Transcending “Cultures”
—
Creating a Shared Understanding between Computer Science and Sport

Gerhard Fischer

Center for LifeLong Learning & Design (L^3D)
Department of Computer Science and Institute of Cognitive Science
University of Colorado, Boulder

Abstract

Historically, computer science and sport as scientific disciplines represented different “cultures” with their own worlds for investigation, their own approaches, and their own methodologies. Creating a shared understanding between these disciplines has the potential to benefit both of these “cultures” and to serve as a source for new possibilities enriching both fields.

1 The Two (or Many) Cultures

C.P. Snow has identified in his book [Snow, 1993] two cultures (in his case: the literary intellectuals and the natural scientists) “who had almost ceased to communicate at all.” He further claimed that “there exists a profound mutual suspicion and incomprehension, which in turn has damaging consequences for the prospects of applying technology to the alleviation of the world’s problems” and “there seems to be no place where the cultures can meet.” For the purpose of this article, I intentionally do not attempt to define the concept of a “culture” precisely, but use it primarily to differentiate between computer science and sport as two different cultures. Over the years in our research center, we have experienced and brought together many different kinds of cultures such as people from academia and from industry, software designers and software users, and students and researchers from different countries around the world. Beyond these uses the concept is also used to characterize different approaches to work, education, and learning [Bruner, 1996].

In a world of increasing specialization where the Renaissance scholar is a person of the past, the organizers are to be congratulated for defining the objectives of this symposium as “conceived for all those who are interested in an exchange of experiences and ideas regarding the use of computer science in support of the development of theory and practice in sport.”

I strongly believe that the differences between cultures should not only be seen as an obstacle, as a limitation, or a source of incomprehensibility, but as a foundation for new insights, possibilities, and creativity. In many situations having different viewpoints helps one discover alternatives and uncover tacit aspects of interesting problems to cope with.

In the context of this paper, the concept of a "culture" is used broadly and is defined by *common* concerns, attitudes, standards, patterns of behavior, approaches, assumptions, and values. Examples of cultures are: intellectual cultures (as identified by Snow); computer science and sports (as explored and discussed in this symposium); system designers and system users (as participating stakeholders in design processes, for example in architectural design or computer system design); basic science and applied science, universities and industry; and different national cultures.

2 Overcoming the "Symmetry of Ignorance" through Mutual Learning

"If a lion could speak would we understand him?" Wittgenstein

We live in a world in which the Renaissance scholar (the person who knows everything important) does not exist anymore. Even in narrowly defined fields (for example, as high-functionality computer applications such as operating systems and word processors), "experts" do not exist anymore. The (individual) human mind is limited and there is only so much we can learn and know. The distribution and decentralization of knowledge between different individuals, different professional groups, and different artifacts (e.g., books, computer programs, films, etc.) creates the fundamental problem of how we can overcome the "symmetry of ignorance" [Rittel, 1984] and create an increase in socially shared cognition, practice, and understanding [Resnick et al., 1991] through mutual learning, thereby avoiding rigid divisions between disciplines, the lack of mutual comprehension, and misplaced feelings of superiority or disdain in different professional groups. We have to find ways and to develop means to allow different cultures to talk to each other and to engage them as active participants in solving problems and in inventing the future (e.g., to liberate social scientists from their passive consumer and Cassandra role, and to make technologists aware that technological changes and innovations do not happen in isolation but in existing social networks involving people). Accepting the fact that distinct domain of human knowledge exist creates a number of important challenges:

1 specialists have to put their knowledge in language non-specialists can understand, and

2 environments, objects, and languages need to be created to afford the possibilities for mutual appreciation and to support efforts in understanding and learning from each other.

3 Computer Science to Sport

In this section I will first enumerate briefly some of the areas of computer science that have been, are or could be, successfully used and exploited for the needs of researchers and practitioners in sports and then describe in a more detail some of our own research efforts.

Computational media have become ubiquitous for all disciplines and have changed how people think, work, learn, and collaborate [Bush, 1945; Norman, 1993]. Therefore many developments of computer science have been successfully exploited in sports. Examples are:

1 computational support for empirical research methods (e.g., statistical packages to analyze data, spreadsheets to discover dependencies between the data);

2 databases, expert systems and digital libraries (e.g., video material of famous athletes) can serve many purposes such as:

2.1 helping coaches to analyze game statistics, put them into graphs, and sift through video tapes of selected athletes (for an example, see: http:www.siscommedia.com/);

2.2 serving as a motivating tool to explore problems in human motion, physics and mathematics (http://www.terc.edu/handson/f94/cartcam.html) in conjunction with video analysis software;

2.3 developing instructional/teaching videos for athletes and teams to demonstrate the correct technique or strategy in a given context (videos of this type are provided for example by some of the German Olympic Centers); or

2.4 coupling a simulation component with the integrated expert system, database, and video component providing the additional opportunity to analyze “what if” scenarios (for an example of this approach in tennis and table tennis, see [Uthmann, 1995]).

