Growth mindset — Student feedback loop

Buzzmath: Engaging curious minds

Promoting student persistence by improving feedback loops in Buzzmath

Context

- Feedback is a core aspect of learning.
- There are different types of feedback with different impacts on students.
- Buzzmath has developed a new feedback loop, and wishes to observe its impact on student persistence in accomplishing tasks.

RESEARCH CONTEXT

Regardless of teaching method, providing students with feedback plays a critical role in their persistence, in developing their interest, and in their learning (Hattie and Temperley, 2007). They receive feedback from multiple sources, for example, their teachers, peers, the physical consequences they observe during manipulations, etc. Moreover, digital learning environments, like Buzzmath, find added value in the feedback they provide to students, given their potential to reach a vast audience instantly and in an individualized fashion (Liu, 2016). Feedback from digital learning environments can take several forms, with variable impacts on students. For example, in a complex problem, true-false feedback gives students fewer options for improvement than directly showing them the elements that they have not yet mastered (Gresalfi and Barnes,2016).

Seeking an overall improvement of its platform, Buzzmath developed a new feedback loop that can be applied to several problems. Originally in the form of true-false feedback, the new feedback loop proposes that the students only repeat the elements that require improvement, without having to redo what they already completed successfully. To validate the impact of this change in platform on the students, we conducted a study in collaboration with researchers from UQAM. The aim was to determine if the detailed feedback loop leads to improved persistence in completing tasks among Grade 5 students. The study's hypothesis was that more precise feedback will lead to improved student persistence.

Methodology

PARTICIPANTS

Seventy-five (75) students from four Grade 5 classes were invited to participate in the study. Since the data was collected at the end of the year, the students had a mathematics level comparable to that of Grade 6. All of the students were 10 to 11 years old, and were familiar with the Buzzmath platform.

EXPERIMENTAL APPROACH

With the goal of verifying the impact of the new feedback loop on student persistence in completing tasks, the experimental approach illustrated in Figure 1 was used. After a short questionnaire on their interest in mathematics, the students navigated the two different versions of Buzzmath, for a total duration of 30 minutes (2 x 15 minutes). Each of the two versions involved 14 equivalent problems, half of which included problems with a change in the feedback loop, and the other half with no change. The problems were chosen based on maintaining a constant level of difficulty between the 2 tasks, and presenting problems that were as varied as possible, at the Grade 6 level. All of the problems were represented in both the initial version and the new version, to avoid mistakes related to minor details. The problems retained were similar to those provided as an example in the context section.

Methodology

- 4 Grade 5 classes participated in the study.
- All of the students solved problems in both versions of Buzzmath.
- Some of the problems featured enhanced feedback, while others did not.
- Persistence was measured by the number of validations of a problem and the time committed to the task.

