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TOWARDS A LEAN APPROACH TO GAMIFYING EDUCATION

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Abstract

Many university students struggle with motivational problems, and gamification has the potential to address these problems. However, using gamification currently is rather tedious and time-consuming for instructors because current approaches to gamification require instructors to engage in the time-consuming preparation of course contents (e.g., for quizzes or mini-games). In reply to this issue, we propose a "lean" approach to gamification, which relies on gamifying learning activities rather than learning contents. The learning activities that are gamified in the lean approach can typically be drawn from existing course syllabi (e.g., attend certain lectures, hand in assignments, read book chapters and articles). Hence, compared to existing approaches, lean gamification substantially lowers the time requirements posed on instructors for gamifying a given course. Drawing on research on limited attention and the present bias, we provide the theoretical foundation for the lean gamification approach. In addition, we present a mobile application that implements lean gamification and outline a mixed-methods study that is currently under way for evaluating whether lean gamification does indeed have the potential to increase students' motivation. We thereby hope to allow more students and instructors to benefit from the advantages of gamification.

Keywords: Gamification, limited attention, present bias, mobile application.

1 Introduction

Motivation is the force that drives our actions, and volition is the willpower to stay with our actions even when we encounter impediments (e.g., boredom, anxiety, or an unstructured study environment). Both, motivation and volition, are important antecedents of academic success. However, many university students struggle with motivational and volitional problems that, in turn, lead to missing or late assignments, cramming, test anxiety, withdrawal, and poor performance (Wolters 2003).

Gamification, that is, the *"use of game design elements in non-game contexts"* (Deterding et al. 2011, p. 9), is a potential solution to motivational problems. Hence, gamification has received great interest in research and practice: Leading technology consultancies call gamification one of the most important technology trends of the coming years (Deloitte 2013, Gartner 2014). The success of fitness apps such

as Runtastic or Freeletics, which have accumulated millions of users within only a few years, is largely based on the effective use of gamification[1]. Also leading e-learning platforms such as Codecademy or Khan Academy employ gamification to motivate their users[2]. Consequently, the number of scientific articles on gamification has increased tremendously, as is evident in the numerous reviews that have appeared in recent years (e.g., Bui et al. 2015, Hamari et al. 2014, Seaborn & Fels 2015).

Despite the potential of gamification for increasing student motivation, only few instructors actually use gamification in their courses – and prior research has identified the great effort that gamification requires from instructors as a likely adoption barrier: Case studies on gamification, for example, consistently identify the great amount of required effort as a problem. Such studies, for instance, comment on *"time overheads"* (Iosup & Epema 2014, p. 5), *"big effort"* (Domínguez et al. 2013, p. 291), or *"time costs [that…] were substantial"* (O'Donovan et al. 2013, p. 250) for instructors. An interview study with instructors echoes these results, as it finds a *"lack of resources (time, training, classroom setting, and economic support)"* to be a major reason against adopting gamification in higher education (Sanchéz-Mena & Martí-Parreño 2016, p. 182).

For reducing instructors' effort, we propose the *lean gamification* approach, which relieves instructors from the time-consuming preparation of their course contents, and nonetheless promises to promote student motivation through gamification. To illustrate the approach, note that the course syllabi that instructors typically create (to describe their courses) are to some extent similar to 'to-do' lists. This is because such syllabi list the activities that students are advised to do between starting and completing a given course. These activities (to-do's) can include, for example, to attend lectures and tutorials that belong to a given course, read specific papers and book chapters, work through exercise sheets, hand in assignments, give presentations, and take exams. Current approaches for gamifying a course typically involve one of the following two options: First, they add gamified activities to the to-do list that allow acquiring or deepening one's knowledge (e.g., play an educational game that introduces new course contents, El-Masri & Tarhini 2015) or, second, they add activities that allow testing one's knowledge (e.g., a quiz that allows testing one's understanding of the course contents, Santhanam et al. 2015). While these options have great potential for promoting student motivation, they are rather inconvenient for instructors – because these options inevitably require instructors to incur time overheads for preparing their course contents. Lean gamification, therefore, offers a third option: In contrast to option 1 (adding gamified activities for acquiring/deepening knowledge) and option 2 (adding gamified activities for testing knowledge), with lean gamification we propose to gamify the to-do list itself. More specifically, by lean gamification we propose to use gamification to draw students' attention to the learning activities (the to-do's) that they have to perform in a given course, and to the progress (or lack thereof) in working through these learning activities. Using gamification in this way would reduce the time demands on instructors, because instructors have to prepare the to-do's (i.e., the course syllabi) anyway, also without gamification. Software applications using lean gamification would allow students to track their progress in working through the to-do's of the course syllabus. Such applications could, for example, include leaderboards that rank students according to their number of attended lectures, could include progress bars that show to students the progress they have made in reading assigned book chapters, or could include badges for completing assigned exercise sheets.

