The Mathematics Educator
2006, Vol. 16, No. 1, 4–13

What Learner-Centered Professional Development Looks Like: The Pilot Studies of the InterMath Professional Development Project

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& The InterMath Team

In recent years professional developers have reached a consensus about what constitutes effective professional development, referred to in the literature as "learner-centered professional development." InterMath is a professional development project that was developed to address the recommendations for high quality professional development for middle grades mathematics teachers. In this report, I will highlight two cases of InterMath implementation. Then, I will offer a discussion of changes that have been made to InterMath in light of the findings from the pilot studies and report preliminary analysis of the impact of these changes.

> *How can teachers teach a mathematics that they have never learned, in ways that they never experienced?* (Cohen & Ball, 1990)

The above quotation is one of the underlying conundrums of mathematics reform. Recent analyses of mathematics assessments show American students' failure to achieve even basic levels of proficiency on national tests (U.S. Department of Educational Statistics - OERI, 2001) and their low performances on international tests (Cochran, 1999). These test results have been accompanied by the National Council for Teachers of Mathematics' call for mathematics teaching to embody the tenets of constructivism by focusing more on hands-on engagement with mathematics in the service of developing understanding (NCTM: 1991, 1995, 2000). The NCTM standards recommend that teachers pose meaningful, complex tasks for their students, provide opportunities for students to engage in real-world problems, and use manipulatives and technology to support learners in the construction of their own personal understanding of mathematics concepts. While these recommendations are very clear to the NCTM authors, they are completely foreign to many classroom teachers. Given the shifts called for by NCTM and the ongoing problems with student performance, there is clearly a rationale for rethinking both the role and the format of professional development (e.g., National Council for Science and Mathematics [NCSMT], 2000; National Partnership for Education and Accountability in Teaching [NPEAT], 2000; National Commission on Teaching & America's Future, 1996; Renyi, 1996; Sparks & Hirsch, 1999).

Professional developers in recent years have reached a consensus about what constitutes effective professional development, referred to in the literature as "learner-centered professional development" or "research-based professional development" (NPEAT, 2000). These recommendations include extending professional development beyond the "one-shot workshop," promoting opportunities for teachers to learn in the same ways they are expected to teach, focusing on reflection, and pushing for more content-focused teacher learning (e.g., Ball, 1994; Hawley & Valli, 1999; Krajcik, Blumenfeld, Marx, & Soloway, 1994). As summarized by Kilpatrick, Swafford, and Findell (2001):

> Teachers' professional development should be high quality, sustained, and systematically designed and deployed to help all students develop mathematical proficiency. Schools should support, as a central part of teachers' work, engagement in sustained efforts to improve their mathematics instruction. This support requires the provision of time and resources (p. 12).

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Acknowledgements
The National Science Foundation under grant number ESI9876611 has supported InterMath and the work reported here. Opinions expressed are those of the researchers and do not necessarily reflect the opinions of NSF. Pilot study data collection, analysis, and writing previous versions of this report was completed by the author and members of the InterMath team, including Summer Brown, A. Kursat Erbas, Chad Galloway, Evan Glazer, Brian Lawler, and Shannon Umberger Patton. Ongoing analysis of post-Pilot Study InterMath data has been supported by Laurel Bleich, A. Kursat Erbas, Sarah Ledford, and Drew Polly. Previous versions of this paper have appeared in the Proceedings of the Association for Educational Communications and Technology (2001) and the proceedings from PME-NA XXIV (2002).

The National Partnership for Excellence and Accountability in Teaching (NPEAT) has outlined the aspects that should be included in this new kind of professional development (NPEAT, 2000). Aligned with other proposals for improving professional development, the NPEAT Research-Based Principles provide a guide for professional development. These principles include:

> The content of professional development (PD) focuses on what students are to learn and how to address the different problems students may have in learning the material.
>
> Professional development should involve teachers in the identification of what they need to learn and in the development of the learning experiences in which they will be involved.
>
> Most professional development should be organized around collaborative problem solving.
>
> Professional development should be continuous and ongoing, involving follow-up and support for further learning — including support from sources external to the school that can provide necessary resources and new perspectives.
>
> Professional development should provide opportunities to gain an understanding of the theory underlying the knowledge and skills being learned (NPEAT, 2000).