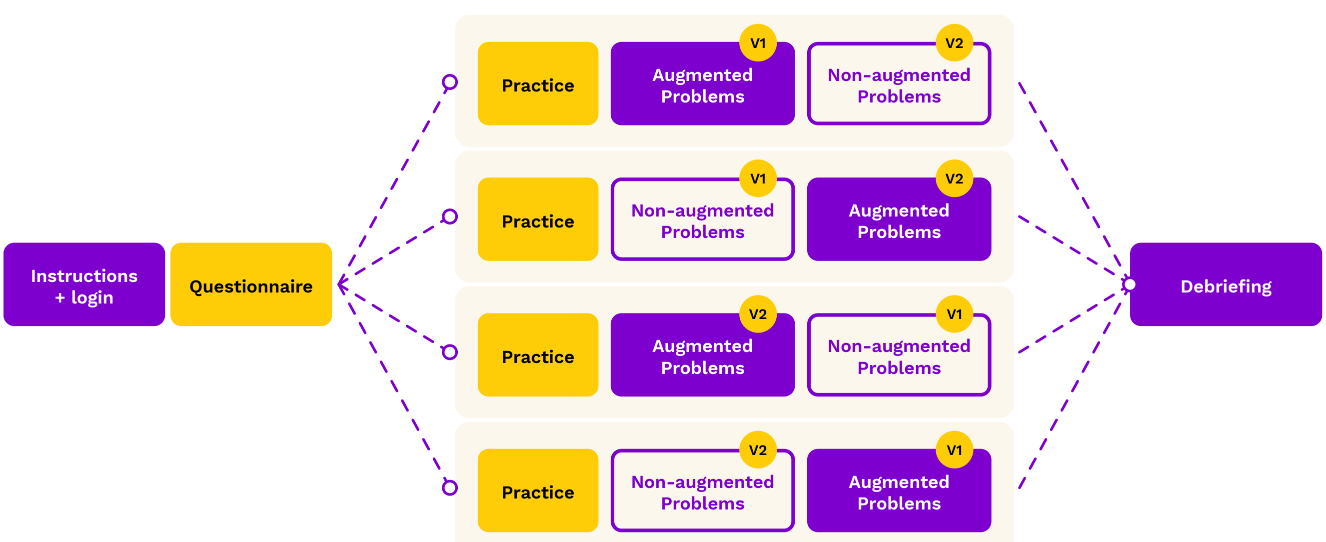

Figure 1. Experimental approach employed

BENCHMARKS

In order to measure student persistence in completing the task, classic behavioural benchmarks of persistence were employed. At an equivalent completion rate, persistence is measured by the number of validations before successfully completing or abandoning a task. (Teubner-Rhodes et al., 2017). The number of validations for each of the problems was measured during the experiment, as well as the time spent on each problem. Since persistence is influenced by the level of student interest (Tulis and Fulmer, 2013; Dweck and Sorich, 1999), we integrated a questionnaire on interest in mathematics, adapted from Preckel et al. (2008 questionnaire) to control the effect of this variable.

Results

PROBLEMS RETAINED FOR ANALYSIS

Since the task was created so that the students would have enough problems to solve and would not finish ahead of time, only the problems that were tackled by at least 50% of the students were retained for subsequent analysis. Ultimately, 6 of the 7 problems for each of the conditions were retained. Table 1 illustrates the percentage of the sample that submitted at least one answer for each of the problems.

Results

- Interest (control variable) did not have an effect on the two persistence benchmarks.
- The number of attempts was slightly greater for the problems without an augmented feedback loop. While not significant, the trend is similar for problems with augmented feedback.
- The time committed to the task is much greater for the problems with augmented feedback, compared with their equivalents with no augmented feedback.

Table 1. Percentage of problems that were validated at least once by the students

	Problems	1	2	3	4	5	6	7
Previous version (flash)	Augmentable	100.0	100.0	90.7	97.3	77.3	85.3	65.3
Previous version (flash)	Not augmentable	94.7	100.0	93.3	80.0	78.7	65.3	52.0
New version (HTML)	Augmented	100.0	98.7	98.7	96.0	80.0	72.0	45.3
New version (HTML)	Not augmented	94.7	100.0	89.3	81.3	74.7	58.7	34.7

CONTROL VARIABLE

The interest scale, comprising 6 items, had high internal coherence (α=0.85). This means that it effectively measured a single construct, namely, interest in mathematics. To ensure that the 4 groups that were assigned to one of the experimental conditions did not differ in terms of their level of interest in mathematics, the analysis of variants (ANOVA) technique was employed. No significant difference was detected between the groups in terms of their level of interest in mathematics ($F(3,71)=2.09$, $p=.11$). Moreover, no significant correlation was identified between level of interest for the two dependent variables (number of validations and time committed to the task).

COMPLETION RATE

Two tests were conducted to compare the completion rates of the different problems. The first was conducted for equivalent problems without augmented feedback between the previous and current versions, and the second was conducted between problems that had a modified feedback loop. Table 2 presents the results. No difference was detected between the pairs of equivalent problems.