From a theoretical perspective, lean gamification is motivated by research on limited attention (Kahneman 1973) and the present bias (Akerlof 1991), which suggests that drawing students' attention towards pending and finished learning activities should increase the learning effort that students exert.

[1] Freeletics is a mobile application for fitness training, which since 2013 has attracted more than 4 million users (www.freeletics.com). Runtastic is a mobile application for runners, which since 2009 has attracted more than 50 million users (www.shortnews.de/id/1149911/fitness-app-runtastic-veroeffentlicht-statistik-der-nutzer), retrieved on 20/11/2016.

[2] Codecademy has more than 25 million users (www.codecademy.com/), Khanacademy has more than 10 million users (www.sri.com/sites/default/files/publications/2014-03-07_implementation_briefing.pdf), retrieved on 20/11/2016.

Increased learning effort in turn is associated with an increase in academic performance (i.e., Marburger 2001). From a practical perspective, lean gamification is motivated by the fact that even the most effective gamification approach has little value if instructors lack the time and resources for actually using it. Hence, there is the need to explore ways that reduce the effort on the side of instructors.

To investigate the merits of lean gamification, we follow the design science research paradigm (Hevner et al. 2004). Adopting the design science approach of Loock et al. (2013), we have two objectives: Our first objective is to create an innovative technological artifact (a mobile application) that, drawing on lean gamification, has the capacity to increase the academic performance of its users. Our second objective is to evaluate the artifact and thereby evaluate the theoretical propositions that underlie the lean gamification approach. To achieve these objectives, we follow the six-step methodology by Peffers et al. (2007) and in this article present the results of the first three steps: We outline the addressed problem by reviewing prior gamification research (step 1), present our research model and the testable hypothesis that guides the design of the artifact (step 2), and present the developed artifact (step 3). We close by describing an ongoing study in which we evaluate the developed artifact and thereby seek to shed light on the usefulness of lean gamification.

2 Literature

2.1 Overview of gamification in educational settings

The term gamification started to proliferate in industry and academia only around 2010 (e.g., Deterding et al. 2011, Hamari et al. 2014, Kundisch and von Rechenberg 2016) but has already received remarkable attention in the literature (see Table 1).

Year	Search Term(s)								
	Gamification			Gamification + Learning			Gamification + Education		
	Scholar	Scopus	WoS	Scholar	Scopus	WoS	Scholar	Scopus	WoS
2009	36	0	0	27	0	0	27	0	0
2010	223	0	0	48	0	0	62	0	0
2011	628	0	6	239	0	2	224	0	2
2012	1,750	96	30	900	23	13	722	18	7
2013	3,470	269	106	2,210	108	53	1,920	83	29
2014	5,340	449	219	3,610	157	98	3,310	127	59
2015	6,760	640	443	4,970	272	226	4,660	242	161
2016*	5,740	514	225	4,080	222	105	3,920	186	70

Google Scholar (scholar.google.com): Excluding patents and citations; Scopus (www.scopus.com): Article title, abstract, keywords; Web of Science (WoS) (www.webofknowledge.com): Topic; *Incomplete count for 2016

Table 1. Search results on gamification literature (as of 15 November 2016).

The literature on gamification can be divided into (1) theoretical/conceptual and (2) empirical contributions (Seaborn and Fels 2015):

The contributions of the theoretical/conceptual strand include definitions of gamification and the delineation of gamification from related concepts (e.g., Deterding et al. 2011), taxonomies of game design elements, and catalogs of theories that might contribute to explaining and predicting the effects of specific game design elements on their users (e.g., Blohm and Leimeister 2013, Nicholson 2012). Such works have appeared in a variety of domains, including games (e.g., Deterding et al. 2011), service marketing (e.g., Huotari and Hamari 2012), business strategy (e.g., Werbach and Hunter 2012), education (e.g., Nicholson 2012), and information systems (e.g., Blohm and Leimeister 2013).

