Against Academic Procrastination: Pedagogical Apps to Implement Distributed Learning in Course Design

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Abstract: Most of the facts and figures, terms and concepts taught in college are learned in the week before examination and forgotten a month after. Although we have known about the very low long-term knowledge retention of cramming since Ebbinghaus' *forgetting curve* in 1885, this learning tactic prevails because it works—at least for passing exams. As university lecturers, we seldom received a training on effective teaching and learning strategies. However, we can follow the evidence-based recommendations from cognitive and educational psychology on how to structure a course to distribute learning. With new pedagogical apps at hand, we can implement *spaced repetition* against procrastination in our course design. This paper outlines a pedagogical project to be conducted across several consecutive semesters. The project follows the *What Works Clearinghouse* practice guide on spacing learning events over time. The recommendations are implemented by using *ARSnova*, a set of innovative web-based question-and-answer apps for quizzing in class and self-quizzing at home.

The Problem: Academic Procrastination

Avoiding of doing a task under one's control that is urgent and necessary and doing something else of minor importance instead, is termed *procrastination*. It is a prevalent human behavior in many situations in life, especially in the academic context of learning. Putting off learning until the final week before an exam or a deadline for submitting an assignment is probably known from one's own study experience. As a teacher, it can be observed by the late submission dates in the usage statistics of the learning management system such as *Moodle*. If procrastination is planned, this widespread phenomenon has got its own term: *student syndrome*. A student will only start to apply himself or herself to an assignment at the last possible moment before its deadline. It is estimated that 50% to 95% of students engage in procrastination, and approximately 75% consider themselves procrastinators. Procrastination leads to lowered academic success, such as lower grades or lower performance on tasks and assignments (Ackerman & Gross, 2005; Schouwenburg et al., 2004; Steel, 2007).

Cramming, i.e., massing all of the study time into a single short session, is a widespread last-minute learning tactic of high school and college students. It has a positive short-term effect on memorization but is counterproductive to long-term knowledge retention. "Cramming is a trade-off: you trade a strong memory now for weak memory later. [...] That's the damnable thing about it – its memory longevity & quality are, in sum, less than that of spaced repetition, but cramming delivers its goods *now*." (Branwen, 2017)

The Solution: Integrate Distributed Learning in Your Course Design

This SoTL[1] project was prompted by the observation that at the start of the major software engineering project in the fourth semester of computer sciences most of the knowledge of previous semesters were forgotten and had to be relearned. The project therefore addresses the problem of *sustainability* in teaching and learning: How can specialist knowledge be taught more *efficiently*, learned more *effectively*, and memorized for the *long-term* beyond a single course and even beyond academic studies? Research on teaching and learning provides answers based on empirical evidence from cognitive and educational psychology (Ambrose et al., 2010; Dunlosky, 2013; Pashler et al., 2007).

[1] SoTL: Scholarship of Teaching and Learning, see, for example, https://my.vanderbilt.edu/sotl/

According to this research, the crucial factors for long-term knowledge retention are two cognitive effects that have been intensively studied for more than a century and are considered to be most supportive of learning:

- *testing effect:* increased retention through *active recall* of memory instead of passive reading (Roediger & Karpicke, 2006)
- *spacing effect:* long-term retention through testing distributed over time (Larsen et al., 2009)

Since Ebbinghaus (1885) the *forgetting curve* and its iterative compensation have been known (Fig. 1). The curve hypothesizes the decline of memory retention in time. It shows how information is lost exponentially over time when there is no attempt to retain it. To take advantage of both effects—testing and spacing—cognitive psychology recommends question-and-answer tools: (a) *quizzing* in the classroom with an audience response system such as *clicker* (Pashler et al., 2007), and (b) *self-quizzing* at home with flashcards according to a repetition algorithm (Branwen, 2017; Leitner, 2011). There is a large body of empirical studies focused on the suitability of clickers for learning based on the testing effect (Chien et al., 2016; Hunsu et al., 2016; Kay & LeSage, 2009). However, these studies are nearly always framed in the context of a single course. There is a lack of long-term studies that investigate the acquisition of competence across a period of several semesters. *Distributed learning*—the combination of the most effective learning strategies, i.e., *practice testing* and *distributed practice* (Tab. 1)—seems to be the best means against procrastination and forgetting. Knowing this, however, is not sufficient. Teachers must *integrate* distributed learning into their teaching strategy and demand it from their students time and again.

