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TEACH-STAT: A PROFESSIONAL DEVELOPMENT PROGRAM FOR ELEMENTARY TEACHERS (GRADES K-6) IN NORTH CAROLINA, U.S.A

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1. Introduction

Teach-Stat is a professional development program for elementary teachers (grades K-6) in North Carolina funded by the National Science Foundation and jointly sponsored by the University of N.C. Mathematics and Science Education Network, the N.C. Department of Public Instruction and the N.C. Science and Mathematics Alliance. The Teach-Stat faculty are developing materials to help teachers expand their knowledge and understanding of statistics and to help them teach it to elementary students through an activity-based, data investigations approach. We expect teachers who participate in the Teach-Stat program will reframe the way they teach mathematics, science and social studies through the integration of data analysis activities into these subject areas. This paper provides an overview of Teach-Stat, a brief description of some of the workshop materials that have been developed for it, and a preliminary report on several research results that are beginning to emerge from the project.

2. Overview of Teach-Stat

The North Carolina *Standard Course of Study* (1989) for elementary school mathematics has for the past four years included a statistics "strand" in each of the grade levels 1 through 6, labelled as "data collection, display and interpretation" in grades 1 through 3 and as "graphing, probability and statistics" in grades 4 through 6. The competency goals in each grade expect students to be able to formulate questions, gather data using appropriate methods, analyze it in various ways (especially using graphical methods, but also with numerical measures in the upper grades), and interpret the results of their analyses both orally and in writing. Because most elementary teachers in N.C. have had minimal exposure to probability, statistics and data analysis during their preservice years in the University, little attention has been paid in many elementary classrooms to these important topics. To assist teachers in the development of their knowledge about statistics and how to teach it, the University of N.C. Mathematics and Science Education Network, through its Director Dr. Susan Friel, obtained funding for three years from the National Science Foundation for the development and implementation of the Teach-Stat project. This inservice, professional development program will not only help teachers expand their understanding of probability, statistics and data analysis, but will also help them learn appropriate ways to teach the concepts to elementary students, to reframe the way they teach mathematics in general (using a data analytic, "investigative" approach), and to incorporate data analysis and statistics into other subjects they teach, especially science and social studies.

During the 1991-92 academic year, University of North Carolina faculty representing nine of the sixteen constituent institutions of the UNC system met in several "seminar" sessions of 1-2 days each. These sessions served to orient the faculty to the content and research components of the project, to give them the opportunity to write the professional development curriculum they would teach from the following summer and to establish the evaluation and research agenda for the program.

During the spring of 1992, fifty-five elementary teachers were chosen from around the state of North Carolina to participate in a residential summer workshop. This workshop was held on a centrally-located college campus and for three weeks the participants were taught the activity-based curriculum in probability, statistics and data analysis which had been developed by the faculty during the previous months. The University faculty who taught the workshop were organized into four teams of 2-3 people and were assigned the responsibility of conducting the institute for

two or three days at a time. Teaming permitted them to do joint planning with other faculty of diverse backgrounds (a statistician teamed with a mathematics educator and a science educator for example) and also to break the participants into smaller working groups. The elementary teachers were chosen to participate in this workshop based on recommendations of the Science and Mathematics Education Center directors at nine sites across the state, and the expectation was that they would be enthusiastic participants, very interested in learning about statistics and in teaching at least one unit on statistics in their classrooms during the coming academic year. This expectation was more than fulfilled by most of these "first-year" teachers as we visited their classrooms and conferred with them on numerous occasions during the 1992-93 school year. In fact, some teachers report that this project has "changed the way I teach". Not only do they appear to be incorporating more data analysis experiences throughout their teaching, but they also seem to be moving toward a more student-directed learning environment in general, in which they facilitate learning rather than direct it. This represents a change to a pedagogical style which more nearly approaches that described in the *National Council of Teachers of Mathematics Professional Standards for Mathematics Teaching* (1991).

During the 1992-93 academic year, the Teach-Stat faculty continued to meet for the purpose of revising the workshop materials while preparing for the second series of workshops to be conducted in the summer of 1993. During the second summer institutes, the first-year teachers were involved in teaching the workshop materials, along with the university faculty, to an additional 24 teachers at each of nine sites around the state. The involvement of the first-year participants in the second-year instruction was quite successful, especially since they could bring with them not only the knowledge gained in the 1992 workshop, but also the year's experience *doing* data analysis activities in their classrooms. They were able to provide much needed feedback to the second-year participants on specific investigations that were presented to children in their classrooms.

