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Implementation of best practices in online learning: A review and future directions

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IMPLEMENTATION OF BEST PRACTICES IN ONLINE LEARNING: A REVIEW AND FUTURE DIRECTIONS

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Abstract

Best practices for helping students learn and retain information have been well established by research in cognitive science [1, 2]. Specifically, repeated testing has been shown in numerous instances to enhance recall. In particular, we know that students retain information best when it has been recalled versus re-studied [3] and rehearsed with delayed (spaced) versus massed presentation [4], and when the items to be studied and later tested are similarly framed [5]. Although these effects were initially demonstrated in laboratory settings, a number of researchers have shown that they generalize to classroom environments [6] and some have demonstrated their utility in fully online courses as well [5]. However, in multiple studies we have found that implementing some of these best practices using publisher-provided textbook technology supplements (TTS) does not meaningfully improve recall [7, 8], at least when these supplements are used "out-of-the-box" in face-to-face courses. We conclude when using TTS in an online environment there is a mismatch between student and faculty goals, in that students are motivated by short-term goals of getting high score of a quiz even if the behaviors used to achieve that score do not enhance long-term recall or generalization of the learned material, which typically are the goals of faculty. We argue that TTS can be reconfigured to reinforce meaningful engagement with the material for all students, regardless of learning history or other individual differences of students [9]. To continue to require the purchase of these TTS by students their use must benefit student learning.

A related empirical question is whether recall of factual information in an online environment is correlated with the later ability to use that information in a novel situation (generalizability). Whereas some researchers have found that factual information learned via repeated testing does help students to draw inferences about the implications of those facts in later testing [3], others have failed to find a correlation between testing effects and generalizability of the learned material [9]. The literature on this question is still somewhat small, however, [see 10 for a brief review] and this is particularly true of investigations involving online learning.

In this paper we review the existing literature of the spacing benefit and online learning. We end with a proposal for the need of new research specific to the online environment that manipulates delayed repeated testing and examines whether successful retention of factual information promotes long-term application of that material.

Keywords: Online Learning, Undergraduate, Cognitive Science, Behavior Analysis.

1 INTRODUCTION

Improving performance in educational settings is a goal shared by students, parents, faculty, and administrators. Fortunately, scientists in many fields (e.g., cognitive, education, behavioral) have provided evidence supporting best practices to maximize learning. A recent review [2] evaluated the efficacy of ten easy-to-use learning techniques derived from basic research in cognitive psychology as having potential to help students achieve their learning goals. Based on published studies of these techniques, they found that study tools such as highlighting, summarizing, mnemonics, and re-reading, while used by many students, have limitations to their effectiveness, such that the techniques only work for certain material or with some students. Of the ten successful techniques identified, repeated testing and distributed (spaced) practice were two practices with much promise as they have been found to benefit learners of different ages and abilities and have been shown to boost students' performance across many criterion tasks and even in educational contexts.

Repeated testing, also known as the testing benefit, has been demonstrated by many researchers to improve learning [e.g.,11, 12, 13]. For example, in one experiment, Roediger and Karpicke [13] asked undergraduates to study a passage about a scientific topic (e.g., "The Sun"). Some students then restudied the passage three more times in consecutive 5-minute periods (the SSSS condition). A second group studied the passage two additional times but then was asked to freely recall as much

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about the passage as possible (SSST condition). A third group was asked to complete three free recall periods following the initial study period (STTT condition). A final test (also free recall) then took place either 5 minutes or 1 week following this phase of the experiment. Roediger and Karpicke found that although restudying produced short-term gains (at the 5 minute test), testing, especially repeated testing (STTT), produced significantly greater gains over the longer 1 week interval. It is important to note that these gains took place even in the absence of feedback about whether students had correctly recalled the passages during the initial test periods, suggesting that something about the retrieval process itself enhances retention. The benefits of repeated retrieval are also not limited to free recall testing. McDaniel et al. found that both multiple-choice and short-answer quizzes improved performance on a final multiple-choice test, relative to just reading the facts being tested [11]. Facts learned via short-answer quizzes were retained the best.

In laboratory investigations, repeated testing often occurs within one session (i.e., often within about a one hour period), also known as massed learning. Many studies have shown that repeated testing is most impactful on learning when the re-test is delayed, which allows for some forgetting to occur and for retrieval to be more difficult [14]. This spaced retrieval is even better for remembering than massed learning [4]. For example, one study taught 7-10 year old children unassociated word pairs and then re-tested them with cued recall either immediately or after the presentation of other word-pairs [15]. They found that the children recalled more words at test when the words were presented in a spaced rather than massed fashion.

