Perfect Scores Indicate Good Students !? The Case of One Hundred Percenters in a Math Learning System

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ABSTRACT
As a teacher or administrator, seeing a student scoring 100% in an exercise series within an online learning system would typically raise no immediate worries. This paper analyzes the "one hundred percenter" sessions in a math learning system. We argue that some student sessions with 100% score may actually not be predictive of student's learning success, and that a frequently exhibited student strategy of getting a perfect score by skipping exercises and repeating series is not ideal.

Keywords
Learning Analytics; Educational Data Mining; User Modelling; Student Behavior; Gamification

1. INTRODUCTION
Many educational technology systems allow students to take exercises multiple times and thus follow a resubmission policy [4; 6]. In this model, students have a chance to revise their answers by looking closely at their errors and the system gives feedback accordingly (which may vary in form and degree of detail). This resubmission policy certainly benefits self-regulated learning. Some of these learning systems limit the number of resubmissions, whereas others leave it unlimited [6]. Nevertheless, a possible negative side effect of this policy is evident as well. Under a resubmission policy, students can potentially take a trail-and-error strategy with little or even no thinking about the exercises and still try to get a high score [1; 4]. To address this issue, randomized initial data can be used to generate new (but structurally similar) exercises and thus avoiding repetitive occurrences of same exercises [5]. This strategy has shown to have a positive impact on students' learning results [6].

In this paper, we conduct an investigation in the context of a math learning system with a feature of resubmission. Log files indicate that a portion of students were eager to achieve a 100% success rate by taking a strategy of skipping exercises with a 'help' of resubmission. As far as we know, this phenomenon has not been studied extensively up to now. Nevertheless, skipping behavior itself is quite common in computer-supported learning systems. If a resubmission policy is allowed, restarting an exercise series or a quiz is technically possible and not as expensive as in paper-and-pencil tests in physical classroom settings. One may argue that students' motivation of achieving a 100% success is not surprising too. In a traditional classroom this happens quite often because students desire their teacher's praise or want to show off their talent with such a high learning

performance. In this paper we thus do not primarily intend to discuss the phenomenon as such, but want to investigate two related questions. First, is this skipping strategy (aborting and restarting an exercise series after a mistake) actually a fast way to achieve a 100% success score, or are there more efficient strategies to reach this goal? Second, from a pedagogical viewpoint, do students who take this strategy perform as good as their learning outcomes seem to indicate – i.e., perfectly?

2. DATA
Bettermarks[1] is an online math learning system. It delivers math learning content in cooperation with K-12 schools (grades 4-10). Since the system provides flexibility to choose math topics and exercise series according to needs of different curriculums, it is frequently blended into classroom teaching by school teachers. Typically, teachers assign exercises (organized in exercise series) to their students and their achievement is in turn reported back to the teachers via the system. Bettermarks employs an unlimited resubmission strategy, which means that students can make as many attempts as they want. With such a feature, students are expected to iteratively make use of more attempts to correct their errors with helps of the system's feedback and/or hints.

After a close look at the sever log file, we found that plenty of the students made many skipping attempts before a 100% success. We termed such an interesting phenomenon as a "one hundred percenter with skipping". They did not take the exercises one after another as some of their peers did. Instead they skipped all the remaining exercises and made a new attempt once an error occurred. From January 2014 till November 2014 we found 8,640 (6.4%) sessions involved in such a phenomenon out of totally 687,688 sessions.

3. ANALYSES AND RESULTS
We identified another two different groups of student sessions with least one 100% success in one attempt of the exercise series. One group is the sessions without any skipping behavior but at least a 100% success once (59,941 in total). The other group contains sessions with a 100% success at the first attempt, but still with next attempts in the same exercise series. We termed this group "strong one hundred percenters" (3,854). The one hundred percenters with skipping showed a totally different learning style than their counterparts without skipping. Upon realizing a problem (e.g., a mistake made or an apparent difficult

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[1] http://bettermarks.com/

exercise), the former group decided to skip over this exercise and the remaining ones in the series, and restarted the series. To the contrary, the ones without skipping chose to continue with the current work. They took every learning chance (as the system designer or the teacher would probably have hoped). Through this behavior, they could still probably learn something from the feedback or the next exercises in the series even though they had made an error. However, their desire to achieve a 100% success was evident through their behavior. The question which style (with or without skips) leads to the shared goal (100% success) quicker is interesting. To answer this question, we counted the students' attempts to a 100% success respectively. Students with the skipping strategy in fact needed more attempts to achieve their desired perfect score (3.6 attempts vs 2.4 attempts). This difference is statistically significant (Welch's t-test with different variance, p<0.001). In other words, students that chose to do all the exercises instead of skipping achieved a 100% success faster. Note that we took the number of attempts as a measure instead of time spent because that would bring individual's faster or slower learning pace as a noise into our analysis.

Interestingly, some of the one hundred percenters continued with their learning activities even after having obtained a perfect score. They even made more attempts right after their achievement of 100% success. In this case, we can hypothesize that the reward-oriented motivation was lower than the intrinsic, learning-oriented motivation: the system would reward students achievement badges once they achieved a 100% success but no more afterwards. We got 129 (1.4%) of such sessions out of the one hundred percenters with skipping, 1,414 (2.3%) sessions out of the one hundred percenters without skipping, and 3,854 (by definition, 100%) sessions out of the strong one hundred percenters. Solely from the participation we can intuitively see that very few one hundred percenters with skipping engaged in their learning activities once they had got the achievement badges in comparison of another two groups. We sought to investigate their learning performance under this situation (only with intrinsic motivation). We calculated their average success rate over attempts after that 100% success attempt. The average learning performance of one hundred percenters with skipping (0.78) is much lower than without skipping (0.91). Unsurprisingly, the strong one hundred percenters take the leading position (0.94). A Kruskal-Wallis H-test confirmed significant difference (p<0.001).

We can now give some answers to our questions stated in Section 1. First, the skipping strategy does not show any advantage when compared to the non-skipping strategy. To the contrary, students who take this strategy needed more attempts to achieve a 100% success at the end. More importantly, one hundred percenters with skipping reveal significantly weaker capabilities than their peers during the attempts after a 100% success. This would put this portion of students at risk especially when teachers only take their best outcome as a rating criterion. Since they do not show any weakness solely on that indicator, their teachers would overlook them (assuming they do fine) and move their attention to the weak students. As such, one hundred percenter behavior with skipping is not a fruitful strategy – it does not make the process of getting the 100% badge more efficient, and in fact students that pursue this strategy did not learn as much as their scores indicate, and less than their peers.

4. CONCLUSION

This work analyzes a portion of students in a math learning environment who achieve a 100% success in an exercise series through skipping exercises and then repeating the series. A closer look at the data in the learning system yielded several insights. The first one is that the adoption of the skipping strategy does not help to speed up to a 100% success. Instead, a non-skipping strategy leads students to achieve a perfect score faster. Another yet more important finding is that one hundred percenter behavior could put students at risk of being overlooked by teachers. They actually do not perform as excellent as their learning performance indicates.

With regard to the motivation of one hundred percenters, achievement badges available in the system, a gamification strategy often used in educational systems, could explain their motivation. Still there could be some other incentives, for example, encouragement or rewards coming from somewhere outside of the learning system. The learning system we studied is integrated into blended teaching settings in most cases. Thus teachers should have much space to motivate their students without a need to solely rely on the learning system's rewarding strategy. Apart from motivation factors, carelessness or a slip [2; 3] could explain one hundred percenters' skipping behavior as well.

5. ACKNOWLEDGMENTS

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