Helping students remember: Can *spaced retrieval practice* improve STEM course performance?

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Background/Need

Foundation:

- Easy-to-implement pedagogical strategies in **STEM barrier courses** are needed, to increase the pool of students capable of STEM careers.
- Spaced retrieval practice is one such memory-enhancing technique, in which multiple questions about the same topic are administered over time, with delays in-between.
- Traditionally, undergraduate STEM courses include only massed retrieval opportunities, in which all questions on the same topic are asked in a short span of time.
- This study builds on two previous NSF IUSE awards (#1431544 and #1609290) which examined the independent and additive effects of spaced retrieval practice in a precalculus course for engineering students. Spacing improved performance by 3-5%, roughly 1/3 - 1/2 of a letter grade.

Study Design

Objectives:

We implemented and assessed the impact of spaced retrieval practice in nine STEM courses at UofL: mathematics, physics, chemistry, biology, psychology and engineering.

Research Questions:

1. Does spaced retrieval practice (versus massed) increase retention of objective-specific knowledge in a variety of STEM courses?
2. Is spaced retrieval practice ineffective in any courses?
3. In those courses in which spaced retrieval practice leads to greater retention than massed retrieval practice, does the magnitude of the spacing-related benefit differ?

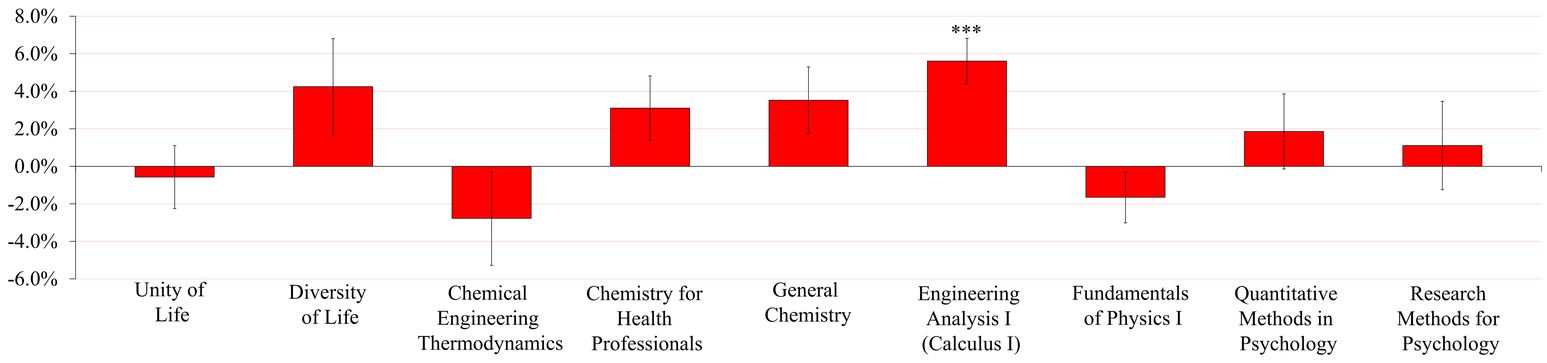
Study Design:

- Within-subjects manipulation, identical in all nine courses.
- For each of 24 learning objectives, 3 quiz questions were either spaced across 3 quizzes over 5 weeks or massed on a single quiz.
- Retention was assessed on a criterial test at the end of the semester.

Weeks	Learning Objectives*	Condition	Quiz 1	Quiz 2	Quiz 3	Quiz 4	Quiz 5
			Week 3	Week 5	Week 7	Week 9	Week 11
1-3	1, 3, 5, 7	*Massed*	3				
	2, 4, 6, 8	*Spaced*	1	1	1		
4-5	9, 11, 13, 15	*Massed*		3			
	10, 12, 14, 16	*Spaced*		1	1	1	
6-7	17, 19, 21, 23	*Massed*			3		
	18, 20, 22, 24	*Spaced*			1	1	1
* LO assignments were counter-balanced across two student groups.		# Items per Quiz	16	20	24	8	4

Results

Mean Difference in Performance on the Criterial Test (*spaced – massed)*



Course	*M*	*SE*	*t*	*df*	*p*
Unity of Life	-0.6%	1.7%	-0.340	101	.735
Diversity of Life	4.2%	2.6%	1.659	50	.103
Chemical Engineering Thermodynamics	-2.8%	2.5%	-1.110	41	.274
Chemistry for Health Professionals	3.1%	1.7%	1.812	111	.073
General Chemistry	3.5%	1.8%	1.980	60	.052
Engineering Analysis I (Calculus I)	5.6%	1.2%	4.641	179	< .001
Fundamentals of Physics I	-1.7%	1.4%	-1.209	105	.229
Quantitative Methods in Psychology	1.9%	2.0%	0.928	73	.357
Research Methods for Psychology	1.1%	2.4%	0.472	29	.641

- Clear cut evidence of a spacing effect was obtained only in the calculus course for engineering students.
- The magnitude of the effect was 6%, similar to that in the precalculus studies, and the positive effect in calculus was robust across subpopulations.
- Modest , but nonsignificant gains were found in one biology course, both chemistry courses, and the psychology courses.
- No discernible effect was found in one biology course, thermodynamics and physics.

Discussion

Summary and Implications:

- This study confirms a positive effect of spacing for mathematics undergraduate education, but generalizability of spaced retrieval benefit across STEM domains is elusive.
- Results support the adoption of spaced retrieval practice to increase student success in mathematics.
- Increasing success in mathematics should support STEM education broadly.

Future Work:

- Investigate potential moderators of applied spaced retrieval practice, such as intrinsic spacing within courses, type of knowledge being recalled, and individual differences in the student samples.
- Continue to study spaced retrieval practice in the classroom to understand applied benefits.

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