

# On the Acceptance and Effects of Recapping Self-Test Questions in MOOCs

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**Abstract**—Learners in Massive Open Online Courses (MOOCs) are reiterating over the provided course material - especially self-tests - to consolidate their knowledge. This is a manual and often cumbersome process as MOOC platforms do not provide personalized revision opportunities. This paper introduces the design and concept of a flashcard-like recap tool based on spaced repetition learning techniques. The recap material is derived from existing self-test questions. The usage rates of the recap tool were observed in three courses and peaked before graded assignments, primarily before the final exam. When choosing the question quantity, learners preferred either the smallest option or wanted to revise all of the available questions, whereas the average number of questions per recap session increases over time. Recap tool users who completed a recap session showed smaller error rates than those who stopped a recap session abruptly, while learners who skipped questions performed worst. Course participants who used the recap tool throughout the course achieved on average more of the available points. Statistically highly significant differences were detected for all observed courses. An additional survey (N=79) gathered qualitative feedback and impressions from the learning community.

**Index Terms**—Spaced Learning, MOOCs, Self-Regulated Learning, Technology-Enhanced Learning

## I. INTRODUCTION AND BACKGROUND

Traditional Massive Open Online Courses (MOOCs) often follow a linear learning path [1], [2]. Each week new content is introduced, which itself is organized in sequential items. Learners within the courses can receive points in the weekly homework and a final exam, which then leads to a certificate at the end of the course. Most MOOCs provide self-tests - small ungraded exercises like multiple-choice tests - in between video lectures to allow learners to verify the acquisition of the newly learned content [3]. Such a structure is convenient from the course administrator perspective. However, it does not necessarily reflect the actual learning path of a learner [1], [4], [5]. Learners go back and forth in the provided learning material, repeating and rewatching content as they require.

On the one side, learners - especially those with prior knowledge - might skip videos where content is introduced and jump directly to the self-tests to check if they know the topic well enough and only refer to the videos if they didn't receive a good score [6]. On the other side, learners might include additional revising sessions to consolidate their knowledge [7]. In both scenarios, these self-tests play a central role in the

learning process. According to a survey conducted on the HPI MOOC Platform, 67.8% of the users (N=351) voted for a training mode as an extension for self-tests within MOOCs to practice their knowledge.

The personalization of the learning process in MOOCs has been subject to recent studies in the last years [8]. It's often limited to optional learning resources and tools to ensure all learners having access to the essential learning material equally and to avoid an unfair bias towards common learning patterns [9]. Such learning support also has to be adaptive to the learner to trigger the maximum degree of engagement. A case study for one of the first adaptive MOOCs was presented by Sonwalkar [10] for the course *Molecular Dynamics for Computational Discoveries in Science*. The author developed a pedagogical framework with an Adaptive Mobile Learning (AMOL) system. AMOL includes different learning strategies and dynamic content rendering to support individual learning styles. It also includes adaptive and immediate feedback after each quiz attempt to encourage learners. Another approach for adaptive learning is spaced repetition [11], [12]. The idea is to review the information that is known well less often and focus more on those facts which are not known immediately. This raises the ability to recall information.

One of the first psychologists studying memory and forgetting was Ebbinghaus [13]. In several experiments he found out that people forget up to 75% of what they have learned after 48 hours. He also stated that repetitive learning reduces the number of facts we tend to forget. His research showed that "the retention of new information degrades rapidly unless it is reviewed in some manner" according to Stahl, Davis, Kim, *et al.* [14]. The German science journalist Leitner [15] developed an algorithm that enables efficient learning with flashcards: the Leitner System. It is based on spaced reviews repeating the flashcards sequentially to increase the time learners retain knowledge. Cards are grouped into several boxes depending on how good the specific content is known.

Nickson [16] emphasizes that "when practicing multiple-choice questions it is essential that you have access to the answers, or go to the trouble to find out the correct answers soon after testing yourself". This can be difficult in an analog approach. However, in digital learning environments like MOOCs, this allows new interactive possibilities to enhance the learning experience. Feedback for incorrect answers can be

presented instantly to the user, as well as further explanations, reading material and references.

The overall idea of this paper is the integration of a flashcard-like environment on existing self-tests in a MOOC context. The advantage is that already existing data can be used to provide a new learning experience. Learners can recap all of the course topics in one place instead of referring to each self-test separately. There is no need for the teaching team to create additional content as existing self-test questions are reused. To examine the acceptance and usage, as well as the effects of such an additional learning tool, we formalized the following research questions:

RQ1 How is the flashcard-like recap tool utilized by the learners?

RQ2 When do learners make use of the recap tool?

