

## IMPLICATIONS OF EDUCATIONAL REFORM IN CYPRUS ON THE TEACHING OF PROBABILITY AND STATISTICS AT THE SECONDARY SCHOOL LEVEL

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*Since 1995, the participation of Cyprus in TIMSS has been consistently marked by poor student performance in mathematics (Muller, Martin, & Foy, 2008; Papanastasiou, 2002). In view of this, it is encouraging that as of 2005—shortly after the accession of Cyprus to the European Union—the government of Cyprus has initiated educational reform efforts. Revisions in the national curriculum aim, among other goals, towards helping students develop their critical thinking skills and research capabilities, and becoming active citizens (Ministry of Education and Culture, 2008). Studies have shown that statistics courses have the potential to enhance such skills in students (Derry, Levin, Osana, Jones, & Peterson, 2000). This paper examines the educational reform currently taking place in Cyprus and its implications on the teaching of statistics and probability at the secondary school level.*

### BACKGROUND

Over the past couple of decades there have been several recommendations regarding changes in the way statistics courses are taught with researchers suggesting that instruction allows students to build models and develop their thinking capabilities (Chance, 1997; Watts, 1991; see also Keeler & Steinhurst, 2001). Given that “demands for dealing with data in an information age continue to grow” (Franklin & Garfield, 2006, p.363), less emphasis should be placed on formal statistics and probability and “an empirical frequency-based approach to probability that is also an important foundation for later work in theoretical probability” should be used in statistics courses (Watson, 2006, p.127). “Courses in statistical thinking have the potential to improve students’ general reasoning capabilities” (Derry, Levin, Osana, Jones, & Peterson, 2000) therefore, statistics courses should be taught in such a way as to help students develop such capabilities.

### CYPRUS EDUCATIONAL SYSTEM AT THE SECONDARY-SCHOOL LEVEL

The Cyprus educational system is highly centralized and controlled by the Ministry of Education and Culture (MoEd). Public as well as private secondary schools operate on the island and are all liable to supervision by the MoEd. Mathematics is a compulsory subject for all students up to and including grade 12. Statistics and probability are included in the secondary public school curriculum in grade 12 only (Ignatiou & Zotos, 2007a, 2007b). Students in the upper secondary grades may fulfill their mathematics requirement by taking a core mathematics course or an advanced mathematics course. The core mathematics textbook for grade 12 begins with a chapter on statistics followed by a chapter on combinatorics and a chapter on probability (Ignatiou & Zotos, 2007b). The advanced mathematics textbook ends with a chapter on combinatorics followed by a chapter on probability and last, a chapter on statistics (Ignatiou & Zotos, 2007a).

### PROBLEM

Cyprus participated in the Third International Mathematics and Science Study in 1995 and in almost all activities of Trends in International Mathematics and Science Study (TIMSS) since then. Throughout these studies, Cyprus has been performing poorly on mathematics assessments. A comparison between the TIMSS 1995 and 2007 results as well as between the 1999 and 2007 results indicated a decrease in the mathematics achievement of 8<sup>th</sup> grade Cypriot participants (Mullis, Martin, & Foy, 2008). In the 2007 TIMSS the average scale score for 8<sup>th</sup> grade students in Cyprus on data and chance was 464 whereas the TIMSS scale average was 500 (Muller, Martin, & Foy, 2008). This is not surprising since i) topics on data and chance taught up to and including grade 8 are considered to be only for the more able students and only 3% of Cypriot 8<sup>th</sup> graders are taught topics in this domain (Muller, Martin, & Foy, 2008) and ii) the intended mathematics

curriculum in Cyprus revealed that topics in data and chance are only included in the mathematics textbooks for grade 12 (Ignatiou & Zotos, 2007a; 2007b).

Among the problems of the Cypriot educational system listed in the UNESCO Report on Education in Cyprus, which was released after the TIMSS 1995 results, was that teachers do not involve students in the learning process (Papanastasiou, 2002). In addition, based on the current curriculum, students are expected to learn mathematics without exploration or modeling and as a result most of them are unable to develop conceptual understanding or communication skills (Trezami, 2009).

#### CYPRUS EDUCATIONAL REFORM

In view of these issues, it is encouraging that since 2005 the government of Cyprus initiated an Education Reform Program (MoEd, 2008). This program includes revisions in the national curriculum for all subjects. The MoEd set up 20 committees which are responsible for the creation of the revised curriculum materials which in turn were expected to be submitted to the MoEd at the end of summer 2009. The school year 2009-2010 is planned to be used for the piloting of these materials (Demetriou, 2009). However, as of January 2010, no official announcement had been made regarding the progress achieved relative to this plan.

According to the MoEd, the revised curriculum needs to help students develop into active citizens, to enhance their critical thinking and research capabilities, “to include a variety of teaching methodologies and introduce flexibility in the school program, so that the teacher may use the most appropriate approach for the particular class” (2008, p.36). According to the Minister of Education and Culture, Dr Demetriou, “the student of today, from the beginning of his school life, should come to direct contact with the world of science so as to understand it, judge it, live it, and participate in its functions” (2009, p.33).

