

The Virtual Mathematics Exploratorium design goals and educational applications

Mathematics contains at least 3 structurally different parts: concept formation, problem formulation and problem solution. Although the major part of a professional mathematics book is concerned with concept formation (= definitions), mathematics education (especially at the school level) is concerned mainly with solutions of pre-formulated problems. A basic idea that underlies the design of the VME is to make use of the computer supported multi-media based presentation technology in order to support the mathematical conceptualization process through visualizations of - and interactions with - mathematical concepts and formulas.

An important use of the VME will be as what could be termed a “**Skeleton in the closet website**” with the motto: “All you ever wanted to know about mathematics but were afraid to ask”. Here students can explore the “pre-requisite concepts” that they are supposed to know at e.g. the university level, and consequently do not dare to ask about during a lecture because of fear of losing face in front of the teacher as well as their fellow students. In this way the VME can help to **overcome some of the transition difficulties** between the different levels of mathematics education, which is a growing problem that is gaining increased recognition both in educational and political circles.

The VME will be designed to be of use for students in general when preparing for an exam on a mathematics course. Moreover, it will be especially useful for the growing number of older students that have not (yet) managed to pass the exams of their mathematics courses. The overview and conceptual connectivity made possible by this way of presenting information should be a valuable aid in preparing for an exam – especially when the student is not presently following a live presentation of the relevant material.

An important idea that underlines the design of the VME is the conviction that no real questions can be answered in an automated fashion. In fact, it is only when the questions of the learner break the pre-programmed framework of the system that the real (= non-trivial) learning process begins. Hence the learner must be given access to live knowledge sources that can discuss the questions and guide the learning process. We are presently working on the design of a help-service system for Conzilla, where electronically certified knowledge sources will be available for the learner to contact in order to discuss issues that come up in connection with a certain concept¹. In this system, teachers will be able to enter into learner-initiated online discussions about their favorite subjects with learners from all over the world that have navigated themselves into a place where some non-trivial questions have come up. In this way the VME will serve as a platform for “**non-trivial mathematical pursuit**” with a design that supports communication “man-to-man via machine”. This design will take advantage of the network in order to create a better match between teacher knowledge and learner interests than that which can be found within most educational systems of today. These ideas are discussed in more detail in [1] and [2].

¹ This is the goal of a masters thesis project in interactive learning environments that is carried out at CID by Johan Olsson under the supervision of Ambjörn Naeve.

The design of the VME has been started by Ambjörn Naeve as outlined above. However, the aim is that the future development should be carried out in a distributed manner, where a multitude of contributors (= knowledge gardeners) can link their own knowledge patches to patches created by others that they feel have something relevant to offer. For example a knowledge patch on the subject of Geometric Algebra² is presently being brought into the VME by Mikael Nilsson, as part of his masters thesis project in mathematics under the joint supervision of Ambjörn Naeve and Lars Svensson³.

The **primary learner target group** of the VME are university students with an interest to improve the conceptual foundation for their mathematical studies by filling knowledge gaps that have been created during earlier parts of their education.

The **secondary learner target group** are high-school students with an interest to find out more about mathematical concepts and how they are related to each other.

The **primary teacher target group** is the educational reformists, struggling to make use of the unstructured plethora of educational raw material that is available on the Internet in order to create more interesting and stimulating learning experiences for their students.

The **secondary teacher target group** is the teachers that want to continue their own education within the field, without necessarily taking time-out from the everyday duties of teaching.

The overall aim of the VME development project is to create a system that supports **first class mathematics education** for as many learners as possible. It should be in the common interest of universities and schools to collaborate in such an effort, since there is an increasingly felt need for customizable and individually adaptable learner support at all levels of the mathematics educational system.

References

[1] Naeve, A., *The Garden of Knowledge as a Knowledge Manifold - A Conceptual Framework for Computer Supported Subjective Education*, CID-17, TRITA-NA-D9708, Department of Numerical Analysis and Computing Science, KTH, Stockholm, 1997. (http://cid.nada.kth.se/sv/pdf/cid_17.pdf)

[2] Naeve, A., *Conceptual Navigation and Multiple Scale Narration in a Knowledge Manifold*, CID-52, TRITA-NA-D9910, Department of Numerical Analysis and Computing Science, KTH, Stockholm, 1999. (http://cid.nada.kth.se/sv/pdf/cid_52.pdf).

² Geometric Algebra is a fascinating and little known area of mathematics, which has been championed by Prof. David Hestenes of Arizona State University. It holds the potential to revolutionize many parts of traditional mathematics education. See below (or http://modelingnts.la.asu.edu/GC_R&D.html) for further details on this subject.

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