THE KEEPING IN SCHOOL SHAPE PROGRAM: HOW TO MAINTAIN SKILL PRACTICE OVER SCHOOL BREAKS

C. van de Sande, K. Lock
Arizona State University (UNITED STATES)

Abstract
Just like physical skills, cognitive skills grow rusty over time unless they are regularly used and practiced. This means that school breaks can have negative consequences on student learning. The “summer gap” effect has been documented in many school subjects but is most pronounced for mathematics which requires a strong foundation of prior knowledge. To address this issue, we introduce a mobile, engaging, innovative, cost-effective, and flexible program that was designed for the very purpose of helping students stay fresh on pre-requisite mathematics skills and concepts. The Keeping in School Shape (KiSS) program embodies retrieval practice by sending students a multiple choice mathematics question daily via text messaging over school breaks. Following their responses, students receive immediate feedback and solutions. We discuss the design of the KiSS program and results involving participation patterns, confidence, and accuracy. The KiSS program can be tailored to meet the needs of other researchers and instructors.

Keywords: Summer learning loss, retrieval practice, mathematics skills.

1 INTRODUCTION
“If you don’t use it, you lose it” is the sad reality of what happens to skills and abilities that are not practiced over time. In school students must not only remember what they learn throughout the year, but they must also retain what they have learned from one year to the next. However, the traditional 9-month school calendar, in which schools open their doors in the fall and then close them during the summer months, was not designed with this concern in mind. [1] By a conservative estimate, summer vacation sets K-12 students back by one month of instruction, that is, it causes them to lose one month of grade-level equivalent skills relative to national norms. [2] This “summer gap” effect is especially pronounced in mathematics, perhaps because students have more opportunities [3] and motivation [4] to read and learn new vocabulary during the summer than they have to practice and learn mathematics. Within mathematics, summer learning loss is most pronounced in skill areas that rely heavily on knowing facts and performing procedures since these types of knowledge fade quickly in the absence of sustained practice. [5,6]

And the summer slide extends beyond high school. We now know that university students who take the summer off between sequential introductory mathematics courses are significantly more likely to perform poorly than are students who take closely-related courses in the same academic year. [7] Furthermore, taking time off has the most harmful impact on strong students, those who performed above average in the first course – which may lead to the loss of talented students from majors that require mathematics course sequences. The Keeping in Summer Shape (KiSS) intervention is a mobile, engaging, innovative, and cost-effective program that is being used to help students stay fresh on pre-requisite skills and concepts during gaps in formal instruction.

One way to bridge the gaps in formal instruction is to regularly ask students to recall previously learned material during their time off between courses. The benefits of this learning activity, known as retrieval practice, have been repeatedly documented in both laboratory settings and in authentic classrooms. [8,9] Neurologically, it is believed that retrieval practice strengthens memory traces, contributing to reprocessing (and perhaps elaboration), or building associations that facilitate transfer. More recently, a theory positing a relationship between storage strength (relative permanence of memory trace) and retrieval strength (momentary accessibility of memory trace) has been suggested.

In effect, retrieval practice leads to flexible understanding, improves higher order thinking skills, and promotes knowledge transfer by making apparent to students what they have and have not mastered. [10]. A central idea of retrieval practice is that testing represents an opportunity for learning, rather than functioning solely as assessment. Although testing is usually thought of as a neutral activity (one that allows learning outcomes to be measured), there is now substantial evidence supporting the fact that taking a test usually enhances later performance on the material relative to rereading it or to
having no re-exposure at all [11]. This phenomenon has been dubbed the “testing effect.” [12] In essence, testing provides students with retrieval practice opportunities that have been shown to be beneficial not only for retaining information, but also for knowledge transfer. [13-15]

