

VRMath - An Environment for Knowledge Construction of 3D Geometry Concepts and Processes in Virtual Reality Microworlds

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Abstract

There are many powerful ideas in the use of computer graphics to aid learning and teaching in mathematics. One such powerful idea is the trend toward the utilisation of learning environments with real-time 3D visualisation and accessibility to the Internet that enable students to express their own ideas, engage in multiple knowledge representations and perspectives, and manipulate and share knowledge for collaborative learning. VRMath is informed by the above ideas. Its *raison d'être* is to provide elementary school students with a rich learning environment for the construction of 3D geometry concepts and processes and for advanced 3D modelling and simulations.

1 Three components of VRMath

VRMath integrates multiple semiotic resources including typological (e.g., language, symbol, button) and topological (e.g., virtual reality space, colour, graph) resources [Lemke 2001]. It consists of three main components:

Virtual Reality (VR) interface: This is an affordable desktop VR technology using VRML (Virtual Reality Modelling Language) to visualise 3D geometry. With its power of generating real-time dynamic 3D scenes, students are able to freely move around in virtual space, and view geometrical objects from different perspectives. This component acts as a semiotic sign to reflect the students' mental geometrical images and also as place where students can modify/extend their mental images.

Programming Interface: This component extends LOGO language to include modelling with 3D objects and engagement with more geometrical terms. It is supported with many user-friendly GUI widgets. Students utilise this component to express, design and create virtual geometrical microworlds by specifying commands, writing procedures, and debugging programs.

On-line discussion forum: This component serves as an information centre for gathering information, providing help, asking questions, and publishing microworlds. This component thus enables students to share ideas with learning peers.

2 Construction processes

The construction processes begin with a 3D turtle. Students must have some knowledge about LOGO commands and syntax such as FORWARD (FD), BACK (BK), LEFT (LT) and RIGHT (RT). To enable users to operate in the third or Z dimension within 3D space, commands such as ROLLUP (RU), ROLLDOWN (RD), TILTLEFT (TL), TILTRIGHT (TR) etc. have been included.

VRMath inherits LOGO paradigm, in which it uses an egocentric frame of reference. Students envisage themselves as the turtle moving in space, and then the turtle tracks become the geometrical objects. For example, to construct a frame of a cube, it could be programmed as in the following commands:

```
PD // PENDOWN
REPEAT 4 [ FD 1 RT 90 ]
RU 90 FD 1 RD 90
REPEAT 4 [ FD 1 RT 90 ]
FD 1 RD 90 FD 1
TR 90 RU 90 FD 1 RU 90 FD 1
TR 90 RU 90 FD 1 RU 90 FD 1
PU // PENUP
```

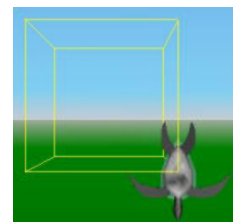


Figure 1 Frame of cube

Moreover, VRMath employs two other frames of reference system: fixed object and coordinate system. For fixed object reference, commands such as ABOVE, BELOW, FRONT, BEHIND, BESIDE and BETWEEN etc. are included. For coordinate reference, commands such as UP, DOWN, EAST, WEST, NORTH, SOUTH, LOCATE and GOTO etc. are used. The egocentric and fixed references are relative to the turtle or any object, whilst the coordinate reference is absolute.

In addition to turtle tracks that draw lines, students can use CREATE command to make certain primitive objects of 3D shape such as BOX, CAN, BALL, and CONE etc. And even the frame of cube can be an object too if it is written as a primitive procedure. Every object can be rescaled, rotated and translated before and after it is created.

While programming involves mostly text editing, VRMath also provides many GUI interfaces such as Material Chooser and Colour Bar for changing objects' colours. The VRMath colouring model can also change objects' transparency to get a perspective view of objects. At any time, students can save or restore their progress to or from on-line database, or join the discussion forum for inquiries or ideas.

After a virtual space is built, students can publish the microworld with descriptions viewable on web page, or make the project public so that other students can access and/or modify the project.

3 Features and future

VRMath project reifies many powerful ideas derived from philosophy, semiotics, psychology, constructionism and computer technology. Its environment makes learning an active process and a better communication between reality and mind. It is, however, still a developing project. The VRMath research team is always seeking new insights and innovations that will lead to refinements that result in a more efficacious learning environment.

References

LEMKE, J. L. 2001. Mathematics in the middle: measure, picture, gesture, sign, and word. *Web document*. Available: <http://academic.brooklyn.cuny.edu/education/jlemke/papers/myrdene.htm> Access date: 20 Jun 2001.