UNIVERSITI PUTRA MALAYSIA

ANIMATION FOR VISUALIZATION OF SOME ALGEBRAIC CONCEPTS

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By

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July 2003

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Presenting the sciences and teaching the courses in an interactive way is one of the most attractive aspects of the web and educational technology. Many mathematical softwares demonstrate how these technologies make advance topics more accessible and complex mathematical concepts more understandable. The common problems in mathematics teaching process; is the difficulties, undergraduate students encounter in understanding math concepts, theories and problem solving. These problems can be overcome through using creativity in developing math teaching tools and styles. The objective of this project is to use macromedia Flash to make many confusing and complex math concepts simple, visualized and interesting and also to develop a part of a package of animated and visualized mathematical courses. Flash ability and flexibility are the features of this tool which help the designer to develop demonstrating of algebra concepts in a virtual environment. This research will use Macromedia Flash for developing a visualized package of algebra course (Introduction to Algebra (MTK 3001)).

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

ANIMASI UNTUK VISUALISASI BEBERAPA KONSEP ALGEBRA

Oleh

ABDULWAHID MOHAMMED ISMAIL

Julai 2003

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Mempersembahkan sains dan mengajar kursus-kursus melalui cara interaktif merupakan salah satu aspek terbaik rangkaian dan teknologi pendidikan. Banyak sofwer matematik telah memperlihatkan bagaimana teknologi ini telah membuat tajuk-tajuk sukar dipelajari dan konsep matematik yang sukar boleh difahami. Masalah umum dalam proses pengajaran matematik ialah kesukaran yang dihadapi oleh pelajar dalam memahami konsep, teori dan penyelesaian masalah. Masalah ini boleh diatasi melalui penyelidikan bagi mencari alat dan gaya yang lebih kreatif yang dapat digunakan bagi pengajaran matematik secara lebih berkesan. Objektif projek ini ialah menggunakan Macromedia Flash bagi melaksanakan banyak konsep matematik yang kompleks dan mengelirukan menjadi lebih mudah, dapat digambarkan dan menarik dan dapat juga menjadi sebahagian daripada pakej visualisasi dan animasi kursus matematik. Keupayaan Flash dan kebolehlenturannya merupakan antara ciri-ciri alat ini yang dapat membantu pereka bentuk menghasilkan kaedah menunjuk cara konsep algebra dalam persekitaran maya. Penyelidikan ini akan menyumbang pemikiran dalam cara ini dengan menggunakan Flash bagi menghasilkan pekej Pengenalan kepada Visualisasi dan Animasi Algebra (Introduction to Algebra (MTK 3001)), pekej ini boleh diperolehi pelajar dan pensyarah secara atas talian dan juga dalam cakera padat (CD).

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Abdulwahed M. I

I certify that an Examination Committee met on 9th July 2003 to conduct the final examination of Abdulwahid Mohammed Ismail on his Master of Science thesis entitled "Animation For Visualization of Some Algebraic Concepts" in accordance with Universiti Pertainian Malaysia (Higher Degree) Act 1980 and Universiti Pertainian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfillment of the requirements for degree of Master of Science. The members of the Supervisory Committee are as follow:

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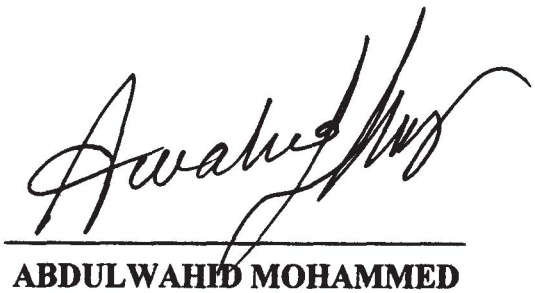
DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



ABDULWAHID MOHAMMED

Date: 26 SEP 2003

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CHAPTER 1

INTRODUCTION

1.1 Overview of the Visualization of Algebra

Nowadays the rapid development of technologies in general, multimedia and the internet in particular, tremendously changed many aspects of our life. The field of education is positively affected by this information revolution. There are huge amounts of information stored on the CDs or published on the internet, which people can use them any time.

Presenting the sciences and teaching the courses in an interactive way is one of the most attractive aspects of the web and educational softwares. Many math softwares demonstrate how these technologies make advance topics more accessible and complex math concepts more understandable.

With the recent development in computer sciences and software engineering, universities, researchers and programmers, are producing many math softwares and home pages which are designed to provide on-line mathematical courses and tutorials, using different tools and different computer languages.

Using virtual environment in education makes the learning process more interactive and exciting for students. For more effects, the researchers and programmers working hard to find more creative means and computer aids to visualize and express math concepts, formulas and problem-solving through computers. On the other hand, the student's

difficulties in understanding math concepts and problem-solving procedures, make them keen to deal with that kind of products.

Visualization is defined in the dictionary as " a mental image." In the fields of computer graphics and engineering design the term has a much more specific meaning [1].

