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Enhancing Perceptions of Mathematics Assignments by Increasing Relative Problem Completion Rates Through the Interspersal Technique

CHRISTOPHER H. SKINNER
KIM HALL-JOHNSON
Mississippi State University

AMY L. SKINNER
Mississippi University for Women

GARY CATES
JIM WEBER
Mississippi State University

GREGG A. JOHNS
Mississippi State Hospital

ABSTRACT. Students solved mathematics problems from 4 assignment pairs. Each control assignment contained 18 target multiplication problems that were 4 × 1-digit (4 × 1), 4 × 2, 4 × 3, or 4 × 4. Each paired experimental assignment contained 18 similar problems plus 6 interspersed 1 × 1-digit problems. After computing problems from each pair of assignments, the students rated them and chose 1 for homework. Across all assignment pairs, problem completion rates were greater on the experimental assignments, and significantly more students chose a new experimental, rather than control, assignment for homework. Furthermore, as the discrepancy between problem completion rates increased across assignment pairs, the probability of students' choosing the experimental assignment for homework and rating the experimental assignment more favorably with respect to difficulty, effort, and time also increased. The relationship between student choice behaviors and relative problem completion rates has theoretical and applied implications for choice research and the design of activities composed of discrete tasks.

HARING AND EATON (1978) posited a learning hierarchy describing stages in academic skill mastery. The first stage of the hierarchy involves increasing response accuracy (i.e., skill acquisition). After students acquire skills, educators must ensure that the students are proficient with those skills and can perform useful or functional behaviors with them (Skinner, 1998). Thus, educators should design related instructional activities to ensure that students can perform skills both accurately and quickly (i.e., fluency or automaticity). Educators must also program for generalization across time (i.e., maintenance), stimulus generalization (i.e., applying skills across similar tasks), and response generalization (i.e., adapting skills).

One consistent finding related to the stages of skill mastery is that following skill acquisition, increasing the number of learning trials or the amount of time students spend engaged in active accurate responding can enhance fluency, maintenance, and generalization (Albers & Greer, 1991; Berliner, 1984; Binder, 1996; Greenwood, Delquadri, & Hall, 1984; Ivarie, 1986; Skinner, Fletcher, & Henington, 1996). To provide more opportunities for active academic responding, educators often assign independent work after students have acquired, but not yet mastered, a skill.

Although educators may assign tasks such as independent seat-work, it is the students who choose whether to engage in the assigned tasks or other behaviors (Skinner, Robinson, Johns, Logan, & Belfiore, 1996). In some instances, students choose to engage in assigned tasks, but in others they choose to engage in passive off-task behaviors (e.g., staring at their assignment) or more active, disruptive behaviors (Shapiro, 1996). Although educators can use physical guidance to encourage or even force students to respond or respond correctly (e.g., one could use a hand-over-hand instructional technique to physically prompt students to sweep a floor or swing a golf club), physical guidance cannot be used to occasion target responses that take place within the skin (e.g., one cannot physically guide students through cognitive responses such as reading). It is essential, therefore, that researchers and educators develop theories, principles, and techniques that allow us to predict and control student choice behavior (McDowell, 1988).

Much of the research focusing on student choice behavior has been based on Herrnstein's (1961) matching law, which predicts that when students are given a choice of two incompatible or competing behaviors and all other variables are held constant, they are more likely to engage in the behavior that results in the higher rate of reinforcement (Myerson & Hale, 1984). Researchers have shown that the matching law can predict and control students' choice of academic versus disruptive behaviors in educational settings (Martens & Houk, 1989; Martens, Lochner, & Kelly, 1992). In both studies, the greater the discrepancy between rates of reinforcement, the more likely students were to engage in the behavior(s) that resulted in the greater rate of reinforcement. Other researchers who experimentally manipulated reinforcement procedures across two competing academic

Address correspondence to Christopher H. Skinner, Department of Counselor Education and Educational Psychology, P.O. Box 9727, Mississippi State, MS 39762. E-mail: Cskinner@colled.msstate.edu

behaviors showed that manipulating relative, as opposed to absolute, (a) rates of reinforcement, (b) quality of reinforcers, and (c) reinforcement delay all influenced students' choice behavior (Mace, McCurdy, & Quigley, 1990; Neef, Mace, & Shade, 1993; Neef, Mace, Shea, & Shade, 1992; Neef, Shade, & Miller, 1994).

