InterMath¹--Professional and Cognitive Development through Problem Solving with Technology
Evan Glazer
University of Georgia, United States of America eglazer@coe.uga.edu.
InterMath project group, intermath@coe.uga.edu http://www.intermath-uga.gatech.edu/
Learning and Performance Support Laboratory - University of Georgia
Center for Education Integrating Science, Mathematics, and Computing - Georgia Institute of Technology
A pdf version of this paper can be found on the web at: http://www.arches.uga.edu/~eglazer/nime2001.pdf

Abstract
InterMath is an Internet-based (http://www.intermath-uga.gatech.edu/) project with the goal of designing and implementing a series of workshops and ongoing support programs that feature contemporary applications of technology and mathematics pedagogy in the middle-grades. Technology is used to deliver the curriculum through web-based materials and to explore the mathematics using cognitive tools such as dynamic geometry software, spreadsheets, and graphing calculators. Objectives of InterMath include

• strengthening the middle school teacher's knowledge and understanding of mathematics,
• providing a support structure (on-line & in-school) to aid teachers in implementing and integrating technology tools for doing mathematics, and
• providing a structured inservice curriculum that follows Georgia's Quality Core Curriculum objectives as well as reform efforts expressed in publications by the National Council of Teachers of Mathematics.

InterMath is a collaborative effort among the University of Georgia, Georgia Institute of Technology, and nine regional technology centers in the state of Georgia. InterMath, a five-year effort to design and implement a series of field-based workshops and ongoing support programs to assist both teachers and administrators in effecting mathematics reform, is funded through the National Science Foundation.

A Vision for School Mathematics

The pedagogical shifts embodied in a series of documents published by the National Council of Teachers of Mathematics (NCTM) emphasize vastly different approaches to mathematics teaching and learning than are typical in today's classrooms (NCTM, 1989, 1991, 1995, 2000). Rather than static knowledge and skills detached from both other domains and everyday events, mathematics is viewed as problem solving, reasoning, and communicating so that students are empowered to confidently "explore, conjecture, and reason logically [about the world around them]" (NCTM, 1989, p.5). This change in learning philosophy reflects a need for mathematics that is based in an information-rich and technology-based society. Learning goals should incorporate values that reflect mathematics for life, mathematics as a part of cultural heritage, mathematics for the workplace, and mathematics for the scientific and technical community (NCTM, 2000).

One way to support these goals is to provide teachers extended opportunities to experience and do mathematics in an environment supported by diverse technologies (Dreyfus & Eisenberg, 1996). The development of mathematical understanding occurs when technology is used as a cognitive tool that supports thinking, reasoning, and problem solving (Jonassen & Reeves, 1996). The use of cognitive tools such as dynamic geometry, graphing calculators, spreadsheets, and symbolic processors, can provide opportunities and experiences for exploration, developing understanding, interpreting and communicating about mathematics (see Bransford, et al. 1996; Schoenfeld, 1982, 1989, 1992; Silver, 1987). Our approach in the InterMath project focuses on using these tools to develop mathematical power--understanding, using, and appreciating mathematics.

Project Overview

Description and Goals
InterMath (http://www.intermath-uga.gatech.edu/) is an Internet-based project with the goal of designing and implementing a series of workshops and ongoing support programs that feature contemporary applications of technology and mathematics pedagogy in the middle-grades.

InterMath has two primary teacher components:

• workshops comprised of in-class portions and a "follow-along" component in which participants create curriculum for use in their own classrooms.
• an ongoing system to support teachers beyond the initial laboratory/workshop.

Intensive support is provided throughout the workshops under the close tutelage of InterMath facilitators distributed throughout the state. The site-based component focuses heavily on scaffolding in-school reform efforts. As participants near completion of the laboratory portion, they transition to the ongoing support system—a peer community to ensure continuity beyond the

¹The InterMath project has been funded by the National Science Foundation [Grant #9876611]. The views and opinions of the authors do not necessarily represent those of the National Science Foundation.
active problem solving with technology. Participants explore •
riately, these situations expose misconceptions and
ere the graphing calculators' resolution caused certain
ad of focusing on algorithms (Grassl & Mingus, 1997; Heid, 1988; Maury,
: (1) gives an appropriate level of challenge, (2) appeals to the sense of curiosity, (3) provides the learner with a sense of
rolling a problem, or working with an application. The key elements of a write-up consist of the learner’s synthesis,
unication, mathematical ideas, interpretation, and utility of an investigation. Final projects, focusing on a technology-
ehanced mathematics investigation of the individual participant’s determination, are submitted and discussed at the end of the
workshop. Participant productions are placed on the InterMath website for public sharing.
The laboratory leader presents demonstrations and explanations, clarifies problems, and demonstrates alternative
solutions using a projected image from the leader's workstation. In a typical session, a leader might allocate one-third of the time
in whole-group mode, and during the balance of the meeting provide direct support for participants working on their projects or
units, either individually or in groups. In addition to the 45-hour workshop, the 55-hour “follow-along” course will promote the
use of technology to enhance mathematics teaching in their home school and to extend each participant’s expertise. This
additional component to the workshop promotes reflective practice among the participants, emphasizing realistic applications of
technology in middle school teaching. Each participant's web page contributions includes conceptual work, projects, activities for
their classroom, and links to related teaching-learning resources in order to establish a highly connected framework of
resources.