In short, numerous researchers and policy-makers now assert that teachers should take charge of their learning, be provided with motivational and challenging ways to learn, and should have the opportunity to decide what is most relevant for their students (Hawley & Valli, 1999).

InterMath

InterMath, a National Science Foundation-funded initiative, was developed to address the recommendations for high quality professional development for middle grades mathematics teachers. Originally, InterMath was developed to be a 15-week (45 seat hours) face-to-face workshop supported by a variety of technologies including an extensive Web site that provides over 500 open-ended investigations (http://www.intermath-uga.gatech.edu). InterMath's Web site also included an interactive dictionary of common middle grades mathematics terms, a discussion board, and a section designed to house teachers' electronic portfolios of work from their InterMath courses. InterMath was specifically created to help address a critical deficiency in teacher content knowledge in the state of Georgia (Southern Regional Education Board [SREB], 1998). This problem was a result of the number of middle grades teachers teaching out of field or holding a "generalist" degree in elementary education that did not provide the teachers with a rich enough content background to develop needed content and pedagogical knowledge.

InterMath's initial goals included the improvement of teachers' mathematical skills and knowledge through open-ended explorations; an understanding and ability to use software to support the development of mathematical thinking; and the creation of a community of teachers who support each other in implementing the explorations-based approach in their classroom. In implementation, there is considerable room for teachers to choose their own path to success – they select which problem(s) they want to work on in each of the critical content areas; they select the approach they want to use to solve the problem; and, ultimately, the teachers decide the depth of learning they take from the class by choosing to explore more challenging problems or add extensions to the problems.

InterMath embodies many of the professional development principles mentioned earlier. It provides an extended opportunity for teachers to engage in mathematics in the same ways they should engage their own students in mathematics. Further, the format of InterMath allows teachers to work with their peers, select the problems on which to focus, and use a variety of tools to support their own work. In fact, in the pilot offerings and many of the current offerings of InterMath courses, teachers have developed their own calendars for completing assigned work. While many of the teachers who have participated in InterMath courses were not necessarily seeking an introduction to reform-based approach to mathematics, all have reported learning about aspects of the NCTM standards that help define a quality mathematics experience.

In this report, I will highlight two cases of InterMath implementation. Because these have been discussed elsewhere (e.g., Brown *et al*., 2001; Erbas, Umberger, Glazer, & Orrill, 2002), they will be brief with particular emphasis on the findings. Then, I will offer a discussion of changes that have been made to InterMath in light of the findings from the pilot studies and report preliminary analysis of the impact of these changes.

The Pilot Studies

Two InterMath pilot studies were conducted simultaneously in two different locations. One began with seven teachers and ended with four, while the

other included 24 to 28 teachers at various points in the semester. Both courses lasted an entire semester, meeting three hours per week every week. Both pilots used the original InterMath format, which engaged learners in mathematics from across the four strands: algebra, geometry, number sense, and statistics/probability.

Both studies relied heavily on field notes taken by graduate students who acted as participant observers during each workshop. In both pilot studies, these students supported the InterMath instructors and recorded field notes for the research. Additionally, I (Orrill) visited the larger workshop three times and the smaller workshop one time, taking field notes as an external observer. In those visits, the goal was to gain a non-participant view of the learning environment. For the purposes of the pilot study, three weeks of field notes were selected from each class. They came from early in the semester (week 2 or 3), mid-semester (week 6), and later in the semester (week 12–14). These weeks were chosen because they represented the beginning, middle, and end experiences for the courses.

