ARSNOVA.CARDS: HOW TO SUSTAINABLY PROMOTE MOBILE LEARNING WITH A FLASHCARD APP

C. Adam, D. Kamutzki, K. Quibeldey-Cirkel
Technische Hochschule Mittelhessen, THM (GERMANY)

Abstract

The paper deals with the sustainability problem of teaching and learning: How can specialist and methodological knowledge be efficiently taught, effectively learned and retrieved from memory beyond the study period? Empirical teaching and learning research provides answers based on the theories and findings of cognitive science, learning and memory psychology. Two learning-promoting effects that have been researched for over a hundred years are of crucial importance for long-term retention: "Testing Effect" through active recall of memory content instead of repeated passive reading and "Spacing Effect" through distributed testing. Since Ebbinghaus (1885) the forgetting curve and its iterative compensation has been known. In order to use the testing effect and the effect of distributed practice for sustainable teaching and learning, quiz tools are recommended: quizzing in the classroom with an audience response system (ARS) and self-quizzing at home with flashcards to be learned according to the repetition intervals of Leitner or Woźniak.

With the »ARSnova« open-source software project at THM, an innovative browser-based flashcard app has been developed in recent years that supports distributed learning on the go and in the classroom: https://arsnova.cards The card format and the number of virtual card sides were adapted to the study-specific contents and requirements, e.g., card types for lecture notes, learning units, glossaries, commands from programming languages, formula collections, design patterns, exam questions, quotations, subject bibliographies, and vocabularies. There is also a lecture card type optimized for projectors to give lectures with arsnova.cards instead of PowerPoint or Keynote. The gamified audience response system https://arsnova.click described in an EDULEARN17 paper [1] is embedded in the flashcard app. It can be accessed at any time without leaving the browser.

arsnova.cards is not a traditional flashcard app like Quizlet or SuperMemo. Because it not only supports the learning of study contents with digital index cards, but also the revision and learning of lecture notes. The app is designed as a mobile Personal Learning Environment (PLE), a virtual place where learning time is spent intensively on cognitive activities such as reworking transcripts, creating learning cards and repeatedly answering learning questions. This contrasts with learning management systems (LMS) such as Blackboard or Moodle, which in practice are used mostly only as platforms for distributing lecture scripts. The concept of arsnova.cards enables the teacher to evaluate the learning process of the students in order to award bonus points for taking and reworking lecture notes and for repeated card learning during the course of the semester.

The focus of this paper is on the conceptual and technical measures to sustainably promote mobile learning with flashcards. It shows how usability and user experience (UX) of a browser-based learning tool can be increased. In addition to "Ease of Use", "Joy of Use" is a decisive intrinsic motivation for the long-term use of an app. We describe the UX measures using screenshots to enable a transfer to the development of other mobile browser-based teaching and learning apps.

Keywords: mobile learning, distributed learning, intrinsic motivation, extrinsic motivation, user experience, bonus awarding, flashcard, Personal Learning Environment.

1 HOW TO OVERCOME THE FORGETTING CURVE

Our SoTL project (Scholarship of Teaching and Learning, https://my.vanderbilt.edu/soTL/) was prompted by the observation that at the start of the major software engineering project in the fourth semester of computer sciences at THM 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 [2, 3]. 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 [4]

Spacing Effect: long-term retention through testing distributed over time [5]

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 [6], and (b) self-quizzing at home with flashcards according to a repetition algorithm [7, 8]. There is a large body of empirical studies focused on the suitability of clickers for learning based on the testing effect [9, 10, 11]. 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—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.

![The Forgetting Curve](image)

*Figure 1. The forgetting curve (red) and how repetitive learning (green) tends to prolong retention [12].*

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 [13]. This can be achieved by quizzing on students’ preparation for class and by posing clicker questions according to Mazur’s peer-instruction method [14]. On the other side, students space their learning events over time by self-quizzing with flashcards at home and on the go [15]. 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.

