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Becoming a Leader in Mathematics: A Study of Leaders' Professional Development Experiences, Awareness, Beliefs, and Attitudes

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ACCLAIM's mission is the cultivation of *indigenous leadership capacity* for the improvement of school mathematics in rural places. The project aims to (1) understand the rural context as it pertains to learning and teaching mathematics; (2) articulate in scholarly works, including empirical research, the meaning and utility of that learning and teaching among, for, and by rural people; and (3) improve the professional development of mathematics teachers and leaders in and for rural communities..

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Abstract

This study describes (a) potential mathematics education leaders' professional development experiences, awareness, beliefs, and attitudes and (b) the subsequent changes in these constructs as they participated in a leadership development program. The context of the professional development was a three-week institute and a year-long follow-up. The participants were 37 K-12 teachers and administrators and post-secondary faculty from schools, colleges, and universities in the Appalachian areas of Kentucky, Tennessee, West Virginia, and Ohio. To describe leaders' professional development experiences, awareness, beliefs, and attitudes, researchers developed a questionnaire that contained both Likert-scaled and open-response items. Participants completed the inventory three times over the course of the program. To determine if statistical significance could be associated to the overall means of the three data collections, researchers performed a Mauchly's test of Sphericity and a post hoc Sphericity Assumed or Greenhouse-Geisser analysis. In cases of statistical significance, researchers conducted a Pairwise Comparison analyses to determine the exact location of the significance. The analyses showed statistically significant changes in leaders' experiences, awareness, and attitudes.

Key Words: mathematics professional development, mathematics teacher leadership, mathematics teacher beliefs, mathematics education

Becoming a Leader in Mathematics: A Study of Leaders' Professional Development Experiences, Awareness, Beliefs, and Attitudes

The principles underlying effective professional development in mathematics education have recently undergone important shifts. In the past, the primary strategy for professional development was to use outside experts to increase teachers' knowledge, usually about mathematics, a particular teaching approach, or a specific program. Howe and Stubbs (1997) point out that this passive approach to professional development is unlikely to effect school-wide change. More recently, the view of effective professional development has broadened significantly to include job-embedded, ongoing opportunities for professional growth and systemic change (Guskey, 2003; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003; National Council of Teachers of Mathematics, 2000; National Staff Development Council, 2001; Sparks, 2004). As a result of these substantial shifts, mathematics leaders must align their beliefs and attitudes toward this new approach to a professional development model that fosters continuous improvement for teachers and students.

Loucks-Horsley (1997) suggested that identifying and changing teachers' beliefs should be the primary goal of professional development. Therefore, in order to design effective professional development for prospective mathematics leaders, designers must understand leaders' beliefs about and attitudes towards professional development. Laurenson (1995) posited that teachers' stated beliefs about teaching are not always consistent with their practice. To determine if mathematics leaders' beliefs about professional development affect their professional development practices, providers must understand the leaders' beliefs about and attitudes toward professional development. Unfortunately, the research on mathematics leaders' professional development beliefs and attitudes is virtually nonexistent.

In this paper we describe a year-long study focusing on mathematics leaders as they participated in a program designed to develop leadership skills and to learn effective strategies for conducting professional development. Our research followed the mathematics leaders through a three-week institute and into the subsequent school year in which they had opportunities to put what they learned from the institute into practice with teachers locally.

This study sought to describe (a) potential mathematics education leaders' past experiences with, awareness of, beliefs about, and attitudes toward professional development and (b) changes in their awareness, beliefs, and attitudes as they participated in a three-week leadership institute and subsequent follow-up meetings.

ACCLAIM Leadership Institute

The research was conducted in the context of the ACCLAIM Leadership Institute (ALI) sponsored by the Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics (ACCLAIM), one of 15 Centers for Learning and Teaching funded by the National Science Foundation from 2000-2004. The ALI ran for three weeks in July 2003 on the campus of one of the ACCLAIM partner universities. Three, two-day follow-up meetings were held the subsequent school year in the November 2003, March 2004, and June 2004.

ALI goals**.** The primary goal of the ALI was to prepare cadres of mathematics education teachers, administrators, and faculty from the Appalachian areas of Kentucky, Tennessee, West Virginia, and Ohio to become local leaders of mathematics education. They were to return to their area and develop and conduct mathematics professional development with other teachers and postsecondary faculty. A secondary goal was to establish a network of mathematics

education leaders who would work together to build mathematics capacity in the region through collaborative activities and service to their state and locale.

Institute Leaders. ACCLAIM staff sent applications to K-12 teachers and administrators and post-secondary faculty in schools, colleges, and universities across the four states. Forty-one educators applied for the program; ACCLAIM staff selected 37 of them. ALI leaders were quite diverse, representing a wide range of demographics. Table 1 provides summary information about the 37 leaders.

