EVALUATION OF EIGHT PROJECTS TO IMPROVE THE EFFECTIVENESS OF ELEMENTARY AND HIGH SCHOOL TEACHERS OF MATHEMATICS AND SCIENCE

A Report Prepared for the
Arizona Board of Regents

by

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ABSTRACT

Eight projects designed to improve the effectiveness of mathematics and science teachers in elementary and secondary schools in Arizona were implemented during 1984 and will be completed by August 1985. Approximately 550 teachers representing communities throughout the state attended programs and specially designed institutes that were held at the three state universities.

The projects addressed the problems of mathematics and science teaching from several viewpoints: improving the content knowledge of teachers, improving methods of teaching, and improving student attitudes and interest.

Information from the evaluation of these projects, and from interviews with project directors, participants, and administrators, demonstrated that the projects achieved their major goals and that the content knowledge and teaching skills of project participants have been enriched.

Most participants would not have been able to enroll in the projects without the financial support that was provided by these eight grants.

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METHOD

Evaluation of the eight mathematics and science projects comprised six steps: a review of the files, on-site interviews of the project directors, site visits to two project participants in their classrooms, telephone interviews of a sample of the project participants, compilation of the results of an evaluation questionnaire administered to teachers participating in local inservice classes, and telephone interviews with school administrators. Evaluation activities were conducted during the period of late November 1984 through mid-February 1985.

The review of the files covered the original proposals, any publicity material prepared for the projects, and quarterly reports submitted by the project directors. The quarterly reports varied in content but generally contained one or more of the following: progress reports, project evaluations by both directors and participants, and various pre-project and post-project questionnaires designed to assess changes in content knowledge and attitudes.

An interview schedule was used to guide the on-site discussions with the project directors (see Appendix A). The schedule was intentionally open-ended to allow for discussion of factors unique to each project and review of the materials used.

One project,the Mathematics Diagnostic Teaching Project at the University of Arizona, featured in-classroom observation and consultation for the participants in addition to the coursework conducted at the university. For this project the reviewers made classroom visits to two of the participants to observe both their teaching and the supporting consultation provided by the project staff.

The views of participants in each of the eight projects were obtained in two different ways. In-depth telephone interviews were conducted with a sample of the participants of all eight projects except the 333 teachers attending the local inservice courses as part of the Science Inservice Training project conducted by Drs. Lawrenz, Gordon, and Horak. Of the 201 telephone calls that were initiated, 61 interviews were completed, a sample of 26 percent of the 235 participants involved. The interviews each lasted from 25 to 35 minutes and were conducted using the questionnaire in Appendix B.

The views of the 333 teachers attending the local inservice courses as part of the Science Inservice Training Project were surveyed by compiling their responses to an anonymous questionnaire administered by the project directors at the close of the fall 1985 classes. These questionnaires were delivered straight to The Delta Group for review before being returned to the project directors to be tallied for their own evaluation. The items seleced from the questionnaire for this review are shown in Appendix C, along with tallies of responses to each item.

Finally, telephone interviews were conducted with administrators of the schools in which project participants are teaching. The interviews, each lasting 15 to 20 minutes, were conducted using the schedule in Appendix D. Of the 163 telephone calls initiated, 51 interviews were completed, a sample of 22 percent of the 231 schools involved.

EVALUATION BY PROJECT

Mathematics and Diagnostic Teaching Program

Dr. Carol Larson
University of Arizona

Thirty elementary teachers took two graduate courses during the fall of 1984: Mathematics Diagnosis and Remediation (ELEM 632) and the Mathematics Practicum (ELEM 694). For the practicum two teaching assistants, under the direction of Dr. Larson, helped the teachers implement the diagnostic teaching methods in their own classroom during the fall of 1984 and continuing on a bi-weekly schedule through the spring of 1985. Also during the spring of 1985 the teachers will participate in three one-day follow-up workshops to exchange ideas and to polish their skills in diagnosing, sequencing, and organizing for mathematics instruction. A sum of $28,500 was granted to support the project.

Purpose

Students in any heterogeneous classroom differ greatly in their abilities and achievement in mathematics and in their

attitudes toward mathematics. Teachers must be able to assess these differences and to design effective instructional programs for students at all levels. Grouping for specific needs is a useful strategy for differentiating instruction, but most elementary teachers have had little or no training in grouping or in classroom management for grouped and individualized instruction in mathematics. Teachers need not only new ideas and techniques but also on-going support for trying the new techniques in their classrooms.

Implementation

Information on implementation for all the projects was obtained from quarterly reports and from interviews with project directors and participants. Participant teachers were recruited during March and April 1984 through program descriptions circulated to teachers and school department heads by graduate students and professors in elementary education. Sixty-two teachers applied, an unprecedented number for a graduate course in mathematics education. Dr. Larson attributed the high number of applicants to the fact that tuition was to be waived under terms of the grant. This impression was confirmed by the participants interviewed.

A panel of three educators selected the 30 participants based on an effort to obtain a broad geographic distribution within the Tucson area and a range of backgrounds in mathematics. This range indeed was achieved. Some participants have masters degrees and many years of teaching, while others have been teaching for only one or two years. A broad geographic distribution was also achieved, thus ensuring a spread in the socioeconomic status of the students taught by the project participants.

Instruction began in August 1984. Shortly thereafter the two teaching assistants began regular on-site observation and consultation with each participant to help implement the new techniques in their classrooms. Although not originally planned, these on-site visits are continuing during the spring of 1985 because both the project staff and the participants have found them to be critical to the success of the project. The three one-day workshops are scheduled for February 6, March 4, and April 29, 1985.

Three graduate credits were granted for the diagnostic methods course and one credit for the practicum. Course requirements included a final examination and a final report on implementation of the program by each participant in his or her classroom. Course requirements and instructions for preparing three

the final report were outlined clearly and thoroughly in advance by the project director.

So far, the project has been implemented exactly as proposed and as advertised to the participants, except that even more on-site assistance is being provided. The only change from the proposal is in scheduling: the project began in the fall of 1984 instead of the spring due to a delay in approval of the grant.

Evaluation

Information on evaluation of all the projects was obtained from the project directors through quarterly progress rep rts and personal interviews. During the last week in August 1984, participants in this project completed a preliminary questionnaire describing their current curriculum, methods of diagnosis, teaching activities, and ways of differentiating instruction. A similar questionnaire was to be administered in December 1984 and again in May 1985. Final program evaluation will be based on a comparison of responses to all three questionnaires plus the information recorded during on-site visits by the teaching assistants. Dr. Larson also has planned a further comprehensive evaluation of the continuing effects of the project after one year has elapsed and will include personal interviews with all participants.

Results of the December questionnaire have not yet been tabulated, and evaluation has therefore only begun. Nevertheless, the project staff had several observations to share:

1. The participants are now using commercial textbooks more as a resource than as the backbone of their mathematics instruction.

2. The participants have become more active in the planning of instruction, in the assessment of student skills, and in the use of a wide variety of materials and activities.

3. The participants have begun to group students by skill needs, employing at least two groups and sometimes three.

4. The participants are beginning to use manipulative materials effectively. In fact $60,000 was spent in 1977 to supply local schools with geoboards and

Base-10 materials, but the materials are only now being brought out of their wrappings and put to use.

5. The participants have developed a strong support network among themselves for the sharing of ideas and activities.

On-site visits and telephone interviews with participants fully confirmed these observations by the project staff. On-site visits also confirmed that the course techniques appear to be equally effective with students of both high and low socioeconomic status.

Survey of Participants

Interviews included on-site clasroom observations of two participants and extended telephone discussions with others using the questionnaire in Appendix B as a basis. Information from the discussions and reported in earlier sections above will not be repeated here.

All participants expressed very strong enthusiasm for the project and the project staff, in spite of what was perceived as a heavy workload imposed during the school year. Without exception the participants felt that the contribution of the project to their teaching and to their students' achievement far exceeded their expectations. All reported that their students are expressing increasing enjoyment of mathematics and that many have experienced a complete reversal of previously negative attitudes toward mathematics. All participants interviewed plan to urge their colleagues to enroll if the project is offered again.

The two third-grade teachers observed on-site were using successfully several key techniques of the project, including grouping for instruction and the use of manipulative materials to explain place value. Instruction was orderly and lively at the same time, and the students in both classes participated with vigor. Neither teacher had yet developed a satisfactory system for recording and responding to student errors occurring in those student groups working independently, but one teacher and both project staff members were aware of the problem and had made plans to deal with it.

Recruitment. Participants enrolled because of a clear sense of inadequacy or stagnation in the teaching of mathematics. Only one enrolled solely on the advice of her school principal.