In addition to the extensive field notes analyzed, the data analyzed for this report included tape-recorded interviews with several participants (eight in the larger class and all four participants in the smaller class) and both instructors. Interview participants in the smaller workshop included all of the participants at the time of the interview. In the larger group, the participants were randomly selected. Pre- and post-workshop surveys were administered, asking participants to rate the importance of, and their comfort with, using technology in mathematics and using open-ended investigation approaches. We also considered the written work of those participants who were interviewed as part of the data analysis.

We relied on traditional qualitative data analysis methods of coding and sorting to find emergent categories (Coffey & Atkinson, 1996). Using this approach, we identified several emergent categories that appeared repeatedly and used those as a framework for our thinking. Those included: Support, Interaction, Barriers, Presentation, and Adoption. Once we had defined the categories and made initial assertions, we checked the data to find examples both supporting and refuting those assertions and then refined the assertion as appropriate. Each case is briefly discussed below with a cross-case analysis following.

Case 1

Description

One of the two InterMath Pilot workshops took place near Atlanta, GA, and was taught by a University of Georgia (UGA) mathematics education professor. The participants included 24 to 28 full-time middle school teachers who had enrolled in a UGA graduate program. Even though the participants were all certified to teach mathematics, some were teaching subjects other than math. The teachers participated in the InterMath workshop as their first experience in a degree program established between their school district and UGA's mathematics education department. Participants had chosen to join the degree cohort, but had no choice in their coursework as part of the program. Two InterMath team members offered assistance in the class each week and participated in the data collection effort.

The class met weekly in the evening for three hours. During the first hour portion of each class, the instructor demonstrated one or two problems, talking through the mathematics and the technology used. For the remainder of the class, participants explored the investigations using software programs such as NuCalc (http://www.nucalc.com/), Geometers' SketchPad® (GSP; Jackiw, 1990), and spreadsheet software and completed reports of their problem solving processes to include in their electronic portfolios. The instructor and graduate assistants walked around the room to assist the participants, when requested, with technological and mathematical questions.

Trends

Over-reliance on the instructor. The participants seemed to perceive the instructor and graduate assistants as *experts*. They relied on the instructor rather than each other for technological and content area support. Moreover, they seemed to view the instructor as the "owner" of the class. Even after seeking help from the graduate assistants, the participants often wanted the instructor's approval. In one instance, a participant was exploring an investigation in which he needed to find the maximum volume of a box. The participant asked one of the graduate assistants how he could incorporate technology into the investigation. More specifically, he wanted to know what technology he could use. The graduate assistant discussed some of his options. Instead of exploring these routes on his own and finding multiple representations of the problem, the participant told the graduate assistant that he was going

to ask the instructor which way he should explore the investigation. The participant was seeking a "correct process" for solving the investigation. He only wanted to explore the problem the way the instructor/owner would.

The instructor's actions both encouraged and discouraged this over-reliance on him. In our analysis, the instructor's actions that encouraged an over-reliance included his positioning himself in an ownership position in the way he directed the workshop conversations and selected problems to investigate. Further, he sought little input from the participants about exploring the problems he had chosen during the first hour of class, leaving the participants in a passive role, which was characterized by noticeable off-task behavior by some participants. However, the instructor promoted participant independence and ownership during the second portion of each class period. During this portion of each meeting, participants were given the freedom to select which problems they worked, how they chose to work those problems, and what technology they used. Further, they were able to work with partners or alone. In this workshop, participants chose to work individually on their write-ups with little communication with other participants even though they were able to work with partners. This instructional approach may have contributed to participants' frustration with the level of support they received in the workshop. The choices that the participants made within the learning environment, because of the freedom offered by the instructor, actually contributed even more to the frustrations as the participants chose not to rely on each other, instead preferring to rely on the instructor, or, if the instructor was not available, graduate students, for support. The class, in observations during the second half of the workshop, when the participants were engaged in their own investigations, was described as being very quiet other than the sound of mouses clicking and graduate assistants talking to the participants.

