interact with computers and to what extent the computer interfaces are developed for successful interaction with humans (Myers, 1998). HCI Research has been a key factor that has driven the evolution of computing as we know it and nowadays almost all software that is written provides some type of user interface. HCI itself is interdisciplinary, resting on foundational principles of computer science, psychology, design, human factors, and ergonomics. However, HCI techniques themselves cannot fully evaluate the effectiveness of a learning user interface (Coppin, 2011). Generally, the relationship between a learner (and multiple learners) and the computer(s) involve a rich number of processes and dynamics happening in and around learners’ context.

The purpose of this workshop is to establish a better sense of the relationship between HCI and LS. Particularly, the workshop aims to explore if the right questions can be set and whether the intersection between HCI and LS can offer some answers towards the construction of more effective learning tools and interfaces.

**The Learning Sciences**

Learning sciences has its roots in the cognitive science revolution, which demonstrated that modeling the cognitive aspects of the brain was useful for understanding behavior. Based on its origin in psychology, research on cognitive science primarily built on conducting controlled laboratory experiments of simplified tasks that focused on a specific aspect of cognition. As Lave (1988) demonstrated, these artificial tasks did not adequately describe or predict cognition in the wild. So, while cognitive science research claimed implications for learning and education, it was not clear that these held validity and therefore, there was little general interest in putting the implications into practice. Thus, the Learning Sciences community split off to concretely address the problems of learning and education. It retained cognitive science's emphasis on theory and model building, and a scientific approach to conduct research.

† Website: https://surfacelarning.org/HumanComputerInteraction
A first emphasis of the LS is on theories of learning: what goes on in the mind. Techniques for encouraging learning, in both formal and informal education, should build on a sound understanding of how people learn (Bransford, Brown & Cocking, 2000). A second emphasis is on theories of instruction: what goes on in the world. While the former has implications for the latter, the latter cannot be solely derived from the former. Useful theories in both areas can inform practice. For instance, cognitive apprenticeship (Collins, Brown & Newman, 1989) combines a cognitive theory of learning with an apprenticeship theory of instruction; in comparison to traditional apprenticeship, the focus is on cognitive skills. Learning by Design (Kolodner et al., 2003) combines a case-based reasoning theory of learning with a problem-based learning theory of instruction. A third emphasis of the LS is on design-based research: simultaneously improving and studying learning. Although controlled experimental studies are still valued, additional focus is given to creating effective activities or environments. One influential technique was design experiments (Brown, 1992), which prescribed a process of iterating between controlled laboratory studies and realistic field studies.

A fourth emphasis of the LS is on the social aspects of learning. Learning often occurs through the support of others (e.g., Vygotsky, 1978). It is also situated in a specific social context that affects learning (e.g., Lave and Wenger, 1991). As a complement to this social perspective, there has been increased interest in considering individual identity formation (Rick et al., 2012). A fifth emphasis is on valuing multi-disciplinary perspectives. Unlike cognitive science, the term Learning Sciences is intentionally plural. Researchers from education, psychology, computing, design, anthropology, and other areas, contribute to the LS field. There is both an emphasis on inclusion but also valuing the individual perspectives and contributions of each field (or Learning Sciences) At the same time, there has been an emphasis on strengthening the core. There are increasingly more academic programs that directly align themselves with the Learning Sciences. The first of these, Northwestern University, accepted students in 1992. A sixth emphasis is on international participation. While the early conferences were held in the USA, recent conferences have included Australasia and Europe.

The year of 1991 saw both the first conference of the Learning Sciences (ICLS, organized at Northwestern University) and the founding of the Journal of the Learning Sciences (JLS, publisher Lawrence Erlbaum Associates, founding editor Janet Kolodner). The conference would next meet in 1994 and continue at a biennial basis. Around the same time that the LS community was establishing itself, there began to be interest in supporting collaborative learning with computers (Stahl, Koshmann & Suthers, 2006), under the umbrella term Computer-supported Collaborative Learning (CSCL). This was particularly influenced by the arrival of computer networks and the Internet. This research movement was also theory driven, separating it from more general e-learning. It stressed collaboration among the students beyond simply splitting up a task: learners needed to negotiate and share meanings (Dillenbourg, 1999). The first use of the term for an event (often considered the start of CSCL) was at a NATO-sponsored workshop in Maratea, Italy in 1989. The first full CSCL conference was organized at Indiana University in 1995. It has continued at a biennial rate since then.

At the 2002 conference, the two fields were officially combined under the governing body of the International Society of the Learning Sciences (ISLS). The relationship had been close before as many of the foundational articles for CSCL were published in JLS. However, it should be noted that there is still some tension between CSCL and the LS. While LS is broader, it did not simply swallow CSCL. At the next conference, a CSCL Community inside ISLS was founded. In 2006, to further highlight the special designation of CSCL, the International Journal of Computer-Supported Collaborative Learning (iJCSCL, publisher Springer Verlag, founding editors Gerry Stahl and Friedrich Hesse) was established. Springer Verlag has also started a CSCL book series to cover specific topics relevant to CSCL in depth (first volume published in 2003).

