

Learning Benefits of On-Line Spaced Education Persist for 2 Years

B. Price Kerfoot*,†

From the Veterans Affairs Boston Healthcare System and Harvard Medical School, Boston, Massachusetts

Purpose: A total of 537 urology residents participated in a randomized trial of on-line spaced education in 2005 that used 96 American Urological Association Self-Assessment Study Program questions as educational material. I investigated whether the learning gains generated by the spaced education program could be detected 2 years later.

Materials and Methods: A test instrument was constructed with 60 of the 96 Self-Assessment Study Program questions from the 2005 trial. These multiple choice questions were delivered to residents from September to November 2007 via daily interactive e-mails. Residents submitted answers on line and were included in analysis if they completed 85% or greater of the questions.

Results: Of the 537 residents in the 2005 trial 206 (38%) were still in residency and volunteered to complete the test. Of those residents 104 (50%) were randomized to the spaced education cohort, 102 (50%) were randomized to the bolus cohort and 147 (71%) submitted answers to 85% or greater of the test questions. There were no significant differences in age, gender, degree or training year between the cohorts. Residents in the spaced education cohort had significantly greater test scores than residents in the bolus cohort (mean \pm SD 70.2% \pm 9.0% vs 66.8% \pm 10.6%, effect size 0.35, $p = 0.03$).

Conclusions: On-line spaced education can generate improvements in learning that are retained 2 years later. Although the effect size is modest, the persistence of detectable knowledge differences between educational interventions after such a long duration is exceedingly unusual. Further research is needed to determine how spaced education can best be used to optimize lifelong learning for urologists.

Key Words: education, medical; internship and residency; educational technology; urology; retention (psychology)

THE retention of learning from traditional and on-line sources is often quite poor.¹⁻⁹ On-line spaced education programs attempt to improve knowledge retention by harnessing the pedagogical merits of the spacing effect. The spacing effect refers to the psychological finding that educational encounters that are repeated during spaced intervals result in more efficient learning and greater retention compared to that of the massed distribution of educational encounters.¹⁰ This effect has a distinct neurophysiological basis. A re-

cent study demonstrated that spaced learning in rats improved neuronal longevity in the hippocampus and the strength of the rat memories correlated with the number of new cells in this region of the brain.¹¹

In a 2005 trial to assess the efficacy of on-line spaced education 537 urology residents preparing for the November 2005 national in-service examination were randomized to receive 1) a validated set of 96 American Urological Association SASP study questions in June 2005 for self-study or 2) daily spaced

Abbreviations and Acronyms

RI = retention interval

SASP = Self-Assessment Study Program

SI = spacing interval

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Study received institutional review board approval.

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* Correspondence: Veterans Affairs Boston Healthcare System, 150 South Huntington Ave., 151DIA, Jamaica Plain, Massachusetts 02130 (telephone: 774-286-9230; FAX: 857-364-6561; e-mail: price.kerfoot@gmail.com).

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education e-mails during the 27 weeks from June to December 2005.¹² Each daily e-mail contained 2 of these 96 study questions. After initial presentation the identical questions were then resent to the residents 1 and 3 weeks later. This expanding pattern of spacing intervals was shown to improve learning retention compared to intervals of equal duration.¹³ The educational content provided to the residents in the 2 cohorts was identical. During the 14 weeks after completing the spaced education program residents in each cohort were tested using a subset of 32 of the 96 study questions. Residents in the spaced education cohort had significantly greater learning and retention than those in the bolus cohort even after adjusting for differences in study question use.¹²

Followup studies have since confirmed the educational efficacy of the spaced education methodology.^{14,15} However, it is unclear how long the learning benefits of this methodology persist. Two years after the completion of the 2005 trial I investigated whether the learning gains generated by this spaced education program could still be detected.

METHODS

A test instrument was constructed with 60 of the 96 validated SASP study questions used in the 2005 trial. None of these 60 questions had been used for the 32-item delayed test in that trial. These questions were selected by a urology expert based on content validity. Each SASP question contains several elements, including 1) a multiple choice question on a core urology topic, 2) the correct answer to the question, 3) a detailed explanation of the correct and incorrect answers, and 4) a reference to pertinent data in the medical literature. SASP study questions are developed through an iterative process of content validation and psychometric analysis by a panel of 10 to 12 urologists on the American Urological Association/American Board of Urology examination committee.

The SASP multiple choice questions were delivered to residents from September to November 2007 via daily interactive e-mails and answers were submitted on line. Residents were included in analysis when they submitted answers to 85% or greater of the questions. Test scores were calculated as the number of questions answered correctly normalized to a percent scale and analyzed with the 2-tailed t test. Intervention effect size was measured by Cohen's *d*,¹⁶ which expresses the difference between the means in terms of SD units with 0.2 generally considered a small effect and 0.5 considered a moderate effect. The study received institutional review board approval.