Participation. All interviewed mentioned that such an intensive course was a heavy burden to carry during the school year, but without exception they felt the benefits of immediate application in their classrooms, with sustained support and assistance from the project staff, far outweighed the inconvenience.

None felt they would have been able to participate without the tuition waivers provided by the project grant. Two, however, said that had they known beforehand how exceptionally valuable the project would be, they would have raised the money for the tuition themselves.

District support. All participants received support from their local schools or districts in the form of letters of recommendation, professional credit, credit toward salary increases, and released time for the three spring workshops. Some also received financial help from their schools to stock their classrooms with resource and manipulative materials, while others had to provide these out of their own pockets.

None of the those interviewed were expected to train fellow teachers this year, although most planned to do so next year after the project is over. All have been sharing ideas with their fellow teachers.

Quality of the program. As classroom teachers of elementary mathematics, all the participants felt that the program not only met their perceived needs but far exceeded them. Specifically mentioned were help in grouping, classroom management of individualized instruction, strengthening of their own understanding of concepts in mathematics, help in teaching problem-solving skills, help in using manipulatives, and new ideas and resources for mathematics activities.

All considered the project to be very well-organized and the staff to be exceptionally well-prepared and skilled in all areas being taught. Most felt the time allotted for the workload could have been extended but realized that that might have been impractical during the school year. All were impressed with the abundance, variety, and creativity of the materials and activities presented.

The participants expressed particular gratitude for the ready and useful help provided by the project staff. All felt that one of the most beneficial aspects of the project was this classroom follow-up, which provided both support and incentive to use the techniques taught in the course.

Course follow-up. Participants urged the continuation of

personal consultations and workshops beyond the duration of the project, and two said that any activity involving Dr. Larson and her staff would be helpful--anytime and anywhere.

Utility of the program to present classroom teaching. All participants reported using all techniques presented in the project, although some were using only two skill groups as yet, not the three groups advocated by Dr. Larson. All found the course content to be directly useable in the form in which it was presented even though the participants taught a range of grade levels from one to six.

Survey of Administrators

Telephone interviews were conducted with administrators of schools in which the project participants are presently teaching. The administrators were unanimous in their praise of the project. All but one had urged their teachers to enroll because the project was to be directed by Dr. Larson, for whom they had a very high regard. Apparently Dr. Larson has been especially helpful to school districts in the Tucson vicinity in updating and improving their mathematics curricula.

All administrators reported that their teachers were using the project ideas and techniques in their own classrooms and were sharing ideas with their fellow teachers. Several administraors reported that enthusiasm for the techniques had generated a new excitement about mathematics in both teachers and students. The administrators cited the classroom follow-up as being one of the most helpful aspects of the project.

All administrators said they would welcome similar projects and would urge their faculties to apply. It is just this kind of program, they felt, that infuses a new spirit of interest and confidence into the teaching of mathematics.

Conclusions and Comments

From every perspective this project has succeeded both in achieving its purpose and in meeting the needs of its participants. Key factors in its success include:

1. skill and dedication of the project staff,
2. careful planning by the project staff,
3. high level of utility of the course content,

4. appropriate mix of theory and practical techniques,

5. project format.

The last factor, project format, needs elaboration. The distinguishing characteristic of this particular project is the on-site follow-up and support of each teacher by the project staff. Paradoxically, this in-classroom follow-up both ensured the project's success and limited its scope. Unless a project director can tap several skilled teaching assistants, the number of participants in such a project must be limited to enable the project staff to carry out the on-site activities. Furthermore, and for similar reasons, the location of any comparable project would be restrictd to university environs or to a well-staffed outreach location of a university. These limitations could be overcome, however, if university budgets or project funding were generous enough to permit hiring qualified staff and locating them temporarily in more isolated regions of Arizona.

This project clearly merits replication in other areas of Arizona. But farsighted action by funding agencies will have to be taken if benefits are to extend beyond its present location.

Problem Solving for Secondary School Teachers

Dr. Elias Toubassi
University of Arizona

Twenty secondary mathematics teachers participated in a five-week summer institute that focused on three areas: 1) problem solving with microcomputers, 2) exploratory problem solving as a classroom teaching method, and 3) the application of mathematics in real-world situations. Participants attended three courses to earn a total of seven graduate credits. The courses taken were: Computers in Senior High Mathematics (3 units), Exploring Problem Solving (3 units), and the Mathematics Practicum (1 unit).

Participants represented twelve state-wide communities, and the non-Tucson residents were housed on the university campus. The amount funded for this project was $24,078.

Implementation

Brochures were mailed to all high schools and district offices in Arizona to announce the Institute course offerings and to elicit applications from teachers. Each application had

to include a vita, letter of interest, letter of recommendation, and a letter from the principal or supervisor stating his or her willingness to provide post-institute opportunities for the teachers to share ideas and materials with their colleagues. The rigor of the application process was intended to attract participants who were committed to the use of mathematics as a problem-solving tool. Twenty participants were selected in April; 16 of the 20 were certified in mathematics.

Institute classes were held daily from 8:00 p.m. to 4:00 p.m. from June 11 to July 13, 1984. Participants were required to submit a final paper for each of the three courses. This requirement for "three papers in five weeks" was not stated in the brochure and thus was not well-received by the participants as reported in their telephone interviews. With this one exception, all course work was implemented as proposed and advertised to the participants.

Participants in the Institute have been invited to attend a one-day conference for an exchange of ideas and to assess the impact of the program. The conference will be held in June of 1985 on the Univerity of Arizona campus. A grant from the University of Arizona Foundation will provide room, board, and travel expenses for the participants.

Evaluation

In on-site interviews with Dr. Toubassi and Dr. Stevenson during December 1984, they described the Institute as "one of the most successful in their entire teaching experience." According to both directors, special interactive dynamics were built up due to the fact that most of the participants lived together on one floor of a university dormitory. The participants supported this conclusion in telephone interviews by stating that they worked and socialized together "just like a family unit." One participant wrote, "People in town should have option [sic] of staying in dorm." Clearly, group cohesion was enhanced by the close daily proximity of most participants living together in a dormitory. These group dynamics contributed significantly to the overall success of the Institute.

An evaluation questionnaire was completed by the participants at the conclusion of the Institute in July 1984. The questionnaire included 42 items of information ranging from educational and employment background to course evaluation. Generalized comments from the questionnaire indicate results such as:

1. courses lived up to participant expectations;
2. instructors presented the material clearly;
3. material was well organized;
4. assigned projects were helpful;
5. most participants would recommend the courses to colleagues;
6. all participants would like to see the Institute continued next summer.

The proposed Institute Evaluation by Staff (Davidson, Goodman, Stevenson, and Toubassi) was accomplished by informal dialogue between Dr. Toubassi and Dr. Stevenson. There was no written report.

A Phase Two Evaluation questionnaire was sent to participants in January 1985. The purpose of this evaluation was to ascertain the extent to which participants have actually implemented Institute course ideas and used Institute materials in their own school settings. Results from this questionnaire will be included in the final report to be submitted to the Board of Regents on May 1, 1985.

Survey of Participants

In-depth interviews were conducted by telephone using the questionnaire in Appendix B. A summary of the responses of all participants interviewed follows.

Recruitment. The program was well advertised by sending brochures to the high schools and district offices throughout Arizona. This method was seen as effective by the participants.

Participation. As previously described, the out-of-town participants voiced no objections to living in Tucson for five weeks. Twelve of the participants indicated that they would not have been able to attend the Institute unless financial support had been provided.

District support. Applicants to the program were required to include some statement about their willingness to share ideas and materials with their colleagues when returning to school in

the fall of 1984. Project participants agreed that sharing of this sort among teachers is very helpful as well as effective.

Quality of the program. Participants were very enthusiastic about the fact that the Institute had been worthwhile. They stated that the program was well organized and the instructors were prepared. The course in Exploratory Problem Solving was valued highly by all participants. The computer course was criticized due to the wide range of student background and ability in the class. Participants strongly recommended grouping the class into several ability levels to enable more advanced students to work at their own pace. The Mathematics Practicum was considered useful; however, participants felt it required too much work for only one credit. Participants were given help when needed, and the level of difficulty of the classes and assignments was considered to be appropriate both to student abilities and to the purposes of the Institute.

Course location and facilities. Living away from home or commuting was not a problem for any participant. Dormitory life was viewed as enormously helpful to the learning process.

Utility of the program to present classroom teaching. Many of the participants are applying concepts that they acquired from the class in exploratory problem solving. As teachers they feel more enthusiastic about mathematics and are using more high-interest approaches in their classrooms. One participant stated, "The concept of how to attack math was grasped!" Also, teachers gained a great deal of useful information for computer applications in their classrooms. One teacher reported using the microcomputer as an extended blackboard.