Although these testing and spacing benefits were initially demonstrated in laboratory settings, a number of researchers have shown that they generalize to classroom environments [6] and some have demonstrated their utility in fully online courses as well [5].

1.1 Benefits of online learning

Online learning may be particularly useful in helping students gain extra practice with difficult material outside of class so that they are more prepared to participate in class discussions that require higher level thinking. As online learning has increased in popularity [16], so have the number of empirical investigations designed to test its effectiveness for student learning. A number of researchers have found improvements in student learning using online study tools, hereafter referred to as textbook technology supplements (TTS) [5, 17, 18]. For example, using a within-subjects design, McDaniel et al., found that students in an online course performed better on exam items when they had previously answered multiple-choice or short-answer questions about those items [5]. Gurung examined TTS from three different publishers and found positive correlations between time spent using these online tools and students' performance on in-class assessments, even when controlling for GPA [17].

Van Camp and Baugh [18] examined the use of publisher provided online learning tools (*MyPsychLab*, Pearson) in their Introductory Psychology course and found that students believed the tools helped them learn and that they enjoyed using the online tools as part of the course. While Van Camp and Baugh found that students who used the tools did better than students who did not, when the tools were required for the class, there was no difference in the mean course grade compared to courses not using the tools. One possible conclusion is that good students use tools when they're available and not-as-good students do not.

1.2 Failure to find online learning benefits

Not all studies that have assessed the effectiveness of TTS have produced such positive findings, however [19, 20]. Several experiments from our own lab [7, 8], using TTS from two different publishers (Norton's *SmartWork* and Pearson's *MyPsychLab*) revealed no meaningful improvements on in-class quiz performance when students used TTS as a component of the course compared to instances where the TTS was not used. The general paradigm we followed was to randomly assign students to either use or not use TTS to prepare for in class quizzes during one half of the course and, had there been a benefit, they would demonstrate a testing benefit accordingly. In other words, half of the students would presumably benefit from using online study tools (quizzes, or, in one experiment, responding to a writing prompt) in the first half of the quarter whereas the other half should benefit during their "TTS weeks" which were assigned to them for the second half of the quarter. To determine whether the benefits occurred, we examined in class quiz scores on chapters corresponding to "on" and "off" weeks (and sometimes multi-chapter exam scores depending on how the course schedule was structured). Across four experiments using this design, we failed to find improvements on in-class assessments as a function of TTS use, except in one case, in which the level of improvement was statistically significant but small (3.5% increase in scores). In a fifth experiment, we also attempted to manipulate students' use of the TTS in order to create a spacing effect. There we used a between-subjects design where students were randomly assigned to complete a publisher-provided online quiz either *before* the in-class quiz (the massed condition) or *after* the in-class quiz (the spaced condition) but before the midterm exam in which that chapter's material would be included. We reasoned that students in the after condition would benefit from retrieving material that they had been tested on earlier relative to students who had taken the quiz for that chapter's material (perhaps the night before) and then "moved on." Thus, we expected students completing the online quizzes before the in-class quiz would perform better on that quiz but more poorly on those chapter items on the midterm exam; the reverse was expected for the students taking the online quiz after the in-class quiz. We found no significant effect of spacing condition on students' in class assessment scores.

Recent work by Becker-Blease and Bostwick [21] also showed few learning gains associated with students' use of a TTS featuring adaptive quizzing (Macmillan's *LearningCurve*). Tools that feature adaptive quizzing are designed to provide students with more difficult questions as they master easier ones, "adapting" to an individual student's current state of understanding. Instructors teaching multiple sections of introductory psychology were asked to randomly assign one section to use *LearningCurve* as part of the course requirement. Completion of adaptive quizzes to a criterion level of performance counted as 20% of the grade in these sections, whereas in the other sections, students had access to *LearningCurve* but its use was not required. Learning gains, as measured by improvement from a pre-test at the start of the quarter to a post-test at the end, were not significantly different across the sections with and without the *LearningCurve* requirement. In their second study, all students in one section of introductory psychology were required to complete a series of adaptive quizzes as part of their course grade. Although Becker-Blease and Bostwick found that students' performance on the adaptive quizzing portion of the course (number of difficult questions answered correctly) positively predicted their post-test and final exam scores, this correlation was significantly diminished when students' pre-test scores and SAT scores were partialled out. They propose that although some students might use these kinds of TTS to boost their learning, others may not use them or use them effectively, even when they are part of the course requirement. This is a similar conclusion to that drawn by Van Camp and Baugh [18] who found that requiring use of Pearson's *MyPsychLab* did not improve overall course grades in those sections, although students who chose to use it performed better on class exams.