In related investigations of student choice behavior, researchers manipulated assignments and showed that when students were given assignments they preferred, they were more likely to choose to engage in those assignments (see Dunlap & Kern, 1996). Although those findings suggest that in some instances, educators may be able to alter assignments to make them more acceptable to students without reducing learning rates, research on response effort suggests that when given a choice of two competing assignments with equivalent reinforcement procedures, students are more likely to choose or prefer the assignment that requires the least effort (Cooke, Guzaukas, Pressley, & Kerr, 1993; Horner & Day, 1991). One can occasion that reduction in effort by making assignments briefer (e.g., Kern, Childs, Dunlap, Clarke, & Falk, 1994) or by replacing difficult, time-consuming tasks with easier, briefer, or previously mastered tasks (e.g., Cooke et al., 1993). The problem with reducing assignment length or difficulty is that that process can reduce opportunities to respond and, consequently, reduce target skill acquisition, fluency, and generalization (Binder, 1996; Greenwood et al., 1984; Skinner, 1998).

Recently, the authors of several studies have shown that students' perceptions of mathematics assignments can be enhanced by lengthening, not reducing, assignments (Cates, Skinner, Watkins, & McCurdy, 1998; Logan & Skinner, 1998; Skinner, Fletcher, Wildmon, & Belfiore, 1996; Skinner, Robinson et al., 1996; Wildmon, Skinner, & McDade, 1998). In the first of those experiments, students worked on two computation assignments: a control assignment containing 16 three- by two-digit (3×2) problems and an experimental assignment containing 16 similar 3×2 problems plus 6 interspersed 1×1 problems (Skinner, Robinson et al., 1996). When given a choice of which assignment they wanted for homework, significantly more students selected the experimental assignment with the additional interspersed problems than selected the control assignment. Those findings were then generalized across students (e.g., sixth-grade students in Logan & Skinner, 1998) and tasks (i.e., reading problems in Wildmon et al., 1998). In each of the aforementioned interspersal studies, the number of target problems was equivalent across control and experimental assignments. In a more recent study, Cates et al. (1998) extended that research by showing that significantly more students preferred an assignment with eighteen 3×2 target problems plus 6 additional interspersed 1×1 problems over a control assignment with just fifteen 3×2 target problems. Those results indicate that the interspersal technique can be used to increase the probability of students' choosing an assignment lengthened by over 20% (i.e., 20% more target 3×2 problems plus the additional brief interspersed problems).

Researchers have attempted to determine what characteristics of interspersed problems account for the effectiveness of the interspersal technique. Skinner, Robinson et al. (1996, Experiment II) interspersed different types of problems among the target problems and found that the novelty of the interspersed problems did not account for students' preference for the experimental assignments. Skinner, Fletcher et al. (1996) found that when they interspersed easier but more time-consuming problems with more difficult but briefer problems, the relative ease of the interspersed problems (i.e., the 1 × 1 problems were easier than the 3 × 2 problems) did not cause students to prefer the assignments with interspersed problems.

One causal explanation supported by research is that the students preferred the experimental assignments because the additional interspersed problems (e.g., 1 × 1 problems) required relatively less time to complete than the target problems (e.g., 3 × 2 problems). Skinner, Robinson et al. (1996) linked that causal hypothesis to the matching law when they suggested that during independent seat-work, when no immediate feedback or contingent reinforcement is delivered, problem completion may serve as either a positively or negatively reinforcing event. Thus, interspersing the briefer problems may have caused an increase in problem completion rates and relative rates of reinforcement, which, in accordance with the matching law, would account for students' choosing the experimental assignment, preferring it, or both. If Skinner, Robinson et al. (1996) are correct, then altering relative problem completion rates should have an effect on choice behavior that is similar to the effect of altering relative rates of reinforcement. Thus, our purpose in the current study was to extend research on the interspersal technique by examining the impact of different rates of problem completion on students' choice and perceptions of academic assignments. We manipulated relative problem completion rates across assignment pairs by altering target problems across assignment pairs.