Recommendations for future programs. Most participants wanted to see the same format used again. The team of instructors was seen as providing a balanced approach. Suggested new topics included courses such as number theory, a review of calculus, using computer programs with graphics, geometry, and beginning programming. A redistribution of the Institute's seven credits was proposed as follows:

computer programming.....2 credits
computer software.....2 credits
exploratory problem solving.....2 credits
practicum.....1 credit

Participants expressed the need for such an institute to

continue, and many of them had already told colleagues and less-experienced faculty to be sure to inquire about the potential for such an Institute in the summer of 1985.

Survey of Administrators

In January 1985, letters were sent by the project directors to inform school principals that participants had successfully completed the Institute. As part of each participant's application, administrators had written letters to express their willingness to provide teachers with opportunities for sharing the knowledge acquired at the Institute. The project director's January letter reminded administrators of this commitment.

During telephone interviews, several principals indicated that the commitment had not been upheld. While all principals reported initially supporting participant applications, approximately 40 percent of the administrators had neither observed in the participants' classrooms nor discussed the value of the Institute.

Administrators expressed positive attitudes toward the program in general because teachers had the opportunity to grow and learn about how to teach mathematics. Many administrators noted that the participants were demonstrating more self-confidence as a result of the Institute courses. The principals were unanimous in concluding that one teacher's new ideas and enthusiasm can stimulate other faculty members or even an entire mathematics department.

Conclusions and Comments

Instructors and participants alike felt the project was a success and provided positive growth experiences for all. Furthermore, the skills learned have since filtered back to 20 different school districts throughout the state. Students in high-school mathematics classes have benefited from the increased knowledge and skills of their teachers. Continuation of the program would extend its benefits to many more teachers of high-school mathematics in Arizona.

Pilot Program for Increasing the Number of Proficient Teachers (INPT)

Dr. Lehi Smith
Arizona State University

Twenty teachers from the Phoenix area were selected by their district administrators to participate in a two-year program to

become certified in mathematics. Prior to enrolling in the INPT program, these teachers were certified and taught in other subject areas such as history, remedial reading, home economics, and elementary education. Since the fall of 1983, classes have been held at night in a Scottsdale high school during the school year and will continue on the campus of Arizona State University through the summer of 1985. When completing this program, participants will have earned 30 undergraduate credits in mathematics and computer science. Although INPT began in 1983, funding of $17,500 from the Arizona Board of Regents provided tuition and textbooks for participants during the summer and fall of 1984 and will continue to do so through the spring and summer of 1985.

Purpose

There is a continuing shortage of adequately prepared mathematics teachers. In close cooperation with the Mesa Unified District, the Scottsdale Unified District, the Paradise Valley Unified District, the Phoenix Union High School District, the Glendale Union High School District, the Tempe Union High School District, and the Tempe Elementary District, the Department of Mathematics at Arizona State University has devised a program for increasing the number of well prepared mathematics teachers.

Implementation

Dr. Smith contacted the district superintendents to discuss the program features. Each district then identified experienced teachers who had distinguished themselves as accomplished teachers in areas other than mathematics. These teachers had limited backgrounds in mathematics but showed potential for learning.

In the fall of 1983 these teachers registered at Arizona State University at their own expense with the intention of becoming certified to teach mathematics in junior or senior high school. They have attended classes for two hours, two nights a week, during the academic years of 1983-84 and 1984-85, and they have also attended classes full time over a period of seven weeks during the 1984 summer session. They will complete the program in a final 1985 summer session.

The majority of participants have been assigned to special sections for program course work; however, they have met the same course standards as students enrolled in regular classes of the mathematics department. Dr. Smith reported that the

participants are doing very well in their course work. He credits the districts for having selected such qualified teachers.

It is important to note that this project was conceived and implemented with the full support of the cooperating school districts. Dr. Smith stated that such a broad-based cooperative effort between the university and the neighboring school districts significantly affects the implementation of such a program.

Evaluation

Initially, participants were screened using a two-hour mathematics aptitude test in order to determine their qualifications for undertaking the lengthy and arduous course of study that was proposed. Other evaluation is based on examinations in each course the participants take. Dr. Smith reported that course grades for the participants have ranged from A's to C's and added that such grades are quite high when considering the context of a mathematics department. He expressed the opinion that school district administrators should also evaluate teachers with measures such as attitudes toward teaching new content in mathematics or improved self-concept.

Dr. Smith's opinion was supported strongly by the participants interviewed. One participant reported that the program "course work had been a tremendous strain but worth it." Others explained that the struggle with calculus had not only helped with teaching algebra but also built up self confidence.

Districts will continue to monitor the success of their teachers for two years. This information will be compiled and a final report will be issued to include such information and its implications.

Survey of Participants

Interviews with the participants revealed a rich and broad range of teaching experience. Many of the participants had taught in elementary schools for 10 years or more and were very enthusiastic about moving into an entirely new content area in junior high or high school mathematics. One remedial-reading teacher stated that she was ready for a change and added that she had never studied mathematics before starting in this program. Another teacher taught home economics for 18 years before deciding to seek certification in mathematics. A summary of responses of all participants interviewed follows.

Participation. All teachers felt the course scheduling at night during the school year and for summer sessions at Arizona State University was convenient.

District support. District administrators are committed to participating actively in the recruitment and placement of teachers who enroll in this program. In fact, if a teacher does not complete the entire 30-hour program, that teacher receives no district credit for partial fulfillment with less than the ten required courses.

Quality of the program. All participants said the program was meeting their objective to attain certification in mathematics. Plenty of help has been provided. In fact, one participant stated that, "We were a small class and so we got a lot of extra help."

In general, participants felt that the program was well organized and that course instruction as well as assignments have been appropriate for them. Several students would like to have seen geometry and/or trigonometry taught before calculus. A refresher course in algebra was requested also.

Utility of the program to present classroom teaching. Participants will not have secondary mathematics certification until they complete the program in August; however, several of them are using program concepts in teaching junior-high algebra. All of the participants are eager to apply for mathematics teaching positions and are looking forward to working in new content areas.

Survey of Administrators

In the telephone interviews, administrators expressed concern about the lack of qualified mathematics teachers in the Phoenix area. All principals said that this project's cooperation between the school districts and the university mathematics department had resulted in attracting and selecting qualified participants. Many administrators attributed the high caliber of this program to Dr. Smith's efforts.

The administrators were unanimous and enthusiastic in recommending that other teachers in their school participate in the program. One district administrator recommended a needs assessment in the schools so that program participation could be expanded to include not only highly experienced teachers but also teachers who could develop into good mathematics teachers when given such training as the INPT program provides.

Conclusions and Comments

The long-range design of this program and the course content have proven both rewarding and difficult for the participants. The program has provided a guided, focused method for the participants to achieve certification in mathematics while continuing in their present teaching assignments. Furthermore, the course of study has not been just "another university program"; rather, it has been structured to take into account district needs as well.

According to Dr. Smith's projections, this program will "supply state schools with at least 15 fully certified mathematics teachers at a cost of less than $1150 per teacher--a rate probably more cost effective than in any other existing program."

At this time, as the number of mathematics teachers continues to decline, a program such as INPT demonstrates that cooperative efforts between the universities and local school districts can supply part of the need for adequately trained mathematics teachers. Further, such programs can be economically feasible.

Improving the Effectiveness of High School Chemistry and Physics Teachers

Dr. Joseph Harris
Arizona State University

This project was designed primarily to provide basic content knowledge of chemistry, physics, and associated mathematics for underqualified science teachers or for those qualified in another discipline, allowing them to be certified to teach chemistry or physics or both. The project was designed secondarily to allow qualified chemistry and physics teachers to upgrade their knowledge, to modernize existing skills, and to develop lines of communication among themselves and with university faculty.

Four mechanisms were proposed to achieve these goals: basic chemistry and physics courses offered during the two university summer sessions in 1984 and in 1985; a special, non-laboratory chemistry course for teachers at the university's Alhambra facility during the fall of 1984 and spring of 1985; a series of full-day workshops, lectures, and symposia devoted to special-interest topics in chemistry, to take place during the academic year 1984-85; and a regular newsletter to build and maintain communication among science teachers. An amount of

$31,100 was granted in support of the project, largely to provide tuition waivers for the participants.

Purpose

The purpose of the project was twofold: to increase the pool of qualified high-school teachers in the physical sciences and to upgrade and invigorate the knowledge of currently qualified high-school teachers. Teaching the same material again and again, with the same methods and demonstrations, can cause any teacher to lose enthusiasm and consequently to lose effectiveness. Moreover, in fields that are changing as rapidly as chemistry and physics are, content knowledge quickly becomes outdated. All teachers of the physical sciences, therefore, need a mechanism for continuing education and for acquiring new laboratory techniques. Furthermore, they need to be able to exchange insights and ideas, and they need to have ready access to the university faculty who eventually will be teaching their own students in order to prepare those students for their college careers.