RQ3 How do learners perform when using the recap tool?

RQ4 Does the usage of the recap tool correlate with the course performance?

This work will describe the underlying concept and implementation details of the prototype in Section II. In Section III, several metrics about the acceptance and usage of the proposed recap tool are defined, analyzed and discussed. Thereafter, future directions and other enhancements are outlined in Section IV. This paper concludes with Section V.

## II. CONCEPT AND IMPLEMENTATION

The recap tool prototype shows how a flashcard system based on self-test questions with a simple repetitive learning approach is realized in the HPI MOOC Platform. The goal is to allow effective learning with repetition techniques combined with enhanced user experience through client-side rendering. To implement a flashcard system based on self-tests in MOOCs, the following requirements have been identified:

- Learners should be able to practice their skills independently from the current course structure.
- The recap tool should provide instant feedback if an answer was correct or wrong.
- If users realize a lack of knowledge on a certain topic, they should be provided with more information.
- The system should use an algorithm that adapts the questions according to the user's performance.

The main goal is to provide a more personalized and repetitive learning experience. For the first iteration of this prototype, the scope of the recap tool is limited to one course at a time. When starting a recap session, the learner can choose the quantity of the questions to be recapped. By default, there are four different options: small (10 questions), medium (20 questions), large (50 questions), and complete (all available questions). As the recap tool only considers questions from self-tests that have already been made available to the course participants, selection options might be omitted if the required amount of questions is not available. Upon choosing the number of recap questions, the system selects a random set of the available questions and prompts the learner to answer one question at a time in random order. The mechanics

of the supported question types are explained in detail in Subsection II-A. The recap tool dynamically adopts the correct and incorrect answers following a spaced repetition approach. The implemented algorithm is described in Subsection II-B. If the learner's answer was incorrect, there will be additional time to review the question before the next one appears. At the end of the recap session, learners receive feedback about their performance including the number of correct and incorrect answers. Based on the performance, the system suggests topics that should be revised by the learner. Screenshots of the different stages in a recap session are shown in Figure 1.

The recap tool was implemented as an extension to the existing microservice architecture [17]. An API provides questions, which then are displayed by a frontend component. All questions of the current recap run are stored in the browser, so no additional loading times occur in a single recap session.

### A. Supported Question Types

For this iteration of the recap tool, two question types are supported: Multiple-choice and multiple-answer questions. Both types have predefined answers and the user has to choose the correct one(s).

1) *Multiple-Choice*: Multiple-choice questions have exactly one correct answer. As soon as a user clicks one of the provided answers the question gets evaluated. The user receives instant feedback whether the answer was correct or not.

2) *Multiple-Answer*: Multiple-answer questions are not limited to a single correct answer. Since more answers can be correct the same approach as for multiple-choice questions would not work. To overcome that, a concept similar to the game *MineSweeper*<sup>1</sup> is used. If a user selects a correct answer, it will be marked accordingly and can not be changed anymore. The user can now continue until all correct answers are selected. If the user selects a wrong answer the correct solution is displayed.

3) *Administrative Question Exclusion*: As not all questions are feasible to be used within the recap tool, teaching teams can exclude questions from this mode. This might be needed if a question is not fully self-contained when it references a previous question from the same self-test.

### B. Repetitive Question Ordering

The recap tool supports learners to train weak skills more than strong ones, following a spaced repetition strategy. The so-called spacing effect indicates that learning over a longer period is more useful compared to last-minute studying. Learners have the chance to repeat questions they did not answer immediately later up to three times during the same recap session. This scales the idea of spaced repetition within a single recap session. The repetitive algorithm using spaced repetition within single recap sessions is illustrated in Figure 2.

<sup>1</sup>[https://en.wikipedia.org/wiki/Minesweeper\\_\(video\\_game\)](https://en.wikipedia.org/wiki/Minesweeper_(video_game))