Insert Table 1 here

As the table illustrates, the majority of leaders were female, Caucasian, high school teachers, and from a rural locale. Sixteen leaders had more than 20 years of experience as teachers or administrators, and seven leaders had less than five years of teaching experience.

During the first year, attrition from the program was relatively small. Two leaders left the program at the end of the three-week summer institute, and four leaders never attended follow-up meetings during the subsequent year.

Summer ALI**.** The ALI was conducted weekdays from July 6 through July 25, and all leaders were housed in two fraternity houses at the university. All sessions were held in a large meeting room of one of the houses. Sessions were conducted from 9:00 a.m. to 11:30 a.m. and from 1:00 p.m. to 5:00 p.m. During the evenings, planned and spontaneous informational and social activities were conducted. The ALI used national and local experts to address key issues in mathematics education, leadership, and professional development.

The first eight days of the ALI were devoted to building the leaders' knowledge base about mathematics standards-based teaching, curricula, assessment, and programs in general. Leaders analyzed and reflected on mathematics teaching practices through videocases. Representatives from three NSF-funded curriculum centers had leaders analyze NSF-funded mathematics curriculum materials. Leaders also learned about effective classroom assessment practices in mathematics and about a tool to conduct comprehensive evaluations of mathematics programs. Finally, they learned and discussed how being situated in a rural context might affect mathematics teaching and learning.

The last seven days of the ALI focused on building the leaders' knowledge of professional development and leadership skills. Leaders were introduced to a variety of goals and approaches to professional development in mathematics and discussed how to plan effective professional development. Leaders viewed videocases of professional development activities to help them analyze professional development practices and solve problems that could arise in future experiences. Through a variety of activities, leaders reflected on their strengths and weaknesses as professional development providers. Finally, leaders learned strategies for addressing critics of the current reform movement in mathematics.

Professional development projects and mentors. During the subsequent year each leader was expected to conduct professional development the sending school or district. Participants could apply for mini-grants for up to $5,000 to carry out the plans. To receive the grants, leaders had to collaboratively develop a professional development plan with a group of teachers, administrators, or college faculty in their locale and submit the plan for review and approval by ACCLAIM staff. Leaders were given until late October to meet with local educators and submit a professional development plan. The plans were then reviewed by ACCLAIM staff, and those

plans that were deemed unsatisfactory or lacking were sent back to leaders for further revision. Two of the 31 plans submitted were approved in this initial review. Eventually 31 plans were approved by ACCLAIM staff by December 1.

Leaders were assigned local mentors who had considerable experience in developing and conducting professional development in mathematics education. The mentors attended a one-day orientation and workshop, at which ACCLAIM staff provided information about their responsibilities. The mentors' responsibilities included providing emotional and professional support, helping leaders develop their professional development plans, and working with leaders to solve implementation problems. Against that background, mentors were required to have at least three personal visits with each of their leaders, attend at least one ALI follow-up meeting, and maintain regular email contact with their leaders. At the end of the year mentors were also asked to complete a questionnaire describing the strengths and weaknesses of each leader assigned to them.

Follow-up meetings. Since most of the initial professional development plans required revision, the November follow-up meeting was devoted primarily to helping leaders revise their plans. Staff discussed and gave examples of each component of the plan and provided an overview of evaluation strategies. The two-day March 2004 follow-up meeting was devoted to discussing issues and addressing problems that arose during leaders' professional development projects. Staff and mentors met with leaders in small groups to discuss successes, barriers, and concerns regarding their professional development activities.

The June 2004 follow-up meeting centered on reporting and discussing successes and challenges in the leaders' local professional development projects. ACCLAIM staff presented information about (a) teachers' stages of growth as defined in the Concerns Based Adoption

Model (CBAM) (Hord, Rutherford, Huling-Austin, & Hall, 1987) and (b) strategies for connecting mathematics to their communities through place-based activities (Raymer, 2001). At this meeting, staff informed leaders that ACCLAIM had agreed to provide additional mini-grants up to $20,000 to conduct local professional development. To receive these funds, however, two or more leaders had to work collaboratively across multiple school districts. Leaders would have to meet with local district personnel and submit a professional development plan as before. Two of these projects were funded for the 2004 school year.

Methodology

The methodology entailed gathering data from the ACCLAIM leaders on three different occasions – July 2003, November 2003, and July 2004. To assess leaders' professional development experiences, awareness, beliefs, and attitudes, researchers developed a questionnaire entitled the *ACCLAIM Professional Development Inventory* (APDI).