Implementation

The project directors circulated project descriptions to 74 junior-high and high schools in the Phoenix area. From the 48 responses they received, they selected selected 26 to participate in the two summer-session sequences in 1984. Of the 26 who started, 23 completed the first summer session and 17 completed the second summer session. The project directors reported that they had expected a heavier enrollment. They attributed the low participation to the fact that no stipends were offered along with the tuition waivers. For poorly paid teachers who have to supplement their salaries during the summer, stipends would compensate for the loss of those supplemental salaries due to enrollment in the course.

All participants interviewed said they enrolled in order to refresh their knowledge and to get to know other science teachers in the region. Two enrolled because they also wanted to meet university faculty and find out what would be required of their students when they entered the university.

Six credits were offered for each of the summer-school courses. In addition to the lecture and laboratory requirements of the courses, which together accounted for five of the six credits, the participants had an opportunity to conduct special projects individually designed to address their own teaching

situations. These projects provided the sixth credit for each course.

The special chemistry course offered at the Alhambra facility did not include a laboratory section because Alhambra has no laboratory facilities. Enrollment in this course has been light. Participants feel they are too tired and have too much preparation to do in the evening to take difficult evening courses during the school year. They feel that the best time for such courses is in the summer.

The workshops, however, have been well attended and enthusiastically received. Participants accounted for this by the fact that no homework is required and the topics covered are timely and very useful for their own classroom teaching.

Several issues of the planned newsletter have been circulated to project participants. The newsletter is edited by Dr. Birk but contains articles by several of the project participants. The newsletter focuses entirely on aspects of teaching chemistry, rather than on theoretical knowledge, and it contains instructions for setting up and carrying out interesting laboratory demonstrations, for obtaining hard-to-get supplies, and for enlivening chemistry classes in a variety of ways. All participants interviewed find the newsletter useful.

In response to requests by participants, the project staff recently has planned a course in teaching methods for the physical sciences, to be offered in the spring of 1985. It was not clear whether tuition waivers for that course will be provided out of grant funds for this project.

Evaluation

No pre-project baseline information was collected on the knowledge and skills of the participants. The acquisition of basic knowledge in the summer courses and the Alhambra course was or will be measured by examinations. The project staff reported that the same academic standards have been imposed on the participants as on regularly enrolled undergraduate students in analogous courses. Under these standards, participants in the summer courses did very well, with mean scores in the 90s.

Workshops were to be evaluated by means of questionnaires and by a survey of participants one year after the project is completed, in order to see how participants are applying their new knowledge and techniques to their teaching. No results are yet available to report in this review.

Survey of Participants

Participants were unanimous in their judgment that the project was worthwhile. Some said they were pleasantly surprised: they had expected to find university faculty cold and uninterested in the teaching problems of high-school science teachers. Apparently the reverse was true, and all participants reported continuing contacts with the faculty by telephone, letter, and personal visits.

Participation. All participants mentioned that participation would not have been possible financially if tuition waivers had not been provided.

District support. Districts generally provided professional credit toward salary increases. No participants interviewed had been asked to conduct inservice training for colleagues, although all said they have shared new ideas.

Quality of the program. The participants judged the project to be carefully planned and to provide even more useful knowledge, techniques, and ideas than they had expected. The instructors were always well prepared and, more importantly and unexpectedly, they were very good teachers themselves who served as excellent models for teaching and for demonstrating laboratory techniques.

Abundant help was offered during the summer and has continued to be available to the participants throughout the academic year. Both help and assignments were carefully geared to the backgrounds of the participants.

Course follow-up. All participants have valued the workshops and newsletters. Some expressed a desire for in-classroom observation, as well. In-classroom observation originally was planned by the project directors, but it has not been possible due to tight schedules.

Utility of the program to present classroom teaching. All but one participant said they have been able to use the demonstrations, laboratory experiments, computations, and formulas directly in their classroom teaching. Little or no adaptation has been required. The one participant who is not using much of the material has been teaching life sciences and not physical sciences this year.

Survey of Administrators

All high-school principals interviewed expressed enthusiastic support of the project. Although one principal had not visited his teacher's classroom, the others had and all had discussed the project with their teachers. Those who had visited the classrooms had noted more emphasis on laboratory experiments, more efficiency in lesson presentations, and more self-confidence in the teachers.

All principals expressed a desire for further opportunities of this kind for their teachers. All would send more teachers if similar projects were available. One also suggested a similar project concentrated more heavily on physics.

Conclusions and Comments

This project has been well received by both participants and school administrators and appears to be achieving its major goals. The factors that raise it above the level of an ordinary summer-school offering include:

1. the interest, concern, and dedication of the project staff;

2. the fact that the project staff are judged to be both good scientists and good teachers;

3. the continuing workshops and newsletters.

For a relatively modest sum the project is providing a good service to high-school teachers of chemistry and physics. Enrollment for the summer of 1985 may be expected to increase as a result of the favorable reports of present participants to their colleagues in the teaching field.

Teaching Methods in Secondary School Science

Dr. Anton E. Lawson
Arizona State University

Fifteen high-school science teachers from the Phoenix area participated in a two-week workshop course, PSE 594: The Psychology of Science Teaching Strategies (two credits). The workshop focus was directed toward familiarizing teachers with the "learning cycle approach" used by Dr. Lawson in the course Methods of Teaching Biology (BIO 480). Presently this course is

the only methods course taught at the university for prospective high-school science teachers.

As potential supervising teachers for student teachers, workshop participants learned about the ideas and methods taught to BIO 480 students and designed a learning cycle. The amount granted for this project was $5,200, of which $4,272 was paid to Dr. Larson as one month's salary.

Purpose

In the proposal for this project, a twofold purpose was stated: 1) to train practicing secondary science teachers in methods of teaching science that would encourage scientific understanding and general thinking skills in students; and 2) to arrange for these teachers to supervise future student teachers who have been enrolled in a university methods course emphasizing the same method of teaching science. This process thus would provide continuity between what students learn in the methods course at the university and what they see being practiced by supervising teachers in classrooms.

Implementation

Application materials were sent to 39 teachers who requested them. Twenty-two applications were received and letters of acceptance were sent to 15 teachers. Dr. Lawson sent out an extensive six-page application in order to assess teachers' philosophy and teaching methods. He wanted "inquiry-oriented" and "hands-on" workshop participants since this teaching style would be most compatible with methods taught in the course.

During the two-week workshop, teachers read selected articles and used workbooks that emphasized a learning-cycle approach to science teaching and to the development of reasoning. Workbook materials had been assembled at a workshop in which Dr. Lawson participated. When asked about the actual format of the present workshop, Dr. Lawson could not recall the daily schedule. A participant reported that teachers worked in groups to explore the workbook materials and design their learning cycles.

As listed in the proposed timetable, initial assignments of student teachers for fall 1984 were not implemented. Dr. Lawson stated that no workshop participant had been assigned a student teacher for the 1984 fall semester. Furthermore, no plan was indicated for implementation of participation of supervising teachers in methods classes as listed for spring 1985 in the timetable.

Evaluation

Dr. Lawson administered a 12-item pre-instruction and post-instruction questionnaire to workshop participants. Results indicated that teacher attitudes were affected somewhat by their knowledge of methods acquired in the course. They agreed strongly that high-school science should be taught using the learning-cycle method and indicated that they planned to use the ideas and materials developed in the course.

A follow-up eight-item evaluation questionnaire was sent to participants to assess whether or not they had incorporated the learning-cycle methods into their science classes. Responses were received from 11 of the 15 participants. While teachers felt that learning cycles are a good idea, many of them had not used them in the classroom due to time constraints. All participants responded that they were more sensitive to differences in student reasoning ability. Many participants suggested that the course was too short to allow them to complete the writing of a learning cycle. All said they needed more time to learn about cycles as well as to write them.

Survey of Participants

Telephone interviews with teachers elicited information that was quite similar to the information given to Dr. Lawson in the follow-up questionnaire. Generally, the participants were very interested in learning more about methods of the discovery approach. Again, participants talked about how time-consuming it was to design and use learning cycles. A summary of responses of all participants interviewed follows.

Recruitment. The participants learned about the program from information sent to their schools.

Participation. Participants said that they would rather have had a four-week program.

District support. Some participants received professional credit and others received nothing at all. Teachers were not expected to share ideas with peers; however, several had given learning-cycle ideas to colleagues who had tried the method and liked it.

Quality of the program. The program was organized and the instructor was prepared. The allotted time for the course definitely was not realistic. As one participant said, "You can't take one method and change it in a few weeks!"