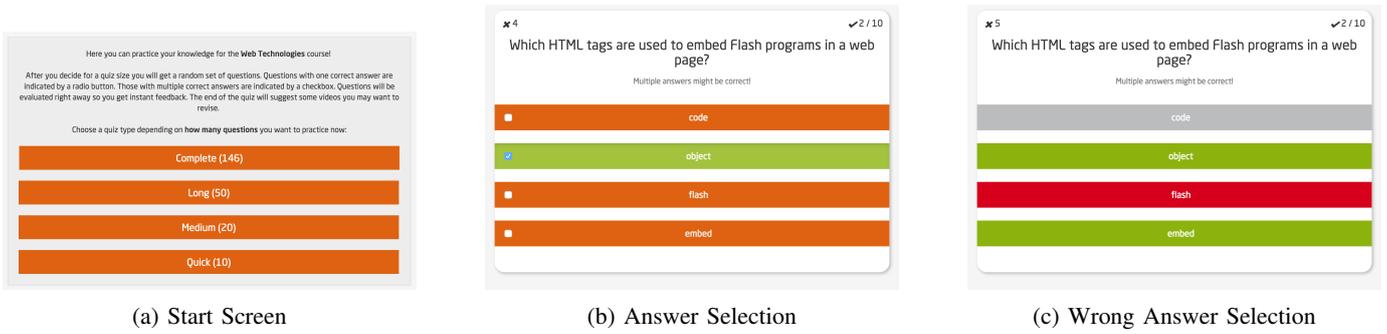


Fig. 1: Prototype Screenshots

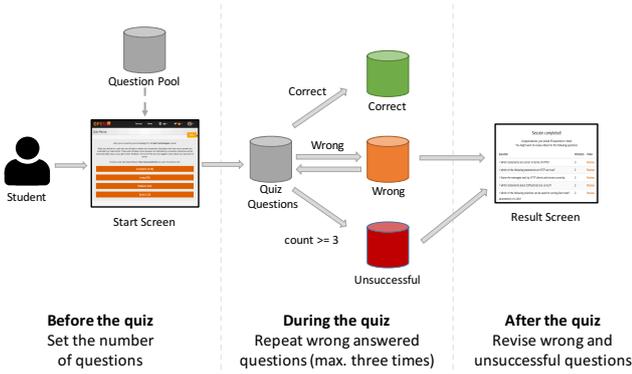


Fig. 2: Repetitive recap tool concept: Repeat incorrectly answered questions up to three times and present them in result page with recommended videos

### III. EVALUATION

To analyze the learning behavior in regards to the recap tool, we conducted a series of quantitative studies, which aimed to answer the defined research questions. Hereby, the focus was primarily set on the learner’s interaction with the recap tool, when they referred to the recap tool and with which settings they preferred to learn. Although it is an interesting topic worth looking into, this study does not reason about the learner’s intention and motives to start a recap session. In addition to the quantitative studies, further insights were gathered through a survey among the learners who utilized the recap tool during a course period.

#### A. Methodology

All results presented in the work are based on usage data of openHPI, an instance of the HPI MOOC Platform, which specialized in providing MOOCs about Information and Communications Technologies (ICT), IT systems engineering, and other computer science-related topics. The presented prototype can also be deployed in another context, but differences in the learning behavior might occur.

For the quantitative analysis, three MOOC courses were selected from openHPI. All courses ran for six weeks in 2019. This ensured a sufficient amount of available recap questions, as well as a good motivation for learners to recap the content

of the first weeks before the final exam. Some metadata about the courses is included in the left portion of Table I.

*bpm2019*: This course about business process modeling was held from May 15, 2019, to Jun 26, 2019. The course was available in English and accommodated 2092 learners who participated actively in the course. In total 151 learners used the recap tool (7.22%) with overall 162 questions.

*ibmpower2019*: In this course, the topic was on technologies around IBM Power Systems including Hardware and Operating Systems, Software Development, Artificial Intelligence, and Blockchain. The course was held in English from May 1, 2019, to Jul 2, 2019. 85 of the 1255 active learners (6.77%) made use of the recap tool with 80 questions.

*internetworking2019*: This German-speaking course was addressed to learners who wanted to learn about the inner workings of the Internet with its well-known applications like the World Wide Web and email delivery. The course was supervised by the teaching team from Oct 28, 2019, to Dec 17, 2019. In total, 2798 learners actively participated in the course of which 563 learners (20.12%) utilized the recap tool with 210 questions.

The recap tool was available to all course participants over the whole course period with all suitable questions which were released up to this point.

To capture the learner’s behavior and interactions with the recap tool, the learning analytics framework introduced by Renz, Navarro-Suarez, Sathi, *et al.* [18] was extended to gain more insights into the actual application of the tool. When a learner starts a new recap session, an event is captured which includes all the required user settings like the chosen number of recap questions, as well as a unique identifier for this recap session. Besides, for every answered recap session an event is stored to reason about the learner’s performance. At the end of a recap session, another event is fired to indicate the wrap up of this session.

The survey for the qualitative evaluation was conducted with an earlier version of the recap tool within a course about web technologies in 2015. However, there are no major differences between the recap tool utilized for qualitative and quantitative analysis. While the mechanics and the algorithms remained unchanged, the user interface was improved and support for learning analytics was added.

