Applied Mobile-Assisted Seamless Learning Techniques in MOOCs

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Abstract. As Massive Open Online Courses (MOOCs) are nowadays used in an increasingly ubiquitous manner, the learning process gets disrupted every time learners change context. Mobile-Assisted Seamless Learning (MSL) techniques have been identified to reduce unwanted overhead for learners and streamline their learning process. However, technical implementations vary across the industry. This paper examines existing MSL research and applied techniques in the context of MOOCs. Therefore, we discussed related MSL research topics. Afterward, eleven characteristic MSL features were selected and compared their implementations across five major MOOC platforms. While web applications provide a bigger feature set, mobile clients offer advanced offline capabilities. Based on the findings, a concept outlines how MSL features can enhance the learning experience on MOOC platforms while considering the technical feasibility.

Keywords: Seamless Learning · MOOCs · Mobile Learning

1 Introduction

Massive Open Online Courses (MOOCs) offer free online education at scale for everyone who has access to the Internet. In the past limited to stationary computers, nowadays an increasing number of people access the Internet via mobile phones, tablets and other mobiles devices on a daily basis in a subconsciously way. Along with that, users have the possibility to move away from stationary learning towards learning-on-the-go [18]. However, mobile learning is not suitable for every learner as learning behaviors differ [13]. Learners are able to choose from a variety of devices, methods and situations. They pick their most preferred context to achieve the best learning outcome. As learning activities do not always occur in the same setting, Sharples states the importance of "supporting a continuity of learning success across context and devices" [16]. Seamless learning techniques reduce the overhead that is created every time learners experience context changes during their learning process. While de Waard et al. emphasize that "seamless learning for MOOCs will enhance many contemporary learners" [21], seamless learning possibilities are often not explicitly promoted to the learner. Moreover, they are integrated by the MOOC providers to enhance

Accepted at: EMOOCS 2019
The final authenticated version is available online at https://doi.org/10.1007/978-3-030-19875-6_3

the general user experience. By taking a closer look, the impact of convenience functionality on the learning outcome and efficiency becomes evident. Therefore, this work examines the following research question: How are seamless learning techniques applied in major MOOC platforms across all client applications?

In this paper, we examine and discuss multiple features of MOOC platforms that support seamless learning. Hereby, we highlight resulting advantages for the learners and challenges for platform providers when adopting these features. Additionally, we compare the availability of these features for major MOOC platforms to create a comprehensive overview of the current level of support for seamless learning. Furthermore, we present a concept on how to streamline and enhance the seamless learning experience for MOOC platforms. While pedagogical advantages are shown, we will also focus on technology-enhanced learning methods and technical feasibility in order to be useful for the learners.

2 Pedagogical Rationale

Wong distinguished between two forms of seamless learning [23]. On one side, the author identified the process of combining learning activities inside and outside the classroom in higher education. On the other side, Wong recognized the trend of increased mobile and ubiquitous learning opportunities triggered by more and more one-to-one learning situations (one device per learner) [4]. As these personal devices are used in a variety of different situations, it became noticeable that the learning process is required to adapt to context switches. This second form is also known as Mobile-Assisted Seamless Learning (MSL) and is in the focus of this work. Wong and Looi formalized the ten levels of MSL by researching the ways context switches can occur [24]. They defined the following ten levels, which are widely accepted in the community:

- MSL1: Encompassing formal and informal learning
- MSL2: Encompassing personalized and social learning
- MSL3: Across time
- MSL4: Across locations
- MSL5: Ubiquitous knowledge access to learning resources
- MSL6: Encompassing physical and digital worlds
- MSL7: Combined use of multiple device types
- MSL8: Seamless switching between multiple learning tasks
- MSL9: Knowledge synthesis (prior, new knowledge, multi-disciplinary)
- MSL10: Encompassing multiple pedagogical or learning activity models

As a result of one-to-one learning, learners were also encouraged to be more independent in their learning process. This connects MSL to Self-Regulated Learning [25] as learners have the opportunity to learn not only what they prefer but also at which pace, in which order or in which context. Furthermore, increased learning independence promotes Self-Directed Learning [7] where learners start new learning journeys due to intrinsic motivation.

3 The Status Quo of MSL in MOOCs

An extensive summary of research possibilities for MSL in MOOCs was given by de Waard et al. [21]. They referred to the ten levels of MSL by Wong and Looi as categorization for research strands. Influenced by their work, this section discusses specific research studies of applied MSL concepts through technology-enhanced learning techniques in the context of MOOCs. Hereby, the focus is drawn to studies with potential in automatization while at the same time providing an overview of current research.