Recommendations for future programs. One participant observed that the learning-cycle format is good for teachers with experience. He explained that this method requires more thinking on the part of the student and therefore can create student frustration, which is a potential problem for inexperienced teachers. Thus he recommended that only experienced teachers take part in the program.

Survey of Administrators

During telephone interviews, the majority of administrators reported that they were not aware of their teachers' participation in the project. In general, principals explained that most of the teachers are highly qualified in their fields of biology, chemistry, or physics. Further, many of the teachers are tenured department heads and, therefore, are not observed regularly by the principals.

One administrator who had observed in a participant's classroom supported the method of teaching science inductively in stating: "Students remember methodology, not facts. The hands-on approach helps them think for themselves."

Conclusions and Comments

Use of learning cycles in secondary-school science classes requires more time because students have not been educated using a discovery-process approach. In addition to secondary teachers, elementary teachers need to be trained in such methods so that young students can learn through an interactive process across the curriculum. This method must be introduced to students at an earlier age, preferably in kindergarten, so that they have some experience with it before they encounter it cold in a demanding high-school science class.

On the whole, Renner learning cycles represent one part of the farsighted discovery approach to teaching. Because of their proven value in developing reasoning skills, they should be part of any good teacher's repertoire. In that respect, the purpose of this project was commendable. However, it is clear that the project director did not consider the difficulty of mastering this quite demanding method in such a short space of time,

especially in view of the fact that very few teachers were taught this way themselves and many have no experience whatever with discovery learning.

Making Math Count: A Training Institute for Junior High Mathematics Teachers

Dr. David Gay
Ms. Deborah Rocker
(Dr. Myra Dinnerstein)
University of Arizona

Making Math Count was a three-week institute for training twenty-nine junior-high mathematics teachers held in the summer of 1984 at the University of Arizona. The summer institute was followed by a full-day workshop on November 17, 1984, where participants reported on their classroom use of new techniques. Four courses were offered at the summer institute: 1) Mathematics in the Real World; 2) Microcomputers in Junior High Math Instruction; 3) Encouraging Junior high Students in Math, emphasizing the encouragement of girls and minorities; and 4) Revising the Curriculum, focusing on increasing teachers' effectiveness in implementing their new techniques. Three graduate credits were awarded for the summer institute and one graduate credit for the November workshop. Participants came from all over the state. An amount of $35,200 was granted to cover planning costs and salaries for the project instructors and also to cover expenses for room, board, and textbooks for the institute participants.

Purpose

Students have their first real encounter with higher mathematics during junior high school. It is during this period that they develop strong likes and dislikes toward the subject, and it is also during this period that they begin to make important academic choices that affect their future education in mathematics. Moreover, junior high is the stage when sex and ethnic differences in achievement and in academic and career choices begin to emerge.

The project's objective was to help junior-high teachers encourage continuing interest and achievement in mathematics and encourage girls and minorities, who are often "math avoiders," to understand the importance of mathematics to real-life situations and future job opportunities. To achieve this objective, the project directors planned to introduce teachers

to the use of computers for problem solving, to new approaches and methods in mathematics education, and to materials and activities that can be used to supplement the new approaches.

Implementation

Participants were recruited by means of a flyer circulated to schools throughout the state. Junior-high mathematics teachers with at least three years of teaching experience were given preference. Participants enrolled for several reasons:

1. this was the first summer program designed specifically for junior-high teachers of mathematics;

2. new ideas were needed to enliven mathematics teaching;

3. the present junior-high mathematics curriculum needs revising;

4. Virginia Horak was to be one of the instructors.

Very few of the participants were aware beforehand of the heavy emphasis on encouraging girls in mathematics. Indeed the brochure made very little of this aspect of the project. Nevertheless, all interviewed felt it was a valuable feature of the program. Both project directors and participants acknowledged that the major focus of this feature was on encouraging girls and not on encouraging minorities.

The courses originally were intended to provide six graduate credits. The university subsequently reduced the credit offerings to three for the summer--because the institute was only three weeks in length--and one for the November workshop. Though the credits were graduate credits, they cannot be applied toward a graduate degree at the university. While the courses were modified and refocused significantly for the project, all had been offered previously either at the University of Arizona or at the University of California at Berkeley.

The courses were presented substantially as described in the proposal, except that the computer course was hampered by the lack of sufficient computers and by the wide range of participants' backgrounds in using computers. The course concentrated mainly on the use of LOGO for problen solving and reduced the original emphasis on software review. Since LOGO is an excellent educational tool, this narrowed focus was probably

wise considering the short time-span of the institute. The course was taught by Dr. Davidson rather than by Dr. Willis Horak, as originally planned (see the review of the Science Inservice Training Program below).

The November workshop was attended by all participants, and each one presented his or her plans and procedures for implementing the institute techniques. All participants interviewed found the workshop a valuable feature of the project.

Evaluation

Dr. Gay designed the extensive evaluation component of the project. Several pre-institute and post-institute questionnaires were administered to determine attitudes toward mathematics, attitdes toward the roles of women in society and in the marketplace, and attitudes toward the institute itself. Evaluations of each corse were also solicited, as well as daily written comments and suggestions. Participants interviewed found this last practice very helpful.

Participants were also asked to survey the attitudes of their own students prior to attending the summer institute and again prior to attending the November workshop. Most expressed surprise at the negative results of the first survey and some satisfaction at the more positive results of the second. In telephone interviews the participants stated that the results of those two surveys convinced them of the need for such an institute as nothing else had.

Finally, all participants were evaluated by assessing the quality of their work on projects and in examinations. While the project directors originally stated that graduate standards would apply to these assessments, they conceded in personal interviews that the standards were geared more individually to the needs of the institute participants.

Results of the formative and summative evaluations have not yet been tabulated. However, an "eyeball" survey of the questionnaires indicates that positive attitudinal changes definitely occurred and that the institute was effective in stimulating new ideas and classroom practices. Participants interviewed by telephone confirmed these conclusions wholeheartedly. Several stated that the institute was the most useful and stimulating experience they had had in all their educational careers.

Survey of Participants

Although the project directors reported that one participant did not respond favorably to the institute, all who were interviewed by telephone were warmly enthusiastic. In general, they found that interaction with the other participants, deliberately fostered by the program format, was as useful and invigorating a feature as all other aspects of the course. All reported that their own students relish the new activities and formats, with some of their students expressing for the first time an appreciation and enjoyment of mathematics.

Participation. None found it a hardship to live away from home for three weeks. In fact most felt that this enabled them to concentrate better on the institute activities.

District support. All received professional credit and letters of support. Since returning to their classrooms, all have served as inservice resources for their colleagues and some have provided inservice workshops for their entire districts.

Quality of the program. Except for the computer course, all phases of the institute were considered to be very well planned and well taught. Participants specifically pointed to the outstanding teaching of Virginia Horak and Joyce House. Plenty of help was provided for all activities and courses were pertinent to actual classroom teaching.

Course follow-up. All participants felt that the November workshop cemented the strategies learned in the institute and provided a valuable forum for exchanging ideas. Some also characterized the workshop as a reunion, confirming the strong fellow-feeling that was fostered during the summer institute.

Utility of the program to present classroom teaching. All participants reported using the new ideas and techniques in other subject areas as well as in mathematics. All felt that their sensitivity to student needs and differences had been greatly expanded. Most felt that similar courses should be required in every undergraduate teaching program.

Survey of Administrators

Administrators interviewed uniformly declared themselves very impressed with the results. One administrator had not recommended his teacher for the program since he had only moved

to that school this last fall. However, he has observed her regularly, and it was clear from his comments that he has seen her use many specific elements of the project's techniques and strategies. He was so intrigued by her success with the strategies that he asked her to conduct several inservice classes and demonstrations for the rest of the mathematics faculty. He also ordered many of the materials used in the project for other faculty to use.

The other administrators, who had originally recommended their teachers for the project, were equally happy with the results. The students clearly were thriving under the new approaches and expressing far more enthusiasm for mathematics than before.

The administrators said they would send all their teachers to such a program if that were possible. They were unanimous in concluding that the project has had a significant effect on both their teachers and their students.

Conclusions and Comments

In spite of some changes in format and some difficulty with the computer component, the project appears to have achieved its original objectives. Participants did indeed learn new and effective techniques for stimulating their students' interest in and appreciation of mathematics. Furthermore, all evidence indicates that the participants are applying their new knowledge and strategies with noticeable results.

The project directors would like to repeat the institute for three more summers, using present participants as panelists and resource personnel. Such a plan might represent an effective way of capitalizing on a strong start and of reaching a wider audience of junior-high teachers of mathematics.

