INTRODUCTION

Mathematical knowledge is significantly different from other kinds of knowledge. It is abstract, universal, highly structured, extraordinarily interconnected, and of immense size. Managing it is difficult and requires special techniques and tools.

Mathematicians have developed (over the last two or three millennia) many techniques for managing mathematical knowledge. For example, there is a large collection of techniques based on the use of special symbols and notations. Although these techniques are quite effective and have greatly advanced mathematical practice, they are primitive in the sense that the only tools they require are pencil and paper, typesetting machines, and printing presses.

Today mathematics is in a state of transition. Mathematicians are using the Internet in new ways to find information and to share results. Engineers and scientists are producing new kinds of mathematical knowledge that is oriented much more to practical concerns than to theoretical interests. This is particularly true in the field of software development where software specifications and code are forms of mathematical knowledge. Computers are being pushed to perform more sophisticated computations and to mechanize mathematical reasoning. Mathematical knowledge, as a result, is being produced and applied at an unprecedented rate.

It is becoming increasingly difficult to effectively disseminate mathematical knowledge, and to ascertain what mathematical results are known and how they are related to each other. Traditional ways of managing mathematical knowledge are no longer adequate, and current computer and communication technology do not offer an immediate solution. Since mathematical knowledge
Mathematical Knowledge Management

is vital to science and technology, and science and
technology is vital to our society, new ways of
managing mathematical knowledge based on new
technology and new theory are needed.

This article introduces the main issues of man-
aging mathematical knowledge. It is organized
as follows. The Background section describes
mathematics as a process of creating, exploring,
and connecting mathematical models. The spe-
cial characteristics of mathematical knowledge
and the four main activities that constitute the
management of mathematical knowledge are
discussed in the Main Focus of the Article. The
Future Trends section introduces Mathematical
Knowledge Management (MKM), a new field of
research, and discusses some of the challenges it
faces. The article ends with a conclusion, refer-
ences, and a list of key terms.

The management of mathematical knowledge
is an emerging field of research. Researchers are
just starting to build a foundation for it. This article
focuses on the core concerns of the field. Except
for a few remarks, it does not discuss the parallels
between mathematical knowledge management
and mainstream knowledge management. Nor
does it discuss how techniques for managing
mathematical knowledge can be applied to the
management of other kinds of knowledge. These
are important topics for future research.

BACKGROUND

People often associate mathematics with a body of
knowledge about such things as numbers, spatial
relationships, and abstract structures. However,
this view of mathematics is misleading. It suggests
that mathematics is something static and dead, but
mathematics is actually the opposite—dynamic
and alive. It is more productive and accurate to$view mathematics as a process for comprehending
the world that consists of three intertwined activi-
ties (Farmer & von Mohrenschildt, 2003).

The first activity is the creation of mathemati-
cal models that represent mathematical aspects of
the world. Mathematical models come in many
forms. A well-known and important example is
the model of real number arithmetic composed
of the set of real numbers, and operations and
relations involving the real numbers such as +,
×, and <. Real number arithmetic includes vari-
ous submodels such as arithmetic of the natural
numbers 0,1,2,... and arithmetic of the rational
numbers like 2/3, 31/17, and so forth. Real number
arithmetic and its submodels capture the essen-
tial elements of counting, measurement, motion,
and much more. Real number arithmetic itself is
a submodel of complex number arithmetic and
many other mathematical models.

The second activity is the exploration of math-
ematical models to learn what they say about the
mathematical aspects of the world they model.
There are several means of exploration. The ex-
plorer can state a conjecture about a model and
then attempt to prove that the conjecture is true
by virtue of being a logical consequence of the
defining properties of the model. The explorer can
also formulate a problem concerning the model
and then compute a solution to it by mechanically
manipulating a representation of the problem using
rules determined by the model. A third approach,
which is sometimes very effective, is to visualize
some facet of the model with a diagram, picture,
or animation.

The last activity is the connection of mathemati-
cal models by identifying and recording
relationships between models. Models can be
related to one another in various ways. Examples
includes two models being equivalent in a cer-
tain sense, one model containing another as a
submodel, and one model generalizing another
model. A collection of interconnected models
facilitates the creation and exploration of new
models. New models can be built from old models,
and then the results about the old models can be
applied to these new models according to how
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