ACCLAIM Professional Development Inventory (APDI). The questionnaire had five sections and took leaders about an hour to complete. The first section presented various types of professional development activities (workshops, institutes, action research, mentoring/coaching, etc.) and asked leaders about their experiences with and awareness of each of these professional development activities. The second section listed seven specific goals for professional development (enhance teacher mathematics knowledge, enhance teacher knowledge of instructional skills, enhance technology skills, enhance student performance, etc.). Leaders were asked about their experiences with and awareness of professional development that reflected each of these goals. In the third section, twenty different professional development practices, many extracted from Lourks et al. (2003) were presented. Leaders were asked if they believed

that these practices would be effective in meeting important professional development goals. In the fourth section, leaders' attitudes towards professional development were assessed by focusing on their *confidence* in conducting professional development, *enjoyment* in conducting professional development, and perceived *value* of professional development. In each of these first four sections, leaders' responses were coded on Likert scales. Finally, the fifth section presented open-response questions that asked leaders to: (a) describe their best and worst professional development experiences and explain their choices; (b) identify what they believed to be the most critical barriers to conducting effective professional develop; (c) list their concerns about being professional development providers; and (d) identify their personal strengths and weaknesses as professional development providers.

Cronbach alpha coefficients were used to determine the internal reliability for the entire APDI for each administration and equivalency reliability for the first four Likert-scale sections across the three administrations. The Cronbach alpha of the APDI at each administration was: June 2003—0.97; November 2003—0.95; and June 2004—0.95. Cronbach alphas for each section across the three administrations were: Professional Development Participation—0.96; Professional Development Goals—0.93; Professional Development Beliefs—0.96; and Professional Development Attitudes—0.93. These high reliability coefficients indicate that the APDI had internal reliability at each administration and equivalency reliability for each section across administrations.

Data collection. The APDI was administered to ALI leaders on three occasions—the first day of the ALI in July 2003, the first day of the November 2003 follow-up meeting, and the first day of the June 2004 follow-up meeting. Of the 37 leaders, 35 completed the APDI in July 2003

(two attended the ALI late), 32 completed it at the November meeting, and 27 completed it at the July meeting. In all, 22 leaders completed the APDI on all three occasions.

Data analysis. To address the first goal—describe leaders' professional development experiences, awareness, beliefs, and attitudes—we tabulated the APDI responses for all 35 leaders at the beginning of the ALI. For each item on the APDI, we calculated an overall mean and found the percentage of leaders that responded to each Likert scale category. The items were then ranked according to the overall mean. For the open-response items, we categorized leaders' responses by identifying common themes. Collectively, this data provided us with a snapshot of the leaders' professional development experiences, awareness, beliefs, and attitudes prior to the ALI.

To address the second goal—changes in experiences, awareness, beliefs, and attitudes as the leaders participated in a three-week mathematics leadership institute and subsequent follow-up meetings—we tabulated the Likert scale items and open response items as previously described from the 22 leaders who completed the APDI on all three occasions. In addition, to determine if any statistical significance could be imputed to the overall means of the three data allocations, we performed a Mauchly's test of Sphericity and a post hoc Sphericity Assumed or Greenhouse-Geisser analysis. In the case of statistical significance we conducted Pairwise Comparison analyses to determine the exact location of the significance. These analyses reported the statistical significance represented between the three administrations of the APDI by analyzing each data collection with one another independently.

Results

In this section we describe (a) the leaders' initial professional development experiences, awareness, beliefs, and attitudes and (b) the subsequent changes that occurred over the year-long study.

Initial experiences, awareness, beliefs, and attitudes. The leaders' initial experiences, awareness, beliefs, and attitudes provided an interesting snapshot of the leaders upon entering the ALI. We gathered information about the leaders' professional development experiences and awareness from two sections of the APDI: (a) the types of professional development in which they had engaged as either a participant or leader; and (b) the goals of professional development in which they had engaged as either a participant or leader.

In order to understand their experiences with and awareness of professional development activities, we presented the leaders with a list of various types of professional development activities and asked them to indicate for each activity whether they had *facilitated or led* (3); *participated in* (2); *not participated in, but heard of* (1); or *never heard of it* (0). We ranked the items by the overall mean and then calculated the percentage of leaders who responded to each Likert scale category as shown in Table 2. A higher mean (close to 3) indicated that more leaders had facilitated or participated in this type of professional development activity. A low mean (close to 1) implied that few leaders had facilitated or participated in this type of professional development and more were less familiar with this type.

Insert Table 2 here

The highest rated types of professional development reflected traditional practices whereby teachers facilitated or participated in workshops, seminars, or institutes. Practically everyone had led or participated in workshops (100%), seminars (91%), and institutes (96%). Leaders were less involved or had not heard of professional development that focused on analysis and reflection (study groups, action research, case discussions, mathematics research) or that included becoming part of a learning community (study groups, electronic networks). About two-thirds of the leaders had served as mentors or had been mentored during their career.

The section of the APDI on professional development goals used the same Likert scale as the previous section but asked leaders to describe their involvement in professional development that reflected the specified goals. We ranked the items by the overall mean and calculated the percentage of each Likert scale category as shown in Table 3.