In our SoTL project, we will implement the teaching strategies recommended by What Works Clearinghouse [6] and foster the most effective learning strategies recommended as outcome from psychological studies [3].
2 THE DIGITAL TOOLS NEEDED

A decade after the publication of the What Works Clearinghouse (WWC) practice guide [6], 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, collectively referred to as »ARS nova« ("ARS" for Audience Response System), that help to implement the WWC recommendations in course design:

arsnova.app [16] offers clicker functions, instant feedback and formative assessment. 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. In relation to the performance of the whole class, the personal progress indicator may show a 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. 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.

arsnova.click [17] is a game-based alternative to arsnova.app. It offers gamification elements such as nicknames, countdown, sound, and ranking lists similar to »Kahoot!«. It offers not only multiple choice, but also formats such as numeric estimation question and short answer. Up to 26 answer options are possible, as long as the alphabet. You can include emojis, images, videos, source code and formulas in questions and answers. And quiz teams can compete against each other. We care about data protection: We do not store any data on the server, all quizzes remain in the teacher’s browser. This innovation (web storage) guarantees data protection in accordance with the European Data Protection Act (DSGVO) when used in educational institutions in the European Union. The didactic particularity of arsnova.click is the bonus option for the top players. Extrinsic incentives in the form of bonus points, which can be credited to the result of the final examination of a subject, are widely used at German universities. The »ARS nova« development team goes one step further here: the bonus is awarded in a live competition at the beginning of a lecture to check the preparation and at the end of the lecture to keep the students’ attention high. A knowledge quiz with bonuses at the beginning and end of each lecture leads to more and more presence throughout the semester and promotes active learning in the classroom.

arsnova.cards [18] (henceforth »cards« for short) includes podcasts for complex flashcards and sends push notifications as soon as the next repetition cycle is due.
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 [19].

The two tools arsnova.app and arsnova.click have already been described technically and didactically in several publications (https://arsnova.eu/blog/literatur). In the following, we describe »cards« (Fig. 2) as in the card-based introduction to the platform and address the reader personally: https://arsnova-cards/demo. The screenshots show the German language setting. There will also be an English version until the EDULEARN19 conference.

The maxim of »cards«

Organize. You can find the knowledge from your studies anytime and anywhere with a few clicks, even many years after your studies, when you have disposed of your transcripts long ago. One day—at work, in a team meeting—you’ll need the knowledge from your studies back.

Learn. The flashcards are digital: you can insert pictures, podcasts and videos. Are you studying a STEM subject? Use the most complicated mathematical formulas and syntax highlighting to write any program code quickly and cleanly onto a card. You can install the open source software »cards« for free as a personal learning environment on your laptop. So you can learn your cards everywhere without the need for the internet.

Memorize. The cards of your learning workload will be presented to you for learning on the days calculated by cognitive science. This is the most effective learning method against forgetting. The push messages on your mobile phone or emails remind you to repeat what you have learned.

Pomodoro: not only Italian for tomato

Francesco Cirillo developed the popular »Pomodoro Technique«™. The name derives from the fact that Cirillo used an egg timer for his time management technique, which had the shape of a tomato. We built the Pomodoro technique into a stylish analog clock (Fig. 3).

![Figure 3. The Pomodoro timer breaks down work into intervals, traditionally 25 minutes in length, separated by short breaks. Each interval is known as a "pomodoro".](image)

A Pomodoro time unit is displayed to you with the orange arc of a circle. The narrow red arc represents the elapsed time. You can recognize the pauses provided by the Pomodoro technique by the blue arc of the circle. During a pause you will not be shown another card to learn. In this way, we prevent you from overstraining yourself, for example on the eve of an exam, and from harming your health through uninterrupted card learning (science calls it »massed learning«).

Digital boxes: Card indexes

There are about 20 study-specific types of card indexes that can be selected during creation. Each card index contains only cards of the same type, unless it is composed of several card indexes of different types, such as the demo card index on the start page. Some card types have a difficulty level indicated by the color of the card: green for basics, blue for advanced, and red for experts.

Card types differ in the number of card sides. Not only front and back sides are possible, but also further virtual sides to deepen the learning content or to indicate web resources and literature. Learning, design-pattern and examination cards also have a learning objective level based on the taxonomy of Anderson & Krathwohl [21]: Understanding, Applying, Analyzing, Synthesizing, Evaluating, Innovating. For the formulation of the learning objective at the learning-objective level selected, suitable verbs are suggested in the card editor.
Digital shelves: Repetitoriums

According to Wikipedia, repetitorium (from Latin repetere, which translates to repeat) means the repetition of knowledge and skills, usually to pass an exam. A repetitorium (rep) on the »cards« platform combines several card indexes. To stay in the picture: In your IKEA shelf, these are all the shoe boxes that belong to a course in terms of content and therefore stand together (see the background picture of the start page in Fig.2). In learning mode, the cards of all card indexes belonging to the rep are presented for learning according to a repetition algorithm. Your professor can give you bonus points for the regular learning of a single card index or a repetitorium of card indexes.