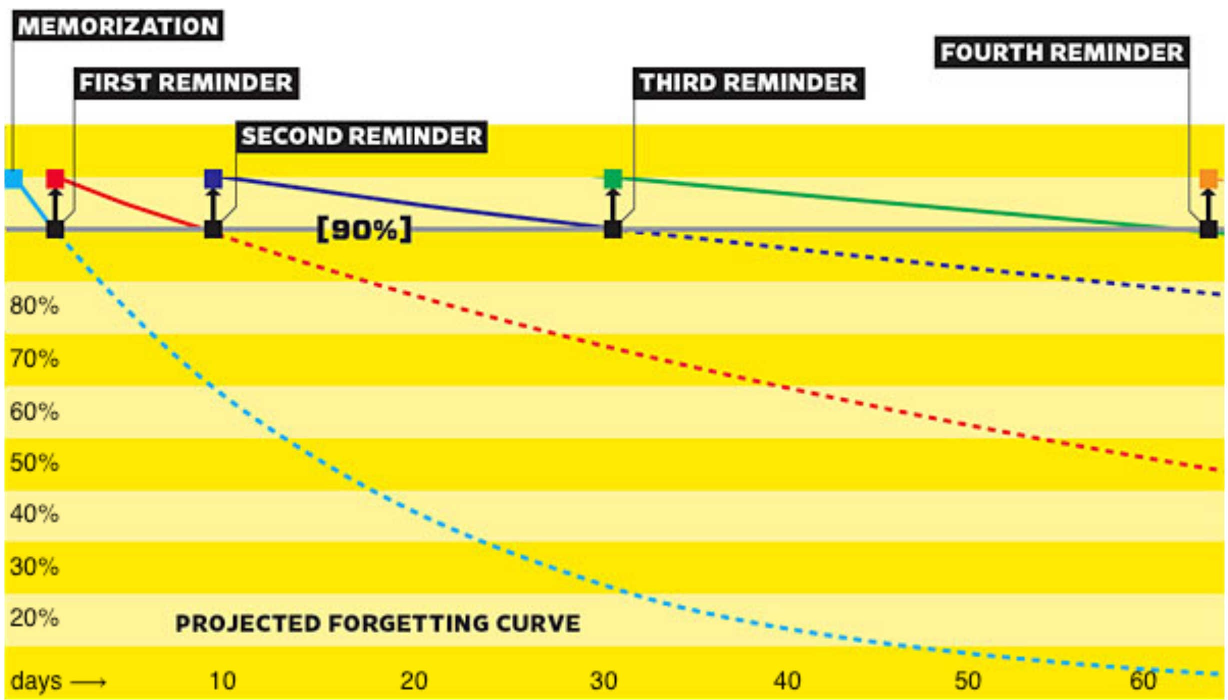

Figure 1. The *forgetting curve* and how to reduce its slope by spacing repetitions over time (Branwen, 2017)

Our project addresses the *cross-course alignment* of learning objectives. In the curriculum of computer sciences at the THM University, the expertise of web engineering is to be acquired during the first three semesters. Therefore, the methods of teaching, learning, and assessing this expertise, in the relevant courses on programming and software engineering, must be coherently aligned. For this goal, we use the web-based course planner *eLP* [2] developed at the University of Wuppertal. It enables teachers to structure and plan their courses in accordance with Biggs' model of *constructive alignment* (Biggs & Tang, 2011). The course planner allows to specify the competences to be acquired, the taxonomy levels to be reached and the intended learning outcomes as well as the learning activities, assessment methods and tools to be used. The idea is that exactly those educational goals are met and assessed which are supposed to be learned and trained during a course.