How can we stem the loss of learning over school breaks for students who have busy lives and do not wish to spend their breaks from school studying and preparing for the upcoming semester? Keeping in School Shape (KiSS) is a nudge campaign that delivers regular retrieval practice opportunities to students over breaks from school. The KiSS program could be used during lengthy summer breaks or during other holiday breaks. In the same way that a daily desk calendar can prompt people to work on a solution to a puzzle (e.g. a tangram) when they rip off the previous page and see the new puzzle for the first time, KiSS puts daily problem nudges in front of students to entice them to solve them. Unlike paper desk calendars, though, KiSS delivers the nudges electronically and interactively, through text messages. In this way, the KiSS program, although designed initially for mathematics, could be tailored to deliver retrieval practice in any subject area.

2 METHODOLOGY

The first KiSS program, KiSS1.0, was delivered over the three month long summer break between spring and fall semesters for a single class of university students who were enrolled in the second course of an introductory mathematics course sequence (van de Sande, xxx). A second version of KiSS, KiSS2.0, was then designed to deliver the program to a larger student audience and to facilitate the delivery of the problems and feedback following responses.

2.1 Infrastructure of KiSS2.0

The KiSS2.0 program was a configuration of an online quiz program, solution videos, and messaging software delivered through mobile devices (Fig.1). The quiz program, FlexiQuiz (https://www.flexiquiz.com/) is a commercial online quiz delivery program that allows for differential feedback based on responses to multiple choice problems and that tracks participation timing and responses. The short solution videos (1-2 minutes) were housed online on youtube (https://www.youtube.com/) and included a brief take away message in addition to the solution of the daily problem. Finally, a script on Google Voice (https://voice.google.com/messages) was used to send bulk individual text messages to all participants daily. These reminders contained a link to the problem of the day on FlexiQuiz.

![Image](image.png)

Figure 1. Design of KiSS2.0.

2.2 Activities

Each day students received a three part activity involving selection of a charitable cause, rating their confidence, and solving the problem. First, students were asked to choose one of five charitable causes that would receive benefits if they answered the daily problem correctly. (We are not reporting on this aspect of the program in this paper, but it was included to incentivize students to participate.) Second, students were shown the problem and asked to rate on a scale of 1 (not at all) to 5 (very) how sure they were that they could solve it. Each confidence rating was accompanied by a representative
emoji, as shown in Fig. 2. Finally, students were asked to choose the correct answer from one of five possible responses to the problem. The problems represented a collection of skills that students had learned in the first course of the sequence and that would be used in the upcoming second course.

2.3 Participation

KiSS2.0 was delivered daily for 25 days over the winter break between fall and spring semesters, with the exception of two major holidays. All students at a large university in the southwest who were enrolled in the second course of an introductory mathematics course sequence before the break were emailed an invitation to participate. 184 students indicated interest in participation by responding with a text message containing a self-selected code name.

3 RESULTS

We wanted students to feel as though they were participating in a program designed to help them keep their recently learned skills fresh, rather than a research study. We therefore did not collect information on specific demographics. All students who participated were at least 18 years of age and were planning at the time on taking the second course in the mathematics sequence the following fall. Fig. 3 shows the percentage of participation from the 184 students who signed up for the program. Although 41% of the students never participated, 12% of the students were very regular participants, responded to 21 or more of the 25 problems, and roughly 20% of the students responded to between 6 and 20 of the daily questions.
3.1 Participation Patterns

In addition to looking at simply the number of times students participated, we were interested in exploring patterns of participation. We therefore charted the days on which students participated, classifying students into 5 categories according to the total number of times that they participated (Table 1). As seen in Fig. 4, the participation of students within each of these categories shared some similarities and consistency.

