Coupling Physical Artifacts and Abstract Representations

Eva Hornecker
artec, University of Bremen,
Bibliothekstr. (MZH), Postfach 330440, 28334 Bremen,Germany
eva@artec.uni-bremen.de

Abstract: We propose an interface that aims at coupling two previously separated model worlds - the real space of physical objects and the virtual space of signs and images: Users wearing sensorized gloves build models in the real world with physical objects. The computer assembles a corresponding virtual model which offers simulation, animation and help-system capacities. We argue that (1) sensual experience is important for acquisation of tacit knowledge, (2) manual and intellectual grasping interact, and (3) concrete and abstract things need to be linked in education.
The basic issues of this Real Reality concept are discussed and an application for vocational training in pneumatics is presented.

Keywords: Real Reality, graspable user interface, augmented reality, vocational education, experimental learning, action orientation, cooperative learning, simulation, sensual experience

Coupling Physical Artifacts and Abstract Representations

Eva Hornecker
artec, University of Bremen,
Bibliothekstr. (MZH), Postfach 330440, 28334 Bremen,Germany
eva@artec.uni-bremen.de

Most new learning media in classroom tend to separate concrete handling of artifacts from abstract, cognitive learning, as books did all along. Physical experimenting gets reduced for time and cost reasons. Yet physical models play an important role for cognition and communication. Sensuous experience of objects can contribute to conceptual understanding, helps to gain tacit knowledge. On the other hand computers are useful tools for analysis, simulation and animation. They can help us to understand the abstract and complex. Our approach aims at bridging those two modeling worlds: the real world of physical objects and the virtual of signs and images. The project described here will show the feasibility and the possibilities of a computer supported learning environment for the subject of pneumatic circuits in vocational training.

The name „*Real Reality*“ was coined around 1993 [Bruns et al 93] in contrast to „Virtual“ Reality. The concept [Bruns 93] bases mainly on a tight coupling of real artifacts with virtual counterparts. The real objects are either models of something (e.g. bricks symbolizing houses) or the thing itself. They are used to construct a system on a workspace. Users operate with sensorized hands (DataGlove) or in a scanning environment with these objects while the computer tracks and interprets their actions and gestures. It synchronously assembles a corresponding virtual model, including the dynamic actions of the users hands. Virtual objects may contain further information necessary for simulation or for a help-system. Both physical and virtual system can be used to experiment with. The users are able to freely change between operations on real and virtual objects. In some application areas it is even possible to export control signals generated by the virtual into the physical system.

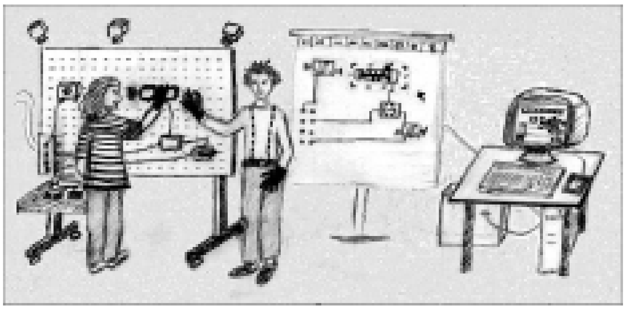

Figure 1: Envisioned Learning Environment

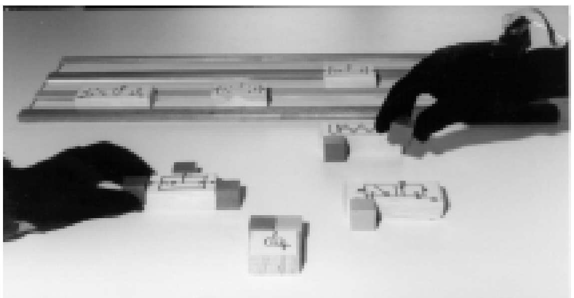

Figure 2: Building a circuit with wooden symbols

The envisioned learning environment [Fig. 1] consists of a traditional experimental workbench for pneumatics, enhanced with computer-media. This includes virtual models and multimedia elements. The students build a physical circuit, directing their attention on the actual task, tracked by the computer. Afterwards the virtual model can be used for simulation and further investigation (animation of inner behavior of elements) or for searching errors and optimization. During assembly the computer might also be used to give advice and add explanations on elements. Such commands can be given with gestures or spoken, thus staying in the „real assembly“ mode or space. In order to let students stay close to the workbench and make the desktop computer as obsolete as possible, projection and audio techniques are used for computer output and feedback. If the subject of electrical-pneumatic circuits is taught, the students can write programs on the computer, which not only drive a simulation model, but also control real devices, thus closing the circle: back from the virtual to the real.

