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What Are the Strategies Used by Seventh Grade Students While Solving Proportional Reasoning Problems?

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ABSTRACT

The aim of this study was to investigate seventh grade students' use of solution strategies needed to solve proportional reasoning problems. A private middle school and two public middle schools of a city located in the inner region of Turkey were selected as the sample of the study. In total, 278 students (157 boys and 121 girls) took part in the study. Survey methodology was used to describe seventh grade students' proportional reasoning strategies. Proportional Reasoning Test (PRT) consisting of five open ended problems was developed by the researchers to determine students' solution strategies. Student responses to each problem were graded by the help of a rubric. Besides, the correct solution strategies used by the students were coded by considering pre-existing proportional reasoning strategies in the mathematics education literature. Analysis of students' correct responses showed eight different solution strategies including cross product algorithm, factor of change, building up, equivalent fractions unit rate, part-to-part reasoning, ratio tables and part-to-whole reasoning. The number of strategies used in each problem ranged between two and five. As a whole, the most frequent strategies used by the students were cross product algorithm, factor of change strategy and part-to-part reasoning strategy. However, cross product algorithm was the most frequent strategy among all strategies. This strategy has no physical referent and lacks meaning for students. Therefore, cross product algorithm should not be introduced to students until they have many experiences with intuitive and conceptual strategies such as factor of change strategy, build-up strategy or unit rate strategy.

Keywords:
Proportional reasoning, seventh grade students, solution strategies, cross product algorithm
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Extended Abstract

Introduction

Lamon (2012) stated that "proportional reasoning is reasoning up and down in situations in which there exists an invariant (constant) relationship between two quantities that are linked and varying together. As the word reasoning implies, it requires argumentation and explanation beyond the use of symbols $\frac{a}{b} = \frac{c}{d}$" (p. 3). Proportional reasoning plays a watershed role at the borderline since it is both a cornerstone of algebra and other higher level areas of mathematics and a capstone of elementary arithmetic, number, and measurement concepts (Post, Behr & Lesh, 1988). Nevertheless, proportional reasoning requires mathematical thinking that is especially difficult for children (Fujmura, 2001). Similarly, Lamon (2007)

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expressed that "of all the topics in the school curriculum, fractions, ratios, and proportions arguably hold the distinction of being the most protracted in terms of development, the most difficult to teach, the most mathematically complex, the most cognitively challenging, the most essential to success in higher mathematics and science, and one of the most compelling research sites" (p. 629). Hines and McMahon (2005) reported that "proportional reasoning is based on the variety of interpretations and strategies shown by students as they reason about proportional relationships" (p. 89). Thus, it is possible to learn about students' proportional reasoning skills by investigating the strategies used by them while solving proportion problems. In mathematics education literature, there is a large body of research related with learners' proportional reasoning strategies (e.g., Bart, Post, Behr, & Lesh, 1994; Ben-Chaim, Fey, Fitzgerald, Benedetto, & Miller, 1998). However, few studies have been conducted in Turkey that focus on learners' use of proportional reasoning strategies (e.g., Akkuş-Çıkla&Duatepe, 2002; Duatepe, Akkuş-Çıkla&Kayhan 2005). Thus, the current study attempted to fill this gap by examining seventh grade students' proportional reasoning strategies. In this sense, the investigated research question was: What are the strategies used by seventh grade students while solving proportional reasoning problems?

Method

The current study used survey methodology to describe seventh grade students' proportional reasoning strategies. The sample of the study comprised of three different middle schools of a city located in the inner region of Turkey. Convenience sampling and cluster random sampling were used to select the sample of this study. In total, 278 students (157 boys and 121 girls) took part in the study. Proportional Reasoning Test (PRT) was developed by the researchers and it was based upon problems discussed in the relevant literature. PRT consisted of five open ended problems and it was developed in parallel with the objectives of revised elementary mathematics curriculum (MEB, 2009).Descriptive analysis of quantitative data primarily consisted of frequencies and percentages. Each problem was graded by using a rubric. Inter-rater reliability was calculated to measure the internal consistency of the PRT. Hopkins (1998) suggested that "the relevant type of validity in the measurement of academic achievement is content validity" (p.72). Therefore, two mathematics educators working at an education faculty examined the problems to establish the content validity of the PRT. Finally, the correct solution strategies used by the students were coded by considering pre-existing proportional reasoning strategies in the mathematics education literature.

Findings

The results of this study were reported based on students' correct proportional reasoning strategies. Analysis of students' correct responses showed eight different solution strategies including cross product algorithm, factor of change, building up, equivalent fractions unit rate, part-to-part reasoning, ratio tables and part-to-whole reasoning. The number of strategies used in each problem ranged between two and five. For instance, students used five different strategies for the fuel problem while they used two different strategies for the flag problem. In addition, the strategies used to solve a problem differed from those that were used to solve another problem. To give an example, students used cross product algorithm, factor of change and equivalent fractions strategies to solve the rectangle problem while they used cross product algorithm, part-to-part, and part-to-whole strategies for the mixture problem.