Insert Table 3 here

The top rated professional development goals centered on teacher learning; only professional development that focused on learning about students and assessment was rated relatively low. Interestingly, one of the lowest-rated goals was *prepare professional developers*, in which only 40% of the leaders had led or participated. Fourteen percent had never heard of and 43% had never participated in professional development that focused on *analysis of student work or thinking.*

We assessed leaders' beliefs about best practices in professional development in two ways: (a) by asking them to respond to a list of professional development practices that had potential for success and (b) by asking them to share their best and worst experiences in

professional development. On the potential-for-success questions, leaders were asked to indicate on a Likert scale of *highly likely* (3), *likely* (2), *seldom likely* (1) and *not likely at all* (0) the degree to which they believed the professional development practices would be effective. We determined the percentages of responses for each Likert scale category, as well as the overall mean, for each professional development practice and created a ranked list as shown in Table 4.

Insert Table 4 here

These data revealed that the teachers came to the ALI believing that presentation, practicality, and collaboration were important for effective professional development. The top seven characteristics rated most effective focused on these practices. On the other hand, leaders felt that professional development focusing solely on alignment of goals, theory, incentives, and experimentation were less likely to be effective. Interestingly, there was not much overall variance in these responses; *highly likely* had a range of 77% to 41% and combined *highly likely* and *likely* responses had range of 100% to 85%. There were no practices that the leaders as a group considered ineffective.

On the open-ended section of the APDI, leaders were asked to describe their best and worst professional development experiences. Analysis of these data required us to categorize the comments by identifying common themes among them. These data amplified the information summarized in Table 4. Again, many leaders indicated that they believed collaboration with others and relevant, practical ideas were important. Many reported here that active engagement in workshops was also important.

To understand leaders' attitudes toward professional development, we asked them to report their level of agreement with statements about their feelings toward professional development. We used a Likert scale with the following choices: *strongly agree* (2), *agree* (1), *neutral* (0), *disagree* (-1), *strongly disagree* (-2). The statements referred to the leaders' enjoyment in professional development, confidence in conducting professional development, and the value on which they placed professional development as an integral part of their work. As in previous sections, we determined percentages for each Likert scale category, the overall mean for each item, and created a ranked list. A summary of this analysis is shown in Table 5. We also asked leaders an open-ended question regarding their current concerns about being a professional development provider.

Insert Table 5 here

Clearly the leaders, at this stage of their journey to becoming professional development leaders, were not as positive about leading professional development as they were about participating in it. While they enjoyed *participating* in professional development (100% agree), they were somewhat less excited about *conducting* professional development (86% agree). This is to be expected, especially from those leaders who had little or no experience in leading professional development. With regard to confidence, they were more confident in helping teachers improve their knowledge of mathematics and teaching (91% agree) and student achievement (94% agree) than in helping teachers change their instructional practices (77% agree). Their confidence with regard to their own abilities (86% agree) and knowledge (83%

agree) was comparatively low. The open response question regarding leaders' concerns indicated similar trends. Their top two concerns focused on confidence issues.

Changes in experiences, awareness, beliefs, and attitudes. In order to assess leaders' changes in professional development experiences, awareness, beliefs, and attitudes as they participated in the ALI and subsequent follow-up meetings, we looked at responses from the 22 leaders who completed the APDI all three times (July 2003, November 2003, June 2004). We analyzed the overall means for each item on the APDI to look for trends. We ranked the items based on the amount of increase or decrease from the first to third administrations and then conducted a statistical analysis to determine if the changes were significant.

As indicated in the previous section, we gathered information about the leaders' professional development experiences and awareness from two categories of the APDI: (a) the types of professional development in which they had engaged as either a participant or leader; and (b) the goals of professional development in which they had engaged as either a participant or leader.

The means from the leaders' responses to the list of professional development activities across all three administrations of the APDI are presented in Table 6. As a reminder, a higher mean (close to 3) indicates that more leaders had facilitated or participated in this type of professional development activity. A low mean (close to 1) implies that few leaders had facilitated or participated in this type of professional development and more were less familiar with this type.

Insert Table 6 here

Teachers' awareness and experience with various professional development activities increased across all items, with one exception (*seminars* remained relatively the same*)*. The ALI clearly increased the leaders' professional development experiences and awareness. The Mauchly's Test of Sphericity indicated statistical significance at .05 level **(Sig = .021)** and the Greenhouse-Geisser post hoc analysis confirmed this significance **(Sig = .000)**. The Pairwise Comparison analyses indicated a statistical significance in all three comparisons over time. These findings were not surprising because the ALI was designed to broaden teachers' awareness of and experiences with a range of professional development activities. In fact, the ALI focused heavily on the three types of activities with the highest change--*case analysis, study groups,* and *mentoring/coaching.* Of course, seminars, institutes, courses, and workshops reflected the least change because the leaders were aware of them most at the outset.

A similar pattern emerged in the results with regard to awareness of and experience with various goals of professional development as shown in Table 7.

