AquaMOOSE 3D: Math Learning in a 3D Multi-user Virtual World

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ABSTRACT

AquaMOOSE 3D is a multi-user, graphical, constructionist environment to help children learn about mathematics and computer programming. In this paper, we present the system design, and results from our first round of formative evaluation.

Keywords

Education applications, end-user programming, virtual communities, CSCL

INTRODUCTION

In AquaMOOSE 3D, high-school students learn mathematics and computer programming by taking part in a graphical, multi-user, constructionist [4] virtual world. Our primary research question is to explore how a 3D graphical world can support mathematics learning. In addition, we are exploring whether this design will help to improve student attitudes towards mathematics.

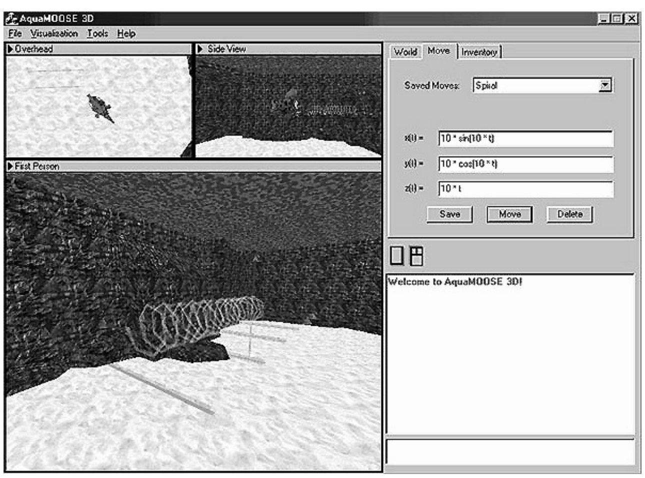

Figure 1.

SYSTEM DESCRIPTION

The current implementation of AquaMOOSE 3D provides multiple users with an underwater-themed world and the ability to chat, move about, and program their avatars to swim mathematically.

Mathematical Moves

Motion in the virtual world can be specified mathematically, using parametric equations. For example, swimming in a sine wave in x and a cosine in y creates a spiral (see Figure 1). The current version supports Cartesian coordinates; polar coordinates will be added in the near future.

A simple template scaffolds the process of entering in mathematical moves (see Figure 2). Different templates are available for different language functions. In our design, we view the programming environment as an integral part of the language [6].

Each time a mathematical movement is executed, the avatar moves along the programmed function, leaving a trail behind itself. The trail is an important artifact; it provides the users with a starting point for conversation, as well as a visualization tool.

In many ways, this resembles the Logo programming language [3] in three dimensions. However, there are some important differences. First, it is a multi-user environment. Students can learn from watching one another in the virtual world, and trading mathematical ideas. Second, while the math in Logo is done from a first-person perspective to facilitate body-syntonic understanding of math [3], the math in AquaMOOSE is designed to look more like the math students see in school in order to facilitate transfer.

In our first version, we have provided one game for students to play: a ring game. Students are presented with a set of rings in the water, and are challenged to try to swim through as many as possible with one mathematical function. This simple game resembles a 3D version of the successful Green Globs software [1]. In future versions, we hope to make the environment more fully programmable, so that students can create their own games and learn through the process of game design and construction [2].

Multiple Viewpoints

Many 3D environments provide the user with a first person perspective view. We found that while this view is helpful for navigation, it is not necessarily the most informative view. We provide three customizable viewing windows and four different camera angles to allow the user to see both their avatar and the world from multiple perspectives at the same time (see Figure 1).