RESULTS

Of the 537 residents in the 2005 trial 206 (38%) were still in residency and volunteered to complete the test. Of the participants 104 (50%) had been randomized to the spaced education cohort in the 2005 trial and 102 (50%) had been randomized to the bolus cohort. Of

these 206 residents 147 (71%) submitted answers to 85% or greater of the test questions. Completion rates were similar in the 2 cohorts. There were no significant differences in age, gender, degree or year of urology training between the cohorts (see table). Cronbach α reliability (internal consistency) of the 60-item test was 0.68.

Residents in the spaced education cohort had significantly greater test scores than residents in the bolus cohort (mean \pm SD 70.2% \pm 9.0% vs 66.8% \pm 10.6%, effect size 0.35, $p = 0.03$). Similar results were obtained when analyzing the scores of only residents who reported most actively using the educational materials during the 2005 trial (71.5% \pm 8.7% in 58 in the spaced education cohort vs 67.6% \pm 10.7% in 53 in the bolus cohort, effect size 0.40, $p = 0.03$).

DISCUSSION

These results demonstrate that on-line spaced education can generate improvements in learning that are retained 2 years later. Although the effect size was modest, the persistence of detectable knowledge differences between educational interventions after such a long duration is exceedingly unusual.^{1,5-7} Differential use of the study questions between the cohorts does not explain these findings since similar results were obtained when restricting analysis to residents who most actively used the educational materials during the 2005 trial. These results are particularly striking since the growth of urology knowledge during these 2 years would have worked to erode any knowledge differences between the cohorts that were attributable to the spaced education methodology. Given this, the ability to detect any knowledge difference between

Characteristics of residents participating in learning retention assessment

	All Participants*		Completed 85% or Greater* of Questions	
	Bolus	Spaced Education	Bolus	Spaced Education
No. residents	102	104	74	73
No. sex (%):				
M	80 (78)	84 (81)	54 (73)	60 (82)
F	22 (22)	20 (19)	20 (27)	13 (18)
Mean \pm SD age	31.6 \pm 3.1	31.1 \pm 2.7	31.9 \pm 3.5	31.2 \pm 3.1
No. degree (%):				
MD	93 (91)	93 (89)	66 (89)	66 (90)
MD/other (PhD, MPH etc)	7 (7)	7 (7)	6 (8)	6 (8)
DO	2 (2)	4 (4)	2 (3)	1 (1)
No. urology training yr (%):				
1	0	3 (3)	0	1 (1)
2	6 (6)	7 (7)	4 (5)	6 (8)
3	37 (36)	42 (40)	29 (39)	28 (38)
4	59 (58)	52 (52)	41 (55)	38 (52)

* No statistically significant differences and percents may not total 100% due to rounding.

cohorts 2 years after the spaced education intervention is surprising.

Recent data indicate that the long-term retention benefits of spaced education can be further improved by increasing the duration of the spacing intervals. Psychologists have noted that the optimal SI increases with the interval during which the material is to be remembered, termed RI.¹⁷ One study showed that that the 3-week SI in the 2005 trial was optimal for a 50-week RI (6% SI/RI ratio).¹⁷ Other studies have shown that the optimal SI/RI ratio is approximately 10% when the RI is substantial. Based on these data we now construct our spaced education programs to use a spacing interval of 6 weeks to optimize retention 1 to 2 years (60 to 100 weeks) later.

The gradual but long-term learning generated by spaced education appears to be particularly well suited for the generation and maintenance of clinical knowledge in health care providers. This methodology stands in stark contrast with the “binge-and-purge” bolus methods of education that are the norm in continuing medical education. Clinician medical training represents a progressively eroding platform of knowledge that must be maintained with time if clinicians are to apply this knowledge effectively to optimize patient care. Further research is needed to determine how spaced education can best be used to facilitate urologist maintenance of certification and decrease the substantial burdens of the maintenance of certification process.

There are several limitations to our study, including the fact that the content focused only on urology and participants were restricted to urology residents. Further study is needed to determine the generalizability of the long-term retention benefits of spaced education to other content domains and to other groups of learners. In addition, the degree to which the knowledge improvements detected in this study were due to improved knowledge acquisition and/or improved knowledge retention is not clear. Studies are currently under way to investigate these 2 possibilities. Also, only 38% of the original residents in the 2005 study participated in this 2-year followup evaluation. While a selection bias in our results cannot be ruled out, this is highly unlikely, given that the 2005 randomization was still well balanced among participants 2 years later (see table). The strengths of the study include its focus on long-term learning outcomes, the large number of participants and its randomized, controlled design.

CONCLUSIONS

On-line spaced education can generate improvements in learning that persist 2 years later. Further research is needed to determine how spaced education can best be used to optimize lifelong learning for urologists and facilitate their maintenance of certification.

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