Both conferences publish a variety of formats, including long, short papers and symposia. Though they are refereed (acceptance rates around 30%) and made publicly available in the ACM Digital Library, ISLS conference publications are not considered archived; authors retain their copyright and can publish the contents elsewhere. This decision was made so that authors could easily expand their conference contributions and submit them to the journals. Both JLS and iJCSCL have quickly grown to be highly influential journals in the education domain. Given the two journals and the conference proceedings, there is an established research literature on the LS. In addition, there have been introductory collections offered for both the Learning Sciences (e.g., Sawyer, 2006) and CSCL (e.g., Koschmann, 1996).

Human-Computer Interaction

Much like the LS, HCI is multidisciplinary in nature. It draws heavily from computer science, engineering, and design while appropriating theoretical and methodological approaches from cognitive science, psychology, sociology, anthropology, communication, and economics among others (Dix, Finlay, Abowd, & Beale, 2003). HCI, as a field, emerged in the late 1970s and early 1980s as personal computers became commonplace and the challenges of creating usable systems for non-experts became increasingly apparent. And, similarly to the LS, cognitive science and cognitive psychology played central roles in early HCI research as attempts were made to develop intricate models of interaction between users and machines (Card, Moran, and Newell, 1983).

HCI has been described as a community of communities (Carroll, 2009), which is reflected in the diverse array of conferences and sub-communities that self-identify with HCI. These conferences include
human factors in computing systems (CHI), computer-supported cooperative work (CSCW), Symposium on User Interface Software and Technology (UIST), Designing Interactive Systems (DIS), Interaction Design and Children (IDC), and Tangible, Embedded, and Embodied Interaction (TEI), to name a few. While these communities are diverse (with different emphases, values, and perspectives), they all have high standards for technological innovation.

One foundation of HCI is usability—the proposition that how usable a system is by its users has a profound effect on how useful it is. Even everyday objects can be systematically analyzed in terms of their usability (Norman, 1988). Unfortunately, even seemingly trivial objects (e.g., doors) are often designed without proper regard for usability, leading to unsatisfactory experiences. While there are established rules-of-thumb for considering usability (e.g., visibility, consistency, error recovery), one of the most fruitful techniques is testing the design with users (Nielsen, 1993). This concentration on human users is even reflected in the field’s name. In its early days, the field was often termed CHI for computer-human interaction; the largest conference in the area is still abbreviated as CHI. In order to indicate the importance of considering the human, the field’s name was changed to HCI, putting the human first.

Just as critiquing a movie is not sufficient for creating a movie, usability evaluation alone is not sufficient for designing usable interfaces. Hence, another focus of HCI has been on interaction design (Rogers, Sharp, & Preece, 2011). These techniques are generally user centered, with user involvement occurring early and often. One common technique is prototyping—quickly creating a low fidelity version of the system to test with users. Getting users involved early can expose problems early and thus significantly save on development time. Over time, the role that users play in the design process has been greatly expanded (e.g., test users, informants, design partners). Even children can be trained to be productive members of a design team (Druin et al., 1998). Design is an iterative process and there is a natural trade off between carrying out more iteration cycles and thoroughly evaluating each iteration. Interaction design favors the former over the latter. Even convenience samples, that do not represent actual end users for the system, can be useful in improving a design.

Over time, there has been a continual broadening of scope in HCI research driven by the expansion of digital technology and its role in everyday life. This, in turn, has led to a corresponding broadening of the unit of analysis—from individual users interacting with individual machines to populations of people interacting through and with technology on a global scale. While there are a few established journals, conferences are the premier venue for publication in HCI. It is not uncommon to find HCI researchers that target two conferences a year for their primary contributions. As a consequence, acceptance is highly competitive (often <20% at premier conferences) and the review process is taken very seriously. Larger conferences, such as CHI, have multiple committees to submit work to with different standards of contributions. Matching submissions to reviewers is often a sophisticated process and papers are usually evaluated by three to five reviewers. It is also not uncommon to have a multi-stage review process where authors are invited to a rebuttal (arguing that faults that reviewers find are not as damning as suggested) or even a revision cycle. Conference publications are considered archival, widely distributed (usually through the ACM digital library) and highly cited.

Synergy & Challenges

While they are separate fields, Learning Sciences and HCI have common roots. Both have a human focus, trying to solve real problems, usually in authentically complex contexts, and both make use advanced technologies to support that goal. Both have an activist tradition that current practice can be improved, and both have a strong bias towards conducting scientific studies and building theory around evidence.

Even though there is a noticeable connection between the fields, the strengths are underexploited. What HCI brings to the table is a focus on design, both what makes for an effective product and what makes for an effective design process. The community continually pushes on what is technologically possible while, at the same time, reimagining the relationships between people, machines, communities, and societies. HCI research on a new technology is likely to exist before it makes its way into Learning Sciences research. As HCI research tends to reflect on putting new technology into practice, learning scientists can appropriate this knowledge for their own developments. In addition, HCI evaluation and design techniques apply to Learning Sciences contexts and learning scientists would benefit from applying them to their own work.