Insert Table 7 here

These goals that were rated lowest at the outset reflected the greatest changes--*developing curriculum replacement units, prepare professional development providers,* and *analyze student work and thinking.* The Mauchly's Test of Sphericity reported no statistical significance. The post hoc Sphericity Assumed analysis, however, indicated statistical significance at the .05 level. The Pairwise Comparison analysis confirmed these results, indicating the existence of a statistically significant difference between the first and third administrations and the second and third administrations of the APDI. There was no statistical significance found between the first

and second data collections. This result indicates that the change in teachers' awareness of and experiences with goals of professional development occurred later in the process than the change in leaders' experiences and awareness of professional development activities. In the end, the ALI served its purpose of expanding leaders' awareness of and experiences with a broader range of professional development activities and goals.

Changes in leaders' beliefs about professional development as reflected in ratings of effective professional development strategies are summarized in Table 8.

Insert Table 8 here

Leaders' beliefs about the effectiveness of a variety of professional development activities changed in both directions from the beginning of the ALI to one year later. Two beliefs that moved to the top of the ratings were *provides time for participants to practice what is learned* (2.86) and *provides sustained and continuous support for participants* (2.86). The goals, *align with participants' learning goals, build learning communities,* and *fosters collaboration and collegiality* remained high. These goals that focused on presentation style (*covers topics in efficient and timely ways, demonstrates expertise in the topics, provides appropriate rewards and incentives, presents material in dynamic ways*) decreased most. Leaders seemed to realize that professional development requires time and that one-shot workshops, institutes, and seminars simply are not sufficient for effective professional development. The Mauchly's test of Sphericity and the post hoc Sphericity Assumed analysis, however, reported no statistical significance at the .05 level. These results were confirmed by the lack of statistical significance indicated by the Pairwise Comparison. As noted in the initial analysis, there were no practices

that the leaders as a group considered ineffective. The only change over time was a movement in the rankings of the practices.

The open-response questions about leaders' perceptions of best and worst professional development experiences over time indicated interesting shifts. The professional development experiences with the largest gains from the first to the third administration of the APDI focused on fostering collaboration (from 13% to 38%) and providing relevant professional development (from 9% to 31%). Leaders seemed to value the importance of building relationships with colleagues as well as engaging in meaningful activities as powerful forms of professional development.

Changes in leaders' attitudes toward professional development as reflected in self-reported ratings of confidence and enjoyment are summarized in Table 9.

Insert Table 9 here

The disposition statement that had the largest increase from the first to the third administration of the APDI was *I have the knowledge base to* ***conduct*** *effective professional development* (1.23 to 1.68). Closely related, the statement with the second highest gain was *I enjoy (or will enjoy)* ***leading*** *professional development activities* (1.36 to 1.73*)*. In fact, all of the dispositional statements increased over time. Statements focusing on leaders' confidence in conducting professional development and influencing teachers' knowledge and student achievement had the highest increases overall. While the Mauchly's test of sphericity found no statistical significance at the .05 level, the post hoc Sphericity Assumed analysis found significance. The Pairwise Comparison analysis revealed only one comparison of significance,

between the first and third data collections. Similar to the change in teachers' awareness of and experiences with various goals of professional development, the changes in attitudes toward professional development occurred most significantly toward the end of the experience. Perhaps these changes were not fully formed for leaders until they had actually conducted their own professional development and began implementing many of the things they had learned in the ALI.

Change in confidence levels also emerged from the leaders' open-ended responses about their concerns. *Lack of experience in teaching and/or providing professional development*, which topped the list on the initial APDI, revealed the largest decrease (25% to 16%), indicating that leaders' confidence levels had risen. The ALI seemed to have had an impact on increasing leaders' understanding of various types of professional development and on bolstering their confidence as professional development providers.

Discussion

In this section, we discuss some of our observations and implications of our findings in the year-long study. The discussion follows the division of the analysis between baseline conditions and subsequent changes.

Initial experiences, awareness, beliefs, and attitudes. The 37 leaders came to the ALI from a variety of backgrounds--K-8 teaching, 9-12 teaching, K-12 administration, and postsecondary teaching. They varied in their years of experience in education; 16 had more than 20 years of experience, 12 had between five and 20 years experience and seven had fewer than five years of teaching experience. Some had facilitated or directed professional experiences

previously; most had participated in considerable professional development; and some inexperienced teachers had participated in very little professional development.

Despite their varied experiences and backgrounds, the leaders came to the ALI with limited beliefs about, awareness of, and experiences with effective professional development. Traditional leader-led professional development, like workshops, seminars, institutes, and courses, dominated their experiences and participation. They came to the ALI with the traditional "stand and deliver" professional development style. The leaders' beliefs and attitudes about effective professional development aligned with their awareness and experience. From their perspectives, quality professional development involved motivational, organized speakers who engaged them and provided them with relevant, applicable information. Because few had participated in professional development that focused on analyses of teaching and learning or building learning communities, they did not view these as viable or effective professional development practices. Non-traditional practices like involving participants in making decisions, aligning activities with participants' individual goals, and promoting experimentation and risk-taking were viewed as less effective.