3 HOW TO PROMOTE LEARNING: INTRINSIC AND EXTRINSIC MOTIVATION

Learning is intrinsically or extrinsically motivated: by an internally controlled learning drive or by external incentive factors. Childlike curiosity, game and interest-driven learning are regarded as prototypes of intrinsic motivation. The pursuit of good grades or a willingness to learn aimed at material remuneration are typical examples of extrinsic motivation. Most students do not learn intrinsically motivated, i.e. on their own initiative during the semester [20]; they postpone learning (procrastination) and learn only a few days before the exam (bulimia learning).

Bonus points motivate extrinsically and on the platform »cards« in many ways. If the awarding of bonus points is restricted to the teaching time, it can demonstrably increase attendance.

Bonus for participation in classroom quizzes

Technique: The gamified quiz app arsnova.click integrated in »cards« enables user authentication. If the teacher activates this access option, the university email addresses of the players are included in the export file of the quiz ranking. The teacher can thus assign the pseudonyms of the quiz participants to their identities for the bonus award.

Didactics: Bonus quizzes can test the knowledge from previous lectures and exercises at the beginning of a lecture. At the end of a lecture they serve as an incentive to actively listen, as the knowledge of the participants is tested by means of the currently conveyed teaching contents. Quizzes provide the individual with personal feedback on his or her learning process. The teacher can use quizzes as a live assessment of the group’s learning performance to revise the content of further lessons. This feedback promotes the self-efficacy experience and thus an intrinsic motivation to learn [19].

Bonus for taking lectures notes and post-editing them

Technique: The teacher creates a card index of the lecture type with a transcript bonus, selects the lecture dates from a calendar, determines the deadline for editing the transcript and determines the maximum number of bonus points. Students can link a transcript card with the lecture card index, link their photographed transcript to a card, and digitally create the post-processing (researched fair copy).

Didactics: Not all lectures have to be transcribed to get the maximum number of bonus points, e.g., students only have to transcribe 10 of 14 lectures. This takes into account that lectures are missed due to illness or other reasons of absence. The photographed transcripts and the digital post-processing completed within the specified period will be checked by a tutor or teacher for meaningfulness, but not for correctness. It should only be rewarded that one has actively dealt with the learning contents during the lecture and at home. We follow the findings of [22] that laptop notes are less effective than handwritten notes. That is why we require photos of the notes for the receipt of the bonus.

Bonus for active participation in lessons

Technique: Students can ask questions with the audience response app »ARSnova lite« which is functionally comparable to »Pigeonhole live«.

Didactics: The questions must relate to the contents of the current lecture, have been included in the question list of the lecture by a moderator (tutor), have been highly rated by the participants and have been dealt with by the teacher during the lecture.

Bonus for regularly repeated learning

Technique: Certain card types, such as glossaries, instruction sets, quizzes or exams, offer the option of learning by a plan, either by Leitner or by Woźniak.

Leitner’s repetition algorithm: Leitner’s learning method (Figure 4) presents cards that have already been learned at certain intervals. Cards that have not been remembered are returned to the first box.
Optionally, the teacher can specify to return them to the previous box. In this way, difficult cards are repeated more often than simple ones. According to Leitner, intervals are: daily (1→2), weekly (2→3), monthly (3→4) and quarterly (4→5). Cards in the last box are regarded as permanently learned. The maximum number of cards to be learned per day is determined by the teacher.

![Figure 4. In the Leitner system, correctly answered cards are advanced to the next, less frequent box, while incorrectly answered cards return to the first box for more aggressive review and repetition [7].](image)

Woźniak’s repetition algorithm: With the »SuperMemo« learning method from Woźniak, the intervals are individually recalculated according to the SM-2 algorithm [8] based on your assessment of how easy or difficult it is to remember the answer. You compare your answer with the answer on the back of the card and rate it on a 6-step scale from "blackout", "wrong answer, but reminds you of the right one", "wrong answer, but easily reminds you of the right one (oh yes!)", "correct answer after long thinking", "correct answer after short hesitation" to "instant and correct". Based on your rating, the time for the next repetition of the flashcard is calculated.

The Leitner plan can be combined with a bonus: The teacher determines the daily workload through the cards to be learned, start time, end time and the length of the repetition intervals as well as the maximum uninterrupted daily learning time in Pomodoro units.

Didactics: At the end of the learning period, the teacher or tutor uses the learning curve over the repetition intervals to assess whether regular and repeated learning has taken place and awards bonus points for the individual learning process (Fig. 5).