Method

Participants and Setting

The initial participant pool included 109 students from two different undergraduate psychology courses. The experiment was conducted in the students' classroom during the first part of the scheduled class period. From that pool of participants, 4 were dropped for failure to follow directions (i.e., they skipped problems) and 11 others were dropped because they did not complete each phase of the experiment. Of the 94 students included in the analyses, 76 were women and 18 men, 18 to 47 years old. Five of the students were freshmen, 9 were sophomores, 43 were juniors, 36 were seniors, and 1 was an unclassified student considering graduate school.

Materials

During each of two experimental sessions, the students worked problems from two pairs of mathematics assignments, or four assignments. Each assignment was presented on one side of an 8.5 × 11-in. sheet of white paper and contained a title, a set of mathematics computation problems, and a key to record the assignment choice and assignment perceptions. Assignments were presented in pairs based on the number of digits in the target problems. For example, if one side of a sheet contained the control assignment with eighteen 4 × 1 target problems, then the opposite side contained the paired experimental assignment with 18 similar 4 × 1 problems plus the 6 additional interspersed, 1 × 1 problems.

We used four different control assignments. The assignments contained 18 target problems and were titled "4 × 1 assignment," "4 × 2 assignment," "4 × 3 assignment," or "4 × 4 assignment." The titles indicated the number of digits in each factor of the target problems (e.g., the 4 × 2 assignment contained eighteen 4 × 2 problems). In all problems, we used only digits greater than 3 to ensure that students had to consistently perform carrying operations.

For each control assignment, a matching experimental assignment was constructed. Each experimental assignment was titled "Mixed Multiplication" and contained 24 problems: 18 similar target problems plus 6 interspersed 1 × 1 problems (e.g., 6 × 7 =). The problems were arranged such that each 1 × 1 problem was followed by 3 target problems (i.e., three 4 × 1, 4 × 2, 4 × 3, or 4 × 4 problems). To equate difficulty levels and order of target problems across assignments, we constructed the 18 target problems on the experimental assignments by altering the sequence of numbers in one or both of the factors on the control assignment. For example, if the first target problem on the 4 × 2 control assignment was 7,865 × 85, the first 4 × 2 target problem on the experimental assignment could be 8,756 × 85, 7,865 × 58, 8,675 × 58, and so forth. In a previous study, altering the sequence of numerals within factors was found to be an effective strategy for making 3 × 2 target problems equivalent across assignments (Skinner, Robinson et al., 1996, Experiment III).

For each assignment, problems were presented in four rows. Problems were not (a) numbered, (b) spaced evenly or consistently, or (c) presented with an equal number of problems across rows or columns. We used those presentation formats to reduce the probability that students would perform a quantitative analysis of the number of target and/or interspersed problems on each sheet and base their assignment choice and assignment perception ratings on those analyses.

Experimental Procedures

The students were given a packet containing a cover sheet followed by four sheets of paper. On the cover sheet, the students recorded demographic data (i.e., age, sex, year in school). Each of the following four sheets of paper contained a control and paired experimental assignment. The four paired assignments were presented on opposite sides of each sheet of paper in random order across students. Furthermore, for each pair of assignments, we randomly sequenced the experimental and control assignments to control for sequence effects (e.g., practice or fatigue).

In the first experimental session, after the students completed the demographic sheet, the experimenter told them that they would be given a limited amount of time to complete as many problems as they could on the first assignment. The students were instructed to (a) work quickly, without making errors; (b) work horizontally across the assignment sheets from left to right without skipping problems; and (c) raise their hand if they finished before being told to stop. The experimenter repeated those instructions and used the blackboard to demonstrate "working horizontally." The students were told to stop after 255 s. Those procedures were repeated with the paired assignment on the opposite page.

After working on both assignments from a pair, the students were instructed to record which assignment would require the most time and effort to complete from start to finish and which assignment was the most difficult. Each of those questions required a forced-choice response. The students were encouraged to look over the two assignments before circling their choice. Next, they were informed that they would have to complete a third assignment for homework and that they could choose which type of assignment they would prefer to complete. Before recording their choice, the students were told (a) that the homework problems would not be identical to the problems they had just worked but would contain the same type, number, and sequence of problems and (b) that they would be required to finish the entire assignment.

During the first session, the procedures were then repeated with the next pair of assignments. Afterward, the procedures used in the first session were repeated in the second experimental session with the third and fourth assignment pairs. When both sessions were complete, homework packets were prepared for each student containing the assignments that each student had chosen. The students were given extra credit for participating in the first session, for participating in the second session, and for turning in their completed homework assignments.

