Incorporating Student Choice in E-learning

Avi Segal, Naor Guetta, Amir Taboul, Guy Shani, Ya’akov (Kobi) Gal
Dept. of Information Systems Engineering, Ben Gurion University, Israel

Abstract. We investigate the possibility of increasing students’ performance and motivation in e-learning through choice: allowing students to choose educational material and questions while learning online. We ran a user study in which 5th grade students were repeatedly able to choose between a pair of math questions that were chosen from ascending skill levels based on performance. Our results show that students answered more difficult questions and obtained better grades when they were allowed to choose the questions than a baseline approach which did not allow choice. Also, we found a strong correlation between the skill levels that were obtained by the students in the choice based system and their class grades. Finally, most students preferred the choice system over a non-choice system.

1 Introduction

Previous research shows that allowing students to make choices while learning improves their motivation and overall learning gains [1, 4, 5].

We developed an e-learning system which enables students to iteratively choose between a pair of questions to answer at each practice step. The pair of questions presented at each step is selected from a skill set and difficulty level that is determined by students’ performance so far. Thus, students can answer questions they prefer, while temporarily (but not indefinitely) avoid frustrating questions that they feel they do not properly understand. We hypothesized that combining choice in e-learning systems will improve students’ performance and satisfaction levels. We conducted a controlled user study in a school where 5th graders used our choice system to answer math questions spanning 4 different skills. We compared our system to a standard sequencing method which presents questions to students by increasing level of difficulty.

The results of the study show that when using choice, students achieve better performance and reach higher mastery levels than when using the standard approach on the majority of skills tested. Additionally, we found a strong correlation between the skill levels that were obtained by the students and their class grades. Finally, in a post usage survey, the majority of the students preferred the choice system over the regular sequential question ordering.

2 Methodology

Our choice based system supports exercises over various topics (e.g. math, English as a foreign language etc) and skills (e.g. integers, fractions, geometry).
Each question is labeled with a difficulty level that is determined by a domain expert. At each time step, the student is presented with two questions, each relating to a different skill. The student can decide which of these problems to solve. When a student shows sufficient mastery in a given skill for difficulty level $i$ by answering correctly a sufficient number of questions of that difficulty level, the difficulty level for the specific skill is increased. The exercise can be terminated when the student has answered a pre-determined number of questions.

We run a study which included 16 students enrolled in the 5th grade. The study was conducted during the summer vacation outside the context of a classroom. We focused on math questions from 4 different math skills — integer operations, fractions, geometry, and word problems obtained from a recognized national exams organization for 5th graders. The questions were divided into 4 levels of difficulty for each skill by a math teacher. We collected overall 48 questions, 3 questions for each skill and difficulty level. All data collected from the students during the experiment was anonymized.

We compared our choice-based approach to a standard sequential approach in which students were presented with a sequence of questions with increasing difficulty. For each skill, students were presented with 4 questions of increasing difficulty. This approach follows the mastery learning paradigm [2] in which knowledge of simple skills should be acquired before moving on to more difficult questions relating to more complex skills. The skills were pre-arranged in a fixed order, identical for all students.

After experimenting with each system, the students were asked to fill a short survey concerning their experience and opinion about each of the systems. The average time spent on the entire study was approximately 60 minutes.

3 Results and Conclusions

Figure 1 (left) shows the performance of students in the choice system compared to the conventional sequential method. Performance is measured as the portion of correct answers on last question attempt, out of the number of different questions answered. As shown by the figure, the performance of students using the
choice method was substantially higher than the sequential method on the Integer, Fractions and Geometry Problems. In contrast, for Word Problems, the precision of the choice method was considerably lower than that of the sequential method. This can be attributed to the unique difficulty of Word Problems. These problems require mapping from a written description to a math formalization and many students find them hard and challenging [3, 6]. The results are statistically significant for the Fractions and Word Problems skills (\( t \text{test}, p < 0.05 \)).

Figure 1 (right) shows the average maximal level of difficulty that was obtained by the students in each condition. The lowest level is 0 and the highest is 3. As can be seen, the average level on all skills, except for the Word Problems, was much higher in the choice based method. Results are statistically significant for the Fractions and Word Problems skills (\( t \text{test}, p < 0.05 \)).

Thus, in 3 out of 4 skills, the students answered more questions correctly, and solved questions of a higher or similar difficulty level, when given the opportunity to choose which questions to answer. We attribute the different behavior on Word Problems to the intimidation effect of the lengthy textual description.

One of the goals of our system is to serve as a diagnostic tool for a teacher to understand areas of strengths and weaknesses of students. for this, we evaluate the correlation between the students proficiency in each math skill as reflected in their end of year diploma, and their success level in each of the systems in the experiment. We obtained the students end of year grades in each math skill and computed a ranking over skill mastery for students in both the choice and the sequential system.

Figure 2 shows Kendall rank correlation coefficient (Kendall’s \( \tau \)) between the diploma ranking and the two systems — the choice system and the sequential approach. Kendall’s \( \tau \) rank correlation is a metric that counts the number of
pairwise disagreements between two ranking lists. Its value ranges from $-1$, denoting perfect disagreement, to 1 denoting perfect agreement, with 0 denoting independence. As can be seen, the correlation of the ranking of the choice system (“Diploma-Choice”) is higher than the correlation of the sequential system (“Diploma-Sequential”).

We also asked students for their own perception of their mastery level of the various skills in the post-experiment questionnaire. The students were asked to provide an evaluation for their mastery of each skill on a scale of 1 to 5. Then, we ranked the skills based on the student’s self assessment and compared it again to the two systems. The results are also presented in Figure 2. As can be seen, the correlation between the student self assessment and the choice system (“Student-Choice”) is higher than the correlation between the student self assessment and the sequential system (“Student-Sequential”). These results provide evidence as to the superior analytic power of the choice system compared with the traditional sequential system.

Finally, we asked the students which of the two systems they preferred. 62.5% of the students preferred the choice based system, while 25% expressed preference to the sequential system and 12.5% did not express any preference.

Our approach provides a proof of concept that combining student choice with selection mechanisms in an e-learning system can improve student performance and satisfaction levels. In future work we plan to test the impact of choice in e-learning on larger and more diverse populations.

References