Teacher Improvement in Mathematics Education (TIME)

Wesley J. Rozema
Northern Arizona University

As an extension of the Mathematics Certification Program developed in 1982, the TIME project again provided mathematics courses and tuition stipends to 58 Arizona certified teachers during the summer of 1984. The Mathematics Certification Program was initiated to respond to the shortage of adequately prepared mathematics teachers in the elementary and secondary schools of Arizona. The program consists of 21 credit hours of mathematics courses, some of which are standard undergraduate

courses at Northern Arizona University while others were designed specifically for the program with designated graduate credit. The entire program can be completed in two summers of ten-week sessions. (It may be worth noting that in order to meet certification standards of the North Central Association, a teacher is required to have completed at least 20 hours of course work in mathematics. Yet to be fully certified by the state of Arizona to teach mathematics, a teacher is required to have completed 30 hours of course work. Therefore, while the program at Northern Arizona University meets the requirements of the North Central Association, it does not meet the certification requirements of the state of Arizona.)

Purpose

Elementary and secondary teachers already certified in areas other than mathematics worked toward retraining for certification in mathematics in order to increase the pool of certified mathematics teachers in Arizona.

Implementation

In mid-December 1983, a description of the Mathematics Certification Program, information regarding the financial aid available through the TIME project, and application forms were sent to every high-school, junior-high-school, and middle-school principal in Arizona. Applications for admission to the program were accepted until March 15, and during that time a total of 92 applications was received. During the week of March 26, 89 letters of admission were sent out, and tuition stipends from TIME funds were awarded to 60 applicants.

Students attended two five-week summer sessions as scheduled. Students were assigned to tracks A, B, and C based on the results of a placement test which is used for all students entering the Mathematics Department at the university. Students were enrolled in the following classes:

MAT 107	Introductory Algebra
MAT 109	Intermediate Algebra
MAT 111	Trigonometry
MAT 112	College Algebra and Trigonometry
MAT 135	Precalculus Mathematics
MAT 136	Analytic Geometry and Calculus I
MAT 599-1	Sets and Logic
MAT 599-2	Statistics and Probability
MAT 599-3	Geometry

MAT 599-4 Mathematical Applications Using Computers
MAT 599-5 Teaching Methods: Algebra and Trigonometry
MAT 599-6 Number Theory

A typical participant's program was four to five hours of undergraduate course work and six hours (two courses) of graduate course work.

During the summer sessions of 1982 and 1983, course guidelines had been established. The TIME project followed through with a third summer-school program to provide mathematics certification for teachers.

Evaluation

Mr. Rozema said that teachers do not expect to work as hard as they need to in the summer mathematics classes. Teachers who were the most poorly prepared felt that the program was too difficult. Mr. Rozema suggested that a more thorough screening of the applicants would reduce the number of students who were at "ground level" in mathematics. He reported, however, that teachers in the program did better on final course examinations than undergraduates taking comparable summer courses.

In October program participants were asked to fill out an evaluation questionnaire. A summary of the 46 questionnaires returned was prepared by Mr. Rozema to indicate strengths and weaknesses of the program and whether or not program participation has been helpful to teachers' classroom application of mathematics. Teachers reported that the program had increased and strengthened their backgrounds in mathematics. Teachers concurred that knowledgeable and effective instructors were a real strength of the program. On the other hand, many felt that course content was too difficult and that too much material was covered during the ten-week sessions.

Survey of Participants

Teachers agreed with Mr. Rozema that more thorough screening and placement of students would permit more meaningful experiences in the course work. A summary of responses of all participants interviewed follows.

Participation. Teachers were delighted to leave the heat of most areas in Arizona to spend five to ten weeks in Flagstaff. Many said, however, that without funding they probably could not return next summer.

District support. In general, teachers received salary increases and yet were not expected to serve as inservice resources.

Quality of the program. Teachers reported that although the program had been difficult, it had given them a better understanding of mathematics. The program was well organized and instructors were prepared. Teachers who had stronger backgrounds in mathematics did not find the courses to be too difficult.

Utility of the program to present classroom teaching. Teachers gained enthusiasm and confidence for teaching mathematics. One participant who teaches sixth and seventh grade mathematics and had taken only one algebra course commented, "I have direction. I can see more of the problems and how to solve the problems." The participants reported that they have acquired a better understanding of the concepts involved in mathematics.

Survey of Administrators

As reported in telephone interviews, administrators were primarily elementary and junior-high principals. The majority of these administrators stressed the need for qualified mathematics teachers at the junior-high level. One principal indicated that recent recertification of junior-high teachers has been scrutinized critically by the North Central Association and therefore has created a lot of pressure on administrators to be sure that teachers are qualified.

In general, administrators were not familiar with the content of the project. Further, most of them could not tell how teachers were using their new mathematical knowledge in the classroom. All of the administrators, however, were aware that more teachers need to be qualified to teach mathematics at the elementary and junior-high level.

Conclusions and Comments

While this program is making a start at training qualified mathematics teachers, some features of the project and interview information raise the following concerns:

1. teachers will be considered qualified when they have completed only 21 hours of courses in mathematics. While this may be sufficient for

teachers of elementary-school mathematics, it may not be sufficient for teachers of high-school mathematics. Yet teachers at all grade levels were lumped together in this project.

2. there appears to be somewhat more concern for pushing the greatest possible number of teachers through the training than for focusing on the differential requirements for teachers teaching at different grade levels.

As both the interview and evaluation results indicate, elementary teachers may not need the same course of study as high-school calculus teachers do. Thus a certification program should be considered to take account of these differing requirements, and institutes for teacher preparation should be designed to meet the certification requirements.
The program at Northern Arizona University appears to have attempted but not succeeded in accomplishing such a design.

Science Inservice Training

Dr. Frances Lawrenz
Arizona State University
Dr. Gordon Johnson
Northern Arizona University
Dr. Willis Horak
University of Arizona

This complex project was designed to improve the qualifications and skills of science teachers who are teaching at all levels from elementary school through high school and who are located in areas of Arizona not usually served by the three state universities. The project has four major components: 1) a conference for 60 school-district administrators held at Arizona State University to identify science needs, serve as science liaisons, and select master teachers to help plan the summer institutes and local inservice courses; 2) three one-day conferences of ten master teachers each to plan and develop the inservice courses; 3) two summer institutes, one for underprepared science teachers held at Northern Arizona University and one to train master teachers to conduct the local inservice courses; and 4) science inservice courses to be conducted during the winter in scattered locations around the state. The summer sessions and local inservice courses provided training in methods of science, science content, computer

applications, and special technological topics. More than 350 teachers have been served by one or more components of this project. A grant of $75,700 was provided to cover salaries of instructors, travel expenses, tuition, and other costs arising from the project.

Purpose

Arizona, like other states, has too few qualified teachers of science. Consequently, teachers with limited backgrounds in science are being asked to teach science classes at every educational level through high school. The three state universities have been addressing this problem recently (see reviews of other projects above), but teachers in remoter areas of the state have not always been able to take advantage of the courses provided. This project was designed to meet the need in two ways: offering an intensive summer institute at Northern Arizona University for 20 underprepared teachers and developing a network of 19 inservice courses offered during the school year in widely scattered regions of Arizona.

The project directors took account of two key considerations when designing the program: 1) district administrators must be involved from the start to ensure local support of the inservice courses, and 2) teachers are the best teachers of other teachers and therefore must play a major role in planning and implementing the summer institutes and the local inservice courses.

Because lack of preparation is most acute in the physical sciences, both summer institutes concentrated on chemistry and physics. For the same reason, local inservice courses stress the physical sciences, too, as well as computer applications in science.

Implementation

Both summer institutes were advertised by letters to the superintendents of all school districts in Arizona. Seventy districts responded favorably, and 70 teachers applied for the summer institute for the underprepared while 41 applied to the leadership-training institute. Teachers who had little or no science background and nevertheless would be teaching science in the fall were selected for the institute for underprepared teachers. Teachers who were identified by their districts as master teachers of science and who provided a wide geographical distribution were selected for the leadership-training institute. When the institutes were conducted in the summer,

however, it was found that many of the master teachers had very poor backgrounds in science, a factor that limited the effectiveness of that institute.

The four components of the project were implemented in stages after funding was received early in 1984. The first component, the planning conference for district administrators, was held at Arizona State University on March 2, 1984. Sixty districts sent representatives.

The second component, the planning conferences for master teachers, was divided into three regional conferences with 10 to 20 teachers attending each. The first was held at Arizona State University on March 23, 1984; the second was held at Northern Arizona University on March 29, 1984; and the third was held at the University of Arizona on April 10, 1984.