3.1 Formal and Informal Learning (MSL1)

MOOCs can be applied in various areas to provide free education. Chen and Bryer connect formal learning to in-classroom situations, while informal learning is driven by the learner's personal interest [3]. Most MOOC providers strive to promote lifelong learning and by this means for informal learning. However, in the context of enterprise learning, MOOCs are partly applied in a classroom-like context for the purpose of employee onboarding and further training [11].

3.2 Personalized and Social Learning (MSL2)

While formalizing the ten levels of MSL, Wong and Looi place the "learner at the center of production of knowledge" [24]. Thus, MOOC platforms aim to support multiple learning paths through the provided material. By promoting Self-Regulated Learning techniques, Rohloff et al. presented a concept for personalized learning objectives which allows learners to focus on specific learning items instead of participating in the MOOC from start to end [13]. Other social features intent to substitute face-to-face-learning [6] which is lost in the MOOC context. The most prominent example of this is a learner forum where learners exchange ideas specific to the learning material. In a series of studies, Staubitz et al. investigated in supporting social interactions and collaborations on MOOC platforms [17]. The authors provided small groups of learners with additional collaboration tools like video conferences, a separate forum and document sharing to be used within such learning groups. They discovered that collaboration and group work needs to be actively promoted and triggered in MOOCs.

3.3 Across Time and Locations (MSL3 & MSL4)

By definition, MOOC platforms are online services and can be used by everybody with access to the Internet. Due to the wide broadband coverage [19], the universal access to MOOC platforms is guaranteed. This impact is amplified by the omnipresence of personal mobile devices and one-to-one learning possibilities [4]. In the original design, MOOCs are time-boxed with a fixed start and end date to concentrate on learning activities and learner motivation. Nevertheless, MOOC providers keep past courses accessible to allow Self-Directed Learning.

These courses might still feature the complete set of learning material. However, they will not retrieve the same level of user activity (by instructors and learners). Hence, some MOOC platforms restrict access to the learner forum. Some MOOC platforms offer recap tools which reuse self-tests from previous learning material to enhance the learning outcome through repetition [2]. Such tools can as well be utilized to provide guidance into the course's topic after learners have been absent from a course for a given period of time and transitioned through multiple context switches.

3.4 Ubiquitous Access to Learning Resources (MSL5)

Building on the general accessibility of MOOC platforms across time and locations, all learning resources can be accessed if the required bandwidth is provided. Learning material and user data are stored online to provide universal access. However, these conditions change in rural areas and developing countries. Here, learners might experience low bandwidth or bad mobile data coverage. Whereas in developing countries, mobile devices are primarily used to access the Internet [19]. Because originally designed as web applications for desktop computers, the interface of MOOC platforms needs to adapt to the smaller screen of mobile devices. Responsive web layouts provide an adequate solution for supporting various screen sizes [12]. However, this approach does not resolve the demand for data efficient network operations and complete offline availability in unstable networks. While offline support can be added to learning web applications [9], native mobile clients provide a more advanced solution. Nevertheless, interactions like enrollments to courses or forum activities are not supported in both approaches. As a result, de Waard et al. support the claim that a "combination of web-based and mobile learning platforms adds to the future vision of integrated ubiquitous and seamless online learning environments" [21].

The most challenging part in providing universal access to all learning resources remains to be in creating solutions for mobile devices with complete offline support that are equivalent to the web applications. As Brady et al. determined, learners less proficient in the taught course language are also more likely to download the provided videos, whereas approaching course assignments created similar effects [1].

3.5 Combining Physical and digital Worlds (MSL6)

Integrating the physical world into a digital product like MOOCs is a challenging part. Nevertheless, some efforts were made to bridge these two worlds. Hagedorn et al. explored how MOOCs could be utilized for preparation or follow-up activities for on-site employee training in a medical context [5]. A similar procedure was applied for university courses at the Hasso Plattner Institute, where MOOCs were utilized as preceded or collateral learning material. Furthermore, the spatial locality of the learners can be used to promote local learning groups or meetups beside online activities. However, such activities should always be complementary as not all learners will have fellow students in their surroundings.