During Teach-Stat's third year, several more "seminars" will be held so the University faculty can write the final revision of the materials that have been used for the last two summer workshops. Two additional manuscripts will also be produced during the year and all are described in more detail in the next section. University faculty will continue to provide extensive and on-going support at each site for the first- and second-year Teach-Stat teachers and from each group of thirty will identify six who will be participating in the "statistics educators" component of the project. These statistics educators will then participate in an intensive one-week workshop taught by the University faculty during

the summer of 1994 at their site to prepare them as regional staff development resource teachers in statistics/data analysis. There will also be a third offering of the summer workshop for an additional twenty-four elementary teachers at each of the regional sites, and the newly-trained statistics educators will work with the University faculty as part of the instructional team.

3. Materials produced by Teach-Stat

A minimum of three manuscripts will be produced by the Teach-Stat faculty and will form the core of the materials that could be used by others to replicate our program of professional development. In addition, other materials may be developed including video tapes of teachers participating in the activities during the summers or guiding their own students through data investigations in the classroom. No student materials are being produced, since most of the activities in the workshops are based on existing materials meant to be done by students in the classroom. Especially useful is the the series of *Used Numbers* books (see the Bibliography for specific titles).

The three manuscripts being developed are tentatively titled:

1. *Teach-Stat: Professional Development Program.* This manuscript will provide a "how to" discussion for planning and implementing a three-week teacher education institute. It will be written in a way that addresses teachers' needs in statistics education, but will be modelled after curriculum materials such as *Used Numbers* in terms of style and format. However, the audience for this manual definitely consists of those educators who are designing and teaching professional development programs for elementary teachers. The so-called "PCAI" format for the investigations in this manual is a modification of the four-stage model given by Graham (1987): Posing the question, Collecting the data, Analyzing the data and Interpreting the results. The model gives a framework to the reasoning process followed in most statistical problem solving and allows for the investigations to be structured in a consistent manner throughout.
2. *Teach-Stat: Investigations for the Classroom.* This manuscript provides a "how to" discussion for planning and implementing activities with elementary students for learning statistics, for learning mathematics using a data investigation approach, and for exploring applications in science and the social sciences using a data investigation approach. This is an "activities" document whose audience is elementary teachers. The activities will be designed to provide them with "investigation starters"

for a variety of purposes. Our first- and second-year teacher/participants in the summer workshops will be contributors to this document - if not actually writing materials, then certainly working closely with the University faculty to develop ideas which are then written by project staff.
3. *Teach-Stat: Statistics Educator Leadership Development Program.* This manuscript will provide a "how to" discussion for planning and implementing an intensive, one-week statistics educators' institute.

4. Preliminary research results

One of the major goals of the Teach-Stat research group has been to enlarge our understanding of the statistics knowledge and the pedagogical techniques for teaching statistics that elementary teachers bring with them to inservice programs such as ours. The obvious benefit of this increased understanding is that we will be better informed as we develop the materials and methods used in the Teach-Stat workshops. Very little attention has been paid in the literature to the statistics knowledge of teachers of any grade level (Shaughnessy, 1992), though the work of Mokros and Russell (1991) does begin to identify specific strategies that elementary teachers use to solve statistics problems involving application of the concept of mean. We know of no research on elementary teachers' pedagogical knowledge of statistics. Thus, our research focuses on developing a base of understanding about elementary teachers' conceptual and pedagogical knowledge of statistics. A brief description of some preliminary results of this research follows.

During the Spring 1992, the Teach-Stat University faculty developed, piloted and revised two instruments to measure elementary teachers conceptual knowledge of statistics and knowledge of statistics pedagogy. Three times in the last fifteen months, the original fifty-five first-year teachers (referred to as Core teachers) were administered the instruments: prior to the summer '92 workshop (referred to as the Pretest: Year 1); on the last day of that summer workshop (referred to as Posttest: Year 1); and at the end of the school year 1992-93 during which they integrated into their own classrooms the activities and knowledge they learned the previous summer (referred to as Post-Posttest: Year 1). The Post-Posttest results have not yet been fully analyzed, but will be used later to see if teaching statistics in the elementary classroom has had any additional effects beyond the summer workshops. In addition to the content and pedagogy surveys, concept maps were constructed by the Core teachers on the first day of the summer '92 workshop and in February 1993, and subsequently analyzed.