View of InterMath. The data showed that the participants' views of the goals and purpose of InterMath fell into one of three categories. In the first category, participants saw InterMath as a "make and take" activity to take into their middle school mathematics classrooms. They selected investigations based on their students' level of mathematics knowledge rather than their own levels. Because of this, the participants did not appear to push themselves to increase their own mathematical understandings. In one class meeting, a participant voiced concern that the investigations seemed too difficult for middle school students. The instructor explained, correctly, that the investigations were meant for the teachers and that the teachers would have to adapt them if they chose to use them with middle school students. Despite this explanation, some of the participants continued to cling to the idea that the investigations were suitable for their middle school students with little modification or consideration of how to present such an activity to that age level. The participants who treated InterMath in this way likely did not benefit much from their participation, given that InterMath is intended as a personal growth activity for the teacher and does not include the creation of materials suitable for classroom use.

A second group viewed InterMath as a technology course in which they wanted to learn how to use the software tools but took little interest in using the tools to develop their own mathematical understandings. In the workshop observations, these participants became excited when using the technology or learning something new on the computer but seemed to focus very little on learning new mathematical concepts and making connections. For example, one of the graduate assistants showed a participant which button to push to display all the Excel functions she might have needed to create a spreadsheet. The participant exclaimed, "Woo-hoo! I'm finally excited about something in here!" This participant apparently either wanted or expected participation in InterMath to lead to more effective technology use rather than to deepen her understanding of mathematics.

The last group saw InterMath as an opportunity to enhance their mathematical understandings. In the interviews, these four participants stressed the learning of mathematics over the learning of the technology as the focal point of the course. Given that mathematical development was one of the key goals of InterMath, the low number of people in this group was disappointing. One explanation for this might be the paradigm shift represented by InterMath. Rather than being focused on the development of classroom materials or other products for student learning, InterMath focuses on teacher learning, and this is a different way of thinking about professional development for the teachers. Another explanation for the small number of participants in this group may be the rather low mathematical knowledge base evident in the participants. The participants particularly seemed to experience difficulties in geometry and thus struggled to make mathematical connections and develop multiple representations that were crucial in the

investigations. However, these were the teachers who seemed most interested in further exploration of the mathematics and also the most reflective about their own mathematical ability.

InterMath adoption to the classroom. Some of the participants had already begun to use InterMath investigations in their classrooms before the end of the workshop. Surprisingly, in class discussions, teachers reported little or no adaptation of the InterMath investigations when they used investigations with their middle school students. This is ironic, given the teachers' discussions about InterMath investigations being too difficult for middle school students. Late in the semester, a participant pulled one of the graduate assistants to the side and shared with her what she had been doing in her middle school classroom. She had assigned her students to choose three InterMath investigations directly from the Web site to work on and to write-up over two weeks. This participant did not make any modifications to the investigations, nor did she offer any guidance to the students in selecting their investigations. However, consistent with underlying philosophies of InterMath, the teacher did encourage her students to work together. In her particular case, the students rose to the challenge of successfully completing the investigations. However, we saw this instance as an atypical occurrence.

Given the fact that a large number of the workshop participants saw InterMath as a course designed to provide them with materials that were suitable for use in their own classrooms, it is not surprising that they used the investigations in their classrooms. From the interviews, we noticed that this wholesale transfer of InterMath investigations from the web site to the classroom was accompanied by teachers encouraging their students to work alone – a mirror of how the teachers chose to work in the workshop. Further, students often did not receive guidance and were attempting to work problems that were not appropriate for them but were meant to be investigations for the teachers.

Case 2

Overview

The second pilot of the InterMath workshop was led by a mathematics professor and offered on the UGA campus. The workshop met one evening per week for an entire semester, as in Case 1. Two graduate assistants, one from UGA's Mathematics Education department and one from the Instructional Technology department, regularly attended the class to support the learners. The Instructional Technology graduate student, in fact, served in the role of an assistant instructor. A third graduate assistant attended the first few meetings to help support the participants in learning how to make and publish Web pages for their electronic portfolios.

