PREPARING ELEMENTARY SCHOOL TEACHERS TO TEACH STATISTICS: AN INTERNATIONAL DILEMMA

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Most teacher preparation programs neglect statistics during common coursework. Although students may take an introductory statistics course, they are not necessarily prepared to teach statistics content at the elementary school level. Recommendations for the types of experiences elementary school teachers should have are discussed.

INTRODUCTION

The preparation of teachers has been a growing concern in the international statistics education community. This can be seen by the increasing number of sessions focused on the training of teachers at the *International Conference of Teaching Statistics* (ICOTS). Particular emphasis has been evident in topics at ICOTS 6 and 7. The increased level of interest is most evident by considering the overall focus of the Joint ICMI/IASE Study conference in 2008. This conference focused entirely on "Statistics Education in School Mathematics: Challenges for Teaching and Teacher Education."

This increased attention is certainly warranted as research continues to identify the need to prepare teachers to teach statistics. Statistical topics have been in the curriculum for well over 100 years; however the nature of statistics and the role of statistical thinking have become a greater part of the curriculum over the past 30 years. The situation in the United States will be presented as an example for this increased emphasis. This emphasis is similar to that of other countries (e.g., Australia, Ireland, Israel, and New Zealand).

Inclusion of Statistics in the United States Curriculum

The work of the quantitative literacy project in the 1980s greatly influenced the inclusion of data analysis and probability as one of five content standards in the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for School Mathematics* (1989). In 2000, NCTM further emphasized statistical content in the *Principles and Standards for School Mathematics*. Despite the fact that the content was beginning to become a part of the school curriculum, teachers that were now being asked to implement these standards had come from school experiences and teacher preparation programs which did not include statistics as a major focus in their training. This concern was raised in *The Mathematical Education of Teachers* (MET) report (Conference Board of the Mathematics Sciences [CBMS], 2001). In their report, the authors specifically described the issue concerning elementary school teachers:

> despite daily exposure to data in the media, most elementary teachers have little or no experience in this vitally important field. Thus, in addition to work on particular technical questions, they need to develop a sense of what the field is about. (CBMS, 2001, p. 23).

This quote is very telling in that it does not only discuss the technical knowledge, but it raises the very serious issue of understanding the field of statistics. In the United States, the *Principles and Standards for School Mathematics* did not necessarily paint a vivid picture of what statistical thinking involves. According to Moore (1990), statistics is truly the study of the omnipresence of variability. However, variability was not a major component of NCTM's 2000 standards document. In order to expand upon the recommendations of NCTM, the American Statistical Association released the *Guidelines for Assessment and Instruction for Statistics Education* (Franklin, Kader, Mewborn, Moreno, Peck, Perry, & Scheaffer, 2007). The authors were very cautious to point out that the GAISE framework was not constructed to replace the NCTM standards, but rather was created to provide some level of clarity. "This framework provides a conceptual structure for statistics education which gives a coherent picture of the

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overall curriculum. This structure adds to but does not replace the NCTM recommendations" (Franklin, et al., 2007, p. 5). This framework also raised the concern regarding the preparation of teachers, "statistics...is a relatively new subject for many teachers who have not had an opportunity to develop sound understanding of the principles and concepts underlying the practices of data analysis they are now called upon to teach" (Franklin, et al., 2007, p. 5). With these expansions to the K-12 curriculum, it is important to examine what types of steps have been made in teacher preparation programs to address teachers' readiness to teach statistics.

According to Franklin and Mewborn,

> In most teacher preparation programs for elementary and middle school teachers, probability and statistics comprise a small portion of one mathematics content course, and this course is not likely to be taught by a person with a robust background in statistics. (2006, p. 339).