1.3 Mismatch model

A potential problem when integrating technology or any manipulation to improve student learning is the mismatch between faculty and student goals. One of the challenges facing TTS designers is that students will often be interacting with the content in a way that makes them objectively successful as evidenced by performance on quizzes and the like, yet does not necessarily enhance learning. The typical student is not only taking multiple classes simultaneously, each demanding some of her attention, she will also be spending time with family obligations, friends, perhaps a job, eating, sleeping, and so on. Thus, to be a successful student she will have to learn how to budget her time. This means finding ways to be efficient in completing assignments. In a TTS it is often the case that students can successfully streamline their progress by having the textbook on hand, searching Google, or working with a friend. Students will choose ways to interact with the content that is not necessarily what the instructor expects or wants the student to be doing. In other words, the strategies students use may make them successful in terms of earning points or getting a grade, but this is not necessarily the same as doing the learning the instructor has in mind. Even if one assumes that a student is fully engaged and not seeking "shortcut" strategies, she may not necessarily identify which learning strategies will be most effective, as Karpicke and Blunt [22] showed when they asked students to judge which of a number of study techniques (rereading, generating a concept map, free recall) would be most effective. Student judgements incorrectly predicted that concept mapping would yield better learning than retrieval practice when, in fact, the opposite was true. None of this is a condemnation of students -- to paraphrase Skinner [23], the student is always right and will engage in strategies that make her successful. The responsibility falls to the instructor to ensure that what the students do allows them to learn the material.

One specific example of where a mismatch could occur might be if an instructor used the SQ3R model (survey, question, read, recite, and review) [24] as a framework for designing their online tools. The SQ3R model is fairly ubiquitous (something a quick Google search reveals). Instructors assume that students will follow something akin to this model: they read the chapter, recite the material (the place where the TTS would most likely be used as a tool for "reciting" the material), and then review the chapter material again if they did not score well on the online quiz.

In our own work examining the effectiveness of TTS, one of our starting assumptions was that the items in the online quiz would not have to be the same or even similar (on same page of content) in order for online supplements to "work" because the function of the online test was to give students feedback about their general level of comfort with recalling the material. That is, we made the assumption that students would use the TTS for their "recite" activity, and follow this with a "review" as a way to prepare for their in-class assessments. Research has shown, however, that testing can improve later recall even if feedback is absent and no review of material occurs [13]. Where multiple-choice items are concerned, however, most evidence for testing effects has been demonstrated in studies where the target items are identical [25] or closely related versions of the initial test items [5] . In fact, items that are on the final test but were NOT part of the initial test, even if related to the overall topic, are often used as controls to demonstrate that only tested material receives the "bump." We had assumed that online quizzing would function in a different way, that is, to catalyze an iterative "retrieve-review" process, triggered by the feedback students received about their overall level of success in recalling chapter material. In this model, whether test items match or are tightly yoked in online versus in-class assessments would not be as critical.

Although we probably *could* get testing effects using online technology where students are presented with identical (or very similar) questions, the fact that these effects require no active recognition of their global level of comfort with the material means that using that approach will likely not lead to lasting and generalizable learning gains. If we assume that we can reliably get testing benefits through the use of online quizzing, the question remains as to whether or not students will be able to recall material *only* if it is the same question (or slightly modified) or if it will generalize. Clearly, most faculty set more ambitious goals for student learning than simply answering already-asked questions.

Even getting students to process information more deeply or effortfully in online environments may be necessary but not sufficient to get the kind of learning we want. Karpicke and Blunt [22] compared study conditions in which students were either required to 1) study the material once, 2) study the material four times, 3) study the material and then generate a concept map (an effortful task that also requires processing the materials' meaning), or 4) engage in two "cycles" of study-free recall. They found that the study-recall-study-recall iterative process seemed to produce the best retention of material, for both verbatim and inference questions on the final test. Asking students to do a common "active learning" task such as generating a concept map does not seem to trump the benefits of repeated recall, punctuated by opportunities to review the material.