The statistics content surveys given to the Core teachers (both Pretest and Posttest) included twelve open-ended items which required them to read and interpret graphs (lineplot, histogram, boxplots and a scatterplot); answer questions about the concepts of mean, median, and mode; answer questions about what is "typical" about a given set of data and then make predictions from the data, among others. The items on the content survey were scored on a holistic basis using a scale of 0 (no response) to 4 (fully acceptable response). On the Pretest, there was a wide range of responses to each of the items (Bright *et al.*, 1993b). For questions related to graphing for example, only approximately one-third of the responses reflected good understanding of the content knowledge being assessed. Teachers' knowledge with regard to interpreting boxplots and scatterplots and with regard to measures of center was similarly weak with their justifications often incomplete and inaccurate. The Posttest saw some noticeable improvements in the clarity of explanations offered by the teachers, in part evidenced by greater use of statistics vocabulary. Comparison of the scores across administrations indicates a significant improvement on all but one of the items, which presented an ambiguous situation for the teachers' response. An especially interesting research effort arising from further analysis of the content survey data is focusing on efforts to determine if there are patterns to elementary teachers' development of ideas regarding the "center of the data" when presented with a graphical display of data (Berenson *et al.*, 1993c). Before instruction, teachers tended to fixate on "large" features of the graphs like the range of the data or the horizontal scale or the modes to explain "center" (the graphs consisted of a line plot in one item and a histogram in another). After instruction, teachers focused more on numerical measures obtained from the graphs, especially the median, instead of the graphical features themselves. Additionally, teachers' responses concerning "center" and "typical" were examined for stability over different graphical representations. Teachers were generally less stable in their fixations and ideas on the Pretest than the Posttest (Berenson *et al.*, 1993c).

On the statistics pedagogy surveys teachers were asked to discuss the statistics concepts that they thought were most appropriate for third graders and how they would teach them. In addition, they were asked to discuss their teaching strategies if students had access to manipulatives and/or calculators. Teachers' perceptions of the important statistics concepts shifted between the Pretest and the Posttest (Bright *et al.* 1993a) from what are classified as "isolated content" and "simple processes" (e.g., graphing, probability and organizing data) to "process" ideas (e.g., formulate questions, interpret data). Teachers seemed to have internalized the PCAI model used in the summer workshop, at least to the extent that

their views changed about the statistics ideas appropriate for children to know. On the Pretest, most of the instructional strategies dealt with data gathering, graphing, and computing statistical values. On the Posttest a shift was noted in their teaching strategies to the use of a larger variety of data representations, extended discussion with children about the question formulation and follow-up questioning by the teacher to help children develop meaning for the interpretations of the data. This again reflects the instruction presented in the summer workshop, so the teachers seem to have internalized its goals. These shifts in perception are not surprising, however, since prior to the project the statistics background of most of the Teach-Stat teachers was weak and change was almost guaranteed. Further research is being conducted to measure additional changes in the statistics teaching strategies of our Core teachers after they have taught their own students during the recently completed school year and after they have taught their colleagues in the professional development workshops this summer.

The concept maps were examined to look at the ways elementary teachers represented their understanding of the broad area of statistics (Bright and Friel, 1993). The first analysis of these maps focused on categorizations of the statistics concepts included in their maps. Once the categories of concepts were determined, a map was coded as containing that concept if any of the key terms were found on the map. The percentage of maps which included each category of concepts was then computed. A great deal of diversity was found in their maps as evidenced by that fact that only three categories were included in more than 50% of the maps (collect data, measures of center, and tables/charts) and seven other categories appeared in 40-50% of the maps (counting, surveying, analyze data, graphs only, school graphs, normalizing summaries, and probability). In a second analysis of this data, special attention was paid to the teachers' understanding of the relationships among four critical statistics concepts in the N.C. *Standard Course of Study* (1989): graphing, collection of data, prediction, and measures of center. Only 3% of the maps included none of the four critical concepts, while 14% included one concept, 33% included two concepts, 36% included three concepts, and 14% included all four concepts. Graphing was included most often (91% of the maps) followed by collection of data (62% of the maps), measures of center (60% of the maps) and prediction (29% of the maps). As this analysis shows, graphing seems to be the only concept that is part of a large majority of elementary teachers' common understanding of statistics. It suggests that teachers may not be very familiar with, and may not be able to understand fully, the goals and objectives of emerging national and state curriculum frameworks. If these national and state standards are to be

implemented, teachers must develop a better understanding of statistics concepts and we expect our research will help to identify areas of statistical thinking that need to be addressed explicitly in professional development workshops.

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