The class began with seven teachers; however, by the end of the fifteen weeks, there were only four participants in regular attendance. One of the teachers who dropped the course did eventually complete it as an independent study. Two of the participants who completed the pilot course taught eighth grade pre-algebra and algebra at a rural middle school. The other two participants came from a private middle school—one was a sixth grade mathematics teacher, and the other was the school's technology support person who also had a mathematics education background. In general, this class was highly cooperative, with teachers from the same schools working together both on solving problems and creating their portfolios.

What the Participants Learned

There were some overarching successes in this pilot class. First, the participants learned how to use technology to create and post write-ups of their mathematical investigations on the InterMath website. Specifically, the participants learned how to use computer software that included web page development tools and FTP (file transfer protocol) clients. On average, the participants posted seven write-ups during the course. These write-ups often included links to spreadsheets and/or GSP files.

Second, the participants learned to identify and appreciate certain aspects of reform-based issues in mathematics teaching and learning. As evidenced through their final interviews, the participants noted the value of problem solving, learning through collaboration and communication, finding multiple solutions and answers, and asking extension questions. For example, when asked what students in an ideal mathematics classroom would be doing, one participant commented, "Well, after all this, problem solving." Another participant said that an ideal classroom to her would be one in which the students were "asking questions, and they're showing their classmates what's happening and sharing ideas and thoughts and communicating with each other." A third participant mentioned that the most important things she learned from the InterMath experience were "The importance of thinking and not just computation. ... And collaboration." She also stated, "I've even told my kids that there are lots of ways to find an answer, and oftentimes the answer's not the important part." It was

clear that mathematics and mathematics education pedagogy were key issues to these participants.

What the Participants did not Learn

There were also some critical areas in which learning did not seem to occur as expected. First, the participants did not seem to greatly expand their mathematics content knowledge. Approximately 61% of the write-ups posted were about investigations that were taken from the Algebra or Number Concepts units on the InterMath Web site. These units correspond to the majority of the topics that are covered in middle grades mathematics. Only 25% of the write-ups focused on Geometry problems, and only 7% were Data Analysis problems. One participant mentioned that after she and her partner struggled with a problem that was hard, they would simply, "close that one up, and we'd do another one." Issues with participants' lack of perseverance and unwillingness to try new areas, possibly relating to issues of low mathematics efficacy or the perpetuated notion that mathematics problems should be easily solved within a short time, were prevalent.

Second, the participants did not become comfortable with using a variety of mathematical software in doing their investigations. Approximately 86% of write-ups indicated that the authors used spreadsheets to help them with the investigations. Not surprisingly, spreadsheets were the only software with which the teachers had considerable experience when they began the workshop. Only 18% of write-ups illustrated use of geometry software, and only 4% mentioned the use of graphing software. One participant stated that she and her partner "felt more comfortable using a spreadsheet. And it's just because...that's what we could maneuver better with." Again, the teachers were not pushing themselves very far in terms of the problems they chose to work and the ways in which they chose to work them.

Finally, the participants did not develop a variety of mathematical approaches to solving problems. Most of the participants relied solely on numeric patterns or measurements to justify their solutions to the investigations. None of the write-ups offered conceptual explanations or tried to rationalize why the numeric patterns or measurements must have given the correct answer. More disturbing, they also did not seek to use extensions to push their thinking and/or their students' thinking further, even though that was an explicit focus of the instructor. The instructor commented that even when the participants wrote extensions, they did not try to solve them. This fact may relate to the same issues that prevented attempts at difficult problems —including seeing the extensions as something their students would not be able to do or worrying that they, themselves, could not adequately answer the extensions they had written.

Cross-Case Analysis

Several findings spanned across both cases. There were also some findings within each case that we were unable to reconcile. For example, we are not sure why our attrition level was high in the second pilot. For that class, the three participants who dropped out were all from a single school. This raised questions for us about the nature of working with peers as well as whether it is feasible to keep teachers from diverse districts engaged in this professional development if they are not working with others from their school district. We can speculate about the role of peer participation in keeping the teachers engaged or the need for more accessible locations; however, it is difficult to know how to address the attrition problem, which has persisted since the pilot studies.

