Building up the notion of Dependence Relationship between Variables: A case study with 10 to 12-year old students working with *Math Worlds*[1]

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Abstract

This paper reports the results from a study with 10 to 12-year old students working on activities involving various functional representations (graphs, tables, and numerical relationships) in a motion phenomena simulation environment such Math Worlds. Results from the study suggest that pupils that have not been received formal instruction in algebra symbolism are able to evolve towards a better understanding of functional relationships, when working with a variety of representation systems. Duval's registers theory was used for activity design and data analysis. This study is part of a broader project entitled Enseñanza de las Matemáticas con Tecnología (EMAT) (Teaching Mathematics with Technology), which was developed by the Mexican ministry of education at the end of the 90s (Rojano, T., 2003).

Introduction

At the end of the 90s, Mexico's Secretariat of Public Education (SEP) together with the Latin American Institute of Educational Communication (ILCE) undertook the initiative of implementing an educational innovation and development project known as Teaching Physics and Mathematics with Technology (EFIT-EMAT). The principles listed below were the underpinnings of the project conception: a) Didactic principle through which classroom activities are designed following a phenomenological treatment of the concepts taught. b) Specialization principle through which tools and pieces of content software are chosen. The selection criteria were derived from the specific didactics of each subject (Physics and Mathematics). c) Cognitive principle through which tools are chosen that enable direct manipulation of mathematical objects and phenomenon models through executable representations. d) Empirical principle according to which tools proven in some educational system are chosen. e) Pedagogic principle through which ICT usage activities are designed in order for them to promote collaborative learning and interaction among students, as well as among teachers and students. f) Equity principle with which tools are chosen that enable secondary school students to have early access to powerful scientific and mathematical ideas.

Specifically EMAT (Teaching Mathematics with Technology) is a model that contemplates use of a variety of technological pieces (specialized software and graphic calculators) each of which is very closely related to the specific didactics. In concrete terms usage of *dynamic geometry software* was included for topics of geometry; *spreadsheets* were included for teaching of algebra, arithmetic-algebraic problem solving, and probabilities topics; *graphic calculators* were included for introduction of algebraic syntax and problem solving; simulation *software* and *software* to represent movement phenomena were included to teach mathematics of variation. This article reports on the

findings of a pilot study on the activities designed for work with mathematics of variation.

Background

There has been recently a growing interest on children's potential to learn algebra at early stages of their development. In some of these *early algebra* studies the possibility of teaching algebra to young students (7 to 8 year old) has been explored through problem solving activities that elicit the algebraic nature of arithmetic competency (Carraher et al, 1999 and 2000). Other approaches emphasize the role of young children drawings and representations in word problem solving processes as a basis to develop algebraic ideas (Dougherty and Zolliox, 2003). Smith and Davis (2001) say that the history of algebra may be used as a source of information about the possible difficulties faced by young students when they are introduced to algebraic thinking. L. Lee stresses out the idea of considering the relevant aspects of different methods used to teach algebra (as a language, a way of thinking, a tool, or generalized arithmetic) to encourage the learning of algebra (Lee, 2001). Every study, however, has reported the feasibility of introducing young students to the algebra domain either by using algebra symbolism or through other representations. The purpose of this study is to investigate the possibility of introducing fundamental algebraic ideas to students from elementary schools through the use of representation systems such as Cartesian graphics and numerical tables generated by a learning tool that includes a motion phenomena simulation environment.

Theoretical Framework

Theoretical references on representation devices are based on R. Duval (1999), who describes how semiotic registers provide an effective way to materialize knowledge and deal with mathematical objects. In this regard it is necessary to promote a kind of learning, where several representation devices are integrated and coordinated in such a way that the student does not mix up the mathematical object and its semiotic representation, and relates the mathematical object to several representations. R. Duval claimed that it is necessary to encourage three cognitive activities: 1) *formation* (create a representation to describe an object); 2) *treatment* (transform the representation into the device); and 3) *conversion* (transform the representation of a device into another).

Our research takes these elements as a basis for the development of a didactic strategy to design learning activities, which enable students to approach up algebraic concepts such as functional variation through the cognitive activities of *treatment*, *conversion*, and *formation*.