[2] https://www.elp.uni-wuppertal.de

To achieve sustainability in teaching and learning, *concerted efforts* of teachers and learners are necessary. Procrastination and cramming should be fought against on both sides: On the one side, teachers implement distributed learning in their lectures (Benassi et al., 2014). This can be achieved by quizzing on students' preparation for class and by posing clicker questions according to Mazur's *peer-instruction* method (Mazur & Watkins, 2009). On the other side, students space their learning events over time by self-quizzing with flashcards at home and on the go (Kornell, 2009). These teaching and learning strategies should be interleaved in both ways: content-wise and time-wise. Learned expertise from previous courses should be incorporated into new tasks, thus, making already-learned material a prerequisite for learning new material. This will enforce repetitive learning within a course and across courses from previous semesters.

In the classroom, events of relearning ought to be spaced over increasingly longer periods of time. And finally, exams ought to be considered the ending part of distributed learning. They should be held after the longest possible period of time after the last lecture. In order to achieve a maximum spread of engagement with the subject matter, the end of semester breaks would be best. This way, exams become an integral segment of spaced repetition and will lift up Ebbinghaus' forgetting curve once again.

#	Learning Strategy	Description	Effectivity
1	Practice testing	Self-testing or taking practice tests on to-be-learned material	Very effective under a wide array of situations
2	Distributed practice	Implementing a schedule of practice that spreads out study activities over time	Very effective under a wide array of situations
3	Interleaved practice	Implementing a schedule of practice that mixes different kinds of problems, or a schedule of study that mixes different kinds of material, within a single study session	Promising for math and concept learning, but needs more research
4	Elaborative interrogation	Generating an explanation for why an explicitly stated fact or concept is true	Promising, but needs more research
5	Self-explanation	Explaining how new information is related to known information, or explaining steps taken during problem solving	Promising, but needs more research
6	Rereading	Restudying text material again after an initial reading	Distributed rereading can be helpful, but time could be better spent using another strategy
7	Highlighting and underlining	Marking potentially important portions of to-be-learned materials while reading	Not particularly helpful, but can be used as a first step toward further study
8	Summarization	Writing summaries (of various lengths) of to-be-learned texts	Helpful only with training on how to summarize
9	Keyword mnemonic	Using keywords and mental imaginary to associate verbal materials	Somewhat helpful for learning languages, but benefits are short lived
10	Imagery for text	Attempting to form mental images of text materials while rereading or listening	Benefits limited to imagery-friendly text, and needs more research

Table 1. Most effective learning strategies (Dunlosky, 2013, p. 13, 20)

In our SoTL project, we will redesign consecutive courses crucial for the expertise of *web engineering.* For this aim, we will implement the following teaching strategies recommended by *What Works Clearinghouse* (Pashler et al., 2007):

#	Recommendation	Level of Evidence
1	Space learning over time. Arrange to review key elements of course content after a delay of several weeks to several months after initial presentation.	Moderate
2	Interleave worked example solutions with problem-solving exercises. Have students alternate between reading already worked solutions and trying to solve problems on their own.	Moderate
3	Combine graphics with verbal descriptions. Combine graphical presentations (e.g., graphs, figures) that illustrate key processes and procedures with verbal descriptions	Moderate
4	Connect and integrate abstract and concrete representations of concepts. Connect and integrate abstract representations of a concept with concrete representations of the same concept.	Moderate

5	Use quizzing to promote learning. Use quizzing with active retrieval of information at all phases of the learning process to exploit the ability of retrieval directly to facilitate long-lasting memory traces.	
5a	Use pre-questions to introduce a new topic.	Low
5b	Use quizzes to re-expose students to key content	Strong
6	Help students allocate study time efficiently. Assist students in identifying what material they know well, and what needs further study, by teaching children how to judge what they have learned.	
6a	Teach students how to use delayed judgments of learning to identify content that needs further study.	Low
6b	Use tests and quizzes to identify content that needs to be learned.	Low
7	Ask deep explanatory questions. Use instructional prompts that encourage students to pose and answer "deep-level" questions on course material. These questions enable students to respond with explanations and supports deep understanding of taught material.	Strong

Table 2. Most effective teaching strategies (Pashler et al., 2007, p. 2)

The Tools Needed

A decade after the publication of the *What Works Clearinghouse* (WWC) practice guide, new technology-enhanced teaching and learning strategies have seen the light of day: *just-in-time teaching, flipped classroom,* and *peer instruction*. As computer scientists, we developed a set of innovative pedagogical tools, called *ARSnova*[3], that help to implement the WWC recommendations in course design:

- *arsnova.voting* offers clicker functions, instant feedback and formative assessment (Fig. 2).
- *arsnova.cards* includes podcasts for complex flashcards and sends push notifications as soon as the next repetition cycle is due.
- *arsnova.click* is a game-based alternative to *arsnova.voting*. It offers gamification elements such as nick-names, countdown, sound, and ranking lists similar to *Kahoot!*.