The leaders entered the ALI valuing professional development and generally satisfied with previous professional development experiences. For most leaders, especially those with little experience in providing professional development, their confidence in their ability to conduct professional development was quite low. In fact, their greatest concern upon entering was their ability to be effective as a professional development leader. This finding parallels similar results regarding new teachers' confidence and concerns about their ability to teach effectively (Campbell & Wheatley, 1983). These teacher concerns also were reflected in the Concerns Based Adoption Model (CBAM) in teaching (Hord, Rutherford, Huling-Austin, &

Hall, 1987) as normal entry-level concerns. This finding suggests that, as with teaching, becoming teacher leaders might also be developmental in nature.

Changes in leaders' experiences, awareness, beliefs, and attitudes. Leaders' experiences, awareness, beliefs, and attitudes regarding professional development changed during the one-year experience. To determine if the changes were significant and to verify when they occurred, we compared the APDI data from the first and second administration, the second and third administration, and the first and last administration. These results are summarized in Table 10.

Insert Table 10 here

There were significant changes in leaders' experiences and awareness of professional development activities across all three comparisons. In fact, this was the only area in which changes showed up immediately in the first interval. Significant changes in leaders' experiences and awareness of professional development goals were evident later in the second and third intervals. There were no significant changes in leaders' beliefs about effective professional development practices during the ALI. At the initial administration of the APDI, leaders believed all of the practices to be relatively effective. Over the course of the study, the only change that occurred was a different ranking of the practices. Finally, significant changes in leaders' attitudes toward professional development did not occur until much later in the study. In fact, the changes did not occur until after leaders had implemented their own professional development.

Implications for preparation of leaders in mathematics education. This study raises several issues with regard to preparing leaders in mathematics education. First, educators involved in leadership development should pay attention to prospective leaders' prior

experiences in, awareness of, beliefs about, and attitudes toward professional development. They should be aware that extensive experiences with professional development does not usually imply a broad knowledge of professional development, beliefs about professional development that coincide with research, or high confidence in becoming professional development leaders. A comprehensive inventory of prospective leaders' experiences, knowledge, beliefs, and attitudes would be useful to leadership developers as they plan and implement leadership programs. In particular, this information would provide developers important baseline data about prospective leaders that would allow developers to individualize activities, monitor growth, and assess program effectiveness.

Second, changes in beliefs about and attitudes toward professional development during leadership programs appeared delayed when compared to changes in experiences with and awareness of professional development. In some cases, leaders became aware and knowledgeable of new professional development practices; yet they were not convinced that they would be effective or that they could implement them. For example, given the opportunity to apply immediately some of the new professional development approaches that they had just learned in the ALI, 29 of 31 leaders in this study designed professional development experiences that were rather traditional. Because of this delay, leadership developers should be patient and persistent in helping potential leaders increase their repertoire of professional development strategies.

Third, requiring leaders to plan and implement new professional development strategies with the assistance of a mentor seemed to have an impact on beliefs and attitudes. On one hand, some beliefs and attitudes of the leaders in this study did not change until they were required to try strategies with which they had little experience as participants. On the other hand, leaders

were hesitant to try new strategies (e.g., case analysis, analysis of student work, program evaluation) even though national leaders in professional development had used these strategies during the summer institute. Participation in professional development that employs a new strategy seems necessary, but not sufficient, in getting leaders to implement that strategy. The opportunity to implement the strategy with outside support seems critical.

Implications for research on the preparation of leaders in mathematics education. This study sought to describe (a) mathematics education leaders' initial professional development experiences, awareness, beliefs, and attitudes and (b) changes in these constructs as they participated in a year-long leadership development program. While several interesting findings emerged from the data, this study raised more questions than it answered. Further research is needed to clarify and extend the findings of this study. First, the relative effects of the individual components of the ALI—summer institute with videocases, curriculum analysis, program analysis, and self-analysis; professional development opportunities through minigrants; follow-up meeting; or mentors—are unknown. Research that focuses on these individual components has the potential to better inform leadership developers and lead to more effective and efficient leadership programs.

Second, this study revealed that leaders' concerns about taking leadership roles in mathematics lessened over the course of the year-long study. This finding is similar to the Concerns Based Adoption Model (CBAM) research on the nature and development of teachers' concerns as they gain experience in teaching (Hord, Rutherford, Huling-Austin, & Hall, 1987). Although this study provided a cursory glance into this use, it seemed that leaders went through stages of concerns similar to those of teachers as they learn to become leaders. Further research is needed in two areas: (a) to describe more clearly the stages of concerns through which leaders

might pass and (b) identify particular leadership activities and approaches to assist leaders through these stages. A model of stages of concerns would provide an important evaluation tool to determine growth in leadership, and research-based activities and strategies would improve the effectiveness of future leadership programs.