What learning scientists bring to the table is a sophisticated understanding of learning. What makes for effective learning? In comparison to other human-computer interface domains where efficiency or usability can be more easily quantified, measuring learning is complex. Facts, cognitive skills, metacognitive skills, communication/collaboration skills and epistemologies are all worthy of consideration. Motivation too may be more salient in a learning context (Soloway, Guzdial, & Hay, 1994). What are the important problems in education and learning that need to be addressed? Using a technology to address a learning goal that is already well addressed through other means, might contribute to our understanding of the technology but does little to improve education. What theories of learning and instruction do we build upon? Just as there are guiding theories from HCI about what makes a usable design or what makes for an effective design process, there are established theories of how people learn and what practices can best facilitate those. A standard HCI practice is applying technology to solve an important problem. Learning can be such a domain and learning scientists can
reflect on which problems are worth solving. As a starting point, the research communities could benefit by being more aware of each other’s perspectives and existing contributions (i.e., cross-disciplinary communication). Building on that would facilitate cross-disciplinary collaboration. Over time, this might even promote interdisciplinary work, where there are simultaneous contributions to both fields.

The Workshop: Purpose and Contribution
The purpose of this workshop is to deepen the community’s shared knowledge and to better the relationship between the fields. This workshop aims to explore how we can better support work at the intersection of the fields. Some questions the workshop intends to address include:

1. How can the Learning Sciences benefit from HCI methods (e.g., usability, rapid prototyping, user-centred design)?
2. What can the Learning Sciences learn from the HCI research field (e.g., being aware of related work)?
3. How do we disseminate answers for the first two questions to the larger Learning Sciences field?
4. How do we better support HCI researchers with some interest in Learning Sciences?
5. How do we better support Learning Sciences researchers with some interest in HCI?
6. How do we better support true interdisciplinary researchers?
7. Are there possibilities to move this conversation forward and perhaps forming a stronger community at the intersection of the fields (SIG, community, CSCL special issue)?

The workshop is based on critical issues in interdisciplinary HCI / LS work or visions of how to advance the relationship between HCI and LS both presented by the participants of the workshop. It is expected that the workshop will produce:

1. Critical discussion and collective analysis regarding case studies described in the accepted papers.
2. The position papers will be published in separate proceedings of the workshop that will be available at the workshop’s website.
3. Generation of a summarising paper (by workshop organisers) based on the workshop proceedings after the workshop.
4. Eventual joint publication of the papers presented in the workshop and an overview of the current tendency of the intersection of HCI and LS in a Journal special issue (to be defined).

Organizers
Jochen Rick’s research interests lie at the intersection of learning, collaboration and new media. He creates innovative and effective educational technologies and researches their value in authentic contexts. His current research focuses on supporting co-located collaborative learning with interactive surfaces. In 2010, he joined the new Department of Educational Technology, Saarland University as a research associate / instructor, contributing a computer science perspective to an interdisciplinary department. Before that, he spent three years as a research fellow at the Open University in Yvonne Rogers's HCI group. In 2007, he received a Ph.D. in Computer Science (area of Learning Sciences and Technology) from the Georgia Institute of Technology; his dissertation research, supervised by Mark Guzdial, investigated the role that personal home pages play in academia. His work on CoWeb (Collaborative Websites) was the first research on using wikis to support learning in university classes.

Michael Horn in an assistant professor at Northwestern University, USA with a joint appointment in Computer Science and the Learning Sciences. He received his PhD in Computer Science and Human-Computer Interaction from Tufts University. Michael's research explores the role of emerging interactive technology in the design of learning experiences. His projects include the design of a tangible computer programming language for use in science museums and early elementary school classrooms; and the design of multi-touch tabletop exhibits for use in natural history museums. Michael has presented work at cross-disciplinary conferences including Interaction Design and Children (IDC), Tangible, Embedded, and Embodied Interaction (TEI), Human Factors in Computing Systems (CHI), ICLS, and AERA; he is on the editorial board for the Journal of Technology, Knowledge, and Learning; and he is the program committee for ACM Interactive Tabletops and Surfaces (2012 and 2013). Michael co-organized a workshop on Technology for Today’s Family at CHI 2012.

Roberto Martinez-Maldonado is a PhD candidate in the Computer Human Adapted Interaction Research Group at The University of Sydney, Australia. His research focuses on analyzing data generated when groups of students collaborate using shared devices to foster teachers’ awareness of their learning processes.. His research grounds on principles of HCI, CSCL, Educational Data Mining and Learning Analytics; he makes use of a number of technologies including multi-touch interactive tabletops, tablets, kinect sensors and databases. He has presented work at interdisciplinary conferences that include Intelligent Tutoring Systems (ITS), Artificial Intelligence in Education (AIED), Interactive Tabletops and Surfaces (ITS) CSCL, ICLS and
References