Table 2. Comparison of completion rates for problems with and without augmented feedback

	Previous version		New version				
	M	ET	M	ET	t	p	d
Without augmented feedback	0.90	0.16	0.85	0.20	1.91	.06	—
With augmented feedback	0.94	0.11	0.96	0.08	1.51	.14	—

NUMBER OF ATTEMPTS

Two tests were conducted to compare the number of attempts between the versions with augmented feedback, and those without. The table and Figure 3 present the results for these two comparisons. A significant difference was identified for the problems without augmented feedback ($t(74)=2.13$; $p=.04$), for a small effect size ($d=0.35$). While this difference is not significantly significant for the problems with augmented feedback ($t(74)=1.73$; $p=.09$), we observed a trend similar to the one in the preceding comparison.

Table 3. Comparison of the number of attempts for problems with and without augmented feedback

	Previous version		New version				
	M	ET	M	ET	t	p	d
Without augmented feedback	1.23	0.90	1.56	0.98	2.13	.04	0.35
With augmented feedback	0.55	0.46	0.68	0.54	1.73	.09	—

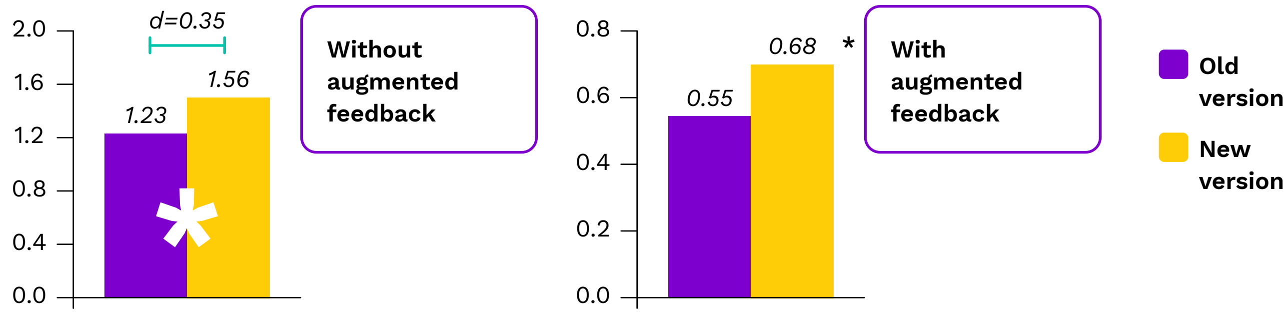

Figure 3. Comparison of the number of attempts for problems with and without augmented feedback

TIME COMMITTED TO THE TASK

Two tests were conducted to compare the time committed to the task between the versions with augmented feedback and those without. The table and Figure 4 present the results for these two comparisons. While the time committed to the task does not differ for the problems without augmented feedback (t(74)=0.44; p=0.66), a significant difference was measured for the problems with augmented feedback (t(74)=5.08; p<.001; d=0.78). The students spent a mean of 30 seconds more working on the problems with augmented feedback (M=93.40,ET=49.14), compared with the problems that were not modified(M=62.50; ET=27.25).

Table 4. Comparison of the time committed to problems with and without augmented feedback

	Previous version		New version				
	M	ET	M	ET	t	p	d
Without augmented feedback	62.69	38.35	65.23	32.31	0.44	.66	—
With augmented feedback	62.50	27.25	93.4	49.14	5.08	.00	0.78

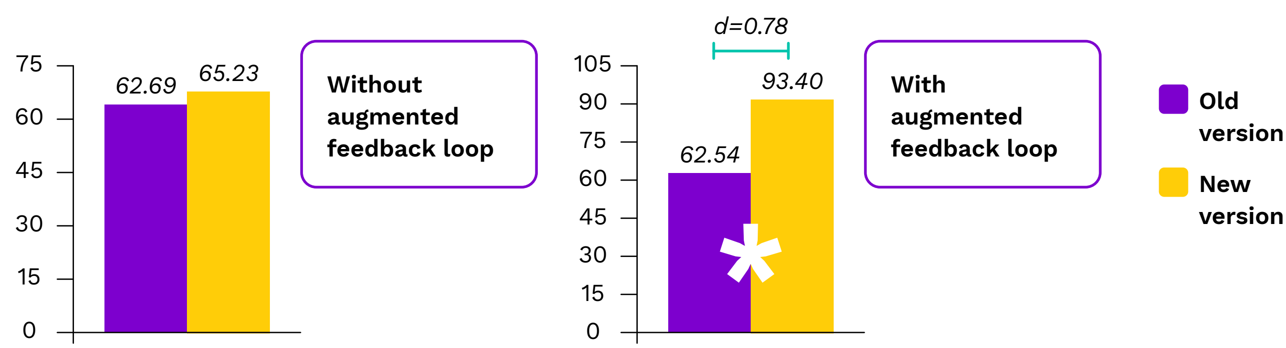

Figure 4. Comparison of the time committed to problems with and without augmented feedback