3.6 Usage of Multiple Devices (MSL7)

As MOOC platforms store learning progress, settings and activities online to guarantee ubiquitous access, multiple clients with varying levels of functionality can access and process such data. Primarily, browsers are used to access the web application, but mobile clients receive more and more attention. To promote the usage of multiple devices, it must be of high priority for the MOOC provider to enable a mechanism that eases the data exchange between devices. In conjunction with MSL3, learners should have straightforward access to previously consumed and following learning materials. This calls for instant synchronization of the required learners' data to continue the learning process on a different device as learners might immediately continue learning in the same context. Apple provides with *Handoff* a similar proprietary mechanism to continue activities on other devices instantly. Rohloff et al. explored a different take on the multi-device usage [14]. The authors utilized mobile devices as companions to the web application by presenting complementary views - like slides or the learner forum - while the web application was playing the video content. Similar results can be achieved by connecting a second screen to the primary learning device.

3.7 Seamless Switching Between Learning Tasks (MSL8)

Learners have to perform various tasks when participating in a MOOC. Most learning material in a MOOC alternates between video content, tests and further reading material. For social interactions (MSL2) learners consult the learner forum. By annotating forum entry with video timestamps, new questions can be created and existing ones can be viewed when the video playback was paused. Thereby, self-organization among learners is promoted.

3.8 Knowledge Synthesis (MSL9)

An important part for reflecting on the content is the process of creating knowledge documents [17] to form connections and identify knowledge gaps [24]. These documents can then either be shared with a small learning group or can be made publicly available to all fellow learners. In support of lifelong learning, new learning topics should be easily discoverable. As de Waard et al. phrased it: "Learning and knowledge are in a constant state flux" [22]. In order to promote further Self-Directed Learning, MOOC platforms may evolve to learning hubs by encouraging learners to discover new learning topics through an advanced search which includes semantic information and learner-created material.

3.9 Encompassing Multiple Pedagogical or Learning Activity Models (MSL10)

Similar to the implementation of formal and informal learning, employing multiple pedagogical models highly depends on the design of a course. Here, multiple factors like experimental learning techniques [8], motivated instructors [20] and sharing of non-curriculum-based content to kickstart learner motivation [21] have been explored.

4 MSL features implemented by MOOC Platforms

This section provides a framework analysis of MSL features implemented by major MOOC platforms [15]. Therefore, the implementation level and feature discovery are evaluated for each MSL feature. As MSL 1, 6 and 10 were previously identified as course design specific, only a subset of MSL levels was used to select distinctive features that enhance the learning experience through technology. Features that are not included in this overview were not applied by any MOOC platform at the time of this study. Due to the advanced state of these MOOC platforms, fundamental capabilities, like archived courses, native mobile clients, responsive web layouts applications, were assumed and thus also not included.

4.1 Comparison of MOOC Platforms

We examined the following MOOC platforms for the framework analysis: edX, FutureLearn, Udemy, Udacity[1] and the HPI MOOC platform. Thereby, the web applications and native mobile clients were explored separately on January 9, 2019. As only small differences between native mobile clients for each MOOC platform exist, the latest mobile client experiences were tested with an iPad (iOS 12.1.1). The web applications were examined through the Chrome browser (version 71.0.3578.98) for macOS. Each MSL feature was either categorized as *fully provided* (●), *partially provided* (◐) or *not provided* (○). Features which were only applicable for the mobile clients got marked as *not supported* (-) for web applications. Table 1 displays all evaluated features grouped by MSL level.

4.2 Discussion

As Table 1 shows, MSL features are implemented on major MOOC platforms in various degree. By default, web applications offer a bigger feature set compared to mobile clients while FutureLearn is the only examined MOOC platform that does not offer any native mobile clients. The majority of MOOC platforms lack in providing collaboration spaces, as well as supporting learner-created material. Web applications of MOOC platforms should start to offer downloads for primary and complementary learning materials as these are often available in the respective mobile counterparts. In general, mobile clients need to support equal functionality as web applications which can be adapted to the smaller screen sizes and the mobile context. This especially includes providing access to the learner forum, offering downloads of additional learning materials like slides or transcripts, and allowing discussions while watching videos. Additionally, mobile clients rarely promote enhanced learning continuity features, like the next learning item, on a central learner dashboard. In order to become valuable clients, a concept for enhancing MSL should promote mobile clients to make extensive use of multi-screen functionality and advanced offline support. The shown pedagogical implications have to be examined in detail in future research along with the learner behavior as this would exceed the scope of this work.