For our cross-case analysis, we adhered to the categories introduced previously. Based on careful analysis of the findings within the coded categories of the two separate case studies, we were able to develop assertions about the professional development that were true for both cases.

Support and Interaction

We found that support and interaction became intertwined in our cross-case analysis. This intertwining was a direct result of the nature of interactions in these courses. It seemed that nearly all interactions, whether between participants or including the instructor, were focused on addressing the participants' concerns about their activities at a given moment. We noted that there were two distinct kinds of interactions: affective (those aimed at providing positive feedback or other information to keep the teachers motivated) and intellectual (those interactions that provided the information teachers needed in order to make progress on the problem with which they were working). Based on our data, the affective interactions were particularly important between participants. Several times the learners commented that they felt unprepared for InterMath until they began talking with the other participants or until they began to find out from the support staff that others were having the same kinds of problems. In more than one case, this "same boat" effect prevented our participants from dropping out of the workshop.

Another support and interaction issue that appeared was the overwhelming number of procedural questions that were asked by the participants. In both of the pilot workshops, the participants' questions often focused on how to use particular pieces of software until about the halfway point of the course. Later in the courses, there was more focus on process-oriented thinking, but the procedural questions never faded entirely. This finding raises a number of questions about supporting the teachers in learning what was intended in the workshops and about who needs to provide support and what that support should look like. In Case 1, we had about 25 teachers with three support people (two graduate assistants and one instructor). In Case 2, we had one instructor and either one or two graduate assistants in every class session, but ended with only four participants. Despite, or because of, the presence of so many knowledgeable others, the participants resisted engaging with each other for problem solving, instead turning to those perceived as owning information. This phenomenon leaves an open question about whether InterMath was successful in helping the participants see mathematics as being about problem solving and other processes. It seems likely that they still held the traditional idea that math is about right answers and that the teacher's role is to have those answers.

Finally, while we provided every opportunity for collaborative learning, few teachers chose to engage in it. Even in those instances where teachers worked as pairs or trios, they tended to work individually on the problems and relied on others only when they were confused or unable to continue alone. We also found that among the teachers who did work together, almost every group included teachers from the same school. These findings, taken together, lead to two insights: first, teachers seem to work with people they already know and with whom they feel "safe," and second, teachers are not naturally predisposed to working in groups. This second point may explain many teachers' reluctance to include group work in their classrooms —reinforcing the need for the professional development environment to model the desired classroom environment.

Barriers and Difficulties

There were two main barriers to InterMath's being as successful as possible across the two cases: technology and "goals." The technology problems were related to participants' inexperience with the specific mathematics tools (e.g., Geometer's SketchPad®) and the need for them to learn to use web development tools to be successful in the workshops. Hardware problems and firewall issues throughout the workshops exacerbated this lack of knowledge and comfort. These were particularly common in Case 1. In both classes, the difficulties with technology were worse during the first several weeks of class with the first half of each 15-week workshop being spent with participants struggling to make and publish web pages. Given that the Web page development component of the class was secondary to the mathematical goals, this was particularly problematic.

The barrier due to "goals" was caused by a mismatch between the participant goals and the workshop goals. In our follow-up interviews and surveys, for instance, a large number of participants indicated that learning technology was their personal goal for participating in InterMath. While this group was satisfied with their InterMath experience, learning technology was not the InterMath team's primary goal for the participants. The InterMath team had hoped to promote a different vision of teaching and learning mathematics — certainly technology was a part of that vision, but not the central focus.

Another large group of teachers seemed to think that the InterMath workshop provided an opportunity to become familiar with the InterMath website as a tool that could be used in middle-grades classrooms. While there are investigations on the InterMath website that could be useful for middle school students, the purpose of the site is to enhance teacher mathematical understanding. Because teachers saw the site as a tool for use in their own classrooms, many completed only problems they felt their students could complete. This meant that many of the teachers did not challenge their own mathematical abilities at all.