Can repeated testing of specific items somehow lead students to be able to generalize their understanding to related questions or even make inferences about the material or use it in novel ways to generate solutions to problems? Carpenter [10] recently reviewed the empirical evidence on whether testing effects transfer over time, across testing formats (e.g., multiple choice vs. short answer), and across content areas and found that the testing effect can transfer in each of those situations. There are other demonstrations that testing of a specific fact can improve recall of related facts. For example, Chan, McDermott, and Roediger [26] found that repeated testing of specific facts (e.g., where do toucans sleep?) led to improved recall of related but untested facts (e.g., what other bird species is a toucan related to?).

Butler [3] demonstrated (in the laboratory) that repeated testing is better than repeated studying even when students are asked factual questions during the initial testing (e.g.,"Bats are one of the most prevalent orders of mammals. Approximately how many bat species are there in the world?") and inferential questions during final test (e.g., "There are about 5,500 species of mammals in the world. Approximately what percent of all mammal species are species of bat?"). Further, Butler found testing superior to studying when students had to make inferences about a new domain that was different from the initially tested domain, yet sharing some parallels (e.g., initially tested on bat wing structure with final test about aircraft wings).

Although one could argue that these facts do not represent different content domains, testing of one fact had a "bootstrapping" effect on recall of other facts. It is unclear whether or not this bootstrapping effect of repeated testing might occur not just for factual questions (Bloom's Remember level) but also whether repeated testing at one level might enhance performance on higher levels (e.g., Bloom's Apply, Analyze, Evaluate levels, [27]).

Nguyen and McDaniel [28], in a laboratory study, manipulated whether students learned material using a 3R (read, recite, and review) approach or a Meta3R approach. The Meta3R approach included the standard reading and reciting tasks (in their study, free recall of information orally recited into a tape recorder). Before engaging in the review, however, subjects had to make Judgments of Inference (JOI). A JOI entailed making a self-assessment of how well the student believed he or she could use the information read about to make inferences or solve problems relevant to the topic. For example, when reading about how brakes work, a student would be presented with the item "On a scale of 0 (definitely will not) to 100 (definitely will) how likely are you to be able to distinguish between the different types of brakes/pumps?" (p. 62). Nguyen and McDaniel found that students who made JOIs performed no better than students using the standard 3R approach on fact-based multiple choice items on the final test. However, students using the Meta3R technique outperformed students using the standard approach on inference-based multiple choice items. Both 3R conditions led to better recall than note-taking control groups. It seems that if we want students to be able to extrapolate beyond the test items in the online quiz, they may need a metacognitive experience where they indicate whether or not they have thoroughly learned the material and, in response to that feedback, take the final step of reviewing the material. Laboratory studies can ensure that students take this final review step. It is a significant challenge, however, to ensure this behavior occurs in the online environment.

Some degree of mismatch between instructor expectations and student behavior may be remedied by requiring students to engage in some reflection. The challenge is that unlike an in-class exam or an oral presentation, it is difficult if not impossible to monitor what students are actually doing when they are interacting with the TTSs. As Figure 1 suggests, instructors really have limited control over how students interact once the system is in place. Taking steps to improve student learning must begin with a careful analysis of the use of basic cognitive psychology applied to college student learning (see [1, 2] for examples). Additionally, one powerful factor generally neglected by cognitive psychology comes from behavior analysis (see [29] for a review of techniques) which leverages the power of operant contingencies to affect changes in student responding.