The procedures used were identical for both classes, with one exception. In the first class, there was a 21-day interval between sessions. In the second class, there was a 23-day interval between sessions.

Experimental Design, Dependent Variables, and Data Analysis Procedures

We used a within-group design to compare each student's mathematics performance across paired experimental and control assignments and to analyze assignment choice and perception data following exposure to both sets of assignments. To control for sequence effects (e.g., practice and fatigue), we presented the four assignment pairs and the experimental and control assignments within each pair in random order across students. To assist students in distinguishing assignments, thereby reducing multiple-treatment interference, we gave each assignment sheet a title that described the type of mathematics problems on that sheet. In addition, directions were repeated before each assignment (Barlow & Hersen, 1984).

In the current study, the primary dependent variable (assignment choice) and the three assignment perception ratings (effort, time, and difficulty) were dichotomous scale data. We used Cochran's Q tests to ascertain differences between the experimental and control assignments for each of the dependent variables. We used nonparametric follow-up analysis described by Marascuilo and McSweeney (1967) to test for differences across target-problem type (i.e., 4 × 1, 4 × 2, 4 × 3, and 4 × 4 problems) and assignment type (i.e., experimental and control assignments).

We used three separate 4 × 2 [Target-Problem Type: (4 × 1, 4 × 2, 4 × 3, 4 × 4) × Assignment Type: experimental, control] repeated measures multivariate analyses of variance (MANOVAs). We analyzed three mathematics performance variables: (a) number of target problems completed, (b) number of total problems completed, and (c) percentage of target problems completed accurately. Number of total problems completed included both target and interspersed problems on the experimental sheets. We used only problems that were completed to calculate percentage of target problems correct. Therefore, problems that were not attempted or not completed were excluded from this measure of accuracy. If significant main effects were found, we used Newman–Keuls follow-up procedures to determine which levels differed.

Because the hypothesized causal variable related to assignment choice and assignment perceptions was relative, not absolute problem completion rates, we calculated and analyzed a fourth mathematics performance variable—relative problem completion rate (RPCR). For each student and each assignment pair, we calculated RPCR by dividing the total problems completed on the experimental sheet by the total problems completed on the control sheet. We used a one-way repeated measures analysis of variance (ANOVA) to determine if RPCR differed across target-problem type (i.e., 4 × 1, 4 × 2, 4 × 3, and 4 × 4). We used an alpha level of .05 for all comparisons.

Using an answer sheet, one experimenter recorded the number of problems correct and the number of problems completed for each assignment. A second experimenter independently scored and recorded the same data on 21% of the assignments. Interscorer agreement was 100% for each mathematics performance variable (total problems completed, target problems completed, and percentage target problems correct) and each nominal scale dependent variable (effort, time, and difficulty ratings, and homework-assignment choice).

Results

Assignment Choice and Perceptions

Table 1 contains data for the primary dependent variable, student choice, and the summary data for the students' assignment perceptions. We used Cochran's Q test to compare the proportion of students who chose a new experimental-format assignment for homework to the proportion of students who chose a new control-format assignment for homework. Significantly more students chose the experimental assignment rather than the control assignment for homework, $Q(94, 3) = 18.02$, $p < .005$. For that analysis, $\eta^2 = .153$ and power was large (.931). Four related planned comparisons indicated that for each pair of assignments (i.e., 4 × 1, 4 × 2, 4 × 3, and 4 × 4 assignment pairs), significantly more students chose the experimental assignment than chose the control assignment.

We used three Cochran's Q tests to compare the proportion of students who rated the experimental assignment more favorably with the proportion of students who rated the control assignment more favorably for difficulty, time, and effort. Each Cochran's Q test related to those assignment perceptions showed that significantly more students reported that the control assignments (a) were more difficult, $Q(94, 3) = 27.30$, $p < .005$; (b) would require more time to complete, $Q(94, 3) = 34.55$, $p < .001$; and (c) would require more effort to complete, $Q(94, 3) = 16.12$, $p < .005$, than the experimental assignments. For those analyses, η^2s = .211, .263, and .124, respectively. Power was large for all three