## B. Acceptance

The recap tool is designed to be used at every point in the course. However, the courses observed in the quantitative evaluation included graded assignments throughout the course. These graded assignments had to be submitted before a given deadline, which is usually set to the end of a course section/week. These deadlines can have an influencing effect on the learner to use the recap tool more thoroughly.

To study the learner's engagement with the recap tool over time and with regards to the course deadlines, the number of started recap sessions was tracked for each day starting at the time when the first learning material was published. In Figure 3, the total number of started recap sessions per day is shown for each of the three observed courses. As over the course period, learners stop participating in the course, the amount of started recap sessions was normalized by the number of the active learners up to this point as well as by the number of learners who used the recap tool.

All three courses show an increased number of overall recap sessions starting right before each single course deadline. This is a clear indicator for learners recapping course material before taking graded assignments. In two of the courses (*bpm2019* and *internetworking2019*), the maximum amount of overall started recap session was reached before the last deadline in the course, which is usually the final exam and accounts for most of the achievable points. This was not the case for the *ibmpower2019* course. However, this course offered an extended period leading up to the final exam (34 days) compared to the other courses (7 days). Over this period, multiple peaks of started recap sessions formed, which are approximately seven days apart. Aggregating all recap sessions of these 34 days would, however, yield a similar result as the courses with only a seven day period before the last deadline. In total, 450 recap sessions were started in the *bpm2019* course. Whereas the *ibmpower2019* course encountered 268 recap sessions and in the *internetworking2019* course the learners overall started 3855 recap sessions.

Interestingly, the normalized count of started recap sessions presents a different picture. Here, usage peaks before assignment deadlines are not noticeable anymore for two courses - *ibmpower2019* and *internetworking2019*. Still, the ratio of started recap sessions and active users peaks right before the last deadline in each course. On the one hand, this indicates that learners who are last in submitting their final exam are heavily utilizing the recap tool. One possible reason could be a certain level of insecurity and a need for double-checking their knowledge. On the other hand, it underlines the assumption of the authors that the recap tool is more important for the exam preparation compared with the preparation for weekly graded assignments. All three courses show an increasing trend in started recap sessions towards the course end.

## C. Learner Preferences and Interactions

Next to the insights when a recap session was started by the learners, it is worth analyzing how learners utilized the recap tool. Therefore, the chosen number of recap questions

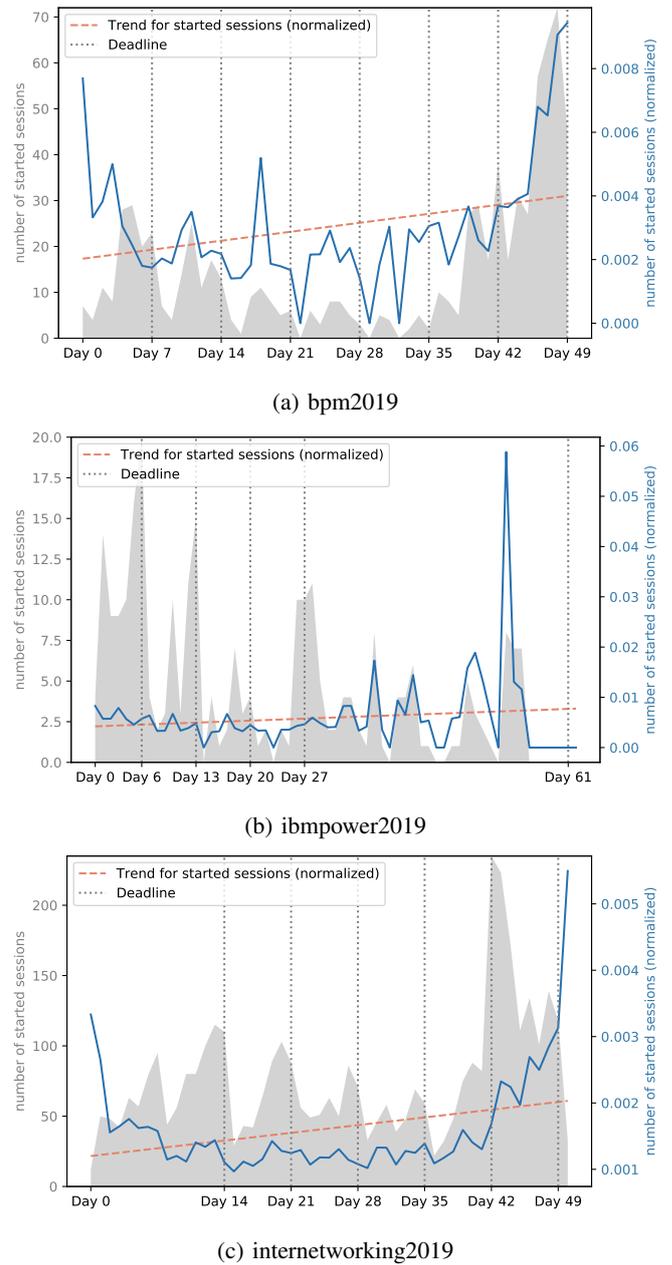


Fig. 3: Started recap sessions over course period (absolute values and normalized by active users and users who used the recap tool)

and the correctness of the answers throughout a recap session is further investigated.