Interpretation of results

The objective of this research project was to determine if the new feedback loop promoted student persistence in completing a task. The time committed to the task corroborates the initial hypothesis, showing that the problems that offer more precise feedback on behaviour lead to enhanced persistence in completing the task. In fact, for an identical completion rate, the problems with augmented feedback generated a mean of 30 seconds more time committed to the task compared with the initial identical problems. This difference was not noted for the problems in which the version was changed without modifying the feedback system. Moreover, this difference has a large effect size, that is, the new feedback loop greatly influences student persistence in completing the task. It should be noted that this result is consistent with the existing literature on feedback systems related to digital learning environments (Gresalfi and Barnes, 2016).

Interpretation

- The time committed to the task corroborates that the new feedback loop promotes student persistence, to a high degree.
- The number of attempts contradicts the initial hypothesis. This is probably due to the novelty effect of some minor changes to some of the elements.
- The new feedback loop promotes student persistence in Buzzmath.

With respect to the number of attempts made before successfully completing or abandoning the task, we noted that at an equal rate of completion, the problems in the new version tended to generate more attempts, independent of whether or not feedback had been augmented. For the change in version without augmented feedback, this difference was significant, but of weak effect size. For the version with augmented feedback, this effect was only marginally significant, but followed the trend of the preceding condition. While contrary to what the literature seems to indicate, this effect is of much smaller size than that of time committed. This contradictory difference with the initial hypothesis could be due to the novelty effect (Annetta et al., 2009). In fact, while the changes in the new version of Buzzmath mostly had to do with level of feedback given to the student, certain minor differences were also integrated (shape of buttons, screen colour...). The participating students were well acquainted with the Buzzmath universe, and quickly detected these minor differences. In addition, the researchers informally remarked on the students' excitement when the new version of Buzzmath was opened, which could explain this small increase in persistence, independent of the new feedback system.

In conclusion, we found that Buzzmath's new feedback loop effectively promoted student persistence in completing the task. Indeed, the students committed more time to completing the tasks for the problems that featured augmented feedback.

Limitations and potential developments

This research had certain limitations that need to be acknowledged. The first was the impossibility of making comparisons between the problems with modified feedback and those without. This was not possible because these problems were not of the same nature to begin with. For example, the multiple matching games could easily integrate feedback focused exclusively on the elements that were still not fully grasped, while a single factual question only involved a single step. Since augmented feedback had already been applied to all of the problems for which it could be employed, it was not possible to only choose similar problems.

The research shows that augmented feedback seems to be linked to greater student persistence. However, it would be even more interesting to determine a link between augmented feedback and learning. But a direct measure of learning was not possible in the case of a pilot study because we would have needed additional resources, namely, a greater number of class visits. Another iteration of the study could address this, however.

While the feedback loop was certainly augmented between the previous and current versions of Buzzmath, there is still room for improvement. The added value of digital learning environments is their ability to take into account not only the students' answers, but to consider their underlying conceptions when providing them with feedback (Liu, 2016). An incorrect conception can come from multiple sources, and each of these sources could be addressed with specific feedback. This type of feedback specific to students' conceptions could be considered in a future upgrading of Buzzmath's feedback system.

Lastly, it should be noted that all of the data was collected using Buzzmath's servers. While this data is already available, few companies use these tools to develop their product (Moshontz, 2017). Although this study was conducted directly in the classroom, it would be possible to conduct various design tests remotely and online using the same methodology, and with a greater number of students. These tests could easily be applied to any modifications designed to augment student persistence in Buzzmath.

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