TABLE 1
No. Students who Chose the Control (Con) and Experimental (Exp) Assignments and Rated the Control and Experimental Assignments as Most Difficult, Most Time Consuming, and Requiring the Most Effort to Complete

		Assignment pair			
Variable	Q	4 × 1	4 × 2	4 × 3	4 × 4
No. students who chose	18.02*				
Con		28	19	15	9
Exp		66**	75**	79**	85**
No. students who chose as most difficult	27.30*				
Con		64	74	83	87
Exp		30**	20**	11**	7**
No. students who chose as most time consuming	34.55*				
Con		56	71	81	85
Exp		38	23**	13**	9**
No. students who chose as most effort	16.12*				
Con		63	74	78	81
Exp		31**	20**	16**	13**

*Cochran's Q, significant at $p < .05$. **Binomial (planned comparison) tests, significant at $p < .05$.

analyses (.990, .999, and .852, respectively). Twelve subsequent planned comparisons for assignment difficulty, time, and effort ratings across all four assignment pairs showed that (a) for the 4 × 2, 4 × 3, and 4 × 4 assignment pairs, significantly more students rated the experimental assignment more favorably than the control assignment for difficulty, time, and effort and (b) for the 4 × 1 assignment pair, significantly more students rated the experimental assignment more favorably than the control assignment for difficulty and effort, but not for time.

We also used post hoc statistical analyses described by Marascuilo and McSweeney (1967) to compare the proportion of students choosing the experimental assignment and the proportion of students who rated the experimental assignment more favorably for time, effort, and difficulty across target-problem types. Significantly fewer students chose the experimental 4 × 1 assignment than chose the experimental 4 × 3 and 4 × 4 assignments ($p < .05$). No other differences were found when the proportion of students choosing the experimental assignments was compared across target-problem types. When compared with the proportion of students who rated the 4 × 1 experimental assignment favorably, a significantly larger proportion of the students rated the 4 × 3 and the 4 × 4 experimental assignments favorably for difficulty, time, and effort ($p < .05$). Significantly more students rated the experimental 4 × 2 assignment favorably for time when compared with the proportion rating the experimental 4 × 1 assignment favorably for time. No other significant differences were observed across difficulty, time, and effort ratings for target-problem types.

Academic Performance

Total problems completed. Table 2 contains the mathematics performance data for total number of problems completed, number of target problems completed, and percentage of target problems completed accurately across all four assignment pairs. Repeated measures MANOVA for total problems completed revealed (a) a significant interaction effect, $F(93, 1) = 80.09$, $p < .005$; (b) a significant main effect for assignment type, $F(93, 1) = 734.11$, $p < .005$; and (c) a significant main effect for target-problem type, $F(93, 1) = 803.54$, $p < .005$. For the interaction, $\eta^2 = .911$ and power was large (1.0). For the main effect of assignment type, $\eta^2 = .945$ and power was large (1.0). For the main effect of problem type, $\eta^2 = .933$ and power was large (1.0). Newman–Keuls simple effects tests on the interaction showed that total problems completed were significantly greater on the 4 × 1 than on 4 × 2, 4 × 3, and 4 × 4 assignments. Total problems completed was also greater on the 4 × 2 than on the 4 × 4 assignment. Follow-up tests for assignment type showed that for each pair of assignments (4 × 1, 4 × 2, 4 × 3, 4 × 4), the experimental assignment resulted in significantly higher total problem completion rates than the control assignment. For target-

TABLE 2
Total No. Problems Completed, No. Target Problems Completed, and Percentage Target Problems Correct on Control and Experimental Assignments

	Assignment pair			
Variable	4 × 1	4 × 2	4 × 3	4 × 4
Total no. problems completed				
Control				
M	13.9	5.4	3.1	2.0
SD	4.1	2.1	1.2	1.5
Experimental				
M	18.5*	7.8*	4.9*	3.2*
SD	5.3	2.8	1.6	2.0
No. target problems completed				
Control				
M	13.9	5.4	3.1	2.0
SD	4.1	2.1	1.2	1.5
Experimental				
M	13.5	5.4	3.1	2.0
SD	4.1	2.0	1.1	1.4
% target problems correct				
Control				
M	77.2	58.0	47.1	33.6
SD	20.4	30.3	34.6	37.9
Experimental				
M	76.3	66.2	50.3	36.0
SD	18.0	27.0	36.8	38.6

*Newman–Keuls, significant at $p < .05$.

problem type, follow-up tests showed significantly more total problems completed on the 4 × 1 than on the 4 × 2, 4 × 3, and 4 × 4 assignments. The students also completed significantly more total problems on the 4 × 2 than on the 4 × 3 and 4 × 4 assignments. Finally, the students completed significantly more problems on the 4 × 3 than on the 4 × 4 assignment.