On one hand, because the participants were able to define and follow their own goals, they were pleased with the outcome. On the other hand, we have concerns about the kind and quality of learning because many of the participants did not seem concerned with their mathematical development. This is a recurring theme in our ongoing professional development work. It is unclear how to balance the identified content needs of teachers as a group with the need for each teacher to buy into the goals of a course.

Adoption

Our final major finding in the cross-case analysis was a disturbing trend among the teachers who implemented the InterMath problems in their classrooms to structure their students' learning experiences exactly as their InterMath workshop

experience had been structured. This was alarming for a number of reasons. First, it may have demonstrated little reflection on the part of the teachers about their students' abilities in mathematics. Further, the teacher participants in both of the pilot workshops had complained that there was not enough structure because there were no clear guidelines for assignments. Yet, they reported implementing this same kind of approach for students who did not have the maturity upon which to draw to cope in this extremely open-ended environment. In short, it seemed that the teachers borrowed InterMath rather than adapting it for use in middle grades. It may be argued that this is the first step of changing practices, but at the conclusion of the workshop, there was no further support for the teachers unless they specifically requested it.

Further, post-workshop surveys indicated that participants were not yet comfortable with the implementation of technology-enhanced problem solving in their own classrooms. This was corroborated by the teachers we interviewed who asserted that they could use InterMath problems and technologies in their classrooms by demonstrating them and by those teachers who asserted that they needed more practice themselves before they could implement InterMath in their own classrooms. While this is, in a sense, the opposite of the problem we saw with wholesale adoption of InterMath for middle grades classrooms, the teachers' discomfort with technology-enhanced problem solving likely prevented their students from having successful experiences with mathematical explorations. However, the InterMath team also recognizes that technology access in many schools precludes the use of technology in ways other than as demonstration tools.

Follow-Up

In the three years since the original InterMath pilots, we have been able to collect data on approximately 12 more offerings of different versions of InterMath. While none of these has been as thoroughly observed and documented as the initial workshops, we have collected survey data from 10 courses, interviews from participants in approximately five courses, and other data, such as performance assessments, in a handful of courses. During the course of these workshops, we have moved to a different implementation plan that involves a train-the-trainer model in which UGA personnel train district-based instructors to teach the courses. Because of the results of the first workshop and our work with various school districts since then, we have modified InterMath in some ways that have led to some different findings from our initial study. Here, I report some of the preliminary findings of these later studies.

One major change to InterMath that is pervasive in these more recent courses is a change to teaching InterMath courses that focus either on only one strand of content (Algebra, Geometry, Number Sense, or Data Analysis) or focus on the issues of using open-ended problem solving to meet the state's new mathematics standards. While we cannot report on data related to the latter point, our sense as a team is that having a single mathematical strand on which to focus helps the participants develop a broader understanding of each of the strands of mathematics.

Support and Interaction

Consistent with our findings in the pilot studies, we have found an ongoing theme that participants perform best when they realize that they are all struggling together. We refer to this theme as the "same boat effect." Participants have described a sense of comfort in knowing that they are all going through the same thing together. In fact, in many of the courses since the pilot studies, and even in the smaller pilot class, working together in some way was critical to the success of the participants.

We assert, based on our more recent data from three workshops in one county that were taught by InterMath team members, that there seems to be a shift in teacher attitude about who "owns" the knowledge. The teachers in this district, unlike those in the pilot studies, seem to recognize that participating in a community is critical for their learning and they rely more on each other. It should be noted that they also rely on the instructor, but they feel more empowered about their own mathematical understandings, as evidenced by comments they have shared on their surveys and with their instructors. Most important, however, is that many teachers now report that they are better able to empathize with their students' struggles because they have gone through similar struggles themselves while participating in InterMath.