The contributions of the empirical strand comprise papers evaluate the impact of game design elements on different psychological and behavioral outcomes. The most commonly stated objective behind using a gamified system is to encourage behavior change in end-users, such as increased partici-

pation, improved performance, or greater compliance. The results of this stream suggest that *"game elements can meet these goals by catering to the intrinsic values of end-users: a user-centered approach, characterized by a focus on the needs and desires of end-users in the design of systems"* (Seaborn and Fels 2015, p. 28). Hence, the efficacy of a gamified system in changing user behavior strongly depends on the context and the characteristics of the user group (Hamari et al. 2014).

A substantial portion of the research in the empirical strand is devoted to exploring the utility of gamification in educational contexts (see Table 1), with the overall objective being to enhance a learner's motivation, engagement, and resulting performance. Not surprisingly, a number of literature reviews have already been conducted that attempt to synthesize the plethora of findings on gamification in education (e.g., De Sousa Borges et al. 2014, Dicheva et al. 2015, McClarty et al. 2012, Faiella and Ricciardi 2015). Basically, the findings in these reviews echo the general results of domain-independent reviews (see, e.g., Seaborn and Fels 2015, Hamari et al. 2014): Applying gamification can indeed positively change a learner's behavior. Further, typical gamification elements include *progression*, *points*, *levels*, *rewards*, *leaderboard* (Dicheva et al. 2015, Seaborn and Fels 2015, Hamari et al. 2014, Faiella and Ricciardi 2015) that, for example, are applied to the outcomes of (multiple choice) quizzes (e.g., Santhanam et al. 2015), mini-games (e.g., Li et al. 2012), homework tasks (Goehle 2013), and the like. In most cases, the system that was employed for gamifying a course (e.g., plugin or extension of a learning management system, third-party platforms, standalone applications) was either specifically developed or customized (Dicheva et al. 2015, Seaborn and Fels 2015).

2.2 Barriers to gamification in educational settings

One should expect that a substantial share of university courses are already gamified, given the great potential of gamification to induce behavioral change, and given the widespread availability of the necessary technology, both on the instructors' as well as the students' side (i.e., smartphones and laptops nowadays belong to most students' standard facilities). However, this is not the case, and gamification is still the exception rather than the rule in higher education. The few articles that deal or at least comment on adoption barriers consistently point out that the required resources (time and costs) to gamify education are a substantial barrier to the adoption of gamification (e.g., El-Masri and Tarhini 2015, Sanchéz-Mena et al. 2016, Domínguez et al. 2013, O'Donovan et al. 2013).[3] An exploratory study of gamification adoption barriers, for instance, identifies a *"lack of resources (time, training, classroom setting, and economic support"* as a major barrier to the adoption of gamification (Sanchéz-Mena et al. 2016, p. 182). One interviewee states that *"much more time is needed in the process of designing and planning the teaching activities [when using gamification]. Moreover, you need much more resources to deliver these activities."* (Sanchéz-Mena et al. 2016, p. 182). Likewise, Domínguez et al. (2013, p. 391) note that *"gamification in e-learning platforms seems to have potential to increase student motivation, but it's not trivial to achieve that effect, and a big effort is required in the design and implementation of the experience for it to be fully motivating for participants."* In the same vein, O'Donovan et al. (2013, p. 250) report on the gamification of a university course on computer games development with a learning management system: *"The monetary and time costs of this system were substantial and need to be considered before deciding to embark on a similar gamification programme. […] The time investment is primarily that of the lecturers and teaching assistant. This is crucial to the success of the system, as the setting of the puzzles and quizzes is very time consuming. We estimate that this required an additional 6 hours of work per week, on top of standard lecture preparation."* So, to summarize, one major problem in current gamification approaches is that they require too much effort from instructors. With lean gamification we want to address this adoption bar-

[3] In the context of educational games El -Masri and Tarhini (2015) suggest five categories of adoption barriers: Resources (time and costs), readiness (instructors' and students' abilities/capabilities), game flexibility, usefulness of the game, side effects (e.g., students' addiction).

rier by picking instructors up from where they are anyway after having defined the concept of a course: a syllabus that defines the learning activities that students need to perform in that course.