In vocational training, some students have a special need to grasp physical circuits in order to get a better understanding of abstract sign-languages. Our system provides visible, instantaneous links between the concrete and its abstract representation, thus helping to abstract, to translate, and to form mental concepts. Concrete artifacts offer an additional possibility to gain theoretical knowledge based on sensual-concrete experience, as physical and intellectual grasping interact. These ideas are based on Piaget and Aebli. As many technical processes in modern production have lost their former material relation, it gets harder for workers to experience physical properties and to acquire tacit knowledge of the still existing material background. Providing this experience in education & training (encouraging students to experience the obstinacy of the material) may substitute somewhat [Böhle 91]. Our system supports different experimental learning modes within the context of action oriented learning. Concentration on a complex task and physical work space constitute a common goal and a social space for collaborative learning. Students can see each other, interact freely, discussing ideas.

As our project is a feasibility study supposed to explore possibilities and problems, we intend to implement only part of the described. A following European Union project will develop a commercial version, using image processing. Because our DataGloves with electro-magnetic tracking don't allow us to handle metal we work with wooden bricks as graspable symbols [Fig. 2]. Up to now we are able to build a model of digital or pneumatic circuits. This is tracked by our Virtual Reality system. The resulting scene file can be processed and simulated by our extended version of the freeware simulator DigSim, PneuSim. Ongoing work includes an interface to the commercial simulator FluidSim-P ((C) Festo-Didactic). We developed an on-line connection, sending each event in the physical model to the simulator. This enables asking for help on elements or starting the simulation by gesture. Our work also consists of the didactical foundation for such learning environments and of HCI-issues. What does natural handling mean? Which kinds of multimedia add-ons make sense?

Another project demonstrates the power of the Real Reality concept in the domain of material flow, using small conveyors to model production plants. The conveyors and a robot can be programmed with Programming by Demonstration, manually teaching distribution rules and paths. [Schäfer et al97].

Our goal is to enable people to change fluidly from hand manipulation to abstract work and vice versa. Computers and their interfaces should assist, not get in the way. In the main application areas construction and modeling are central tasks, either in learning or working contexts. The concept can also be used to combine physical and digital planning tools. Related work stems mostly from Augmented Reality and Ubiquitous Computing research, for example [Fitzmaurice et al 95], [Ishii, Ullmer 97], [Resnick 93] and [Suzuki, Kato 95]. In contrast to all of these we do not sensorize the objects and keep a clear division, yet close coupling between physical objects and their virtual twins, between real system and virtual addition.

References

[Böhle 91] Böhle F. (1991). Kompetenzen für 'erfahrungsgeleitete Arbeit' – Neue Anforderungen an die berufliche Bildung bei fortschreitender Technisierung. In: G. Hurrle, F.-J. Jelich, J. Seitz (Edt.). *Wie bedingen sich Arbeit, Technik und Beruf im industriellen Prozess?* Schüren: Hans-Böckler-Stiftung

[Bruns et al 93] Bruns, F. W., Heimbucher, A., Müller, D. (1993). *Ansätze einer erfahrungsorientierten Gestaltung von Rechnersystemen für die Produktion*. Bremen: artec-Paper 21

[Bruns 93] Bruns F. W. (1993). Eine neue Form des Umgang mit Rechnern – Über die Rückgewinnung von Sinnlichkeit. *Technische Rundschau* 29/30

[Fitzmaurice et al 95] Fitzmaurice, G. W., Ishii, H., Buxton, W. (1995). Bricks: Laying the Foundations for Graspable User Interfaces. *CHI, 1995*, ACM

[Ishii, Ullmer 97] Ishii, H, Ullmer, B. (1997). Tangible Bits: Toward Seamless Interfaces between People, Bits and Atoms. *CHI, 1997*, ACM, Atlanta, Georgia

[Jank, Meyer 91] Jank W., Meyer H. (1991). *Didaktische Modelle*. FfM: Cornelsen Scriptor

[Piaget 59] Piaget, J. (1959). *La formation du symbole chez l'enfant. Imitation, jeu et rêve - Image et representation*. Neuchâtel

[Resnick 93] Resnick, M. (1993). Behavior Construction Kits. *Communications of the ACM,* 36 (7)

[Schäfer et al 97] Schäfer K., Brauer V., Bruns W. (1997). A new Approach to Human-Computer Interaction – Synchronous Modelling in Real and Virtual Spaces. *Designing Interactive Systems, 1997*, ACM, Amsterdam,

[Suzuki, Kato 95] Suzuki, H. & Kato H. (1995). Interaction-Level Support for Collaborative Learning: AlgoBlock - An Open Programming Language. *Computer Supported Collaborative Learning (CSCL), 1995*, Indiana

Acknowledgements

Thanks to my colleague Bernd Robben and the students working at our institute: Martin Faust, Keith-André Piedboef and Cedrik Duval.

This work is being sponsored by the German National Research Foundation (DFG) under grant no. BR 1556/3-2.

For further information see: http://www.artec.unibremen.de/field1/eugabe/index