1) *Starting Recap Sessions:* As described in Section II, learners have the option to choose from up to four quantities when starting a recap session: 10, 20, 50, and all questions. In Table I, the started recap sessions are categorized by the chosen question quantity. In all three courses, the smallest option (10 questions) and the option with all available questions were the most popular ones with the learners (small: 27.99-42.44%; complete: 30.12-55.22%). The large option (50 questions) was

the least popular one. However, while interpreting this statistic, the following facts have to be considered. First, the option *large* will only become available if more than 50 questions are available for recapping. Second, the complete option does not refer to the full set of recap questions at the course end. It always refers to the complete set of questions made available to the course participants up to this point. For example, with a total number of 15 available recap questions, the learner would have had to choose between the small option (10 questions) and the complete option (15 questions).

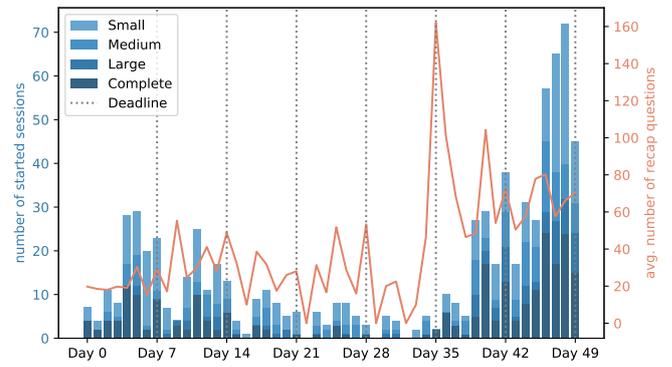
Figure 4 illustrates the chosen question amounts throughout the course. For all three courses, the distribution between the four options stays relatively constant. Therefore, the mean of the chosen question counts is additionally shown for each day. For the courses *bpm2019* and *internetworking2019*, a clear trend of an increasing average number of recap questions becomes visible. Whereas for the course *ibmpower2019*, this metric peaks throughout the extended period before the last deadline. This is another indicator in favor of the previous finding that learners become more motivated to check their knowledge with the recap tool towards the end of a course.

2) *Ending Recap Sessions:* After taking a closer look at the learner’s preferences when starting a recap session, the different scenarios of how a recap session can be ended by the learners are examined. In total, there are three different ways of how active recap sessions can end. In the first scenario, the learner answered all the recap questions that are selected for the recap session and the result screen is presented to the learner. This kind of outcome is further referred to as *regular stops* as this is the indented interaction pattern of the recap tool. At every point in the recap session, the learner has the option to omit the remaining questions by skipping directly to the result screen. These stops are called *early soft stops* because the learner decides to end the recap session but is still interested in the results. Due to the mechanics of modern web browsers used to display the recap tool to the learner, it is always possible that the learner closes the presenting window or tab. For these *early hard stops*, the recap session is ended abruptly and no result screen is shown to the learner. For completeness, there is an extra category for all recap sessions which were started but receive no further user interaction and answered questions (*no show*).

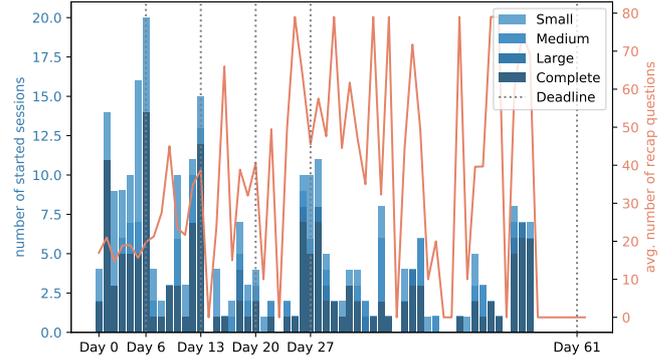
The authors suspect various reasons for ending a recap session ahead of time. Too difficult recap questions or too many incorrect answers in a row can demotivate learners to continue the recap session. To investigate this in detail, an error rate metric (see Equation 1) was defined based on the number of correct and incorrect answers in a recap session.