This particular claim is not unusual and is not limited to the United States. Mathematics and statistics educators who struggle to include more statistics as part of teacher preparation programs across the globe have made similar comments. In order to begin exploring this claim further, the investigation presented in this paper examined course offerings at several institutions of higher education that prepare elementary school teachers in Australia, New Zealand, South Africa, and the United States. This initial exploration was limited to these countries due to translation issues. However, one hope is that this paper will lead to a true global survey initiated at ICOTS which will attempt to provide a more encompassing picture of the current level of statistics preparation future elementary school teachers receive across the globe. The specific research question addressed in this paper is: What is the level of emphasis placed on statistics in coursework aimed at preparing elementary school teachers to teach statistics at institutions in Australia, New Zealand, South Africa, and the United States?

METHOD

Information from the *US News and World Report* was used to select institutions in each of the four countries. Based on the rankings of colleges of education and the number of elementary education graduates each institution was produced, several universities were selected. Once universities were identified, information was gathered regarding required coursework. Once the courses were identified, course descriptions and syllabi, when possible, were collected for examination of the amount of time devoted to statistical content. One major limitation of this investigation is that the information was mined by the author rather than provided by the institutions. It is possible that information was missed during the search process. Individuals with intimate knowledge of the programs would have been able to provide more detailed information regarding the amount of time and emphasis statistics receives during teacher preparation programs. Perhaps, the effort can be continued after ICOTS by recruiting members from institutions that are willing to participate.

RESULTS AND DISCUSSION

The number of institutions from Australia, New Zealand, South Africa, and the United States were 4, 4, 2, and 6 respectively for a total of 16 institutions. For each institution, the number of courses will be presented as well as the percent of time dedicated to statistics across those courses. The results for each country are displayed in Table 1.

The majority of focus for all of the courses was number and operations or numeracy as it was called in some countries. The secondary focus for all of the courses was geometry and measurement. As you can see from the table, many courses did not address statistics during their coursework at all. The one institution in New Zealand that appears to have a significant percentage of coursework dedicated toward statistics actually had statistics in the title. The courses also particularly aimed at helping future elementary school teachers understand the nature of statistical thinking.

Table 1. Results from Analysis of Courses

Country	Institution	Number of Courses	Percent of Coverage
Australia	A	2	0
	B	3	0
	C	2	0
	D	2	0
New Zealand	E	2	50
	F	4	0
	G	2	0
	H	3	20
South Africa	I	3	9
	J	3	9
United States	K	3	11
	L	2	0
	M	3	0
	N	3	11
	O	2	11
	P	2	0

Despite the limitations of this investigation, this preliminary analysis appears to suggest that elementary school teachers are still not adequately prepared to teach statistics. It is clear that preservice teachers are not likely exposed to experiences that will prepare them to realize the new expectations associated with teaching statistics. As the GAISE framework states, "Without such experiences, a middle [or high] school student who has had no prior experience with statistics will need to begin with Level A concepts and activities before moving to Level B" (Franklin et al., 2007, p.13). The same comment applies to future teachers who are entering preparation programs without having prior experiences with statistics during their K-12 schooling. As a result, the statistics education community needs to continue efforts toward increasing the statistical content contained within preparation programs as well as programs aimed at providing professional development for inservice teachers.

IMPLICATIONS FOR PREPARING ELEMENTARY SCHOOL TEACHERS

As mentioned in the MET Report discussed previously, preparing elementary school teachers to teach statistics does not only involve technical knowledge. It also involves understanding the process of statistical thinking. The GAISE framework discusses four components of statistical thinking:

- Formulating a Question
- Collecting Data
- Analyze Data
- Interpret Results

It is important that future teachers are exposed to experiences where they progress through these four components within the same investigation. Elementary school teachers are called upon to lead investigations, which involve these four components. Particularly at the elementary school level, teachers are also asked to construct good statistical questions to guide the investigation. If teachers have not been exposed to those types of experiences themselves, then it is unfair to expect them to be able to meet the increased expectations for teaching statistics. The remainder of this paper will discuss possibilities for training preservice and inservice teachers during preparation and professional development programs, respectively. The experiences that are discussed come from some of the experiences that have been described in the statistics education literature over the past 20 years.