Visualization can be seen as providing the relevant representations to assist the learner in carrying out this cognitive process. The useful aspects of visualization are the translation from representations, which are more abstract to those, which are less abstract. Therefore, current techniques of scientific visualization can bring invaluable insight to students. In particular, in mathematics we deal with abstract structures, which are not understood by most students. To be enlightened and understandable they need some visual representations.

Computer graphics visualization techniques for analysis have quickly become an active area of research and development. Beyond these most obvious aspects of the display of behavior, engineering analysis visualization involves issues such as interaction with a 3-D model, operations on result data and optimization of design variables [2].

Visualization, a term used in the industry since the 1987 publication of the National Science Foundation report Visualization in Scientific Computing represents much more that. Visualization is a form of communication that transcends application and technological boundaries [3].

1.2 Problem Statement

Some programs and courses are considered to be more difficult than others, Many students face difficulties in understanding mathematical courses. The math concepts, theories, formulas and problem-solving procedures need more creative teaching styles and tools than other areas.

Math instructors also have difficulties in communicating math concepts in the classroom. Some students are not able successfully acquire or apply the implicitly received instruction on problem-solving to real-life problems. Some complex math formulas and problem-solving processes create some stress with the lecturers for the students less desire about their courses.

This problem can be overcome through finding more creative tools and styles, for teaching mathematics effectively. The new technology and computer sciences are involved effectively in solving these difficulties, by providing new tools and exciting environment for this purpose.

The important strategies that can be used to help students with math difficulties, are: visualizing math concepts and problems and looking at any visual information that may be provided. Visual Algebra is designed to ease the difficulties many students experience during the transition from arithmetic into the world of algebra [3].

This research is a contribution to this area, using macromedia flash 5, for creating a visual environment in algebra classes, through animating and demonstrating algebra in an interactive and exciting way [4].

1.3 Objectives

The project has the following goals:

1. To provide students and lecturers a visualized package of algebra.
2. To make many confusing concepts visualized and understandable.
3. To help lecturers save time through animated graphics and step-by-step problem-solving.

1.4 Scope

The scope of our research is animating main parts of the undergraduate course Introduction to Algebra (MTK 3001), a compulsory course for some programs in Universiti Putra Malaysia. Macromedia Flash5 will be used to implement the program for teaching the course.

CHAPTER 2

LITERATURE REVIEW

2.1 Past Studies and Review

The researcher tries to summarize the studies and papers relevant to his research. The past studies reviewed are as follows:

Information Visualization

Visualization means to imagine or remember as if actually seeing. Immediately we realize that visualization is in other words, it goes on the mind [5].

The main issue in information visualization can be understood through representation. Visualization is defined as the representation of some concepts of information: and our next question is what to represent, and how to represent concepts of information.

Until recently the term visualization meant constructing a visual image in the mind. But now it has come to mean something more like a graphical representation of data of concepts. One of the greatest benefits of data visualization is the sheer quantity of information that can be rapidly interpreted if it is presented well [6].

There are four basic stages [6] in the process of data visualization, together with a number of feedback loops. They consist of:

- The collection and storage of data itself
- The preprocessing designed to transform the data into something we can understand
- The display hardware and the graphics algorithms that produce an image on the screen
- The human perceptual and cognitive system (the perceiver).

Goguen (2001) believes that for visualization we should have some theories. In the case of scientific visualization, we need scientific theories and proper meanings for the signs and symbols used. Dynamics can be handled by generalizing the algebra that is used, from classical algebra, to a new variant called visualized algebra. The social grounding comes in through the notion of "importance," and the way that visualizations are used in practice [7].

We use visualization as a tool for thinking. It helps us solve problems, realize new designs and processes. Computer visualization is visual thinking with computers. In that context, a visualization software session can become an extension of our own thinking processes [8].

Three aspects of visualization: firstly the underlying data used to create the representation, secondly the forms of interactivity available to the user, and thirdly the input and output information that is explicitly represented by the visualization [9].

It is important to discuss how this information can be used for visualization. Traditionally, some model is constructed from the computed information and used to render new images. Alternatively, it is also possible to obtain new views directly by combining the appropriate pixels from recorded views. It is interesting to note that even when there is an ambiguity on the reconstructed geometry, correct new images can often still be generated [10].

Virtual Environment

Sarah Inkpen [11] explains that educational technology, more specifically virtual reality, holds great promise in the quest of enhanced learning. As visual images, texts and sounds circulate in cyberspace, we may expect a thorough exteriorization of knowledge and a dramatic transformation in curricula and in instructional processes.

Through integrating html, vrml and java script into the environment, she believes that many students can actively inhabit an inclusive computer-generated environment. According to her study, the presentation will include a prototype of a virtual environment designed to have students interact with basic calculus concepts such as rotation of solids, and centre of gravity. This environment, transforming abstract mathematical concepts into dynamic and manipulable objects. In the constructive view, the learner is building an internal representation of knowledge and a personal interpretation of experience, most of the times these interpretations are not relevant. What is meaningful is the development of learning environments which encourage construction of understanding in multiple perspectives. This is in contrast to the typical school environment where the goal is to transfer knowledge to the learner in the most efficient and effective manner possible.