Target problems completed. For number of target problems completed, a significant main effect for target-problem type, $F(93, 1) = 811.11$, $p < .005$, was found. Follow-up tests showed significantly more target problems completed on the 4 × 1 than on the 4 × 2, 4 × 3, and 4 × 4 assignments. The students also completed significantly more target problems on the 4 × 2 than on the 4 × 3 and 4 × 4 assignments. Finally, the students completed significantly more target problems on the 4 × 3 than on the 4 × 4 assignment. Neither the main effect for assignment type, $F(93, 1) = 1.78$, $p = 0.186$, nor the interaction effect for target problems completed, $F(93, 1) = 1.43$, $p = 0.234$, was significant.

Percentage of target problems correct. A similar pattern was found for percentage of target problems correct. A significant main effect for target-problem type,

$F(93, 1) = 73.90$, $p < .005$, was found. Follow-up tests showed significantly higher target-problem accuracy levels on the 4 × 1 than on the 4 × 2, 4 × 3, and 4 × 4 assignments. Target-problem accuracy levels were also significantly higher on the 4 × 2 than on the 4 × 3 and 4 × 4 assignments. Finally, target-problem accuracy levels were significantly higher on the 4 × 3 than on the 4 × 4 assignment. Neither the main effect for assignment type, $F(93, 1) = 3.53$, $p = .063$, nor the interaction effect for percentage of target problems correct, $F(93, 1) = 1.00$, $p = .395$, was significant.

RPCR and Choice

Table 3 contains mean RPCRs (the total problems completed on the experimental sheet divided by the total problems completed on the control sheet) for each assignment pair. Although those differences appear relatively small, ANOVA showed a significant difference, $F(3, 1) = 13.12$, $p < .005$. Follow-up analysis using Tukey's HSD tests showed that the RPCR on the 4 × 4 assignment pair was greater than on the 4 × 1 and 4 × 2 assignment pairs. Furthermore, RPCR was greater on the 4 × 3 than on the 4 × 1 assignment pair. No other statistically significant differences were found for RPCR.

Relationship Between RPCR and Assignment Choice and Perceptions

One of the goals of the current investigation was to examine the relationship between RPCRs and student choice behavior. In addition to RPCR data, Table 3 contains the percentage of students who chose the experimental over the control

TABLE 3
Relative Problem Completion Rate (RPCR) Ratios and Percentages of Students who Chose the Experimental Assignment (Exp) and who Reported That the Experimental Assignment Was Less Difficult (Diff) and Would Take Less Effort and Time to Finish

Assignment Pair	RPCR ratio[a] ($\bar{X}$ Exp/$\bar{X}$ Con)	% Students who Chose Exp	% Students Rating Exp More Favorably for		
			Diff	Effort	Time
4 × 1	18.489/13.851 = 1.335	70	68	67	60
4 × 2	7.819/5.436 = 1.438	80	79	79	76
4 × 3	4.851/3.106 = 1.562	84	88	84	86
4 × 4	3.160/1.957 = 1.615	90	93	86	90

Note. Con = control assignment.
[a]RPCR for each pair of assignments was calculated by dividing the mean for the total number of problems completed on the experimental assignment ($\bar{X}$ Exp) by the mean for the total number of problems completed on the control assignment ($\bar{X}$ Con).

assignment across the four pairs of assignments, along with the percentages of students who reported that the experimental assignment was less difficult, less time consuming, and required less effort than the control assignment across all assignment pairs. Table 3 shows a clear relationship between RPCR and assignment choice and ratings. More specifically, as RPCR increased, (a) the probability of students' choosing the experimental assignment over the control assignment increased and (b) the probability of students' rating the experimental assignment more favorably (i.e., less time, less effort, less difficult) than the control assignment also increased.

