

Chapter XXXIX

Reconceptualisation of Learning Objects as Meta–Schemas

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ABSTRACT

The shift in the way we visualise the nature of mathematics and mathematics learning has presented educational technologists with new challenges in the design of rich and powerful learning environments. Against this background, the design and use of learning objects in supporting meaningful mathematical learning assumes increased significance. I argue that learning objects need to be sufficiently pliable such that both teachers and learners could engage in knowledge construction that provides further avenues for growth and sophistication of mathematical schemas. In this chapter, the author aims to show the limitations of current views about mathematical learning objects and the need to reconceptualise these in terms of generic meta-schemas. A meta-schematic framework would provide the mathematics community with powerful pedagogical tools to support and assess mathematics learning. Two examples of these meta-schemas for geometry are described.

INTRODUCTION

Practitioners' and academics' views about the nature of mathematics and mathematics learning have undergone radical changes. Traditionally, mathematical knowledge was perceived as a collection of facts and symbols that needs to be committed to memory and retrieved at a later time to solve problems. However, the current

dominant epistemological perspective is that the body of mathematical knowledge is not a static entity. Collectively its principals, concepts, codes, procedures, and conventions constitute cultural tools that have been invented and used by communities in order to interpret and function in an environment that has changed as human civilization has developed. As human thinking advanced, people had to invent more advanced mathematical

tools and new ways of representing mathematical ideas that have in turn helped them solve more sophisticated problems. Thus, at a macro level, mathematical knowledge undergoes continuous changes in order to keep pace with the demands of the environment. The above shift in the way we view mathematics and its functions from immutable truths to ever knowledge that provides powerful tools to make sense of one's environment is beginning to pose new questions and challenges for teachers and educational technologists.

BACKGROUND

There are at least two major implications of the aforementioned change in the way mathematics is understood by learners for the teaching of mathematics and the kind of technological tools that can be used to support the learning process. The ever changing and malleable nature of mathematical knowledge calls for novel ways of conceptualising the design and development of mathematical learning environments. Designers need to focus on helping learners acquire mathematical structures that embody a collection of concepts, symbols and procedures. Further, these structures must be flexible enough to assimilate new information and accommodate new mathematical understandings. This structural view of mathematical knowledge and its development addresses the issue of *inert* knowledge that has been highlighted by Bransford (1979). Knowledge is considered to be inert when it is not accessed and used when in fact it can be shown that that knowledge is stored in memory.

The notion of mathematical structures connotes the existence of relations among various components or entities. Cognitive psychologists, in their analysis of knowledge, have identified two major factors that could impact on the quality of knowledge: strength and spread (Anderson, 2000). The starting point for my attempt to represent the quality of mathematics teachers' knowledge

of content and pedagogy is Mayer's (1975) notion of knowledge connectedness. Mayer (1975) described the accumulation of new information in long-term memory as adding new nodes to memory and connecting the new nodes with components of the existing network. He identified two types of knowledge connectedness: *internal* and *external*. *Internal connectedness* refers to the degree to which new nodes of information are connected with one another to form a single well-defined structure or schema. This sense of connectedness refers to both the presence of nodes related to a schema and the quality of the relationships established among those nodes. The broad notion of quality here can be related, in part, to what Anderson (2000) refers to as the strength of a memory trace. Seen in this way, the stronger the connections among the nodes in a particular schema, the better the quality of that structure. Mayer (1975) referred to *external connectedness* as the degree to which newly established knowledge structures are connected with structures already existing in the learner's knowledge base. For example a teacher might be expected to relate a schema for proportion with schemas for ratio or fraction.

Identification of what connections are present in a knowledge structure is one important dimension related to the quality of that structure. Other things being equal, the more comprehensive the connections in a knowledge structure, the more "rich" or more elaborated the structure, the more useful it will be in problem solving (Anderson, 2000). However, it is also apparent that the nature of the connections within a knowledge structure, not just the number of connections, is also important. Some time ago Bruner (1966) referred to knowledge representations as having degrees of "power," and Wittrock (1974) has described both student and teacher understandings as having "generative" capacity. Both power and generative capacity draw attention to the quality of the connections in a knowledge structure. The more

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