The information is not processed by the mind, but constructs it based upon past experience and on going interactions in the world. The instructors generally teach what to think rather than how to think. Creativity and building thinking styles is the ability to use visual or previous experiences to solve problems that never encountered before.

Integration of technology into the mathematics curriculum has changed what and how we teach. Previously, mathematics had become a series of algorithms with little relevance to the world outside the school. With our rapidly new technologies and changing society, it

is important that educators empower students to be life long learners; aiding them in good learning, and encouraging collaborative work. Includes interactive mathematics laboratories, graphing calculators, and multimedia animation's, all these towards the goal of visualization and learning [11].

A virtual learning environment designed to have students interact with basic mathematical concepts will help facilitate understanding, interacting and knowledge building.

Graphing Calculators and Visualization

in the College Algebra Classroom

In his study, Alexandar [12] focuses on visualization of college algebra classroom using graphing calculators and how they can aid in the mathematics curriculum especially in conceptual understanding. According to the study, this technology puts the necessary tools in the hands of the students to discover basic concepts, rules and patterns for themselves, to explore open-ended problems, and to make real world applications accessible in the classroom. Graphing calculators provide students with the opportunity to interact visually with mathematics in ways never experienced before in their education.

The purpose of the study was to investigate how the graphing calculator can provide a visual pictorial form to algebraic concepts, to introduce algebra and graphing concepts using the TI-82 graphing calculator to make easy for students to employ spatial visualization skills to better understand the mathematical concepts.

Alexandar thinks that college algebra is typically taught the traditional way with a fairly narrow algebraic approach. Using TI-82 graphing calculator, the typical approach is supplemented in a way to make the classroom teaching more interesting. Using the overhead projection system in the classroom, before was a passive atmosphere, but now a more active one. Using the TI-82, mathematics makes students personally involved in experimentation and discovery.

The study refers to another advantage of graphing calculator which helps to create an interactive learning environment in which students were able to construct their own mathematical understanding. The study was a continuation of a study done in 1993 at Georgia State University. It was based on the effective use of the TI-81 graphing calculator in the college algebra classroom.

This on-going study was carried out in two sections of college algebra at Georgia State University. The participants consisted of students enrolled in the undergraduate program who were required to furnish their own TI-82 graphing calculator to use in and out of the classroom. The course was designed to implement the use of the graphing calculator as a visualization tool in the college algebra classroom in order to meet the needs and purposes of today's students.

The visualization aspects of the graphing calculator enabled students to fit graphs of functions to pictures and real world situations. The researcher found that students' interact positively with the use of graphing calculators in the classroom. Most students believed

that concrete visualization through the use of the TI-82 graphing calculator was useful to their understanding of algebraic concepts. With the use of the TI-82, also the students were able to view and solve more modeling problems through visualizing problems better and develop their ideas and understanding of mathematics. The strategies used in this study show that the use of graphing calculators help the students to explore more topics and develop their problem-solving skills through the use of concrete visualization [12].

Dr. Super's Virtual Manipulatives

Aghevli and Spikell [13], describe Dr. Super's virtual manipulative as a new class of instructional teaching devices. There are over 20 such physical manipulative including Attribute Blocks, Geoboards, Tangrams, Pattern Blocks, Color Cubes, Dr. Super's Triangles, etc. Pioneering work with virtual manipulative has taken place at George Mason University. These virtual manipulative can be used as hand-held electronic devices or can be offered directly through the Internet. Aghevli and Spikell, have been collaborators on the invention, creation and dissemination of physical manipulative since 1990. They have published or have in press four different physical manipulative products for the teaching of mathematics. The research describes these manipulators as:

> "Hand held electronic devices which create dynamic images of two and three dimensional geometric shapes. The shapes can be manipulated by slides, flips, turns, and scaling to solve animated puzzles and play action games. In the home market, manipulators are captivating devices for fun and recreation. In the school market, the manipulators are fascinating devices, for teaching topics, in problem-solving, geometry, algebra, and pre-algebra mathematics" [13].

The importance of these manipulators appears when we compare between the traditional teaching and the teaching with the use of these manipulators. Traditional teaching in mathematics most of the time leads to the memorization of concepts but not to understanding. In the traditional teaching environment the teacher-centered instruction in which only teachers talking and telling while students do a lot of passive listening and memorizing, with a very little collaborative in the class. This type of teaching is characterized by the phrase, *the teacher is the sage on the stage.* Teachers define terms, give directions, explain problems, answer questions, and otherwise present information to students. In contrast, non-traditional teaching is student-centered instruction in which teacher has a very different role, one characterized by the phrase, *the teacher is the guide on the side.* In this method of instruction, teachers do very little talking and telling. Instead, they create an environment where students become active learners through hands-on activity with concrete objects, called manipulatives.

Both researchers of this study convinced that in order for the non-traditional approach to instruction to be effective they should not be static visual representations of the manipulatives but, rather, dynamic ones. These dynamic visual representations considered as effectively computer generated visual versions of the actual concrete manipulatives[13].