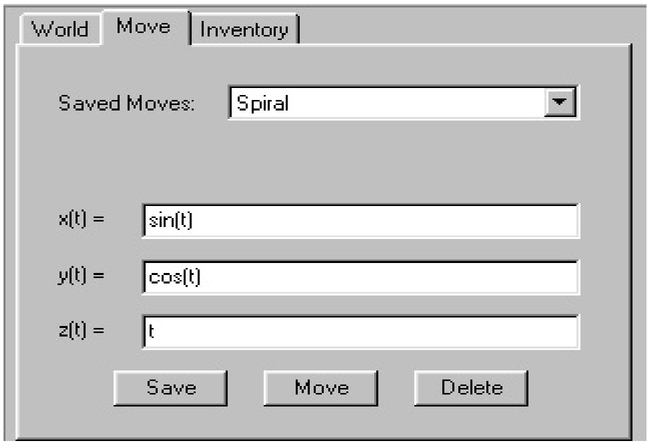

Figure 2.

Visualization Tools

3D can be disorienting [5]. We provide simple tools to help users understand the orientation of the world and the movement possibilities of their avatars. The absolute coordinate space tool displays the x, y, and z axes in the environment. The relative coordinate space tool provides users with an idea of left, right, up, down, and depth within the context of their location.

FORMATIVE EVALUATION

In our first round of formative evaluation, we invited three students to play with AquaMOOSE 3D for a short laboratory session. We observed their interactions with the software and one another. We found that the students were engaged and enjoyed manipulating equations to create strange and complex movement trails. The students interacted both online and with the others in the room. For example, one student called out over his shoulder, "How'd you make that?" The other replied, "Easy—it's just a sine in x and constant in y and z." From our evaluation, we put a new priority on face-to-face as well as remote interaction in our design. While most collaborative systems focus on either collocated or remote interaction, our trial suggests that a combination will be most conducive to learning.

In addition to our informal trial with students, we also showed the environment to a group of six high-school math teachers. The teachers were enthusiastic about the environment's learning potential, and suggested pre-calculus classes might be an ideal audience. We are continuing an ongoing dialog with them through our design process, seeking to tailor the application to their needs and the needs of their students.

IMPLICATIONS & FUTURE WORK

Initial results suggest that 3D multi-user environments hold promise for helping high-school students learn mathematics. We are proceeding with multiple rounds of formative evaluation and iterative design. Initial formative evaluation has indicated that key issues for the future of this type of educational environment include:

- Integrating local and remote interaction
- Helping students stay oriented in the 3D world
- Scaffold programming and mathematics through the programming environment

Planned future studies include evaluations not just of students' learning but also of changes in their attitudes towards and interest in mathematics.

ACKNOWLEDGMENTS

Work on the AquaMOOSE project is supported by grants from the National Science Foundation (grant REC-9876168) and Intel. Additional support for research in the Electronic Learning Communities research group (http://www.cc.gatech.edu/elc) is provided by IBM, Microsoft, and Ricoh.

REFERENCES

1. Dugdale, S. Green Globs: A Microcomputer Application for Graphing of Equations. *NCTM's Mathematics Teacher*, March 1982, 208-214.
2. Kafai, Y., and Harel, I. Children Learning Through Consulting: When Mathematical Ideas, Knowledge of Programming and Design, and Playful Discourse are Intertwined, in *Constructionism*, Eds. Idit Harel and Seymour Papert, Ablex Publishing, Norwood NJ, 1991, 110-140.
3. Papert, S. Mindstorms: *Children, Computers, and Powerful Ideas*. New York: Basic Books, 1980.
4. Papert, S. Situating Constructionism, in *Constructionism*, Eds. Idit Harel and Seymour Papert, Ablex Publishing, Norwood, NJ, 1991, 518.
5. Salzman, M., Dede, C., Loften, R.B., and Chen, J., The Design and Evaluation of Virtual Reality-based Learning Environments, *Presence: Teleoperators and Virtual Environments 8 (3)*, 293-316.
6. Winograd, T. Breaking the Complexity Barrier (Again), in *Proceedings of ACM SIGPLAN-SIGIR* (Gaithersburg, MD, November 1973), ACM Press, 13-30.