Early Statistical Reasoning:

An Exploratory Study of Primary School Students' Use of a Dynamic Statistics Software Package for Analyzing and Interpreting Data

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ABSTRACT

This paper explores the potential of dynamic statistics software for supporting the early teaching and learning of statistical and probabilistic concepts integrated within the mathematics curriculum. It shares the experiences from a case study that implemented a data-driven approach to mathematics instruction using the dynamic data-visualization software InspireData©, an educational package specifically designed to meet the learning needs of students in the middle and high school grades (Grades 4-12). The authors report on how a group of fourteen (n=14) Grade 4 (about 9-year-old) students used the affordances provided by the dynamic learning environment to gather, analyze, and interpret data, and to draw data-based conclusions and inferences. Findings from the study support the view that mathematics instruction can promote the development of learners' statistical reasoning at an early age, through an informal, data-based approach. They also suggest that the use of dynamic statistics software has the potential to enhance statistics instruction by scaffolding and extending young students' stochastical and mathematical reasoning.

KEYWORDS

Dynamic Statistics Software, Probability, Statistical Reasoning, Statistics Education, Stochastical Reasoning, Stochastics

INTRODUCTION

The expanding use of data for prediction and decision-making in almost all domains of life makes it a priority for mathematics instruction to help students develop their statistical reasoning. Leaders in mathematics education have, in recent years, been advocating a much wider and deeper role for statistics in school mathematics (Shaughnessy, Ciancetta, Best, & Canada, 2004; Makar & Ben-Zvi, 2011) since, as pointed out in the Common Core State Standards of Mathematics (CCSS-M, 2010), "statistics provides tools for describing variability in data and for making informed-decisions that take it into account" (p.79). It is now widely recognized that the foundations for statistical reasoning, including fundamental ideas of inferential statistics, should be laid in the earliest years of schooling rather than being reserved for high school or university studies (National Council of Teachers of Mathematics [NCTM], 2000).

Statistics has been established as a vital part of the K-12 mathematics curriculum in many countries. However, instruction of statistical concepts is still highly influenced by the formalist mathematical tradition. Deep-rooted beliefs about the nature of mathematics "as a subject of

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deterministic and hierarchically-structured knowledge" (Makar & Confrey, 2003) are imported into statistics, affecting instructional approaches and curricula and acting as a barrier to the kind of instruction that would provide students with the skills necessary to recognize and intelligently deal with uncertainty and variability. Intuition and mindset about data are systematically ignored in mathematics classroom (Meletiou-Mavrotheris, 2008).

Thus, to promote the development of early statistical reasoning, there ought to be fundamental changes to the instructional practices, curricular materials, tools and cognitive technologies employed in the classroom to teach statistical and probabilistic concepts. Mathematics instruction should encourage statistical inquiry rather than teaching methods and procedures in isolation. The emphasis should be on the statistical investigation process. The teaching of the different statistical tools should be achieved through putting students in a variety of authentic, purposeful contexts where they need these tools to make sense of the situation. Instruction should focus on helping learners understand how one could use these tools in making comparisons, predictions, and generalizations (Rubin, 2005). Through exploration and experimentation with authentic data, children can begin to develop the ability to provide persuasive data-based arguments, as well as generalizations which extend beyond their collected data.

Advances of technology provide mathematics teachers with powerful new tools and opportunities for the teaching of challenging statistical and mathematical concepts to young learners. The appearance, in particular, of dynamic learning environments, provides an enormous potential for making complicated ideas accessible to young learners. These technological tools are, in fact, designed explicitly to facilitate the visualization of mathematical concepts by providing a medium for the design of activities that integrate experiential and formal pieces of knowledge, allowing the user to make direct connections between physical experience and its formal representations (Meletiou-Mavrotheris, 2003; Pratt, 1998; Paparistodemou & Noss, 2004). Having such a set of tools widely available to students has the potential to significantly change the curriculum—to give students access to new topics and insights by removing computational barriers to inquiry (Rubin, 1999). There is evidence that use of such software in the mathematical classroom promotes conceptual change in students and leads to the development of a more coherent mental model of mathematical concepts, including key statistical and probabilistic ideas (Bakker, 2004; Hammerman & Rubin, 2003; Meletiou-Mavrotheris, 2013).

In this article, we explore the opportunities provided by a dynamic data-visualization package for supporting the teaching of statistics and probability at primary school. We share the experiences from a teaching experiment that explored the following research question: *How can the affordances provided by a dynamic statistics learning environment be utilized in the early years of schooling to scaffold and extend children's stochastical and mathematical reasoning?* The study adopted a data-driven, project-based approach to mathematics instruction using the dynamic data-visualization software InspireData© (Hancock, 2006) as an investigation tool. It investigated ways in which young children can use the features of a dynamic statistics software package to formulate conjectures regarding real datasets of personal interest, and to test these conjectures through gathering, analyzing, and interpreting data, and drawing data-based conclusions and inferences.

LITERATURE REVIEW

Research on teaching, learning and student cognition, highlights that the process of teaching and learning in the sciences is complex and cannot be easily reduced to a set of algorithms and procedures (Leach & Scott, 2000). The construction of positive attitudes and meaningful understanding of mathematics and other scientific disciplines is supported by instruction that is collaborative, active,

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