$$errorRate = \frac{|answers_{incorrect}|}{|answers_{correct}| + |answers_{incorrect}|} \quad (1)$$

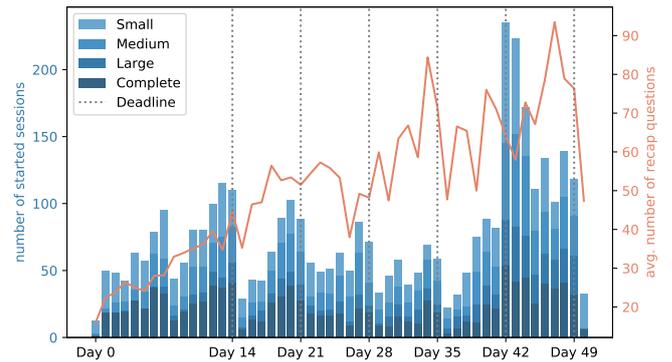
Table II shows the probability of all four recap end scenarios, as well as the calculated error rates for each scenario. ‘Regular stops’ are the most common ending outcome (53.78-78.08%), whereas ‘early soft stops’ and ‘early hard stops’ are



(a) bpm2019



(b) ibmpower2019



(c) internetworking2019

Fig. 4: Selected question quantity for recap sessions over course period

approximately equally likely (8.09-21.56%). Recap sessions with no recorded user interactions are the least likely outcome (4.53-9.78%). As expected by the authors, ‘regularly stopped’ recap sessions also show the lowest error rates (0.11-0.20) in the defined set of ending scenarios. However, ‘early soft stopped’ recap sessions feature on average a higher error rate (0.38-0.45) as ‘early hard stopped’ sessions (0.24-0.31). It is possible to reason that learners who show a bad performance when using the recap tool want to retrieve insights from the result screen to improve their score.

To calculate the statistical differences of the measured

TABLE I: Course Meta Information and Distribution of Selected Question Quantity in Courses

Course	Active Learners	Questions	Recap Users		Sessions	Selected Recap Option							
			<i>N</i>	%		Small		Medium		Large		Complete	
						<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
bpm2019	2092	162	151	7.22	450	191	42.44	85	18.89	35	7.78	139	30.89
ibmpower2019	1255	80	85	6.77	268	75	27.99	36	13.43	9	3.36	148	55.22
internetworking2019	2798	210	563	20.12	3855	1225	31.78	988	25.63	481	12.48	1161	30.12

metric, the Kruskal-Wallis test was applied. The test returned highly significant differences for all three courses (see Table II). Figure 5 shows the distribution of the error rates in the three ending scenarios for all three courses. For determining the difference in each combination, the Dunn-Bonferroni test was used as a posthoc test (see Table III). Additionally, the effect sizes were calculated based on Cohen's *d*. All combinations, but the soft and hard early stops, show statistically significant to statistically highly significant differences with medium to huge effect sizes.

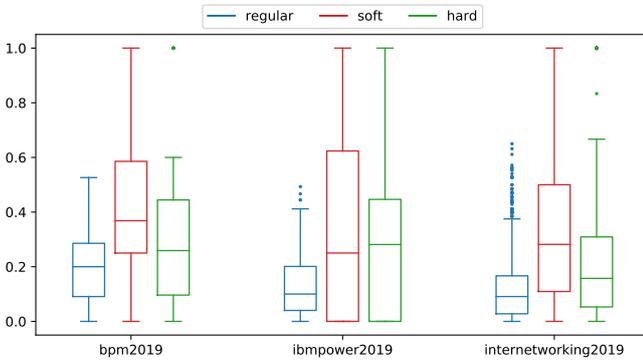


Fig. 5: Error Rates Distribution for Recap Session Ending Scenarios

#### D. Course Performance

The ultimate goal of the recap tool is to help learners to prepare better for graded assignments and, thus, earn overall more of the available points. Therefore, the number of achieved points is a suitable indicator for learning success if the goal is to earn a certificate. To examine the influencing factor of the recap tool in the overall course performance, a one-sided<sup>2</sup> Mann-Whitney *U* test was performed. For each course, the treatment group included all learners who have used the recap tool during the course period whereas all other active learners were assigned to the control group. Additionally, the effect sizes were determined based on Cohen's *d*. Table IV lists the results of the statistical test.