3 Theoretical foundation for lean gamification

From a theoretical perspective, gamification can be distinguished into three parts (Hamari 2014): (1) *motivational affordances* (i.e., the implemented game design elements), (2) *psychological outcomes* (e.g., increased motivation that results from a user's exposure to game design elements), and (3) *behavioral outcomes* that result from the psychological outcomes (e.g., an increase of learning effort that results from an increase in motivation). Concerning the lean gamification approach, we argue that gamifying learning activities (motivational affordance) leads to an increase in the salience of the learning activities (psychological outcome) which, in turn, leads to an increase in learning effort (behavioral outcome). The increase in learning effort, in turn, leads to an increase in academic performance (see Figure 1). While the relationship between learning effort and academic performance is rather straightforward (e.g., Diseth et al. 2009; Marburger 2001), the relationship between gamified learning activities and learning effort is more intricate, and therefore elaborated below. We provide the intuition of our argument first, and then present the theoretical foundation.

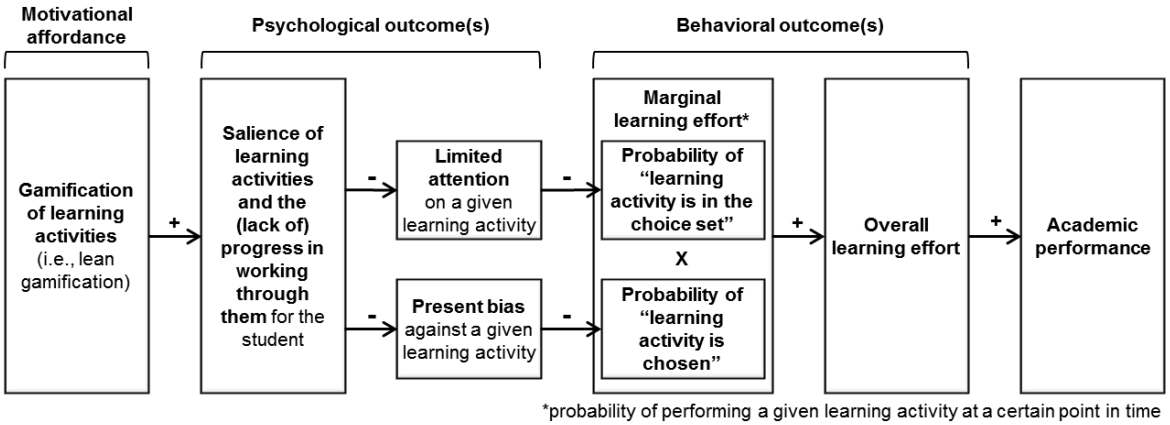

Figure 1. Theoretical foundation for the lean gamification approach.

For understanding the intuition of our argument, note that any student, at any time, is confronted with a number of possible activities that he or she can choose to perform. Some of these activities are the learning activities for the courses that a student has taken in a given semester. However, in addition to these learning activities, there is an endless number of other activities that the student can engage in, such as hanging out with friends, going to the gym etc. When there are many possible activities, it is very likely that a student might be unaware of the necessity (or opportunity) to perform at least some of the learning activities (e.g., attending a specific lecture or tutorial, or reading an assigned paper). Hence, to successfully perform a given learning activity at a certain point in time, the student must first be aware of the necessity (or opportunity) to perform that learning activity. Second, being aware of a certain learning activity, the student must decide to actually perform that learning activity, that is, must decide against postponing the activity (or – if postponing is not possible – skipping the activity).

Starting with the behavioral outcome part of our model, following Diseth et al. (2009), we refer to learning effort as the amount of time spent on studying. We distinguish between the effort that a student exerts at a certain point in time in a given semester (*marginal learning effort*) and the overall effort that a student exerts in a semester (*overall learning effort*). Marginal learning effort depends on two probabilities: First, the probability that a *learning activity is in the [student's] choice set* of activities at a certain point of time (i.e., the student is aware of the learning activity). Second, marginal effort depends on the probability that a *learning activity* in that choice set *is actually chosen* to be performed (i.e., not postponed or skipped). The higher each of these probabilities, the higher is the level

of marginal effort at a given point in time – and a constantly higher level of marginal effort implies a higher level of overall learning effort. To understand this point, imagine the extreme case of a constant maximum in marginal learning effort throughout a whole semester: This would mean that a student is always aware of all learning activities that he or she can perform (i.e., does not forget any of them) and does not skip or postpone any of these learning activities.