Figure 2. *arsnova.voting:* start page, student session page, and options for instant feedback

[3] All *ARSnova* tools are open source software: https://github.com/thm-projects

In summary, quizzing enables self-monitoring and self-evaluation. It can act as a catalyst to stimulate the learner's metacognition, and to encourage him or her to take responsibility for one's own learning in the sense of *self-regulated learning* (Bjork et al., 2013). With *arsnova.voting*, formative assessment is supported both for preparation for class and learning performance in class. There are learning-progress indicators for prep tasks and in-class questions (Fig. 2, middle screenshot). In relation to the performance of the whole class, the personal progress indicator shows a potential need for learning to catch up with the group. Comprehension problems can be communicated to the teacher anonymously by using the "I've got a question" button (Fig. 2, screenshot on the right). Both formative assessment and progress indicators help teachers adapt their lectures to the actual level of learning, for example, by repeating lecture content not yet sufficiently understood. On the other hand, they "assist students in identifying what material they know well, and what needs further study" (recommendation #6 in Tab. 2).

Expected Project Outcomes

During the project runtime, over a period of three semesters, starting in winter term 2017, a large number of flashcards, case studies, pre-questions, peer-instruction concept tests, and review quizzes will be produced for the public domain, i.e., as *open educational resources* (OER). The material will be used in three consecutive university courses on object-oriented programming, web-based technologies, and software engineering. An empirical study accompanies the project to analyze the relationship between teaching and learning regarding the project's aim of minimizing procrastination and forgetting. In total, there will be available for the three courses of ten weekly lectures each:

- 50 sets of flashcards with 2,500 cards in sum for testing key competences in web engineering; some flashcards will be enhanced with podcasts for complex concepts—addressing the WWC recommendation #1 (Tab. 2)
- 3 case studies, i.e., the source code of arsnova.voting, arsnova.click, and arsnova.cards, with 10 bug-fixing exercises on each case study—addressing recommendation #2
- 30 pre-questions on the learning objectives of each course—addressing recommendation #5a
- 4 review quizzes with 5 questions each on interleaved contents of all three courses—addressing recommendation #5b
- 30 concept tests for peer instruction for each course—addressing recommendation #7

If Wi-Fi is not Available in the Classroom

With students bringing along their own mobile devices—BYOD approach to provision instead of tablet classes—teachers can now bring their own Wi-Fi network into the classroom. Besides guaranteeing sufficient Wi-Fi speed for up to 100 students, there will be less distraction from the lecture by browsing to *WhatsApp* and Co since the *ARSnova* page is the only one available via the router (Fig. 3).

Figure 3. "Bring Your Own Network": 100 clickers versus one Wi-Fi router

The mini PC hosts a web server running *ARSnova* tools for quizzing and instant feedback. Installation and starting the server is done with a mouse click. The 100-piece clicker system costs about $5,000 compared to $500 for the combination of PC and Wi-Fi router.

Conclusion

We have outlined our pedagogical project focused on reducing procrastination by implementing distributed learning in course design. It is to be shown that with the help of repetitive quizzing on course material of previous semesters in class and spaced self-quizzing with flashcards at home, learned material will not be forgotten in the long run. In this project, teaching, learning, and assessing are aligned with the competence to be acquired—not for the benefit of passing exams but for one's future job. On the SITE 2018 conference, we will demonstrate our free and open-source mobile tools—audience response, quiz and flashcard apps—that promote student engagement in distributed learning. These apps are *software as a service*[4], i.e., they can be used with any mobile browser without prior installation and at no cost. If Wi-Fi is a problem, all tools can be downloaded on the teacher's laptop and accessed via a mobile router.

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[4] Audience response app: https://arsnova.voting, game-based quiz app: https://arsnova.click, flashcard app: https://arsnova.cards