The third component was the two summer institutes. The five-week institute for underprepared teachers was held at Northern Arizona University from June 11 to July 12, 1984, under the leadership of Dr. Johnson. Classes were conducted in physics, chemistry, and computer science, and included several field trips to local science resources such as the Lowell Observatory. All classes took place in a laboratory/classroom setting that allowed participants to conduct experiments and keep laboratory notebooks while developing theory through an inductive, discovery approach. When interviewed, participants and project directors alike felt that this laboratory/classroom orientation contributed to the success of this institute.

The three-week leadership-training institute was held at Arizona State University from June 11 to June 29, 1984, under the direction of Dr. Lawrenz. Dr. Horak was to have directed that institute but he withdrew due to another commitment. His withdrawal caused a last-minute rearrangement of staff and course content that may have contributed to the fact that this institute was less well received by the participants.

The planning for this institute was based on suggestions generated at the administrator conference and the master-teacher conferences. The institute provided content instruction in the physical sciences and supervision of planning for the local inservice courses to be held during the academic year 1984-85.

The fourth component of the program, the local inservice courses, began in the fall of 1984 and will be continued through the spring of 1985. Nineteen courses are serving 333 teachers throughout the state. These courses were designed and are being conducted by the 19 master teachers who took part in the leadership-training institute. It is interesting to note that these master teachers felt overwhelmed by the content of the summer institute but are regaining confidence now that they are

in turn teaching the material to their colleagues.

Evaluation

The project directors have undertaken a complex and rigorous plan for evaluating the program. A qualitative component comprises participant interviews, questionnaires, and descriptive portrayals. A quantitative component comprises pretesting and posttesting on both content and attitudes of the project participants and of students of fourth-grade and seventh-grade teachers taking the local inservice courses. A detailed evaluation report was submitted with the third quarterly report presenting an analysis of the data collected for the summer institutes. Other analyses have not yet been reported.

Evaluation of the summer institutes revealed that participants responded very positively to the underprepared institute and less positively to the leadership-training institute. The time allotment of three weeks for the latter institute was clearly too short to cover the amount of material planned. The problem caused by the shorter time frame was exacerbated by the fact that many of the so-called master teachers were in fact quite underprepared.

Telephone interviews with the participants confirmed all the findings reported in the project's third quarterly report except that participants in the leadership-training institute now view that experience more favorably than they did right after it was over.

The project directors have visited all inservice classes at least twice and have found them proceding according to plan. They also report that informal responses to the local inservice training courses have been very positive.

Survey of Participants in Summer Institutes

In spite of feeling overloaded at both summer institutes, the participants all agreed that the project has been a lifeline to them in teaching science. Now that they are back in their classrooms, and some are also teaching the local inservice courses, they increasingly see the value of the heavy assignments of their summer programs.

Participation. Teachers enrolled in the various components primarily because they were acutely conscious of their lack of background in the physical sciences. Even those who had comparatively extensive backgrounds in science knew that they needed to update their knowledge and acquire new laboratory techniques. One participant also stated that the project "sounded fun!"

None found participation inconvenient. In fact those who had to live in Flagstaff for five weeks felt that that was one of the best features of the institute because it fostered a constant interchange of ideas and the development of a continuing support network.

District suport. All participants were given support, primarily because the project directors had involved district administrators in the planning from the start. All participants have shared ideas and resources with their colleagues, even if they did not attend the leadership-training institute.

Quality of the program. Participants in the underprepared institute unanimously considered that the program enriched their science teaching. They returned to their classrooms in the fall with greater knowledge, stimulating new laboratory techniques, and over 100 new activities to try with their students.

These participants felt the instructors were very well-prepared and that all but one were excellent models of good teaching. Several participants, however, expressed disappointment with the computer component, which suffered from lack of equipment and from too great a diversity of computer backgrounds among the participants.

As discussed above, participants in the leadership-training institute expressed more reservations about the value of the program. The wide range of backgrounds reduced the effectiveness of the classes, and the instructor in science methods from the Department of Elementary Education did not provide much theory or guidance in methods. Nevertheless, on a scale of one to ten, the average rating for program quality was eight.

Course follow-up. Participants in the leadership-training institute have had a good deal of follow-up contact with Dr. Lawrenz as they have been planning and teaching the local inservice courses. All felt that continuing contact with her has been one of the most valuable features of the program.

Participants in the underprepared institute have had less follow-up, but some have been corresponding with Dr. Johnson and

all had a most enjoyable reunion at the Arizona Science Teachers Conference in the fall.

Utility of the program to present classroom teaching. As noted earlier, participants in both summer institutes found that the program has greatly enriched their present teaching.

Survey of Participants in Local Science Inservice Classes

This survey was conducted by compiling the results of a questionnaire administered by the project direcors as classes ended in the fall of 1984. Items 13 through 23 were selected as being most relevant to the purposes of this review (see Appendix C for the items and tallies of the responses).

Most respondents agreed that the course was useful and not too hard. Most felt that the course provided new methods of incorporating science into the classroom and that it stimulated them to spend more time teaching science. Most felt that their students now enjoy science more and that their teaching has improved.

Laboratory activities were viewed as particularly valuable, especially in helping to understand the concepts covered. A narrow majority felt that there had not been too much emphasis on science concepts.

Finally, most participants found that the material was presented clearly and understandably. Overall, they concluded that they would recommend the inservice classes to others.

Survey of Administrators

All administrators interviewed agreed that this project is outstanding. They had all observed their teachers since the summer institutes and had noticed several improvements in their teaching of science, particularly improved efficiency of lesson organization and presentation and increased self-confidence.

Administrators in those schools with teachers who had participated in the leadership institute were especially enthusiastic. They see the multiplier effect of the local inservice classes now being conducted by those participants as an extremely valuable contribution of the project. One administrator noted that his teacher had had to conduct two separate inservice classes because the local demand had been so great. The two administrators who had observed sessions of the local inservice classes felt that the quality of the content being taught was high, although they did not feel they were in a

position to compare the quality to that of regularly scheduled science courses at the university.

On the whole, the administrators felt that this project was a very helpful way to bring better science teaching to outlying areas of the state. Several said that before this project their teachers had found it difficult to get to the university centers to update their content knowledge. Both the fee-paid summer institutes and the local inservice classes had addressed this problem very well.

Conclusions and Comments

This project has the potential of making a truly significant contribution to the improvement of science teaching in Arizona. Ambitious in scope, it has targeted one of the greatest needs in this area right now: bringing current theory and methods to regions remote from the university centers.

The project directors clearly have worked hard to design and orchestrate a program involving many different groups of people in widely scattered locations. Furthermore, they have planned carefully to document the effort at all stages in order to fine-tune the present project and inform future efforts.

Additional support to expand the project staff--perhaps through the hiring of qualified graduate teaching assistants--might help in the monitoring of the local inservice courses, which indeed are the heart of this project.

GENERAL CONCLUSIONS

Success of the Projects

While the eight funded projects met their program objectives with varying degrees of success, six of the projects clearly were of high quality. One program, the TIME project at Northern Arizona University, could be considered satisfactory, if not exceptional, and one program, Teaching Methods of Secondary School Science at Arizona State University, was not implemented as proposed.

Projects tackled the problem of improving the teaching of mathematics and science from several viewpoints: improving student attitudes and interest (Making Math Count); improving the content knowledge of teachers (Science Inservice Training, Improving the Effectiveness of High School Chemistry and Physics Teachers, INPT, and TIME); improving teaching methods (Problem Solving for Secondary School Teachers and Teaching Methods in Secondary School Science); and improving both instruction and

content knowledge (Science Inservice Training). Teachers throughout the state responded positively to this wide range of course offerings. Indeed, participants in all projects reported that their classroom teaching had been enriched and invigorated by their experiences in the projects.

Participants did not object to living away from home to attend three-week or even ten-week programs. In fact, dormitory living enhanced learning because students spent more time together discussing ideas and course work. They became tutors for one another and thoroughly enjoyed the temporary relief from household chores. The opportunity to exchange ideas and to solve problems together was seen as one of the most successful aspects in all projects. In this way, summer institutes provide a forum where ideas and frustrations can be shared, a process that some participants felt may help to counteract burnout.

Reaction of the Participants to the Projects

All project directors and most participants expressed enthusiasm for the increased content knowledge and exchange of ideas that resulted from the project activities. Evaluation comments were generally positive, and suggestions for change were insightful and constructive.

In general, teachers were excited about their recently acquired skills. Many of them piloted methods in their classrooms during the fall semester and also worked with peers in order to share new approaches with those who had not been able to enroll in the projects. This sharing of ideas has extended the impact of the projects far beyond the targeted populations.

Project timelines ranged from two weeks to a year and a half. Participants thought that shorter institutes should be extended, and participants in long-range programs felt that class scheduling was convenient even when it extended throughout an entire year.