[1] Udacity discontinued their mobile application as of January 9, 2019

Table 1. Comparison of MOOC platforms in terms of MSL support

	Web					Mobile Client				
	edx	FutureLearn	Udemy	Udacity	HPI MOOC platform	edx	FutureLearn	Udemy	Udacity	HPI MOOC platform
MSL2										
Learner Forum	●	◐	○	◐	●	●	-	○	○	◐
Collaboration Spaces	○	○	○	○	●	○	-	○	○	○
Learner Created Material	◐	○	○	○	◐	○	-	○	○	○
MSL3										
Recap Mode	○	○	○	○	●	○	-	○	○	◐
MSL5										
Video Download	○	●	○	○	●	◐	-	●	●	●
Additional Material Download	◐	○	○	○	●	◐	-	○	○	◐
Offline Assessments	-	-	-	-	-	○	-	○	◐	○
MSL7										
Last Visited Item	◐	◐	●	●	◐	○	-	●	◐	○
Multi Screen Support	-	-	-	-	-	○	-	◐	◐	◐
MSL8										
Discussions in Video Context	○	●	●	○	◐	○	-	○	○	○
MSL9										
Advanced/Global search	◐	◐	●	◐	◐	◐	-	◐	◐	○

5 Concept for Enhanced MSL for MOOCs

In this section, we outline a concept to enhance the support of MSL for MOOCs. Based on previous findings in related research and through a framework analysis on MOOC platforms, the concept covers multi-screen capabilities, advanced offline functionality and supports learner-created material. The focus was set on technology-enhanced learning methods and technical feasibility rather than on specific course designs or application areas. Above all, feature completeness across all clients should be considered mandatory for successful MSL.

5.1 Multi-Screen Capabilities

Currently, mobile clients display learning material adapted to their smaller screen sizes. To increase the learning experience, they should embrace multi-screen

support by providing complementary tools for the learner while the video content is presented on an external screen [14]. The same applies if the primary learner device features a sufficiently large screen. Here the data can be shown side-by-side. These complementary tools can provide further static content like matching slides or transcripts, as well as interactive components like discussions, self-tests or annotation tools in order to create learner-created material.

5.2 Advanced Offline Functionality

One shortcoming of mobile devices is an unguaranteed network connection. They are required to handle unexpected network changes as the learner traverses through different context states. Mobile clients pre-download course content to ensure the best possible learning experience by not depending on a connection to the Internet. Learners could manually select the content to be downloaded. However, this requires sufficient storage capacities, as well as for learners to plan ahead. Automated approaches can provide a superior approach by analyzing the learner's behavior and the available learning material. Upcoming material can be downloaded automatically in the background when a stable Internet connection is provided. While the download of static content is trivial, interactive elements require a more selective approach to obtain the desired learning effects. Graded assessments, for example, are often limited in attempts or time. To prevent fraud, an Internet connection could be partially mandatory. Otherwise, learners could launch multiple instances of the same assessments. These measures may not be required if the assessments are ungraded and only used for self-test purposes.

5.3 Support of Learner-Created Material

The learning outcome increases if leaners engage in note-taking activities in combination with passive content consumptions [10]. Therefore, it may be beneficial for the learner to reflect on taught content by creating personal notes. Such learner-created material can be shared with the entire course community, a smaller subset of fellow students or it may be kept private to the learner. A downside of learner-created material is the increase in storage capacities [17]. At the same time, personal mobile devices offer some storage space that can be utilized to provide private learner-created material. In this way, learner-created material can be realized in a limited, but affordable manner.

6 Conclusion

This paper examined applied MSL techniques in MOOCs and highlighted future research opportunities. For that, existing research was discussed and categorized in the ten levels of MSL defined by Wong and Looi. Besides pedagogical implications, technical challenges and requirements of these approaches were shown. MSL 1, 6 and 10 have been identified as specific to the course design or application area, while the remaining levels can be enhanced through technology or

fulfilled through the nature of MOOCs. In a framework analysis, we selected eleven characteristic MSL features in six MSL levels and compared these across the web applications and mobile clients of five major MOOC platforms. The support for MSL varied slightly between platforms while the web applications provided a bigger feature set compared to the mobile clients. At the same time, mobile clients offered an improved user experience through content download for offline usage. Pedagogical implications and learner behavior of the explored MSL features should be examined in detail in future research to provided comprehensive findings.

In order to enhance the support for MSL in MOOCs, a concept was introduced that outlines multi-screen capabilities, advanced offline functionality and support of learner-created material. Here, the focus was set on technology-enhanced learning methods and technical feasibility rather than on specific course designs or application areas. This work creates a foundation for future research in the fields of seamless learning and mobile learning to achieve more adaptive learning environments in the context of MOOCs.

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