<table>
<thead>
<tr>
<th>Number of times participating</th>
<th>Category</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Just once</td>
</tr>
<tr>
<td>2-5</td>
<td>Testing the waters</td>
</tr>
<tr>
<td>6-15</td>
<td>Occasional</td>
</tr>
<tr>
<td>16-20</td>
<td>More on than off</td>
</tr>
<tr>
<td>21-25</td>
<td>Model</td>
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“Just once” students who participated just a single time tended to try out the KiSS program early on, in the first few days after it started. Students in the “test the waters” category also tended to participate early on, clustering their few days of participation together. For instance, such a student might participate for 3 days in a row and then no more. Students in the “occasional” category also showed clustered participation but their participation was throughout the 25 days with large spans of days in which they did not participate. Students in the “more on than off” category showed a similar clustering of participation throughout the 25 days, but with smaller participation gaps. Finally, the “model” students participated consistently, missing only a day or two here and there over the break.

We then asked ourselves whether getting a question wrong might discourage students from further participation. As a preliminary analysis, we therefore looked at the percentage of students who quit participating directly following an incorrect response by the amount of participation. As shown in Fig. 5, it appears that getting a question wrong had a progressively more discouraging impact on students as participation amounts decreased. In other words, getting a problem wrong may be most discouraging for students who have only participated occasionally but has less of an effect on students who are more regular participants. Certainly, these results should be validated by interviewing participants to discern with more detail why they stopped participating and how they felt after getting a problem wrong.
3.2 Confidence

Before solving each daily problem, students rated how confident they were that they could answer the problem correctly. Fig. 6 shows the percentage of confidence ratings that were given by students. Generally, students seemed to feel that the difficulty level of the problems was reasonable since more than half of the ratings given were for the top two levels of confidence, either very confident or somewhat confident. This is encouraging since the problems were intended to serve as a review of material already learned so the goal was not to use problems that students would find extremely difficult or unfamiliar.

Of course, the question that begs to be asked is whether students’ confidence in their ability to solve the daily problem was well founded. Fig 7 shows the percentage of problems that were correctly or incorrectly solved according to confidence rating. As can be seen, students were generally very good judges of their abilities. If a student gave a confidence rating of somewhat confident or very confident, then they were more likely to get the problem correct, whereas the opposite was true for problems for which they were not at all confident or not very confident that they could solve correctly.
3.3 Accuracy

The overall level of difficulty of the problems appears to indicative of review material since 74% of the total responses across all problems were accurate. However, as Fig. 8 shows, there was some variability in accuracy across problems. Most notably, the first problem may not have been a good choice since less than 50% of the students who responded got it correct, and, as mentioned earlier, this may have discouraged students from participating further.

3.4 Conclusions

This implementation of the KiSS2.0 program demonstrated that it is possible to efficiently deliver retrieval practice to students over breaks from school. Using their mobile phones, students are able to respond to problems, receive feedback, and view solutions. Of course, much development work remains to be done. Obviously, it would be desirable to further develop a KiSS program infrastructure to streamline delivery and provide real time dashboard analytics. For instance, students who drop off their participation following an incorrect response could be automatically sent an encouraging message to induce them to resume and try again. Also, a program that could offer varying levels of
difficulty might enhance participation from students who need to begin with the review of more basic material. Finally, attaching resources for further practice to each problem would give students who desire it additional opportunities to solidify their skills.

Despite these areas of improvement, however, the concept of the KiSS program holds great promise for providing opportunities to students to practice material during breaks from formal instruction. Perhaps most importantly, the program could be easily modified to address other subject areas. For example, students learning a foreign language could receive regular practice on vocabulary, grammar, and comprehension so that they can recall this critical and foundational knowledge when instruction resumes following breaks from school.

We are committed to designing resources to help students succeed. Lengthy gaps in instruction set students back and force them to recover lost ground, which may possibly discourage them from pursuing their dreams and goals. The KiSS program is a mobile, engaging, innovative, cost-effective, and flexible program that was designed for the very purpose of helping students stay fresh on pre-requisite skills over breaks from formal instruction. We have set the stage for taking further steps to maximize the promise of the KiSS program, and we invite our fellow researchers and instructors to join us in this endeavor.

REFERENCES


