

Investigating Player Strategies in an Online Math Game Over Time

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ABSTRACT

This study investigates, strategies that students use when playing an online math game. Analysis was conducted on detailed log data from the online game, which was given to elementary school students in an online virtual academy nationwide. Findings of the study suggest that most students adopt a strategy and stick with that strategy throughout their play of the game.

INTRODUCTION

With the increasing use of gaming and electronic games in educational environments [1], the use of analytics and educational data mining for insights into learning offers many promising opportunities to researchers and education professionals. Refraction is one such example, and is a free online game created by the University of Washington that teaches fractions through splitting (<http://play.centerforgamescience.org/refraction/site/>). In the game, players select 1/2 and 1/3 splitters to create the appropriate fractions (1/2, 1/4, 1/6, 1/9, etc). As the game progresses, levels become more advanced; for example, multiple fractions may be required on the same level, or players may be asked to combine fractions. A detailed discussion of the game is beyond the scope of this abstract, and the reader is pointed to the game website for more detail.

METHOD

We investigated all student play across all levels of the game. Because of this high level investigation, we selected variables that would be meaningful across all levels of the game. These variables are briefly identified here:

- *Actions*: the number of actions taken by the player on the level
- *Unique actions*: the number of unique actions taken by the player on the level; this serves to remove any repeated actions, which occur when a player adds then removes a piece
- *Piece IDs*: the number of unique pieces the player used when playing, which indicates how many splitters (invoking math concepts) or benders (invoking spatial concepts) used
- *Unique indexes*: the number of unique places on the board space that pieces were played; this serves to indicate not just unique actions of board pieces used, but also piece placement
- *Time*: how long it took the player to complete the level

We started our investigation by classifying each level of the game for all players; that is, regardless of who the player was, we wanted to categorize all of the strategies seen across all levels. Using the variables identified above, we conducted a hierarchical cluster analysis using Ward's method [2]. This resulted in a three-cluster solution. Cluster 1 strategies were seen in levels where all variables were high; that is, the players were slow and iterative in their play strategy. Cluster 2 strategies were seen in levels with average performance. Cluster 3 strategies were seen in levels where all variables were low; that is, the players were fast and efficient in their play strategy. Armed with these strategy classifications, we then assigned them to their player and put them in game play order. This can be seen below in Figure 1. Cluster 1 appears in red, Cluster 2 appears in green, Cluster 3 appears in blue, and any skipped levels appear in gray.

Visual examination of the clusters laid out over time suggests there is a category of users that stay in Cluster 3 (fast and efficient - green), but we wanted to test this question statistically, as well examine the data to see if another category of user exists. (Note in Figure 1, each line is a player, and progression from left to right is progression through levels.) Therefore, we conducted intersequence distance (ISD) using optimal matching.

Figure 1. Game play sequences

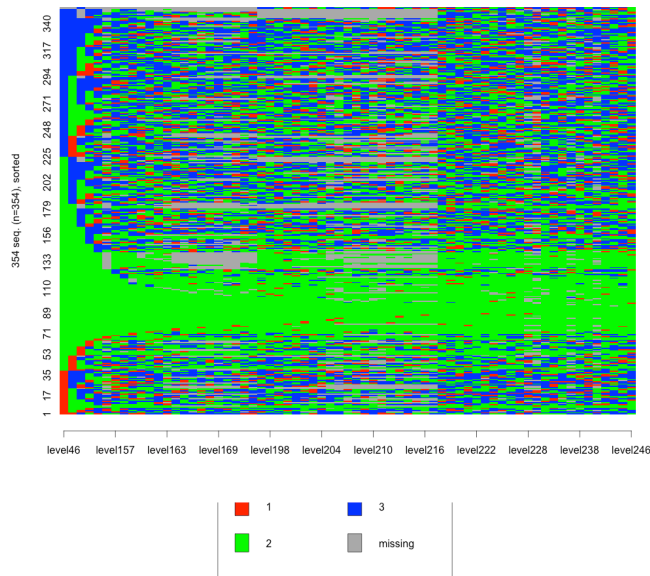
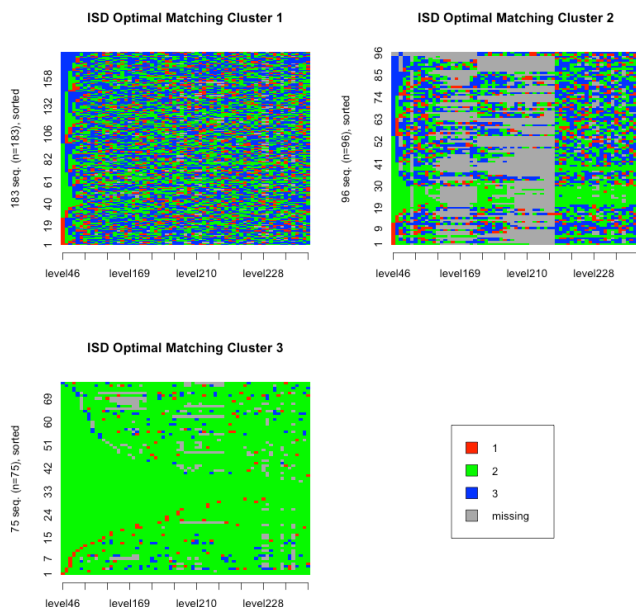


Figure 2. Results of ISD



While sequences of events can be compared and classified manually, this can be difficult with large datasets, and manual classification may miss important distinctions in data [3]. Therefore, we use ISD and optimal matching as a method to compare sequences [4]. In our study, sequences are the Cluster strategies used by a player, arranged in order by game level. ISD is conducted in two stages: computing intersequence distances, and cluster analysis of those distances. The reader is referred to [5] for a detailed explanation of this process.

RESULTS

As expected, we see that one group of users appear to be efficient players throughout all of their gameplay (ISD Cluster 3). We also see that two other groups appear from the analysis: ISD Cluster 1 are players that appear to mix and match strategies throughout their game play, and ISD Cluster 2 are players that appear to mix and match strategies throughout their game play *but also* skip several levels. This distinction was statistically important and warrants further examination. For example, were there levels that were skipped for mathematical reasons? Or were they skipped for scheduling reasons? Given that the data was taken from a nationwide sample, these results are quite interesting and would likely preclude any regional effects. Future research should take these considerations into account.

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