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Original Paper

Students' Learning Patterns in Using the Web-based Summary Box to Improve Their Math Word Problem Solving

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Abstract

This study identifies predictors of student achievement in word problem solving after learning math content in a web-based learning environment that incorporates reading scaffolds. We focused on student use of the self-summary box tool and its power to predict success or failure in math word problem solving. We employed a decision tree model, finding that students' commitment to learning can be a more crucial factor than reading skills in math word problem solving when students use web-based reading scaffolds.

Keywords

word problems, decision tree modeling, summary strategies, learning pattern, disciplinary literacy

1. Introduction

As disciplinary literacy has been an effective instructional approach for STEM topics (Shanahan & Misischia, 2011), the integration of reading strategies, such as mathematical vocabulary help or reading comprehension aids, is of increasing importance in teaching mathematics. In particular, summary writing is regarded as an effective method to help students understand mathematical narratives such as logic, definitions, or proofs (Meyer et al., 2018; Bellocchi & Ritchie, 2011) and to comprehend the key math concepts of a reading text (Adams, 2003). To support students' summary writing of mathematical contents, we designed a web-based tool with self-summary boxes that assist students' math-related reading.

102 eighth-and ninth-grade students (50 boys and 52 girls) in Central Texas participated in this study. Considering the advantages of the summary strategies, we expected that students could increase their word problem solving ability by summarizing math concepts and their characteristics in the text. However, we found that around 23-30% of students who submitted correct answers failed to solve each chapter's word problems. This paper identifies factors that explain why these students showed different

results in word problems, even though the self-summary boxes showed that they had successfully summarized all the text's math concepts.

2. Methods

Students took a reading and math pre-test before they used the tool. Both tests comprised eight questions from State of Texas Assessments of Academic Readiness (STAAR) questionnaires. The reliability of the reading pre-test was 0.7 and that of the math pre-test was 0.77. Students studied three chapters of Algebra I content. Each chapter has texts, images, a self-summary box, and problems. We classified students into two groups—successful and unsuccessful—and determined that successful students had correct answers for the three word problems per chapter, while unsuccessful students provided at least one incorrect answer among the three word problems. Students in both groups had filled in the three self-summary boxes correctly before they solved word problems.

According to our definition, 39 students (38%) were classified in the successful group, and 63 students (62%) fell in the unsuccessful group. We created a feature set (Table 1), which relates to student use of the self-summary boxes and reading content in the tool. Reading time indicates the average time students spent reading the content. Summary box time means the average time students spent on filling out the self-summary. The summary box trial is the average number of trials in which students attempted to fill in the self-summary box until they had submitted all correct answers. The summary box mastery is the average correct response rate across trials that a student submitted.

Table 1. Descriptive Statistics for Features

Features	Minimum	Maximum	Average	Standard Deviation
Reading pre-test score	1	7	4.7	1.94
Math pre-test score	1	10	5.1	1.87
Reading time (in seconds)	187	2237	780	376.81
Summary box time (in seconds)	189	2172	747	430.90
Summary box trial	3	20	5.624	2.68
Summary box mastery	0.2	1	0.69	0.23

A decision tree model was built to classify a binary variable: whether the student belonged to the successful or unsuccessful group. The model was validated using five-fold cross-validation, with ROC as the primary measure of model goodness-of-fit. Fig. 1 shows that the ROC area of this model is 0.82, meaning good predictive power (Bradley, 1997).

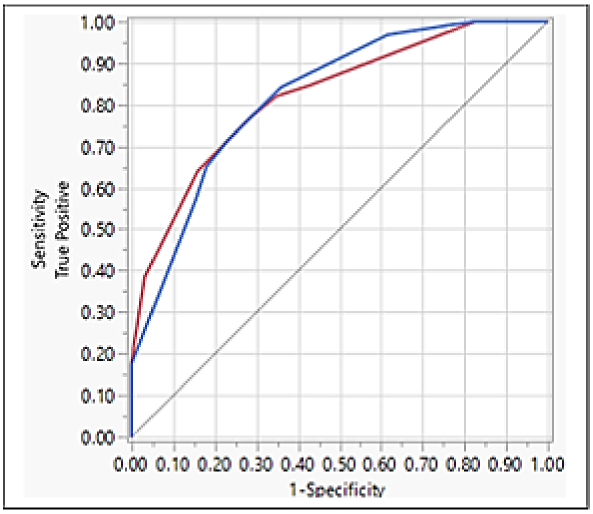

Figure 1. ROC Curve (Red Line: Successful, Blue Line: Unsuccessful Group)

3. Results

Figure 2 displays the decision tree model we used to explain the performance of the successful and unsuccessful student groups. The model implies that all features except summary box mastery were important predictors of why only some students successfully solved word problems after learning math concepts using the self-summary boxes. The math pre-test score appears to be the best predictor differentiating successful and unsuccessful student groups, so it was chosen as the decision tree's starting point. The decision tree splits students into two branches according to prior math knowledge. 48 out of 63 students in the unsuccessful group scored fewer than six points in the math pre-test. For these students, the summary box time was the next best predictor of group placement. 37 out of the 48 unsuccessful group students spent less than 457 seconds on average (around eight minutes) in filling the summary box. In the next step of this branch, 33 out of the 37 unsuccessful group students needed four attempts or more to find correct answers for the summary boxes. Among these 33 unsuccessful group students, 25 spent less than 795 seconds on average (around 13 minutes) in reading the text in each chapter.