3 process languages to describe complex process: [Papert, 1980] discusses how an understanding of subprocedures leads to more descriptive language than step-by-step instructions to describe juggling;

4 augmented realities and ubiquitous computing in which physical and computational worlds are tightly integrated (for details see example below) (for a workshop on "Cooperative Buildings—Integrating Information, Organization, and Architecture”, see: http://www.darmstadt.gmd.de/CoBuild98).

Example of our Work: Domain-Oriented Design Environments. Over the last decade we have developed domain-oriented design environments to support design activities in different domains. These environments transcend other computational environments in the following dimensions:

1 they support human problem-domain communication by bringing tasks to the forefront, putting owners of problems in charge, and reducing the conceptual distance between the world to be modeled and the modeling world. Domain-oriented software is more usable than generic software because users directly interact with familiar entities and do not need to learn new computer-specific concepts;

2 they increase in the “back-talk” of the situation [Schön, 1983] by incorporating critics [Fischer et al., 1993] to represent the knowledge and insights of “virtual” stakeholders;

3 they make argumentation serve design by making design rationale relevant to the task at hand [Fischer et al., 1996];

4 they provide access to contextualized information by retrieving cases in a catalog that come closest to the ongoing design activity; and

5 they provide interesting alternatives to *intelligent tutoring systems* [Wenger, 1987] (where the problem is given by the teacher or the system) and *interactive learning environments* (such as LOGO [Papert, 1980]), which lack support when a learner is stuck.

Example of our Work: Integration of Physical and Computational Environments. In all environments where physical worlds are modeled in computational environments, we need mechanisms to make the computational world aware of what is happening in the physical world and to map events back and forth between the two. The problem is not as challenging in many research projects in L^3D because in the domain chosen, namely design activities, many interactions and events happen within the environment, thereby we avoid tracking the location of physical objects moving through space and/or analyzing speech and vision. One example to support this integration is the Electronic Cocktail Napkin (http://wallstreet.colorado.edu-/ENVD_Mosaic_Files/Sundance_Lab/brochure.html), a computational drawing environment that can parse drawings produced with pen-tablet technology into a form that is interpretable by computer. This allows designers to take advantage of computational support mechanisms, such as editing, critiquing, and simulation in their work.

There is a growing interest in understanding the trade-offs between different design media. Members of our research center have pursued the analysis and integration of different design media for a long time [Arias et al., 1997]. We have:

1 identified the similarities and differences between technical construction kits and programming;

2 overcome the abstract nature of mathematics [Eisenberg & Nishioka, 1997], integrating both the abstract and real-world aspects of mathematics by allowing children to design and construct polyhedral models and sculptures; and

3 integrated technical construction kits with programming by developing a programming environment (called “LegoSheets”) which empowers end-users to program the behavior of computationally enriched physical objects (http://www.cs.colorado.edu/~l3d/systems-/legosheets/)

Beyond our own work, there is a growing interest in blending real-world artifacts with computational media. Physical media and computational media have different strengths and weaknesses. The strength of physical media is their concreteness and that they obey physical laws; their weaknesses are that they are passive, incapable of changing their representations without activity by their users (i.e., all interpretations have to come from the humans and all computations must be done by physically present humans). Computational media have often the reversed strengths and weaknesses: unlike mechanical systems generally, informational systems are largely opaque—that is, their function cannot be perceived from their structure, but they can provide detail on demand, the wisdom of virtual stakeholders can be incorporated (e.g., with critics and agents), and computational processes can extract the relevant information from them.

4 Sport to Computer Science

Transcending the boundary between cultures offers opportunities in both directions. We may ask: what can researchers and practitioners in computer science learn from sports? Following is brief description of a number of topics potentially fitting into this category:

1 Many sports activities can be considered as success models of learning. Not only do people engage in them on a voluntary basis over long periods of time, but they use substantial resources (money and time) to do so. As a research center interested in lifelong learning, we have argued for a long time that we better create environments in which people *enjoy* learning, because no one will engage in an activity over long periods of time without

enjoying it. I claim that sports can provide such success models and one of them, skiing, will be described in more detail below.