Closing Remarks

A strong cadre of mathematics education leaders is needed to improve mathematics teaching, assessment, and learning and to improve mathematics capacity at all levels. In developing effective leaders, it is critical that they have knowledge of research-based professional development practices, appropriate beliefs about the potential of these practices, and the confidence to implement the practices effectively. Against this background, leadership developers must design programs that (a) build on previous professional development experiences, (b) consider the individual differences, strengths, and weaknesses of potential leaders, (c) provide leaders the knowledge of effective strategies and opportunities to implement those strategies, and (d) patiently support leaders as they learn their new roles.

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Table 1

Demographic Data on ALI Leaders

State	#	Gender		Race			Employment				Locale	
		M	F	C	Af Am	As Am	K-8 Teach	9-12 Teach	K-12 Admin	Univ	Rur	Urb
KY	26	7	19	25	1	0	9	8	5	4	24	2
TN	4	2	2	3	0	1	0	1	0	3	3	1
WV	4	1	3	4	0	0	0	2	2	0	3	1
OH	3	1	2	2	1	0	1	2	0	0	2	1
Total	37	11	26	34	2	1	10	13	7	7	32	5

Table 2

Leaders' Experiences and Awareness of Professional Development Activities

Rank	Mean	Type of Activity	% f/l	% part	% hrd	% nh
1	2.60	workshops	60	40	0	0
2	2.20	seminars	17	74	6	0
3	2.06	institutes	9	89	3	0
4	1.91	mentoring/coaching	26	41	29	3
5	1.89	courses	14	63	20	3
6	1.51	study groups focusing on readings	17	34	31	17
7	1.26	action research	11	20	51	17
7	1.26	electronic networks	6	40	29	26
7	1.26	case discussions and analysis	11	20	51	17
10	1.24	mathematics research	3	30	55	12

Table 3

Leaders' Experiences and Awareness of Professional Development Goals

Rank	Mean	Type of Activity	% f/l	% part	% hrd	% nh
1	2.51	enhance teachers' knowledge of technology	57	37	6	0
2	2.47	enhance teachers' knowledge of mathematics	54	40	6	0
3	2.44	enhance teachers' knowledge of instructional skills	49	49	3	0
4	2.32	learn mathematics	34	60	0	6
5	2.27	enhance students' achievement or performance in mathematics	36	55	9	0
6	2.21	develop curriculum	29	66	6	0
7	2.16	enhance teacher's knowledge about students	29	63	6	3
8	2.14	enhance teachers' knowledge of assessment	29	60	9	3
9	2.12	align curriculum, teaching, and assessment	29	59	6	6
10	2.10	revise curriculum	31	51	14	3
11	1.74	analyze student work/thinking	20	43	29	14
12	1.44	prepare professional developers	20	20	46	6
13	1.11	develop curriculum replacement units	17	17	26	40

Table 4

Leaders' Beliefs about Effective Professional Development Practices

Rank	Mean	Type of Practice	% f/l	% part	% hrd	% nh
1	2.77	presents material in dynamic ways	77	23	0	0
2	2.74	provides practical ideas for immediate use	74	26	0	0
3	2.73	builds a learning community	77	20	3	0
4	2.71	fosters collaboration and collegiality	74	23	3	0
5	2.64	models strategies that participants will use with students	77	20	3	0
5	2.64	demonstrates expertise in the topic	63	29	9	0
7	2.61	uses humor and/or interesting stories	47	50	3	0
8	2.60	provides time for participants to practice what is learned	66	29	6	0
9	2.57	provides time for participants to reflect on what is learned	60	37	3	0
9	2.57	provides sustained and continuous support for participants	71	17	9	3
11	2.55	involves participants in decisions about activities	51	46	3	0
12	2.54	covers topics in efficient and timely ways	60	34	6	0
12	2.54	provides opportunities for some participants to become leaders	57	40	3	0
14	2.51	uses technology	33	52	15	0

Rank	Mean	Type of Practice	% f/l	% part	% hrd	% nh
15	2.46	aligns activities with participants' individual goals	51	43	6	0
16	2.40	aligns activities with participants' school or department goals	46	49	6	0
17	2.32	promotes experimentation and/or risk	44	44	12	0
18	2.26	provides theory that supports ideas and suggestions	40	49	9	3
19	2.24	provides appropriate rewards and incentives	37	51	11	0
20	2.15	aligns activities with participants' district goals	41	47	9	3