#### TEACHING IMPLICATIONS OF EDUCATIONAL REFORM IN CYPRUS

##### *The Need for Cooperative Learning and Active Learning Instructional Methods*

Research points towards the benefits of instructional methods which promote conceptual understanding such as those that use student cooperative groups along with student engagement in explaining and reasoning with concepts (Franklin & Garfield, 2006). During instruction in mathematics classrooms, including instruction on data analysis and probability, students should work with classmates to make and test conjectures and should be provided with opportunities to listen to explanations given by other students (NCTM, 2000). This may allow them to compare their ideas leading them to modify or strengthen their own reasoning and clarify their understanding thus developing their critical thinking skills (Garfield, 1995; NCTM 2000). According to the NCTM (2000) “[C]ommunication is an essential part of mathematics and mathematics education” with dual benefits to students since through “speaking, writing, reading, and listening in mathematics classes ... they communicate to learn mathematics, and they learn to communicate mathematically” (p.60).

Instruction in Cyprus in the secondary grades has been traditional, teacher-centered, and does not promote student involvement or group work (Papanastasiou, 2002; Trezami, 2009). However, modern society requires critical thinking and creative participation by all students (Demetriou, 2009; Trezami, 2009). In view of this, the revised mathematics curriculum in Cyprus needs to i) provide opportunities for students to be exposed to active learning and cooperative learning and ii) provide guidelines for teachers as to how to achieve this.

##### *The Need for Real Data and Computer Simulations in the Classroom*

The NCTM indicates that “[D]oing mathematics involves discovery” and that students “should learn to investigate their conjectures using concrete materials” (2000, p.57). Given this statement and considering the increased demand by employers for graduates who are able to work cooperatively to solve problems in their work environments (Mackisack, 1994), it is essential that students are provided with opportunities that help them develop their problem-solving skills as well as their verbal and written capabilities of presenting the results of their solution methods.

In order to help students develop such skills, instruction may include the use of experiments and real data collected and analyzed by the students themselves (Franklin & Garfield, 2006). In general, Garfield (1995) suggests that students learn better when they are involved in hands-on activities which may be completed in cooperative small groups allowing them to apply what they learn in new situations. Moreover, where large data sets are required to demonstrate statistical and probabilistic concepts to students, computer simulations could be used during instruction leading to efficient use of instructional time.

Given the increased computer skills required by employers in Cyprus and the aforementioned benefits of using experiments and real data, reform statistics classrooms at the secondary level in Cyprus should aim at making use of these. Thus, the revised curriculum needs to i) provide opportunities for students to work on hands-on activities that involve data collection and analysis; ii) provide opportunities for students to use computer simulations to study statistical concepts; and iii) encourage secondary mathematics teachers to use experiments and hands-on activities during instruction on probability and statistics.

#### *The Need for Consideration of the Language of Instruction*

Data from a study by Gorgorio and Planas (2001) with immigrant students aged 15-16 in Catalonia, Spain revealed that minority language students who used to remain silent during mathematics class discussions would participate in small-group discussions. "Problem-posing activities were a powerful approach for encouraging students' mathematical thinking, and a useful tool for identifying learner's language difficulties" (Gorgorio & Planas, 2001, p.29). Continuing from this, studies by Macnamara (1967; see also Zepp, 1981) in Ireland, and by Henderson and Sharma (1974; see also Zepp, 1981) in Zambia revealed that when it came to problem-solving skills, students learning mathematics in their first language were superior to students learning mathematics in their second language. Yet, there were no differences in the abilities to perform mechanical computations between students learning mathematics in their first or second language.

Secondary mathematics teachers in Cyprus should consider these language issues as they prepare for instruction in probability and statistics since an increasing number of students in public secondary schools do not use Modern Greek (the official language of instruction in public schools) as their first language. Educational reform in Cyprus needs to provide training for current and prospective teachers at all levels in order to assist them in better helping students.

### TEACHER IMPLICATIONS OF EDUCATIONAL REFORM IN CYPRUS

#### *The Need for Professional Development of Secondary Mathematics Teachers*

Reform efforts in any educational system may only be successful with the cooperation and adequate preparation of teachers to implement the suggested innovations (Frykholm, 1999; see also Mavrotheris & Mavrotheris, 2007). Given that teachers' knowledge may affect students' learning and understanding of the material taught (Stigler & Hiebert, 1999; see also Mavrotheris & Mavrotheris, 2007), and that there is evidence that teachers are not adequately prepared to teach statistical concepts (Carnel, 1997; Begg & Edward, 1999; see also Mavrotheris & Mavrotheris, 2007), secondary mathematics teachers in Cyprus need to undertake professional development programs in order to be prepared to teach probability and statistics to students in the secondary grades using innovative teaching methods (e.g. active learning, cooperative learning, technology-based instruction).

Cyprus has recently participated in the EarlyStatistics Project which aimed to provide online professional development in statistics education to elementary and middle-school teachers in European schools (Mavrotheris & Mavrotheris, 2007). The project provided a virtual community of practice in which teachers across various areas of Europe could exchange ideas regarding instructional practices in statistics classrooms. Such professional development programs may be effective especially for practicing teachers who have not had the opportunity to formally study probability and statistics prior to entering the teaching profession. Middle school but also high school mathematics teachers in Cyprus need to be provided with opportunities to participate in professional development programs in an attempt to be adequately prepared to teach probability

and statistics based on the innovated curriculum materials that will need to be implemented once reform efforts are completed.

## CONCLUSION

Given that we live in a data-driven society, secondary education should enable students to develop data handling and reasoning skills which they could transfer to their workplace upon graduation and to further studies at the tertiary level. The increased attention on probability and statistics during the last couple of decades implies that education in Cyprus should include a more extensive study of this domain by students in the secondary grades. Moreover, the implications of reform discussed in this paper should be considered as educators in Cyprus prepare for instruction on probability and statistics and as the various committees appointed by the Cyprus Ministry of Education and Culture prepare the revised curriculum materials.

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