2 Modern teaching and learning paradigms reconceptualize the role of the teachers to move from "the sage on the stage" to the "guide on the side". Sports has embraced this paradigm for a long time. Teachers in sports act as a coaches and facilitators to support learners in their own self-directed learning activities, rather than as a oracle.

3 Many sports are done in teams—collaborative work practices in cognitive disciplines (such as groupware, computer-supported collaborative work (CSCW), and computer-supported collaborative learning (CSCL)) may be able to learn from the experiences, techniques, and role distributions developed in sports.

5 Example: Skiing As A Success Model For Technology Enhanced Learning Environments

A number of years ago, we carefully analyzed skiing as a success model of instruction and learning [Burton et al., 1984] and extracted some general lessons to be learned for the design of computational learning environments . The major components of the developed framework are:

Use the environment to decouple skills and eliminate prerequisite skills. Figure 1 shows how, through the choice of a suitable terrain, gliding and stopping can be decoupled. The lesson learned here for cognitive domains are:

1 Spelling correctors can be used to help people with poor spelling abilities (e.g., with dyslexia) to focus on their task and be rewarded for it, rather than being penalized for being weak in spelling.

2 Similar arguments can be made for hand-held calculators and systems such as Mathematica (http://www.wolfram.com/), which—if designed properly—will allow people to focus on qualitative reasoning and estimation skills rather than on quantitative skills (which can be handled in today's world by computers).

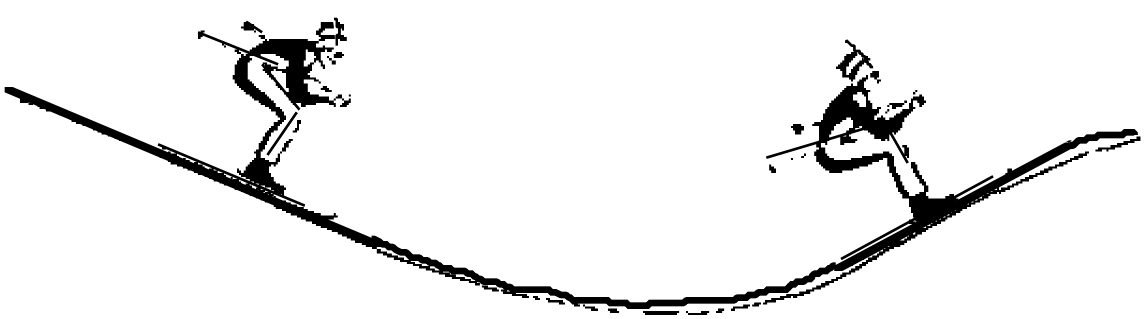

Figure 1: Simplification of a Complex Skill—No Subskill for Stopping is Required

Provide time on task. Humans are good in activities that they do a lot. Ski lifts have allowed human beings to spend time on downhill skiing (the activities they are really interested in) rather than climbing uphill for most of the time. Our effort with domain-oriented design environments (as briefly described above) shares the same objectives: most users are interested in their task, and not in computers per se. By supporting "*human problem-domain interaction*" [Fischer & Lemke, 1988] they bring task to the forefront and push computers into the background. It is important to note that this argument is tied to our top-level goals and objectives: Certainly, if we want to get stronger leg muscles or improve our aerobic abilities (rather than primarily engage in downhill skiing) then ski lifts are counterproductive—just as if we are really interested in the internals of computers, domain-oriented design environments hide those from their users.

Provide safe environments for exploration and discovery. In skiing, safety bindings have allowed skiers to explore more difficult territories without the fear of getting seriously hurt. In a similar way, exploratory computational environments supported by UNDO commands, automatic saving of files, return to known starting points, etc. will allow computer users to explore new things in a safer environment (as pilots in flight simulators can be confronted with dangerous events that they might have to master in a real environment).

6 Implications

Taking it as a given that the number of different cultures in our world will continue to increase, we need to accept the challenge to create new social and technological environments that will provide places where cultures can meet. These places will allow groups of people working in different domains to communicate, work, and learn together by developing objects and concepts that can serve as boundary objects to build bridges between domains and provide common referents and starting points for shared work. These worlds do not exist a priori, but are constructed over time by collaborating communities of practice and communities of interest. In the next example, we argue that the World Wide Web in its current form is not well suited to support this process.

6.1 Example: The World Wide Web—From Broadcast to Collaboration Medium

Traditional Web-based use and instruction engages the Web as a broadcast medium (Figure 2, Model M1). Instructional information is placed on static Web pages and there is little opportunity for users to interact with the information. Many Web sites are evolving into a form that combines broadcast with feedback (M2). In the process of exploring such an information space, users can provide feedback and ask questions via email or by filling out forms.