Preparation of Preservice Elementary School Teachers

It is clear that opportunities for preservice teachers to be exposed to statistics during their preparation programs are limited. Perhaps hoping for a course dedicated to their preparation is unrealistic; however it is the ideal opportunity to prepare teachers. It can be argued that a course focused on statistical thinking, as the teachers will be asked to teach it, would be far more beneficial to future teachers than an introductory statistics course, which is required by most institutions (at least in the United States).

Courses specifically designed for teachers have been developed and implemented at the University of Georgia (Franklin & Mewborn, 2006) and at Appalachian State University (Kader & Perry, 2002). "These courses develop statistical ideas that are relevant to the school curriculum as outlined in the NCTM Standards documents" (Franklin & Mewborn, 2006, p. 337). The course designed at Appalachian State University particular targets elementary and middle school teachers. The major goal of this course is "to encourage active learning through problem solving in the teaching of statistics in the schools. Consequently, statistics should be presented to teachers in the same style considered appropriate for their students" (Kader & Perry, 2002, p. 2).

In these courses, instructors can utilize many of the resources that have been created. In the United States, these include the *Teach-Stat* materials as well as new documents such as *Making Sense of Statistical Studies* (Peck, Starnes, Kronendonk, & Morita, 2009) released by the American Statistical Association (ASA). The *Teach-Stat* materials were "designed to plan and implement a program of professional development for elementary teachers, grades 1-6, to help them learn more about statistics and integrate teaching about and teaching with statistics in their instruction" (Friel & Bright, 1998, p. 90). Although these materials were designed for inservice teachers, they would certainly benefit teachers during their preparation programs. Similarly, the materials developed by the ASA are designed to use with students. However, since it can be assumed that most teachers have not had sufficient experiences with statistics during their schooling, they would certainly be appropriate to include in courses designed for teachers.

Training of Inservice Elementary School Teachers

Inservice teachers are unlikely to enroll in courses at universities. In the United States, inservice teachers are required to attend professional development programs in order to accumulate enough points for re-certification. This situation is not similar to all countries. In Australia, for example, teachers receive permanent certification and are not required to attend professional development in order to become 're-certified.' Perhaps it is important to require professional development, so teachers are required to attend training programs. These programs are particularly important when expectations and standards are modified to include additional content. Statistics is a perfect example of such an area of need.

In order to address teachers' preparation to teach statistics, materials described previously (e.g., *Teach-Stat* and *Making Sense of Statistical Studies*) can be used to develop and implement a long-range professional development program. One other resource that can be used by inservice teachers was described in detail by Kader and Perry (2002). A data analysis, statistics, and probability course was designed for The Learning Math Project. According to Kader and Perry, "The primary goal of the courses is to help teachers develop a robust understanding of mathematics through a series of carefully sequenced multimedia activities and support materials" (2002, p. 3). There are 9 thirty-minute videos as part of this series. These videos could serve as a powerful tool to enhance inservice teachers' preparation to teach statistics.

Regardless of the medium, it is clear that inservice teachers also need to receive training in the area of statistics in order to prepare them to teach the material at an increased level of sophistication.

CONCLUSION

The data presented in Table 1 highlights the issue the statistics education community has in regard to preparing teachers to teach statistics. This paper mainly used the United States to exemplify the fact that we have preparation programs that are not utilizing many tools that exist to effectively prepare teachers to teach statistics. Unfortunately, statistics has not become a major area of emphasis in teacher preparation programs despite its increasing role in the school curriculum.

Perhaps results from a broader survey initiated at ICOTS 8, will help to highlight the dire need to address statistics during teacher preparation programs. To participate in the survey, please visit http://jacobbemath.com and click on the International Statistics Survey on the right-hand side of the homepage or e-mail the author for a direct link to the survey. Until elementary school teachers' preparation is addressed, it is unfair to expect them to meet the increased expectations of teaching statistical content at a more sophisticated level.

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