Construction Kits as Learning Environments

Carol Strohecker

Published in *Proceedings of the International Conference on Multimedia Computing and Systems,*
IEEE Computer Society, 1999, II, 1030-1031.

Originally appeared as Technical Report 99-31, Mitsubishi Electric Research Laboratories

Abstract

Two software applications illustrate principles of microworld design. WayMaker is a tool for constructing maps and virtual scenes of cityscapes. With Bones, users build cartoon-like skeletons from images of dinosaur bones, and experiment with simulated legged locomotion in animating the creatures. Each kit is both a learning environment and a tool for learning research.

Construction Kits as Learning Environments

Carol Strohecker
MERL - A Mitsubishi Electric Research Laboratory
stro@merl.com

Abstract

Two software applications illustrate principles of microworld design. WayMaker *is a tool for constructing maps and virtual scenes of cityscapes. With* Bones, *users build cartoon-like skeletons from images of dinosaur bones, and experiment with simulated legged locomotion in animating the creatures. Each kit is both a learning environment and a tool for learning research.*

Introduction

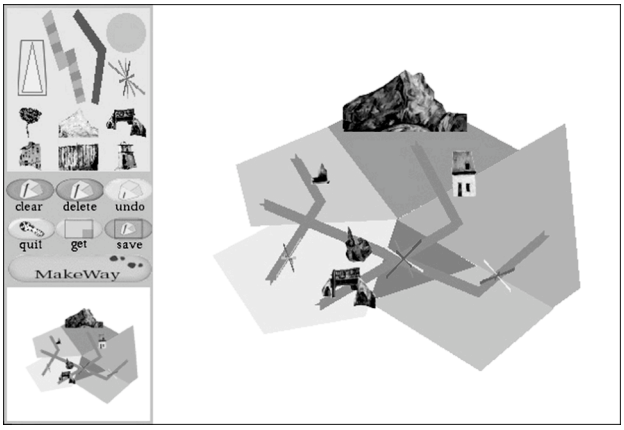
Contemporary theories cast human learning as a process of constructing understandings, a process that is enhanced when the learner is actually building an object in the world. Designing and creating are crucial facets of the learning process.

The interactive nature of computational technologies is highly compatible with this "constructionist" view [1], [2], [3]. Interactive software "construction kits" can be particularly useful learning environments. Such kits, sometimes called "microworlds," consist of elements that characterize aspects of a domain like geometry, topology, or physics [1], [4]. Users work with objects representing elements of the domain, assembling them into interesting designs and larger objects, which then become the basis of animations or simulations. Through these interactions, users focus on properties of the elements and become immersed in thinking about the conceptual domain. As the constructions grow and demonstrate appropriate behaviors, users can develop progressively deeper understandings of the domain. Thus, in these computational kits, there is an interesting relationship between learning and creative design. The kits become tools for learners as well as tools for researchers who study the nature of human learning.

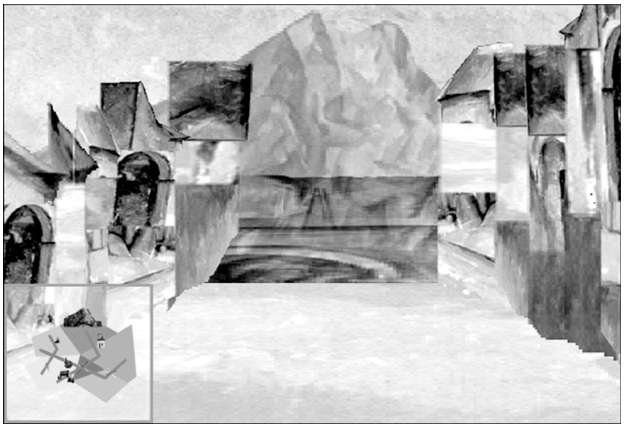
Here I briefly describe two exemplary software construction kits. "WayMaker" is in the domain of spatial cognition and is intended for use by people of all ages [5], [6], [7], [8], [9]. "Bones" is in the domain of motion study, and although anyone may enjoy it, young people may find it particularly appealing [10], [11].

WayMaker

WayMaker is a design tool based on elements of the "city image" as described by the urban planner, Kevin Lynch [12]. *Districts* are broad regions, such as neighborhoods; *edges* are boundaries between one region and the next; *paths* are the channels along which people move; *nodes* are foci to and from which people travel; and *landmarks* are punctuation points used for general orientation. The user positions representations of these elements relative to one another, forming a map.



The software then calculates and displays street-level scenes along paths through the mapped space. The scenes are assembled within two-dimensional, perspective-style frameworks.