Most notably, in two courses (*bpm2019* and *ibmpower2019*) learners who utilized the recap tool achieved on average

<sup>2</sup>A one-sided alternative hypothesis was chosen because it should only be tested if the result of the treatment group is greater than the one from the control group.

considerably more points than the control group (71.62 vs 43.53; 70.50 vs 27.99). The effect is not as distinctive for the *internetworking2019* course. Here, the treatment group earned on average 88.81 points compared to 78.74 points of the control group. In all courses, the treatment group shows a smaller standard deviation compared to the control group. The Mann-Whitney *U* test returned statistically highly significant differences for all courses between learners who used the recap tool and those who didn't. Thereby, medium to huge effect sizes were measured.

However, this statistical test might be skewed as the usage of the recap tool could not be the single influencing factor for good course performances. One can argue that learners who used the recap tool were already more motivated to complete the course with a certificate than those who haven't used the recap tool.

#### E. Survey

For gather additional insights, course participants were asked at the end of the course if they had noticed the recap tool and if they had used it. 61% of the learners who had noticed the recap tool had also used it. Even though the recap tool was released quite late during the course, almost the majority of the participants showed interest in the prototype.

A more detailed survey (N=79) was prompted to the learners at the end of each recap session on the result screen. Participants stated that they used the recap tool up to 15 times, which indicates an intense use for example for exam preparation. Learners seemed to be satisfied with the predefined session sizes. 44% of the participants voted the smallest size (10 questions) as the preferred one. The medium size (20 questions) was voted with 27% second best. That indicates a preference for quick learning sessions. One user liked "to take a break from my everyday work and in that break quickly recap some of the knowledge I acquired in the videos". Other or individual session sizes were only requested by 18% of the participants. Some of them would like to have a selection of topics or a week to learn more specifically. While using the recap tool, 65% of the participants recognized that questions appeared multiple times during their sessions. According to the repetitive algorithm, questions are repeated if they were initially answered wrong. 78% of those users who witnessed these repeating questions liked it. One user said, "the repetition helps me remembering the answer and understanding the content". Another stated that "repeating the question reinforces the right answer".

TABLE II: Distribution of error rates for recap session ending scenarios

Course	Sessions	Regular Stops			Early Soft Stops			Early Hard Stops			No Show %	Kruskal-Wallis	
		%	Error Rate		%	Error Rate		%	Error Rate			$Chi^2$	p-value
			Mean	Std.Dev.		Mean	Std.Dev.		Mean	Std.Dev.			
bpm2019	450	53.78	0.20	0.12	14.89	0.45	0.30	21.56	0.31	0.29	9.78	45.14	<0.001
ibmpower2019	268	68.28	0.13	0.11	11.57	0.36	0.35	11.57	0.29	0.28	8.58	10.66	0.005
internetworking2019	3845	78.08	0.11	0.10	9.31	0.38	0.35	8.09	0.24	0.28	4.53	267.33	<0.001

TABLE III: Dunn-Bonferroni Test for Determining Significant Differences between Recap Session Ending Scenarios

Course	Combination	Dunn-Bonferroni		Cohen's <i>d</i>
		statistic	adj. p-value	
bpm2019	regular-soft	-6.599	<0.001	1.40
	regular-hard	-2.866	0.012	0.60
	soft-hard	3.566	0.001	0.46
ibmpower2019	regular-soft	-2.489	0.038	1.35
	regular-hard	-2.452	0.043	1.09
	soft-hard	0.028	1.000	0.20
internetworking2019	regular-soft	-15.136	<0.001	1.80
	regular-hard	-7.665	<0.001	1.02
	soft-hard	5.028	<0.001	0.43

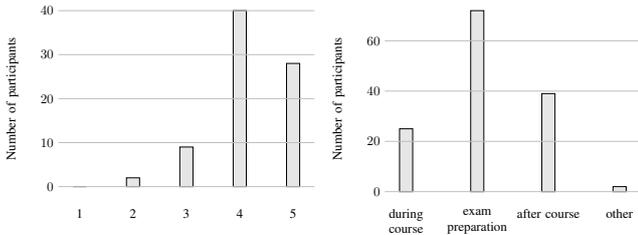


Fig. 6: Results of the recap tool survey: How much they think the recap tool would support their learning experience (left) and when would they primarily use it (multiple answers allowed)? (right)

Learners stated they would primarily use the recap tool for exam preparation, according to 91% of the participants (see Figure 6). Since the prototype was just released shortly before the course ended, this answer might also be arbitrary. Nevertheless, almost half of them (49%) stated that they would also use it sometime after the course to repeat its content. All in all, participants think the recap tool would certainly support their learning experience. On a Likert scale from 1 to 5, they rated the prototype with an average of 4.2. 86% of the participants voted the prototype with 4 or 5 (see Figure 6).