Our primary hypothesis was that differences in RPCR across assignment pairs would account for differences in assignment choice and assignment perceptions across assignment pairs. Table 4 contains a summary of our post hoc findings for RPCR, choice, and assignment perceptions across assignment pairs. For two of the three assignment pairs with significant RPCR differences (i.e., 4 × 1 vs. 4 × 3 and 4 × 1 vs. 4 × 4), significant differences were also found for choice and assignment ratings of time, difficulty, and effort. The one exception was the significant difference in RPCR on 4 × 2 versus 4 × 4 problems, but the absence of significant differences for choice, effort, time, and difficulty across the 4 × 2 and 4 × 4 assignments. The three nonsignificant comparisons across target-problem pairs for RPCR were also accompanied by nonsignificant difference for choice, difficulty, time, and effort, with only one exception. That is, for the 4 × 1 versus 4 × 2 assignments, RPCR, choice, effort, and difficulty were not significant, but the difference in time ratings was significant. Although those comparisons are descriptive, they show a strong correspondence between significant differences on RPCR and assignment choice, and ratings across assignment pairs.

TABLE 4
Summary of Post Hoc Findings Across Target Problem Pairs for Relative Problem Completion Rates (RPCR), Proportion of Students who Chose the Experimental Assignment (Choice), and Proportion of Students who Reported That the Experimental Assignment Would Take Less Time and Effort to Finish and Was Less Difficult

Dependent variable	Assignment pair: 4 × 1 vs. 4 × 2	4 × 1 vs. 4 × 3	4 × 1 vs. 4 × 4	4 × 2 vs. 4 × 3	4 × 2 vs. 4 × 4	4 × 3 vs. 4 × 4
RPCR	*ns*	sig*	sig*	*ns*	sig*	*ns*
Choice	*ns*	sig*	sig*	*ns*	*ns*	*ns*
Effort	*ns*	sig*	sig*	*ns*	*ns*	*ns*
Difficulty	*ns*	sig*	sig*	*ns*	*ns*	*ns*
Time	sig*	sig*	sig*	*ns*	*ns*	*ns*

*Simultaneous confidence intervals, significant at $p < .05$ (Marascuilo & McSweeney, 1967).

Discussion

In the current study, across all four pairs of assignments, significantly more students chose a new experimental-format assignment for homework than chose a new control-format assignment for homework. Although the experimental assignments contained more problems than the control assignments, the students rated the experimental assignments as requiring less effort and time to complete and as being less difficult than the control assignments. Furthermore, across all four assignments, interspersing the additional 1 × 1 problems did not affect the students' rates of responding to target problems or target-problem accuracy levels. Thus, the current experiment confirmed earlier studies that showed that the interspersal technique could enhance students' perceptions of assignments without (a) reducing the number of target problems in each assignment (i.e., watering down the curriculum), (b) reducing accuracy levels on target problems, or (c) reducing rates of target-problem completion (Cates et al., 1998; Logan & Skinner, 1998; Skinner, Fletcher et al., 1996; Skinner, Robinson et al., 1996; Wildmon et al., 1998).

The primary purpose of the current study was to investigate the hypothesis posited by Skinner, Robinson et al. (1996) that during independent seat-work, completing a problem may be a reinforcing event. Researchers investigating the matching law have shown that when given a choice of two academic assignments, if all other variables are held constant across assignments (e.g., task difficulty and effort levels, quality of reinforcers), students are more likely to chose to engage in the assignment that results in the greater rates of reinforcement (e.g., Mace et al., 1990). Furthermore, the larger the discrepancy between the rates of reinforcement, the more likely students are to choose to work on the assignment that yields relatively greater rates of reinforcement (e.g., Mace et al., 1990; Neef et al., 1993). In the current study, we manipulated RPCR by altering the number of digits in the target problems. Results showed that as the difference in RPCR increased across paired experimental and control assignments, the proportion of students who chose and rated favorably the assignment that resulted in greater problem completion rates (i.e., the experimental assignment) also increased in accordance with the matching law. Therefore, the current results support the hypothesis posited by Skinner, Robinson et al. (1996) that during independent seat-work, problem or task completion may be a reinforcing event.

