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Statistical reasoning of middle school children engaged in survey inquiry ☆

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Abstract

The case study examined two groups of grade 7 students as they engaged in four inquiry phases: posing a question and collecting, analyzing, and representing data. Previous studies reported analyses of statistical reasoning on a single inquiry phase. Our goal was to identify the modes of statistical reasoning displayed during group discussions in all phases as children designed and conducted their own inquiry. A content analysis of audio and video recorded discussions yielded 10 statistical reasoning modes: six relate to Garfield and Gal's [Garfield, J., Gal, I. (1999). Teaching and assessing statistical reasoning. In L. V. Stiff, & F. R. Curcio (Eds.), *Developing mathematical reasoning in grades K-12. 1999 Yearbook* (pp. 207–219). Reston, VA: National Council of Teachers of Mathematics] statistical reasoning types involved in the collection, analysis, and representation of data and four modes deal with an aspect of inquiry not exclusively focused upon in the literature on statistical reasoning—i.e., the problem-posing phase. Although students' reasoning reflected an incomplete understanding of statistics they serve as building blocks for instruction.

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1. Introduction

Research in the area of reasoning is of great interest to cognitive psychologists (Holyoak & Morrison, 2005) and mathematics educators (National Council of Teachers of Mathematics [NCTM], 1989, 2000) alike. This attention is due in part to the role that reasoning plays in problem solving and decision-making in general, and to its key function in the "knowing and doing of mathematics" specifically (NCTM, 1989, p. 81). Reasoning is commonly defined as a "process of drawing conclusions" (Leighton, 2004, p. 3), which is based on how one applies one's knowledge to reach goals in various situations (Evans, 1993). According to Holyoak and Morrison (2005), it is at times difficult to tease apart reasoning from problem solving and decision-making. They explain the overlap this way: "To solve a problem, one is likely to reason about the consequences of possible actions and make decisions to select among alternative actions... Making a decision is often a problem that requires reasoning." (Holyoak & Morrison, 2005, p. 2).

Reasoning in the service of problem solving and decision-making is evident in inquiry situations where the goal is to arrive at decisions that will enable a problem to be solved and where a solution must be produced rather than retrieved from memory (Zimmerman, 2000). In other words, the solution is based on *inferences* that people make from the knowledge they have rather than on their recall of the solution. Two general kinds of reasoning, deduction and induction, play a role in inquiry. Deduction is truth preserving (i.e., inference is made to confirm a hypothesis) and involves reasoning from premises that contain general statements, rules, or scientific laws to arrive at specific conclusions that follow logically from the premises (Holyoak & Morrison, 2005; Leighton, 2004). In the context of inquiry, deductive reasoning is involved in the testing of hypotheses, laws, or theories—e.g., "If my hypothesis is true then I should observe some pattern of evidence" that follows from the hypothesis (Zimmerman, 2000, p. 102). Induction is truth expanding (i.e., the inference leads to new knowledge) and involves reasoning from particular data or observations to arrive at a general conclusion. In inquiry, inductive reasoning is involved in making inferences that produce hypotheses, laws, or theories—e.g., If the data show a particular pattern of evidence then I can make hypothesis X (Zimmerman, 2000).

The mathematics community places a high value on reasoning as illustrated in its creation of a "reasoning" standard (NCTM, 1989, 2000). According to Russell (1999), reasoning is the means by which students learn to understand the abstract ideas that make mathematics the discipline that it is. In this sense, mathematics is about generalizations (Russell, 1999), and generalizations are involved in inductive and deductive reasoning. Both reasoning types are included in the reasoning standard for grades 5–8 (NCTM, 1989)—i.e., students must learn about and use deductive and inductive reasoning and make and evaluate conjectures and arguments. These goals are reiterated somewhat differently in the most recent standards (NCTM, 2000; e.g., select and use various types of reasoning), but the thrust is the same. One recommendation to foster such reasoning is to use problem situations, such as group projects involving the use of technology on problems that are of interest to students, and to augment the complexity by including statistics (NCTM, 1989). In essence, these proposals call for middle school students to reason