Table 5

Leaders' Attitudes toward Professional Development

Rank	Mean	Attitude Statement	% sa	% a	% n	% d	% sd
1	1.86	I believe professional development is an important part of teaching.	89	9	3	0	0
2	1.71	I enjoy participating in professional development activities.	71	29	0	0	0
3	1.51	I believe I can improve teachers' knowledge of teaching.	60	31	9	0	0
4	1.49	believe that I can help students improve their mathematics performance through teacher professional development.	54	40	6	0	0
5	1.43	I believe that I can improve teachers' knowledge of mathematics.	54	37	6	3	0
6	1.31	I enjoy (or will enjoy) leading professional development activities.	49	37	11	3	0
7	1.26	I am confident that I can effectively conduct professional development for other teachers.	43	43	11	3	0
8	1.20	I believe that I can influence teachers to change their instructional practices.	43	34	23	0	0
9	1.14	I have the knowledge base to conduct effective professional development.	34	49	14	3	0

Table 6

Changes in Leaders' Experiences and Awareness of Professional Development Activities

Types of Professional Development	7/03	11/03	6/04
Case discussions and analysis	1.50	2.05	2.18
Study groups focusing on readings	1.77	1.89	2.27
Mentoring/coaching	1.95	2.55	2.36
Electronic networks	1.41	1.68	1.82
Mathematics research	1.23	1.68	1.59
Action research	1.50	1.50	1.77
Courses	2.05	2.23	2.23
Institutes	2.14	2.18	2.32
Workshops	2.73	2.80	2.86
Seminars	2.32	2.25	2.27

Table 7

Changes in Leaders' Experiences and Awareness of Professional Development Goals

Goals of Professional Development	7/03	11/03	6/04
Develop curriculum replacement units	1.14	1.73	2.14
Prepare professional developers	1.64	2.23	2.32
Analyze student work/thinking	1.91	2.27	2.55
Enhance students' achievement or performance in mathematics	2.32	2.59	2.82
Learn mathematics	2.32	2.68	2.77
Enhance teacher's knowledge about students	2.23	2.36	2.64
Enhance teachers' knowledge of assessment	2.27	2.23	2.64
Align curriculum, teaching, and assessment	2.14	2.27	2.50
Revise curriculum	2.09	2.14	2.41
Enhance teachers' knowledge of instructional skills	2.64	2.68	2.91
Enhance teachers' knowledge of mathematics	2.64	2.73	2.82
Develop curriculum	2.27	2.14	2.41
Enhance teachers' knowledge of technology	2.59	2.55	2.64

Table 8

Changes in Leaders' Experiences and Beliefs About Professional Development Goals

Effective Professional Development Strategies	7/03	11/03	6/04
Aligns activities with participants' individual goals	2.32	2.50	2.77
Provides time for participants to practice what is learned	2.45	2.82	2.86
Provides sustained and continuous support for participants	2.50	2.82	2.86
Uses technology	1.82	2.07	2.05
Involves participants in decisions about activities	2.55	2.55	2.73
Provides time for participants to reflect on what is learned	2.55	2.68	2.73
Aligns activities with participants' school or department goals	2.23	2.14	2.36
Promotes experimentation and/or risk	2.36	2.18	2.45
Models strategies that participants will use with students	2.64	2.77	2.73
Builds a learning community	2.73	2.59	2.82
Aligns activities with participants' district goals	2.00	2.05	2.09
Provides practical ideas for immediate use	2.82	2.73	2.86
Fosters collaboration and collegiality	2.73	2.73	2.73
Provides theory that supports ideas & suggestions	2.18	2.14	2.18
Covers topics in efficient and timely ways	2.50	2.45	2.27
Uses humor and/or interesting stories	2.32	2.36	2.14
Demonstrates expertise in the topic	2.64	2.41	2.41
Provides appropriate rewards and incentives	2.20	2.27	2.02
Presents material in dynamic ways	2.73	2.59	2.59

Effective Professional Development Strategies	7/03	11/03	6/04
Provides opportunities for some participants to become leaders	2.55	2.55	2.50

Table 9

Changes in Leaders' Attitudes toward Professional Development

Enjoyment, Confidence, and Useful Rating	July 03	Nov 03	June 04
I have the knowledge base to conduct effective professional development.	1.23	1.59	1.68
I enjoy (or will enjoy) leading professional development activities.	1.36	1.52	1.73
I believe that I can improve teachers' knowledge of mathematics.	1.45	1.45	1.73
I believe that I can influence teachers to change their instructional practices.	1.18	1.34	1.45
I believe that I can help students improve their mathematics performance through teacher PD.	1.50	1.68	1.77
I believe that I can improve teachers' knowledge of teaching.	1.64	1.73	1.91
I am confident that I can effectively conduct professional development for other teachers.	1.36	1.64	1.77
I enjoy participating in professional development activities.	1.77	1.82	1.86
I believe professional development is an important part of teaching.	1.86	1.77	1.91

Table 10

Significant Changes in Leaders' Experiences, Awareness, Beliefs and Attitudes

Area of Change	July 03-Nov 03	Nov 03-June 04	July 03-June 04
Experiences/Awareness of Activities	Yes	Yes	Yes
Experiences/Awareness of Goals	No	Yes	Yes
Beliefs	No	No	No
Attitudes	No	No	Yes