Previous researchers have found evidence suggesting that when all other variables are held constant, students prefer assignments that are briefer or easier (Cooke et al., 1993; Horner & Day, 1991; Kern et al., 1994). If completing a problem is a reinforcing event, then in the current study and in previous research of the interspersal technique, relative rates of problem completion across the different assignments could be the causal mechanism responsible for students' choosing and preferring the assignment that required more effort to complete

(Cates et al., 1998; Logan & Skinner, 1998; Skinner, Fletcher et al., 1996; Skinner, Robinson et al., 1996; Wildmon et al., 1998). Thus, in the current study and in past investigations of the interspersal technique, the students may have preferred and chosen the longer experimental assignment because it resulted in relatively higher problem completion rates and rates of reinforcement.

Although the current study has clear applied implications, those implications must be considered in light of the theoretical and methodological limitations associated with the current experiment. Our results provide indirect support for the hypothesis that interspersing brief problems causes increases in problem completion rates and rates of reinforcement, which in turn cause students to prefer those assignments. However, we did not provide conclusive evidence for that causal chain. Relative problem completion rates may operate like, as opposed to being equivalent to, relative rates of reinforcement (Logan & Skinner, 1998). Furthermore, the students' preference for the experimental assignment may not have been related to relative problem completion rates. Instead, the interspersal technique may have caused the students to perceive the experimental assignments more favorably (see time, effort, and difficulty ratings), which may be the sole causal variable responsible for the observed student choice and preference findings. If that is the case, then future researchers should further investigate the causal sequence to determine what characteristics of the interspersal technique caused those favorable perceptions.

If problem completion is a reinforcing event, researchers should attempt to determine if it is a positively or negatively reinforcing event (Logan & Skinner, 1998). Problem completion may be a conditioned positively reinforcing event because students have a past history of being rewarded for completing tasks. Problem completion could also be a reinforcing event because it serves as a stimulus that signals that students are closer to being finished with the overall assignment (see Nelson, 1981, for a similar description of plausible mechanisms that may account for reactivity when self-monitoring is used). Completing an assignment may be reinforcing because after completing an assignment, students are able to engage in higher probability behaviors (e.g., positive reinforcement, Premack principle) without being punished for not completing their assignment (e.g., negative reinforcement, escape punishment). Because educators have reduced assignment demands to reinforce behaviors (e.g., positive practice overcorrect and contingent skipping), it is also possible that problem completion is a negatively reinforcing event because it results in one less academic demand (Logan & Skinner, 1998).

The current study also has methodological limitations that should be addressed by future researchers. First, student choice and perception data required a forced choice that did not allow students to assign equal choice, effort, time, or difficulty ratings across assignments. Future researchers should use procedures that allow for equal ratings. Second, it is not clear if those results would hold up over repeated choice trials. For example, after many exposures to experimental and control assignments, students may learn that the experimental assignments contain additional problems and may begin choosing control assignments because they require less effort to complete. That is particularly likely to occur if assignment completion is a high-quality but delayed reinforcing event and problem completion serves as a low-quality immediate reinforcing stimulus because it signals to students that they are getting closer to the stronger reinforcer, completing the assignment.

Because multiplication computation was not part of the regular curriculum of the students who participated in the current study and no consequences (e.g., grades) were delivered based on mathematics performance, those results may not generalize to typical classroom assignments. Thus, future research is needed to assess the external validity of the present findings. Previous researchers have found that students are more likely to stay on task and less likely to engage in inappropriate or disruptive behaviors when given assignments they prefer (Dunlap & Kern, 1996) or when the rate of reinforcement for appropriate behavior is increased (Martens & Houk, 1989; Martens et al., 1992). Therefore, future researchers should investigate the impact of the interspersal technique on off-task, on-task, and disruptive classroom behavior.

If the findings of the present study are found to have external validity, they have significant applied implications. Interspersing brief, easy tasks would be an efficient way for educators to increase the probability that students will choose to work independently on school assignments across educational settings. Furthermore, the technique may improve students' overall perceptions of learning, school work, or specific academic subjects. Finally, this technique could be applied across a variety of other behaviors composed of distinct tasks. For example, this research may have applications for assembly line workers, exercise-class participants, and students practicing music. Given the efficiency of the interspersal technique and the breadth of application, researchers should continue to conduct studies to more clearly determine the causal mechanism responsible for the effects of the interspersal technique in order to better understand the behaviors, settings, and tasks in which that procedure is likely to be effective.

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