One user suggests allowing focused learning on one particular topic and excluding topics which he already knows. Another user stated that he would like to continue using the recap tool in the future after the course ends. So there appears to be a need to practice the knowledge of the course at a later point in time. He also remarked that getting the same question in a recap session twice is confusing. Another user

summarized: "I consider the tool one excellent study tool; enabling the student to review the understanding of the content in a fast and entertaining way".

#### IV. FUTURE WORK

Although the recap tool was already perceived as useful in the learning process, additional enhancement and further applications were sparked by the user's comments in the survey and the evaluation of the usage data, as well as by recent learning experience developments.

##### A. Variable Scopes

Currently, the recap tool limited to considered all available questions of a course. This is not always suitable for the practicing goal of the learner's recap session. On one side, the learner could prefer to recap a particular course section to specifically refresh or test his knowledge of the taught content. On the other side, the recap tool could also be deployed on a platform-wide basis to recap and test the learned content of previous course enrollments. This aligned with the work of Davis, Kizilcec, Hauff, *et al.* who studied knowledge retention in MOOCs [19].

##### B. Mobile Usage and User Activation

Nowadays many learners access MOOC platforms, next to the traditional web access, via mobile applications. As mobile devices are most of the time directly at the learner's hand, they can also be used to promote quick knowledge recaps on the go or a regular basis through push notifications. For this to work, the system has to be aware of the user's routines and learning behavior, as well as the current course progress to trigger the learner optimally. As a result, the learner receives better support for mobile-assisted seamless learning [20].

##### C. Smart Question Selection

In the existing version of the recap tool, questions for a recap session are selected randomly from the pool of available questions. This approach ensures that all questions can be recapped by a user. However, the user's needs and performance are not considered. The next iteration of the recap tool should feature a more adaptive approach, which weights questions according to the previous performance of the learner. This includes that incorrectly answered questions should be revised more often. Another improvement can be made by selecting questions which are neither perceived as too difficult nor too easy for the learner [21], [22]. In this way, the learner can

TABLE IV: Descriptive Statistics for Achieved Points of Learners Using the Recap Tool

Course	Recap			Control			Mann-Whitney $U$		Cohen's $d$
	$N$	Mean	Std.Dev.	$N$	Mean	Std.Dev.	$U$	$p$ -value	
bpm2019	120	71.62	24.15	777	43.53	37.39	66441.0	<0.001	0.782
ibmpower2019	72	70.50	23.34	464	27.99	34.54	27139.5	<0.001	1.278
internetworking2019	490	88.81	15.08	829	78.74	27.26	247789.0	<0.001	0.429

stay in a flow of engagement and would stop a recap session because of a higher number of incorrectly answered questions. This approach requires to be backed up by a solid learning theory to avoid the learner from overestimating his knowledge as only easy questions were used in the recap sessions.

## V. CONCLUSION

This paper introduced the design and concept of a flashcard-like recap tool based on spaced repetition learning techniques. The recap material is derived from existing self-test questions to avoid additional tasks for course administrators. Learners can independently revise a random selection of available questions. Incorrectly answered questions are repeated up to three times per recap session.

The recap tool was tested on an instance of the HPI MOOC platform. For the quantitative analyses, three courses were observed over the entire course period of at least six weeks. The usage rates of the recap tool peaked before graded assignments, especially before the final exam (RQ2). Learners late in submitting the final exam used the recap tool heavily (RQ2).

When choosing the question quantity for a recap session, learners preferred either the smallest option (10 questions) or wanted to revise all the available questions (RQ1). As throughout the course, more self-tests and, thus, more recap questions become available to the course participants, the average number of questions per recap session increases over time (RQ1).

Recap sessions were categorized whether the learner answered all the prompted questions, a portion of the questions was skipped, or if the recap session was ended abruptly. Learners who completed a recap session showed smaller error rates (0.11-0.20) than those abruptly stopped a recap session (0.24-0.31), while learners who skipped to the end performed worst (0.36-0.45). Statistically significant to statistically highly significant differences were proven for all but one combination among these recap ending scenarios (RQ3).

Learners who used the recap tool throughout the course achieved on average more of the available points and are, thus, more likely to earn a certificate. The statistically highly significant differences were observed for all courses with medium to huge effect sizes (RQ4).

An additional survey (N=79) provided qualitative feedback from the learning community and spark improvements to the recap tool, as well as ideas for further research directions. The recap tool was perceived as a valuable addition to the

individual learning process and the available toolset of the HPI MOOC platform.

By extending the recap tool by more configuration options, learners gain the possibility to recap specific topics more directly. Bringing the recap tool to mobile devices would enable recap sessions in more situations, supporting an omnipresent learning experience.

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