Unfortunately, as the psychological outcome part of our model shows, there are two factors that tend to decrease the probabilities that determine marginal effort. First, humans suffer from *limited attention*, which implies they are not necessarily aware of all activities they can engage in (Kahneman 1973). Second, humans tend to have a *present bias*, that is, they tend to overvalue the immediate gratification and costs of an activity, which is why they tend to postpone activities that they perceive as comparably unpleasant (Akerlof 1991). However, as we will argue in the following, it is possible to counter limited attention and present bias by increasing the salience of the learning activities and of the progress in working through them.

The finding that increasing the salience of an activity helps to counter limited attention has been established in a number of contexts, such as gym attendance (Calzolari & Nardotto 2016) and saving money (Karlan et al. 2016). These studies find, for example, that simple reminders for a certain activity (e.g., exercising, saving) increase the recipients' effort in the corresponding activity. The reason is that the reminders increase their recipients' awareness that a certain activity needs to be done. Accordingly, in the case that a student is not aware of all necessary learning activities, making these activities more salient increases the probability for that the activities are actually performed.

Concerning present-biased behavior, research has found that individuals oftentimes postpone activities they perceive as comparably unpleasant, because they overestimate the current costs (i.e. unpleasantness) of performing these activities relative to the costs that performing the activities would cause in the future (Akerlof 1991). So students, for example, postpone reading an article from one day to the next, implicitly believing that reading the article will be less unpleasant to them on the next day. On the next day, however, their present bias causes them to delay reading the article for another day, and so on. The students' problem is that they perceive their decisions to postpone an activity as independent from one another and tend not to notice that postponement decisions add up. Hence, a countermeasure to present–biased behavior is to make the fact that the decisions to postpone are indeed related (Akerlof 1991) more salient – by making more salient to the student that postponing learning activities increases the count of pending learning activities.

To summarize, increasing the salience of learning activities and the progress in working through them through gamification helps to counter limited attention and present-biased behavior, and thereby increases the probability that a given learning activity is performed at a certain point in time (marginal learning effort). An increase in marginal learning effort increases overall learning effort. As an increase in overall effort has a positive effect on academic performance, we hypothesize the following:

H1: Gamifying learning activities has a positive influence on academic performance.

4 Prototype description

For testing our hypothesis, we developed a mobile application (app) that implements the lean gamification approach. We chose an app as the target platform because our aim to make learning activities more salient implies that students need to be able to access the learning activities with the least possible effort, ideally independent of time and place. An app best possibly fulfills this requirement, as mobile devices are a daily companion of almost all students, and therefore they are better suited than other media, such as websites (e.g., Böhmer et al. 2011). In addition, smartphones and apps are well-known to students, which lowers the need for user trainings (e.g., Bomhold 2013).

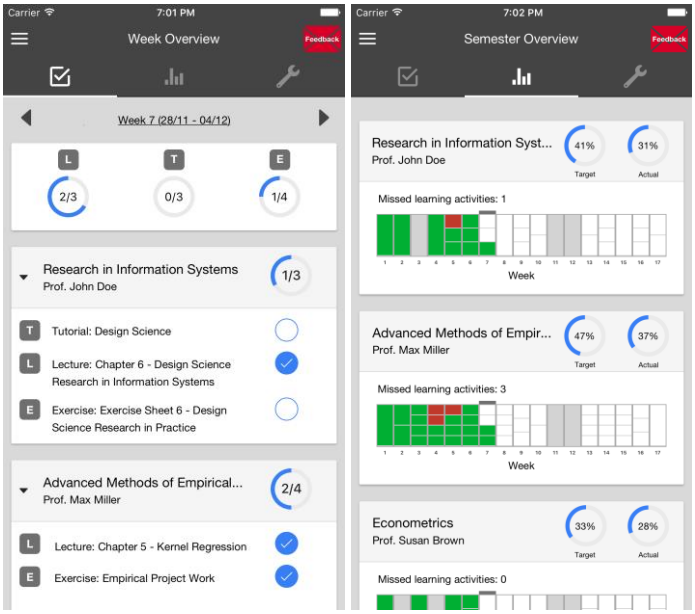

Figure 2. Main screens of the developed app: week overview (left) and semester overview (right).