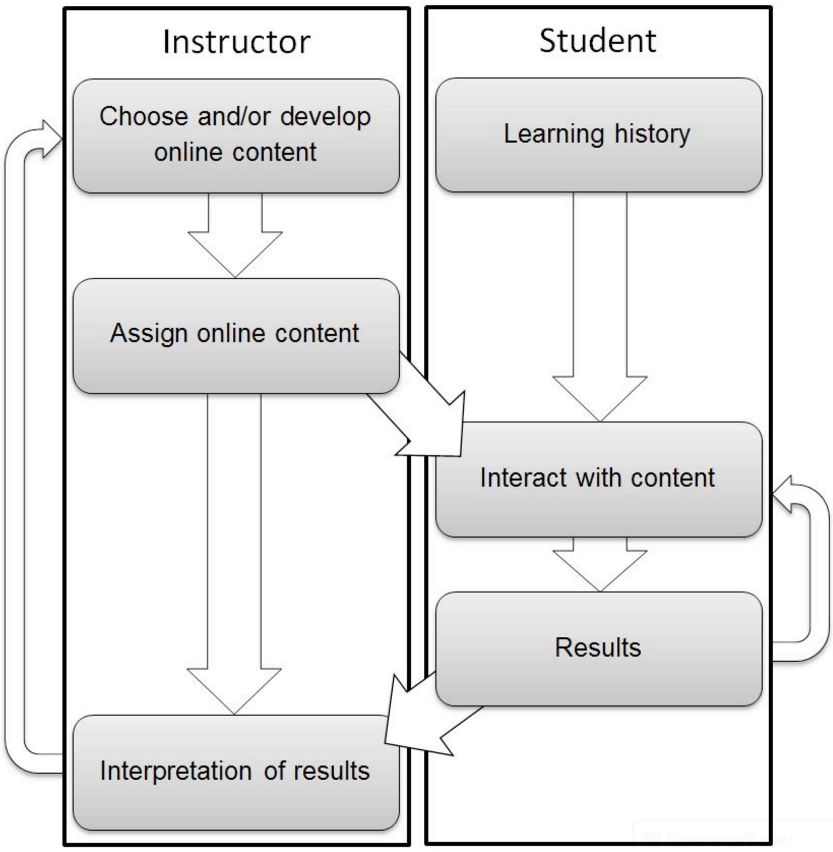

FIGURE 1. A theoretical process of key activities for both instructor and student that must be accounted for in any good learning system.

Initially the instructor must either identify ready-made materials or develop their own online content. What are the course goals? What should students be able to do when they leave the course? Quality content (online or otherwise) should consider the level(s) at which students should be performing. Bloom's Taxonomy [27] is a time-honored system for categorizing educational goals that provides a solid framework for developing content that does more than require students to simply recall facts. This process must be done together with the development of clear, measurable behavioral learning objectives [30] so that both the student and instructor can identify success.

Following the development of the content, the instructor must assign that content. This includes determining the number and type of assignments. Will there be quizzing? Writing assignments? How will those be graded? Repeated testing appears to benefit student learning [2]. Due dates should include consideration of spacing the learning as well as the schedules of assessment [31]. Finally, perhaps the relative value (i.e., proportion of the overall course grade) for each assignment needs consideration.

2 FUTURE DIRECTIONS

2.1 Predictors of student performance

One of challenges often faced when doing research on TTSs in college settings is identifying the source of performance differences in students. Is it due to the TTS or is it due to some prepotent feature of the student? The typical predictors used include GPA and scores on standardized college placement tests (e.g., the SAT and ACT). One promising possibility is grit [32], a construct described as "perseverance and passion for long-term goals" [33].

2.2 Assessment development

Developing an effective TTS that uses online quizzing will require substantial resources to develop an appropriate test bank. In our experience, publisher-provided test banks are of consistently low quality, including those accompanying TTSs. Many of the questions are simply wrong or ambiguous (allowing for multiple correct answers). This is true in spite of the fact that most of the questions are factual or definitional, often drawn straight from the textbook. Even supposedly higher-order questions rarely go much beyond requiring recall of facts. This is relevant to the mismatched goals of instructors and students because poorly designed resources in a TTS can enable students to circumvent effortful behaviors. For example, if the correct answer in a multiple-choice question is a verbatim phrase from the e-text (that is part of the TTS), it is easy to see why students would quickly perform a search for key phrases--this works if the goal is to earn a high score. In addition, although publishers may create different item pools for online quizzes and those provided to instructors for creating exams, it would be more helpful if the items in the online quiz pool were akin to Butler's [3] factual questions and items in the instructor's question database had at least as many inferential questions. Intentionally designing test banks with our current understanding of how student learning works may be expensive, but asking students to pay for TTS that don't enhance their long-term learning is not only already expensive, but perhaps also unethical.

3 CONCLUSIONS

There is no doubt that effective strategies to improve student learning exist and that online may be an excellent platform for engagement with these activities. However, we believe that beginning with the development of clear learning objectives that take into account the fact that students are working to optimize their performance will serve as a solid starting point for developing quality online content. Developing content, online or otherwise, must not allow students to engage in easy success strategies. Content must change student responding so that it is more closely aligned with the instructor's expectations.

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