An essential requirement for users to engage in shared and collaborative activities is to support a third model for the Web: evolutionary and collaborative design (M3). In this model, users can use the Web to collaborate on projects, perform in-depth research on certain aspects of a project, and learn from their peers.

The M3 model poses a number of technical challenges, including the ability (1) to add to an information space without going through an intermediary, (2) to modify the structure and content of the information space, and (3) to integrate the discussion about the design into the information space itself. In our research center we have tackled these problems with a number of prototype systems such as DynaSite (http://www.cs.colorado.edu/~ostwald/home.html), Visual AgenTalk, and the Behavior Exchange (http://www.cs.colorado.edu/~l3d/systems/agentsheets/).

6.2 Exploiting the Unique Possibilities of Computational Media

Printed media and the widespread human ability to read and write are foundations on which our current societies are built. An important question to be asked is: "Will computational media cause a change of a similar magnitude compared to our society moving from an oral to a literary society (and Socrates and Plato argued about the trade-offs associated with this change) or when Gutenberg's printing press eliminated the scribes and gave everyone the opportunity to become literate?" The fact that societies have often overestimated the impact of change in the short run and underestimated it in the long run suggests that we should make every effort to understand the long-term societal impacts of computational media. What are unique properties of computational media that are absent in principle of printed media? And which potentials do these new media offer to transcend the different cultures and which ones will be of specific interest and impact in sports?

Printed media do not have interpretive power—they can convey information to us, but they cannot analyze the work products created by us. Computational media can make information relevant to the task at hand thereby reducing the information overload problem or the need for decontextualized learning. This principle can be illustrated by the current generation of help systems: while Microsoft-Word's "Tip of the Day" provides us with a piece of decontextualized information, few help systems (except for knowledgeable peers around us) provide us with information (explicitly asked for or volunteered) relevant to a breakdown situation in our activity. I claim that current generation of computational environments fall short in many ways to support humans in their activities. By not supporting "human problem-domain interaction" for members of communities (such as researchers in sports), they remain a separable object of observation and practice rather than disappearing in the background.

Technology has played important roles in sports; many more roles than this paper could mention. For example: it has helped us to create a constant practice environment (e.g., ball machines in tennis), increased the "back-talk" of situations (e.g., using video cameras), has eliminated

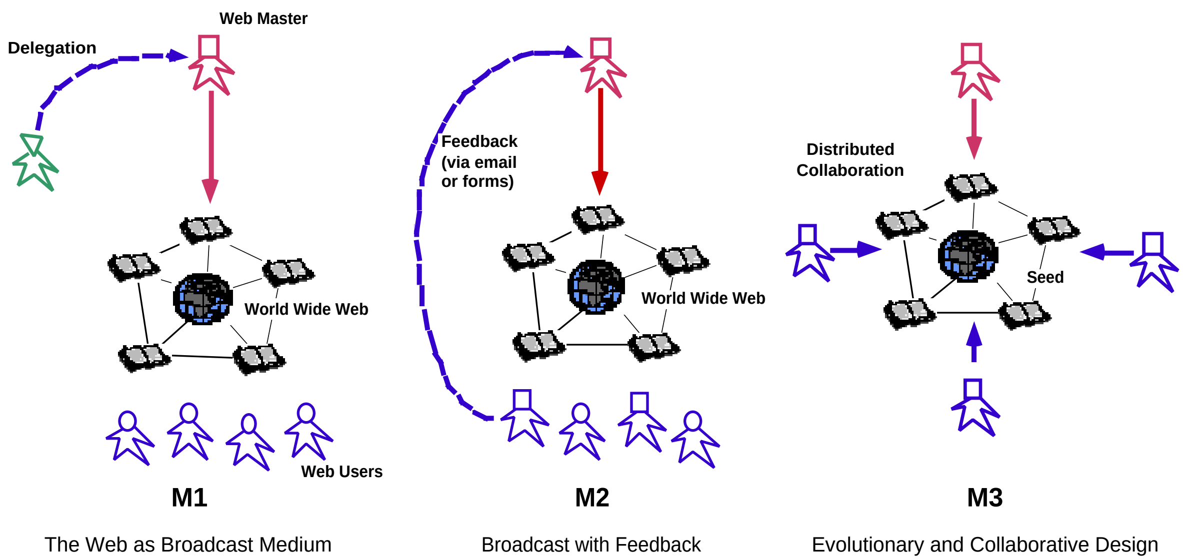

Figure 2: Making the World Wide Web a Medium for Collaborative, Evolutionary Design

prerequisites providing us with more time on task. In other situations it has led to a reconceptualization of the sport itself and has provided new variations of it. Understanding the intricate relationships between media and our physical and intellectual activities remains one of the big challenges for the future.

