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A snap-shot of middle years of schooling students' (fourth – ninth graders) proportional reasoning across mathematics and science topics

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Background

Many topics within the school mathematics and science curriculum require knowledge and understanding of ratio and proportion and the ability to reason proportionally (e.g., scale drawing, surface area, density, probability, molarity, fractions). Proportional reasoning, according to Lamon (2005) is fundamental to both mathematics and science. However, research has consistently highlighted students' difficulties with proportion and proportion-related tasks and applications (e.g, Behr, Harel, Post & Lesh, 1992), which means that, as a result, many students will struggle with topics in the middle years (fourth-ninth grades) in both mathematics and science.

Research Questions

A large corpus of existing research has provided analysis of strategies applied by students to various proportional reasoning tasks (e.g., Misailidou & Williams, 2003; Hart, 1981), Such research has highlighted issues associated with the impact of 'awkward' numbers (that is, common fractions and decimals as opposed to whole numbers), the common application of an incorrect additive strategy, and the blind application of rules and formulae to proportion problems. This research has also emphasised the complexity of the development of proportional reasoning and the need for further and continued work in the field to support students' development of proportional reasoning. In fact, it is estimated that approximately only 50% adults can reason proportionately (Lamon, 2005).

The focus of this study was to take a snapshot of a large group of students' proportional reasoning on tasks that relate to mathematics and science curriculum in the middle years of schooling. As part of a larger project, this aspect of the research was concerned with the development of an instrument that would provide a 'broad brush' measure of students' proportional reasoning and their thinking strategies, and that would have some degree of diagnostic power. This challenge was undertaken with full awareness of both the pervasiveness and the elusiveness of proportional reasoning throughout the curriculum and that its development is dependent upon many other knowledge foundations in mathematics and science.

Methods

The American Association for the Advancement of Science (AAAS)(2001) has identified two key components of proportional reasoning: Ratios and Proportion (parts and wholes, descriptions and comparisons and computation) and Describing Change (related changes, kinds of change, and invariance). The AAAS provided the framework for the development of the proportional reasoning assessment instrument The test included items on direct proportion (whole number and fractional ratios), rate, and inverse proportion items as well as fraction, probability, speed and density items. Guided by the words of Lamon (2005) who suggested that students must be provided with many different contexts, 'to analyse quantitative relationships in context, and to represent those relationships in symbols, tables, and graphs' (p. 3), the items included contexts of shopping, cooking, mixing cordial, painting fences, graphing stories, saving money, school excursions, dual measurement scales. For each item on the test, students were required to provide the answer and explain the thinking they applied to solve the problem.

Frame

Approximately 700 students across Grades 4-9 completed the test. Scoring of students' responses to each item occurred at two levels, and hence a two-digit code was assigned to each response. The first digit in the code identified whether the item was correct (code 1), incorrect (code 2), or not attempted (code 0). The second digit in the code identified the thinking strategy utilised by the student in solving the problem, as gleaned from the explanation of how they solved each problem. In particular, a solution strategy that showed application of elegant ratio thinking (that is, direct use of multiplication and division strategies) was assigned a code of 1, with a solution strategy that showed application of a repeated addition strategy (use of tables of values) assigned a code of 2. These two codes were considered indicative of appropriate proportional reasoning. A code of 3 was given to thinking that suggested (incorrect) additive thinking had been applied, and a code of 4 was given to thinking that suggested that the students' strategy would never lead them to the correct solution. A code of 5 was given when the student left this section blank. Scores of 11 or 12 would indicate a correct solution and application of proportional reasoning. A score of 23 would indicate an incorrect solution with inappropriate additive thinking.

Research findings

Prior to presentation of test results, project teachers had mixed feelings about its capacity to assess their students' proportional reasoning. The ninth grade teachers stated that they thought the test would be too easy for their students; the fourth grade teachers stated that the test was too hard. The highest average score however, for the ninth-graders on one item was just 75%, with the fourth-graders averaging 15% for that item. On several other items, the eighth and ninth graders scored less than 50%. On one particular item, the ninth graders averaged just 21% and the fourth graders averaged 5% for the same item. The results were a wake-up call to all teachers in the project: the fourth and fifth grade teachers realised that there were some very good proportional reasoners in their grades, and the eighth and ninth grade teachers realised that they were taking for granted the proportional reasoning skills of their students. Item analysis and students' results provided direction for targeted teaching. Collectively, results of the whole test suggested that a much greater focus on proportional reasoning must occur in all classes at every opportunity.

References

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