As a whole, some strategies were used more frequently by students than other strategies. For example, in three out of five problems students used cross product algorithm. Thus, this was the most frequent strategy used by students when solving PRT. More specifically, over than three-fourths of the students used cross product algorithm when solving flag and rectangle problems. Similarly, about half of the students used this algorithm to solve the fuel problem. Another frequent strategy used by students was part-to-part reasoning. Roughly, ninety percent of the students preferred this strategy when solving the mixture problem. However, this strategy was not used while solving the remaining four problems. Besides, seven-tenth of the students used factor of change strategy to solve the popcorn problem. This strategy was also used to some extent while solving other problems except for the mixture problem.

The results showed that students used the following strategies less frequently: ratio table, part-to-whole strategy and equivalent fractions strategy. These strategies were used only in one or two problems. Ratio tables, equivalent fractions and par-to-part reasoning strategies were used to solve fuel problem,

rectangle problem, and mixture problem respectively. In addition, build-up and unit rate strategies were used while solving both fuel and popcorn problems.

Discussion

In this study, seventh grade students used eight different proportional reasoning strategies. The most frequent strategies were cross product algorithm, factor of change strategy and part-to-part reasoning strategy. On the other hand, ratio tables, build-up strategy, unit rate strategy and part-to-part reasoning strategy were less frequently used by the students. However, cross product algorithm was the most frequent strategy among all strategies. This strategy has no physical referent and lacks meaning for students. Therefore, cross product algorithm should not be introduced to students until they have many experiences with intuitive and conceptual strategies such as factor of change strategy, build-up strategy or unit rate strategy. In addition, to have students learn such conceptual strategies, teachers should know a wide range of strategies and should be able to use them during classroom practices. Besides, seventh grade students' awareness of proportional reasoning strategies can be enhanced by providing them with textbooks that are rich in tasks requiring a variety of solution strategies. Therefore, textbook authors are expected to share the responsibility in having students adopt a wide range of proportional reasoning strategies.

Yedinci Sınıf Öğrencileri Orantısal Akıl Yürütme Gerektiren Problemlerin Çözümünde Hangi Stratejileri Kullanıyorlar?

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ÖZ

Bu çalışmanın amacı yedinci sınıf öğrencilerinin orantısal akıl yürütme gerektiren problemlerin çözümünde kullandıkları stratejileri incelemektir. Çalışma İç Anadolu Bölgesindeki bir il merkezinde bulunan iki devlet okulunda ve bir özel okulda yürütülmüştür. Çalışmaya 163'ü erkek, 125'i kız, toplam 288 öğrenci katılmıştır. Araştırma, betimsel-tarama tasarımındadır. Öğrencilerin çözüm stratejilerini belirlemek amacıyla açık uçlu beş problemden oluşan Orantısal Akıl Yürütme Testi (OAYT) geliştirilmiştir. Bu problemlere verilen cevaplar dereceli puanlama anahtarı ile puanlanmıştır. Ayrıca öğrencilerin tam puan aldıkları problemlerde kullandıkları stratejiler alan yazındaki orantısal akıl yürütme stratejilerinin tanımları yardımı ile kodlanmıştır. Araştırmanın sonuçları yedinci sınıf öğrencilerinin OAYT' de yer alan problemlerin çözümünde sekiz farklı strateji kullandıklarını göstermiştir. Bu stratejiler içler dışlar çarpımı algoritması, değişim çarpanı stratejisi, parça-parça stratejisi, oran tablosu, artırma stratejisi, denk kesir stratejisi, birim oran stratejisi ve parça-bütün stratejisi olarak belirlenmiştir. Problemlerin çözümünde kullanılan stratejiler birbirinden farklılık göstermiş ve her birinde kullanılan farklı strateji sayıları iki ile beş arasında değişmiştir. Tüm problemlere verilen cevaplar dikkate alındığında öğrenciler tarafından en yaygın olarak kullanılan stratejilerin içler dışlar çarpımı algoritması ve değişim çarpanı stratejisi olduğu görülmüştür. Buna ek olarak, içler dışlar çarpımı algoritması beş problemin üçünde en sık kullanılan strateji olmuştur. Bu strateji öğrenciler tarafından ezbere kullanılan bir çözüm yolu olduğu için araştırmacılar bu stratejinin ancak birim oran, değişim çarpanı, artırma ve denk kesir stratejileri gibi sezgisel veya kavramsal stratejilerle yeterince deneyim kazanıldıktan sonra öğretilmesi gerektiğini önermiştir.

Anahtar Kelimeler:
Orantısal akıl yürütme, yedinci sınıf öğrencileri, çözüm stratejileri, içler dışlar çarpımı algoritması
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