Increasing Children's Knowledge of Pattern Detection and Skip Counting Using a Tablet-based Math Activity

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Abstract: This study uncovers the potential learning difficulties that K-2 students faced while learning about missing number completion in a tablet-based program called RoboTutor. We analyzed 185,064 cases of log-data from 283 students to determine the tutor pass rates and learning curves for each activity within that knowledge component. Students are likely not well-prepared or do not have the prerequisite skills to do this activity, therefore, we conclude that the activities need to be redesigned.

Introduction

Learning number sense involves developing several basic mathematical skills such as number counting, transformation, estimation and pattern detection (Andrews et al, 2015). Young children often need extensive support and practice opportunities to develop their pattern detection and skip counting as it requires the knowledge of multiple mathematical skills. However, this level of support is typically not available to children in low-income families, who are more susceptible to math learning difficulties (Jordan et al., 2006). The RoboTutor program addresses this challenge by designing tablet-based learning activities for children in rural Tanzania (Uchidiuno et al., 2018). In this work, we analyze log data from prior RoboTutor sessions to identify potential improvements to the learning content especially focused on increasing pattern detection and skip counting. We investigated the following research questions:

- Q1. How do the students' error rates change as the pattern detection activity difficulty increases?
- Q2. How are different difficulty features (e.g. counting integer, blank position, etc.) related to students' error rates in this activity?

Method

Learning program

The RoboTutor program aims to provide a supplement or substitute for math and reading activities typically taught to students in K-2 (example activity shown in Figure 1). After mastering number identification, number discrimination, and basic addition, students engage in a pattern detection number activity that asks them to detect the pattern of a number sequence and fill in the next number in the sequence. Students are required to score at least 70% on each 10-question activity to proceed to the next activity; otherwise, they are presented with an easier activity or allowed further practice on the target activity.

Dataset and Analysis

283 K-2 children living in rural Tanzania participated in tablet-based math learning activities. In this analysis, we focused on the pattern detection activity results and how students' error rates changed as the activity difficulty increased. The final data set includes 185,064 cases of log data from 96 different activities (10 questions per activity). The tutor levels were sequential and ordered according to increasing difficulty, such as a broader range of numbers (i.e., 0-9, 10-99, 100-900), larger interval, different blank spaces, etc. We aggregated the log dataset and tracked the pass rates of each session as well as each questions' error rates. Also, we conducted a logistic regression analysis with three input features: tutor level (a range of numbers), numerical interval, and blank location.

Results

First, we explored students' pass rates each tutor (with 10 questions) with a target pass rate of .70. The chance/guessing pass rate of each activity was set at .33 as children could pick from one of three answer options and had three attempts at each question. Also, children could retry any activities they failed. However, most students were performing worse than the baseline rate (33%), scoring an average of 24% on even after multiple attempts (Figure 2).

Next, we explored the children's error rate in each question category with learning curves (Figure 3). In each of the graphs, the x-axis denotes the number of practice opportunities for a given problem, and the y-axis denotes

the average error rate (between 0 and 1). The learning curves corresponding to detecting patterns between 0-9 and 4-9 are smoother than others and decreasing in general, which is a good sign of students learning. However, the learning curves corresponding to detecting patterns between 10-99 and 40-99 are mostly flat but also show wide fluctuation towards the end.

Figure 1. Example activity in RoboTutor.

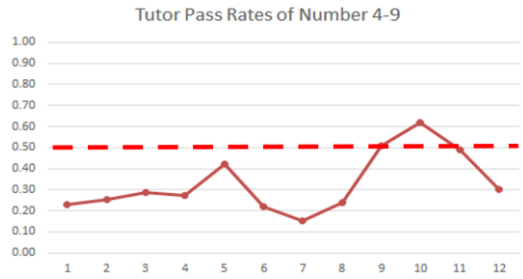
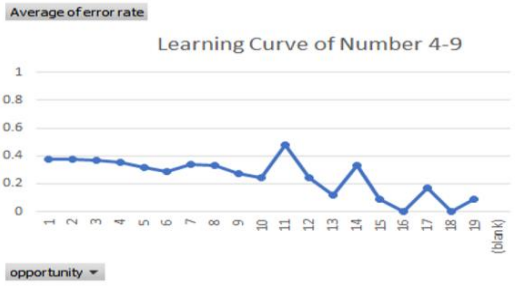


Figure 2. Pass rates of the bubble pop tutors (ex).



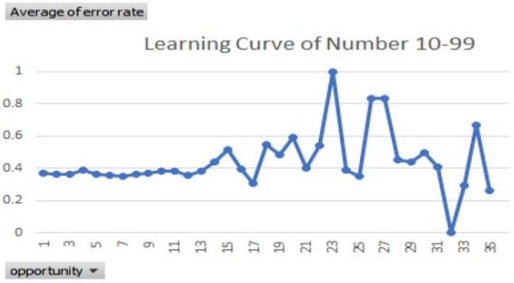


Figure 3. Error rates of each question in the tutors (ex. at numbers 4-9 and 10-99).

A binomial logistic model was conducted to find what factors influence students' error rates. (Table 1). When controlling other relative variables (the question type and hint), two possible factors are a numerical interval and blank locations. We assumed that higher numerical interval would be more difficult, however, it only happens at the 10-99 level ($p < .001$). When controlling other relative variables, the patterns of correction rates were similar in the 0-9 and 10-99 levels, however the direction was reversed in the 4-9 level.

Table 1: Estimation of logistic regression model (*p< .05, **p< .01, and ***p< .001)

Variables Ranges	0-9	4-9	10-99	40-99
Numerical interval (1,2,5,10)	0.015 **	0.036 ***	-0.199 ***	NA
Blank location (1,2,3,4)	-0.017*	0.079 ***	-0.135***	0.005
Other variables	---	---	---	---
(Intercept)	1.049 ***	0.972 ***	1.620 ***	0.957 ***

Our takeaway is that children did not have sufficient background knowledge to engage in and master the activities covering the detection of patterns between 10-99, 40-99, and 100-900. Children need more exposure to basic skills such as adding and subtracting and skip counting within those intervals before they are presented with those activities. We conclude that children need more teaching guidance to engage in and master this tablet-based activity.

References

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