Technology

We have taken a number of steps to alleviate some of the technology problems associated with the initial offerings of InterMath. Three of these steps have significantly impacted the amount of technology participants have to learn in the course of a workshop. First, we have switched from having an HTML-based electronic portfolio to having participants create documents using a word processor that they simply

link to from their main web page. This has significantly decreased the anxiety level of teachers as they work on their write-ups. Second, because of security problems on the InterMath server, we have moved away from using an FTP client to move files to the web site. In some cases, this has lowered anxiety levels, while in other cases it has caused tremendous problems because of incompatibilities between the new technologies and the school districts' technology infrastructure. While we cannot be certain of the effect this will have on how teachers use technology beyond the workshop, we feel confident that this kind of barrier is a significant factor in whether a teacher chooses to use technology in his or her own classroom. Finally, because we have moved, largely, to single content strand courses (e.g., Algebra or Geometry), the number of mathematics applications has decreased from the three covered in the pilot workshops to one or two depending on the specific course in which a participant is enrolled. We do not have any evidence that the number of mathematical applications were problematic for participants before; however, we have noticed that there are still a considerable number of questions in the workshops focused on the technology.

Mismatched Goals

Finally, the pervasive misunderstanding of the purpose of the InterMath courses and web site has continued. Teachers regularly comment that the problems on InterMath are too difficult for their students. More pleasantly, some have noted that they are surprised that their own mathematics knowledge has been pushed beyond the point at which they began. In four years of offering courses, we have concluded that teachers simply have a different mindset about the purpose and goals of professional development than those on which InterMath was developed. This is a problem that we continue to address.

Conclusions

In four years of successful InterMath implementation, we have seen the classes take many forms and we have seen a variety of participants ranging from elementary-certified teachers to those not certified in mathematics at all. We have enrolled high school, middle school, and elementary teachers. All of the InterMath participants have reported that they learned from the InterMath course and many of them say that they would recommend InterMath to a colleague. Considering the paradigm shift InterMath represents in professional development, we see this high level of satisfaction as a success.

Returning to the learner-centered professional development framework upon which InterMath was built, there are some interesting trends and questions that remain. The most important is the question of how we support teachers in understanding that professional development is about their own learning rather than about supporting their students' learning. This mindset, we believe, is largely responsible for the mismatched goals of the project and the participants. Teachers are accustomed to participating in workshops focused on either "make and take" philosophies or focused on pedagogical strategies. The teachers' mental models for professional development are often challenged by participation in a workshop that is focused on their own content knowledge development rather than how to teach content to children.

Second, we note that the learner-centered professional development frameworks recommend that teachers need to own their own learning. This has been a challenge for InterMath participants as they struggle with a number of issues that are largely related to their own efficacy as mathematics learners and teachers and their view of the role of an instructor. Our participants struggled with (a) the notion that they could determine what "adequate" levels of work were, (b) that they could help each other, and (c) that their ideas about how to solve mathematical investigations were worthy of consideration. Because of these mindsets, the participants in earlier InterMath courses often complained that they needed additional feedback or that they did not have as much support as they would like. In response to these concerns, in later courses, instructors provided more structure and feedback, including intermediate due dates and providing feedback on early write-ups, to alleviate these complaints; but in doing so, they limited the level of ownership the participants had.

Finally, InterMath participants have reported that they learn mathematics and they enjoy the course once they are past the technology problems. However, we lack the data necessary to understand how the participants use InterMath ideas (e.g., using technology-enhanced investigations or open-ended problems) in their own classrooms once the workshop has ended. The ultimate goal of professional development is to positively impact student performance and we simply do not know enough to know whether InterMath is doing that. It could be argued, in fact, that even the data upon which the learner-centered professional development principles are based have this same shortcoming. Clearly more work needs to be done by the professional

development community to help develop an understanding of how professional development can positively impact student learning.

Author's Note

InterMath and the work reported here have been supported by the National Science Foundation (NSF). Opinions expressed are those of the researchers and do not necessarily reflect the opinions of NSF.

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