For students whose math pre-test scores were greater than or equal to 6, the summary box trial was the next most important predictor of whether students showed strong word problem solving ability. 16 out of 23 successful group students tried an average of five times or fewer to provide all correct answers for the self-summary boxes. However, 10 out of 15 unsuccessful group students tried greater than or equal to six times. For both branches, the reading pre-test score was the next important predictor. 11 out of 16 successful group students received less than seven points in the reading pre-test. Among the seven successful group students who had over six summary box trials, six students received more than five points in the reading pre-test. For those who obtained greater than five points in the reading pre-test, average reading time was the last important predictor in this branch. Four out of five unsuccessful group students spent less than or equal to 576 seconds on average (around 9.6 minutes) on reading text content, while four out of six successful group students spent over 576 seconds.

4. Discussion

Our findings indicate that students' prior reading and math knowledge levels, as well as their learning patterns in a web-based learning environment, can severely affect their achievement in math word problem solving. Even though prior math knowledge level was the most important predictor of student success in math word problem solving, we found that the average number of trials for the self-summary boxes and how much time students spent in reading or working on them also influenced student achievement. 25 out of the 63 unsuccessful group students committed less time to reading the text (reading time <796 seconds) and working on the self-summary boxes (summary box time < 457). They also averaged over four trials for the self-summary boxes. We interpreted these students' learning patterns as those of non-serious learners who are less likely to focus on the content or learning activity but will try many answers without a serious thought process. This branch, which included those who had scored less than six points in a math pre-test, did not include a reading pre-test score as a predictor. This implies that if we provide students with a computer-based learning environment containing proper reading scaffolds for mathematical text, student commitment or attitudes toward reading the mathematical text and engaging in summary activity can be more crucial predictors of students' achievements than their reading skills.

Disclosure statement

The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

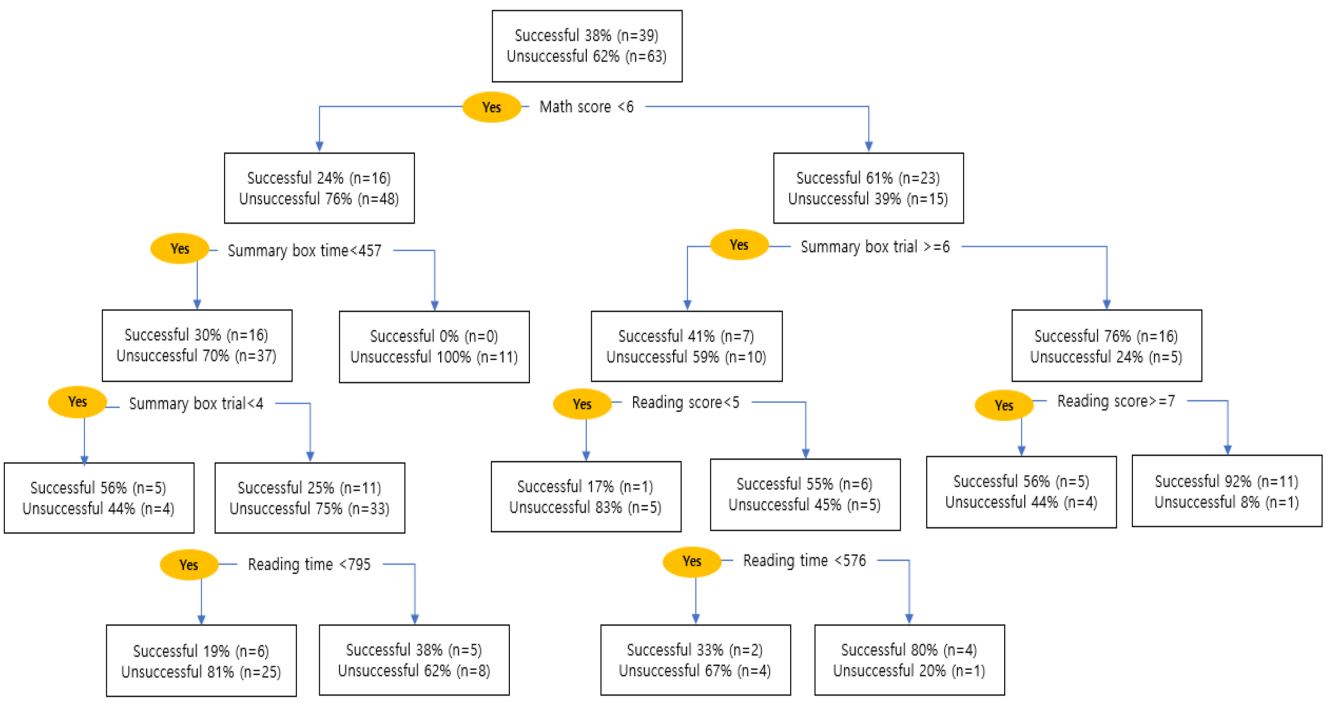

Figure 2. Decision Tree Explaining Successful and Unsuccessful Group Students

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