In our app, after an initial registration, users specify which courses they are enrolled for. Thereafter, they can use the app to see which learning activities they have to perform, they can indicate for each learning activity whether they have already completed it, and through a number of aggregated statistics they can see how many learning activities they have completed and missed so far. The app has two main screens: a week overview and a semester overview (see Figure 2). In the week overview, the learning activities for a given week are listed, grouped by the courses that they belong to. Each activity is presented with a short description, an icon for the type of the learning activity (e.g., prepare lecture, attend lecture, read material), and a checkbox to indicate that an activity has been completed. Students also see statistics on the number pending and completed activities in a given week, which are shown as total numbers and through circular progress bars grouped by courses and activity types. The week overview also allows switching to past and future weeks. In the semester overview, students get a high-level view of their learning activities in a given semester. For each course, students see a timeline that represents the weeks of the semester, while boxes on the timeline represent the learning activities that belong to a certain course. Each box shows the current status of a learning activity through its color (green=completed, red=overdue, white=in future, grey week=no activities). By tapping on a week, the user can navigate to the week overview screen for the corresponding week. In addition to the timeline, users can see summary statistics of their current progress (e.g., circular progress bars compare the "actual" and the "target" numbers of completed learning activities, conditional on the current week). Additionally, the total number of overdue learning activities for each course is shown.

To support the evaluation of the lean gamification approach, the app provides us with two types of data: First, data on tracked actions, e.g., learning activities. Second, data on the in-app behavior of users, for example, on how often users open the app, where they navigate to, etc. (tracked with the analytics software Piwik, www.piwik.org). Furthermore, to minimize the risk for selection bias in our empirical study, we used a cross-platform development technique (ionicframework.com) that allows using the developed app on Android as well as iOS smartphones. The communication with the backend is based on an open-source gamification engine (github.com/ActiDoo/gamification-engine). For more information on the app's functionality and implementation technology, see Feldotto et al. (2017). The mobile application was published in the Apple App Store and Google Play Store in November 2016 (see the project homepage https://studynow.uni-paderborn.de).

5 Empirical research design

To evaluate the merits of the lean gamification approach, we currently conduct a mixed-methods study that explores to what extent using the app promotes behaviors that are conducive to academic performance, and to what extent using the app indeed leads increases academic performance. This study is embedded into a broader study on academic procrastination, which is a very prevalent problem among students and has highly detrimental effects on academic performance (Steel & Klingsieck 2016). For the quantitative part of our study, we conduct a pretest-posttest-(control-group) design. Participants were asked to participate in an online survey that comprised self-report measures for different forms of procrastination (academic procrastination, general procrastination) and the use of mobile devices. In the posttest, besides the measures on procrastination, we will measure perceived learning effort and the extent to that students are satisfied with their academic performance in the current semester. The pretest took place at the beginning of the current semester, the posttest will take place at the end of this semester. In the meantime, the students in the experimental group (n = 91, 58% male, M_{age} = 22) will study with the help of the app. The participants in the control group (n = 183, 71% female, M_{age} = 21) are not informed about that possibility. Instead, they answer the self-report measures in the context of a larger study that investigates self-regulated learning of students. Prior gamification research emphasizes that a multiplicity of individual and context factors are likely to be important in gamification studies (Seaborn & Fels 2015), we complement our experimental study with a qualitative study that is based on the personal diary method (Symon 1998). For our diary study, students of two Master's courses (n=11 & n=15) were asked to use the mobile application and to report on their experiences through three diary entries throughout the current semester.

6 Concluding remarks and future work

Despite the potential of gamification to address motivational problems among students, instructors hardly use gamification. Research on adoption barriers indicates that one reason for this neglect is that current approaches to gamification demand too much effort from instructors, because the current approaches to gamification require instructors to engage in the time-consuming preparation of their course contents. In reply to this issue, we propose a lean gamification approach that is based on gamifying learning activities instead of learning contents. To evaluate the usefulness of the lean gamification approach, we developed a mobile app and currently evaluate the app through a mixed-methods study. We thereby hope to contribute to gamification research in two ways: First, we hope to contribute an innovative artifact that implements gamification in a novel way and expectedly increases the academic performance of its users. Second, by evaluating the artifact we hope to provide first evidence for the usefulness of the lean gamification approach, whose value we established theoretically by drawing on research on limited attention and present bias. In the long run, through our work we hope to allow more students and instructors to benefit from the advantages of gamification.

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