![Figure 5. Learning progress: ① number of cards, ② card index selection, ③ intervals of repetitions.](image)
4 HOW TO PROMOTE MOBILE LEARNING: EASE AND JOY OF USE

Optimized for on the go: The »cards« platform was designed for mobile learning. The app is mainly used for learning on the smartphone. This places special design requirements on mobile usability (ease of use) and mobile user experience (joy of use): one-thumb control, functionally streamlined design, context-sensitive help for one-click navigation, fullscreen mode in smartphone browsers, text scaling, battery-saving dark background, smartphone-sized preview when creating cards (Fig. 6).

![Figure 6. Optimized usability for mobile devices: fullscreen, one-thumb control and text resizing.](image)

Optimized for any screen: »cards« is a responsive HTML5 app, which means that it is not installed, runs in any modern browser on a smartphone, tablet or laptop and adapts visually and functionally to the screen size of the device.

![Figure 7. Optimized for card-based lectures with a projector.](image)
Optimized for full screen and projectors: We use the fullscreen view of the browser to display cards without distraction (Fig. 7). Check out the hints for the edge buttons. You’ll find them behind the question mark on the right. All buttons can be folded in and out with the blue button at the bottom left. During your presentation you are not dependent on the mouse to navigate: With the space key you comfortably get to the next card side and afterwards to the next card.

Figure 8. The gamified quiz app arsnova.click within »cards«.

Integrates the audience response system arsnova.click (Fig. 8): With our gamified quiz app, which is widely used at German universities, you can ask your audience questions at any time without leaving the »cards« app. The project manager uses arsnova.click and »cards« in his lectures. Students also use both apps for their presentations in the graduate seminar or bachelor colloquium.

Figure 9. A Progressive Web App (PWA) is indistinguishable from a native app from an app store.

Behaves like a native app: »cards« is a Progressive Web App (PWA, https://developers.google.com/web/progressive-web-apps/), which means the browser-based app feels like a native app from the store: you can add it to your phone’s home screen from within your browser (add to home screen) and from there access it like an installed app. It starts with a loading screen as fast as a native app and appears without a browser frame. If you allow the notification feature for »cards«, your smartphone will reliably remind you at 8:00 a.m. to learn. The number of notifications can be displayed on the app icon like a mail app (Fig. 9).
Open Source Software: »cards« is a free open-source software under the GNU General Public License. You may install it on your laptop or run it on a server without asking and for free. Currently you still need good Linux knowledge for the installation. Soon a layman can do this with just a few mouse clicks. JavaScript/CSS experts are allowed to change and redistribute the code at will, but should make their changes available to the developer community on GitHub [18] again.

We run a second instance of »cards«: Linux.cards. The cards of this installation prepare intensively for the LPI certification tests (https://www.lpi.org). On learning cards, glossary cards, instruction cards and examination cards, the entire content of the training material of the platform tuxcademy.org is conveyed. The target group includes Linux beginners as well as advanced Linux users.

5 CONCLUSIONS

The paper deals with the sustainability problem of teaching and learning. Within the open source project »ARSnova« at the THM University of Applied Sciences, a mobile browser-based flashcard app has been developed. It supports distributed learning on the go and in the classroom. https://arsnova.cards. »cards« is not a traditional flashcard app such as »Quizlet« or »SuperMemo«. It not only supports the learning of study contents with digital index cards, but also the revision and learning of transcripts. The app is designed as a mobile Personal Learning Environment (PLE), a virtual place where learning time is intensively used for cognitive activities such as the revision of transcripts, the creation of learning cards and the repeated answering of learning questions. The concept of »cards« allows the teacher to evaluate the learning process in order to award bonus points for taking notes and follow-up work as well as for repeated card learning during the course of the semester. The focus of the paper is on the didactic and technical measures for the sustainable promotion of mobile learning with flashcards.

6 FUNDING, NAMING AND LICENSING

The »ARSnova« project was conceptualized in the THM working group Quality in Teaching and Studies (AG QLS). Development and operation are financially supported by THM. With a senior fellowship for innovations in university teaching, the Stiftverband für die Deutsche Wissenschaft and the DATEV Stiftung Zukunft support the »ARSnova« subproject "Digitally against bulimia learning: quizzes in the lecture hall and at home, podcasts on the go". The project name »cards« stands for the central digital medium of the learning platform and has been one of the new generic top-level domains on the web since 2014. The coincidence of the names enables short and concise web addresses for topic-specific installations of »cards«, for example Linux.cards, whereby the subdomain stands for the dedication of the platform. All »ARSnova« tools are free open source software under the GNU General Public License.

Figure 10. Example for a topic-specific installation of »cards«: Linux.cards.
REFERENCES