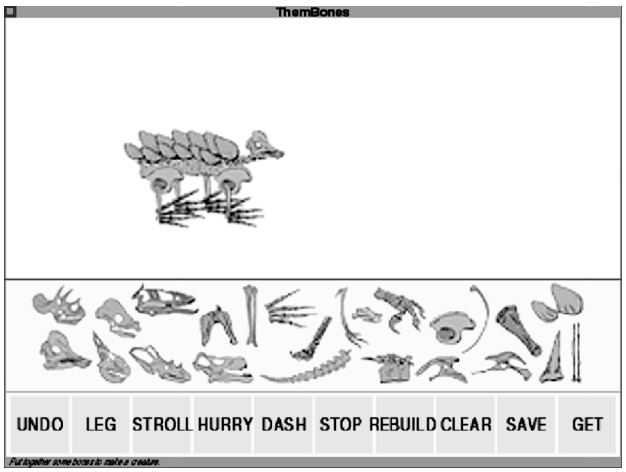


Landmarks, nodes, and edges maintain their relative positions within the districts.

Thus, in a given session, the user's perceptibilities change from abstract overview to street-level, human-scale scenes of a Cézanne-like environment [13]. By constructing maps of real or imagined places and shifting views of the designed places, users can question and develop their understandings of topological relationships.

Bones

Bones is a tool for thinking about the role of center of mass in balance, and the role of balance in locomotion. Users put dinosaur bones together and then animate the skeletal creatures. Bones can go together realistically or whimsically to create cartoon-like dinos.



Each bone has two simple properties: a mass value and a position. These properties determine whether a skeleton will maintain its structural integrity and balance. The software combines the mass value of each bone in determining an overall center of mass for the creature, as well as whether the creature is top-heavy or bottom-heavy and whether its center lies to the fore or rear. These attributes help to determine the creature's structural integrity and gait patterns for different speeds.

The tests for balance depend on the relationship between a creature's center of mass and its supports. In the test for static balance, a standing creature's points of contact with the ground form a base polygon. A line projected downward from the creature's center of mass must fall within this polygon in order for the creature to balance. In the test for dynamic balance, the base polygon changes form as the creature moves. Its shape depends on the gait pattern, which depends on the creature's speed and how many legs it has. A dynamically balanced creature can tolerate many off-balance moments. The software includes gait patterns for creatures with any number of legs and for three speeds of movement [14], [15].

References

[1] Papert, S., *Mindstorms: Children, Computers, and Powerful Ideas,* Basic Books, New York, 1980.

[2] Harel, I., and S. Papert, eds., *Constructionism,* Ablex, Norwood, 1991.

[3] Kafai, Y., and M. Resnick, eds., *Constructionism in Practice: Designing, Thinking, and Learning in a Digital World,* Lawrence Erlbaum, Mahwah, NJ, 1996.

[4] Strohecker, C., "Why Knot?", Ph.D. diss., Epistemology and Learning Group, Media Laboratory, Massachusetts Institute of Technology, 1991.

[5] Strohecker, C., and B. Barros, "Make Way for *WayMaker,"* to appear in PRESENCE: Teleoperators and Virtual Environments, MIT Press, Cambridge MA, 1997.

[6] Strohecker, C., and B. Barros, "A Prototype Design Tool for Participants in Graphical Multiuser Environments," *Proceedings of ACM Special Interest Group on Computer-Human Interaction (SIGCHI Extended Abstracts),* ACM Press, New York, 1997.

[7] Strohecker, C., B. Barros, and A. Slaughter, "Mapping Psychological and Virtual Spaces," *International Journal of Design Computing,* 1998.

[8] Strohecker, C., B. Barros, and A. Slaughter, "A Prototype Design Tool for Participants in Graphical Multiuser Environments," submitted to *Proceedings of ACM Special Interest Group on Computer-Human Interaction,* ACM Press, New York, available as Technical Report 99-01, MERL - A Mitsubishi Electric Research Laboratory, 1999.

[9] Strohecker, C., "Toward a Developmental Image of the City: Design through Visual, Spatial, and Mathematical Reasoning," submitted to *Visual and Spatial Reasoning in Design,* MIT and the University of Sydney, available as Technical Report 99-07, MERL - A Mitsubishi Electric Research Laboratory, 1999.

[10] Strohecker, C., "Embedded Microworlds for a Multiuser Environment," Technical Report 95-07, MERL - A Mitsubishi Electric Research Laboratory, 1995.

[11] Strohecker, C., "A Model for Museum Outreach Based on Shared Interactive Spaces," *Multimedia Computing and Museums: Selected Papers from the Third International Conference on Hypermedia and Interactivity in Museums,* San Diego CA, 1995.

[12] Lynch, K., *The Image of the City,* MIT Press. Cambridge MA, 1960.

[13] Machotka, P., *Cézanne: Landscape into Art,* New Haven, Yale University Press, 1996.

[14] Muybridge, E., 1957, *Animals in Motion,* Dover, New York, 1957.

[15] Hildebrand, M., "How Animals Run," *Scientific American,* May 1960, pp. 148-157.