7 Conclusions

"Travel is fatal to prejudice, bigotry and narrow-mindedness." Mark Twain

I believe that just as there is a physical home and travel in space, there is an intellectual home and travel between different intellectual cultures. I will conclude by briefly describing the importance of moving between cultures in my own professional life. I graduated with a Master's Degree in Mathematics and Sports to become a Gymnasium teacher in Germany. My studies in sports got me interested in cybernetics leading me to computers as general information processors (whereas computers as "number crunchers" were never too interesting to me). Following a two year fellowship in North America to study computer science, I returned to Germany and worked as a research assistant at a University Sport Institute. During this time I introduced the use of computers into sports at the university. A few years later, I faced the difficult decision of deciding about an offer from a national research institute in "Computers and Education" forcing me to choose between a professional career in computer science and sports. One of the advantages of being in computer science is its international character. This has provided me with numerous opportunities to move around in different national cultures, primarily Germany, USA, and Japan. Looking back at these years of moving between cultures, I regard them as an invaluable source of inspiration and opportunity rather than a burden or limitation.

One of the big challenges of the future is to create opportunities for people to experience different cultures. This will require the design of educational opportunities (inside and outside of schools and universities) to allow people to experience the world not as a modern "Babel" characterized by the Balkanization of ideas, but as a "global village" in which mutual understanding, mutual learning, and mutual appreciation will bring people from different backgrounds and different interests together to pursue common goals.

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9 References

Arias, E. G., Fischer, G., & Eden, H. (1997) "Enhancing Communication, Facilitating Shared Understanding, and Creating Better Artifacts by Integrating Physical and Computational Media for Design," *Proceedings of Designing Interactive Systems (DIS '97)*, pp. 1-12.

Bruner, J. (1996) *The Culture of Education*, Harvard University Press, Cambridge, MA.

Burton, R. R., Brown, J. S., & Fischer, G. (1984) "Analysis of Skiing as a Success Model of Instruction: Manipulating the Learning Environment to Enhance Skill Acquisition," In B. Rogoff & J. Lave (eds.), *Everyday Cognition: Its Development in Social Context*, Harvard University Press, Cambridge, MA - London, pp. 139-150.

Bush, V. (1945) "As We May Think," *Atlantic Monthly*, 176(1), pp. 101-108.

Eisenberg, M., Nishioka, A. (1997) "Orihedra: Mathematical Sculptures in Paper," *International Journal of Computers for Mathematical Learning*, 1, pp. 225-261.

Fischer, G., Lemke, A. C. (1988) "Construction Kits and Design Environments: Steps Toward Human Problem-Domain Communication," *Human-Computer Interaction*, 3(3), pp. 179-222.

Fischer, G., Lemke, A. C., McCall, R., & Morch, A. (1996) "Making Argumentation Serve Design," In T. Moran & J. Carrol (eds.), *Design Rationale: Concepts, Techniques, and Use*, Lawrence Erlbaum and Associates, Mahwah, NJ, pp. 267-293.

Fischer, G., Nakakoji, K., Ostwald, J., Stahl, G., & Sumner, T. (1993) "Embedding Critics in Design Environments," *The Knowledge Engineering Review Journal*, 8(4), pp. 285-307.

Norman, D. (1993) *Things that make us smart*, Addison Wesley.

Papert, S. (1980) *Mindstorms: Children, Computers and Powerful Ideas*, Basic Books, New York.

Resnick, L. B., Levine, J. M., & Teasley, S. D. (Ed.) (1991) *Perspectives on Socially Shared Cognition*, American Psychological Association, Washington, D.C.

Rittel, H. (1984) "Second-Generation Design Methods," In N. Cross (eds.), *Developments in Design Methodology*, John Wiley & Sons, New York, pp. 317-327.

Schön, D. A. (1983) *The Reflective Practitioner: How Professionals Think in Action*, Basic Books, New York.

Snow, C. P. (1993) *The Two Cultures*, Cambridge University Press, Cambridge, UK.

Uthmann, T. (1995) "Das wissensbasierte Unterstützungssystem TISSY," In M. M. Richter & F. Maurer (eds.), *Expertensysteme 95 (XPS-95)—Proceedings in AI*, infix-Verlag, Kaiserslautern,

Wenger, E. (1987) *Artificial Intelligence and Tutoring Systems*, Morgan Kaufmann Publishers, Los Altos, CA.