Our Use of Technology
The InterMath workshop illustrates how and when technology can be used appropriately in the mathematics classroom.
The literature describes two distinctly different approaches in the use of technology in classrooms: using the computer as a tool
for exploration or problem solving and using the computer as a tutor that delivers instruction and provides feedback. Research
on the use of computers in mathematics as a tutor and a tutee are usually not situated in problem solving environments. Most
tutor-based technologies are in the form of drill and practice software, which tend to rely on lower ordered skills, and are often
negatively related with student achievement (Jonassen & Reeves, 1996; Wenglinsky, 1998). Jonassen and Reeves (1996) argued
that higher-order thinking occurs in environments where the student is learning with, and not from, the computer. It is this
approach that InterMath promotes and intends to develop among its participants.

Many studies investigating technology-enhanced environments include an emphasis on conceptual development
situations. For example, when calculators and computer software perform calculations and simplifications, teachers have more
time to emphasize why something is happening, instead of focusing on algorithms (Gonz & Mingus, 1997; Heid, 1988; Maury,
1987; Palmier, 1991). Moreover, the imperfections in calculator graphs and computations also provide opportunities for
conceptual development. For example, Dion (1990) found cases where the graphing calculators’ resolution caused certain
functions to appear differently than they are supposed to. In addition, Goldenberg (1998) found that the graphing calculator
window can provoke critical inquiry because different functions can appear to look the same if they are on different domain and
range windows. Finally, Burrill (1992) noticed that the calculator has difficulty simplifying computations with extremely large
and small numbers, consequently producing an incorrect answer. Used appropriately, these situations expose misconceptions and
help students develop a richer understanding of the mathematics being studied.

Cognitive Development
Rationale of Workshop Activities
In designing the workshops, we have kept in mind the work of Malone and Lepper (1987) concerning the design of
instructional environments that are intrinsically motivating. They have identified four sources of intrinsic motivation in learning
activities: (1) gives an appropriate level of challenge, (2) appeals to the sense of curiosity, (3) provides the learner with a sense of
control, and (4) encourages the learner to be involved in a world of fantasy in which learners can experience vicariously rewards
and satisfactions that might not be available to them otherwise. While a workshop leader may not be able to incorporate all of
these sources of intrinsic motivation into every learning activity, incorporating at least one appears to increase the likelihood that
the activity will be intrinsically motivating.

Pertaining to the first source of intrinsic motivation, we have included a variety of problems on a continuum of
difficulty levels. By posing challenging problems within a familiar context, teachers will develop confidence in problem solving
and thus will more likely engage in the activities. The context of the problems enables teachers to safely sample and reflect on
their own approaches to problem solving. The second source of intrinsic motivation is appealing to the sense of curiosity.
Activities can stimulate curiosity by introducing ideas that are surprising or discrepant from the learner’s existing beliefs and ideas. While the mathematical problems posed in the workshop center on middle-school curriculum, they are more open-ended and generative than is typically seen in a traditional middle-school curriculum. Problems can be used as a springboard for ideas and investigations that participants find personally intriguing. Furthermore, teachers are able to choose among several activities in which to actually engage. They can choose activities that are most applicable to their classroom needs and relevant to their mathematical understanding. Since participants can choose activities based on their preferences, the third source of intrinsic motivation (providing the learner with a sense of control) will be reflected throughout the laboratory.

The fourth source of intrinsic motivation is encouraging engagement through fantasy. As an example of a task using fantasy, consider the following problem requiring the use of the Pythagorean theorem:

The learner needs to calculate the distance from point \( a \) to point \( b \) in order to inform Captain James T. Kirk about how to set the transformer beam on the Federation Starship \( Enterprise \) so they can pick up the necessary dilithium crystals directly below on the planet's surface. Kirk only knows the distances of the ship and the crystals from a third point where his scouting party has stopped (Lepper & Hodell, 1989).

Fantasies are more intrinsically motivating when they employ characters and situations with which the learner can identify. Faced with either this fantasy-like problem or a series of abstract problems in which learners are asked to find the length of one side of a triangle, one can imagine which type of problem learners would prefer.

The philosophy permeating InterMath is that teachers must relearn mathematics in a more open-ended, generative manner so they may come to understand what reform documents intend by "meaningful learning." Furthermore, by encouraging teachers to create and modify their own curriculum units, InterMath attempts to avoid what Howson, et al. (1981) warn may be a cause for failed reform -- teachers failing to assume ownership of reform.

### Workshop Content

The mathematics content and concepts of InterMath reflect curriculum that would enhance a teacher's understanding of middle-grades mathematics. The laboratory centers on the middle-school mathematics curriculum per Georgia's Quality Core Curriculum (QCC) and the NCTM Standards (1989, 2000). The InterMath curriculum is meant to engage teachers and is intended to deepen teachers' understanding of mathematical concepts related to the middle school curriculum. Thus, the investigations would likely need to be modified for use with middle school students. There are 13 units that can be used for InterMath workshops. Thirteen units are called Fraction and Decimals, Integers, Rational Numbers, the third source of intrinsic motivation.

### Next Steps

InterMath is at the end of its second year of a five year project. Over the past year, the web-based InterMath materials have been developed and tested with various teachers in the state of Georgia through teacher workshops. A community of teachers has already technology-enhanced materials for their classrooms that can be accessed on the InterMath website (http://www.intermath-uga.gatech.edu). In addition, we are in the process of developing an ongoing support system that will encourage a sustained effort among teachers in the InterMath program. For example, an online discussion forum has been built from the InterMath website so that teachers can share ideas, collaborate on projects, ask questions, and obtain technical assistance. The goal at the end of the five year project is to have a self-sustaining system of resources, tools, and people with a common goal of enhancing mathematics education using technology as a catalyst for change.

### References