Again and again participants explained that the programs had been useful for two important reasons:

1. their content knowledge and teaching strategies had been updated, expanded, and carefully monitored by university instructors;

2. their own feelings of self-confidence as teachers had been strengthened by the positive reactions of their students to their new teaching skills.

Many teachers had been aware of their inadequate content knowledge and were now beginning to feel better about teaching because they knew they were better prepared.

Reactions of Administrators to the Projects

With few exceptions, administrators expressed overwhelming approval of the projects. They saw improved teaching in classrooms and greater enthusiasm among students. They acknowledged that it was probably too soon to note changes in the academic achievement of the students affected by the projects.

Most felt the projects made significant contributions to the teaching of mathematics and science in their schools. They would like to see more of these projects in the future, and they would send as many teachers as they could to attend.

Recommendations for Future Projcts

Project directors conducted one or more course evaluations. Information gathered from these evaluations was used by the directors for planning ways of improving the programs.

In all projects that offered computer courses, the planning was surprisingly poor. Both at the University of Arizona and at Northern Arizona University, equipment and computer laboratories were inadequate. Moreover, classes had been scheduled without taking into account the wide variation in participants' background knowledge. Directors agreed that in future they would have to group within ability levels in computer classes.

Seven of the project directors stated quite frankly that content as well as methods courses in mathematics and science should be taken in colleges of liberal arts rather than in colleges of education. Many of the teachers interviewed supported this view, stating that most education courses in the area of science and mathematics were of little substance or use. The notable exception was the course in mathematics methods directed by Dr. Carol Larson at the University of Arizona.

One project director pointed out the need for working closely with school districts to create a more cooperative relationship between university programs and the teachers who participate in them. Teachers can be more effective if their university course work is compatible with district goals and objectives.

General Comments

Project directors and participants expressed some commonly shared concerns about inservice training in mathematics and science:

1. Colleges of liberal arts offer few mathematics and science courses in the evenings or during summer sessions, thereby making it difficult for teachers to upgrade their content knowledge. Several participants recommended that the state consider certifying specalists in mathematics just as they certify specialists in reading. Courses might then be developed by the universities and offered at times convenient for teachers seeking the specialist certification.

2. Inexpensive instructional materials (for mathematics and science), as well as supplies (for science), are not readily available to teachers. In cooperation with university staff, districts might develop resource centers for developing and maintaining a circulating supply of materials and activities.

3. Science and mathematics teachers feel limited in using creative teaching ideas and strategies by the pressure to prepare students for standardized tests such as the Iowa Test of Basic Skills, and by the pressure to use district-adopted commercial textbooks. Yet the creative teaching ideas would probably develop the kinds of reasoning skills and higher thinking strategies that most educators consider the true goal of schooling.

One Final Observation...

To improve the quality of mathematics and science teaching in Arizona, universities will have to continue to attract teachers to courses and to special projects such as the eight reviewed here. Yet many teachers cannot participate because summer is a time when they must supplement their salaries by taking temporary jobs. In fact, the majority of teachers who participated in these eight programs stated that they would not have been able or willing to enrol

State funds supporting these costs therefore appear to have been well spent. Considering the wide impact of these projects, financial support of this kind may in fact turn out to be an economical way to improve the teaching of science and mathematics.

APPENDIX A

Interview Schedule for Project Directors

APPENDIX C

Items from Questionnaire for Participants in Local Science Inservice Classes

DELTA: Math and Science Projects (continued)

Selected Items from Questionnaire for Participants in Local Inservice Classes

14. The course was useful.

Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
102	133	27	5	0

15. The course was too hard.

Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
40	64	116	47	0

16. The course showed me new ways to incorporate science into the classroom.

Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
110	117	31	8	0

17. Participation in the course has caused me to spend more time teaching science in my classroom.

Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
82	115	44	11	19

18. Participation in the course has caused my students to enjoy science more.

Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
73	123	50	6	17

DELTA: Math and Science Projects (continued)

19. Participation in the course has caused improvement in my teaching.

Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
67	141	47	6	9

20. The science laboratory activities used in the course helped me to better understand the science concepts that were covered.

Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
116	130	21	3	0

21. There was too much emphasis on science content in the course.

Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
43	54	114	55	2

22. The course material was presented in a clear and understandable manner.

Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
80	138	42	8	0

23. I would recommend this course to others.

Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
95	106	41	15	0

APPENDIX D

Interview Schedule for School Administrators

DELTA: Math and Science Projects (continued)

Interview Schedule for Project Directors

1. Philosophy behind the proposal (purpose).

2. Program Format

   course work — credit system

   staffing — new design?

3. Participant Selection

   criteria

   process

4. Evaluartion

   procedures

   instruments

5. Impression of Results

   how course met or did not meet needs
   how course work was evaluated
   (university standards?)
   recommendations from participants
   staff evaluations
   Regents funding--an essential element?
   proposed or definite future plans
   general recommendations for improving the teaching of
   math/science

APPENDIX B

Questionnaire for Participants

ARIZONA BOARD OF REGENTS
Mathematics and Science Projects

QUESTIONNAIRE FOR PARTICIPANTS

Name_____ Project_____
Grade Level_____ Project Director_____
Subject_____
Years Teaching_____

Recruitment

1. How did you find out about the program?

2. What was it that attracted you to the program?

Participation (Costs, location, timing, etc.)

3. Was participation in the program convenient, or a hardship for you? Explain.

4. How could the program have been designed to make it easier or convenient for you to participate in it?

District Support

5. What support to participate in the program did you receive from your local school or district?

Letters of recommendation?	Financial support?
Professional credit?	Salary credit?
Released time?	With substitutes provided?
Travel allowance?	Other support?

6. Were/are you expected to train your fellow teachers on completion of the program?

7. Were/are you expected to serve as an inservice resource on completion of the program?

DELTA: Math and Science Projects (continued)

Quality of the Program

8. Did the program meet you needs?
   If so, how?

   If not, how not?

9. Was the program well organized?

   Were the instructors prepared?

   Was the allotted time realistic for the content presented?

   Were appropriate equipment and materials on hand when needed?

10. Were you given help when needed?

    Was help given at the appropriate levels of understanding or appropriate to your background?

11. Was the format of the program appropriate to the purpose of the institute?

12. Was the level of difficulty of the classes and assignments appropriate to the students enrolled?

Course Location and Facilities

13. How did you find living in a dormitory?

    Was it helpful to the learning process?

    Was it distracting?

    Were the accommodations adequate?

DELTA: Math and Science Projects (continued)

Course Follow-up

14. Did your project provide any post-institute follow-up? If so, in what form?
    - Newsletter?
    - Classroom observation?
    - Personal consultation?
    - Workshop(s)?

15. In what form would a follow-up have been of most use to you?
    - Newsletter?
    - Classroom observation?
    - Personal consultation?
    - Workshop(s)?
    - Other (specify)

tility of the Program to Present Classroom Teaching

16. How are you presently using the content of the program in your present classroom teaching? Be specific.

17. Was the course content useful to your classroom teaching in the form in which it was presented?

    If not, how could it have been improved?

Recommendations for Future Programs

18. If future programs/institutes were offered, would you consider participating?

19. What would you most like to have covered in a future institute?

20. What would be the most useful format for such an institute?

DELTA: Math and Science Projects (continued)

21. Let's dream for a minute: given the necessary personnel and resources, how would you design (or what would you include in) a comprehensive program for improving the content knowledge and teaching skills of math or science teachers?

22. What should undergraduate students include in their programs of study to insure their competence as math or science teachers?

23. What other comments would you like to make about the program?

APPENDIX C

Items from Questionnaire for Participants in Local Science Inservice Classes

Selected Items from Questionnaire for Participants in Local Inservice Classes

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DELTA: Math and Science Projects (continued)

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APPENDIX D

Interview Schedule for School Administrators

ARIZONA BOARD OF REGENTS
Mathematics and Science Projects

QUESTIONNAIRE FOR ADMINISTRATORS

Name_____ School_____
Teacher_____ District_____

1. Did you support the participation of this teacher in the program?

   If so, in what ways?

   letter of recommendation
   released time?
   travel allowance?
   school funds for classroom materials and equipment?

2. Have you observed the teacher's classroom since participation in this program?

   If so, what were your impressions of the teacher's use of new techniques acquired in the program?

   If not, have you discussed with the teacher his or her impressions of the value of the program and his or her use of program techniques in teaching.

3. Do you feel programs of this type make a significant contribution to the teaching of mathematics and/or science in your school?

4. Would you recommend the participation of other teachers in your school in similar programs?

5. Do programs of this type meet district goals and objectives?

   If not, what changes would you suggest?