An evaluation framework for microlearning tools for designing and delivering microlearning content

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June 27, 2021

Abstract

The growing significance of microlearning in the context of digital education, higher education and lifelong learning makes it an interesting field for research. Microlearning can be described as learning through small chunks of learning activities which are designed to be concise and focused. In the studied literature, microlearning content development and the content delivery system were the topics most often researched. The main findings include the potential of microlearning tools to provide an adaptive and personalized learning experience using educational data mining techniques and building learner models. In addition, context awareness provides the potential to take contextual factors into account like location and distraction levels of the learner to enhancing focussed microlearning. Current literature focuses on features and design principles of microlearning tools rather then evaluation criteria making it difficult to adequately assess these tools. Building on the current literature focus on features and design principles together with identifying potentials and shortcomings of current microlearning tools, this research paper aims to conceptualize an evaluation framework for microlearning tools based on core criteria in the context of digitalization and higher education.

1 Introduction

Microlearning is learning in small chunks characterised by short bite-sized lessons (Jahnke et al., 2020). To create these lessons, special tools are used which aid the development of the microlearning material and provide capabilities to deliver this material to the learner. Different stakeholders are involved in successfully using microlearning in higher education. The purpose of this work is to conceptualise an evaluation framework for microlearning tools that capture the design and delivery characteristics. The resulting framework can be used by the different stakeholders to assess existing and future microlearning tools. In this framework the core constructs will be the design and delivery characteristics of the tools.

1.1 Background on microlearning design and delivery

Mobile microlearning is a form of mobile learning characterised by how its learning material is designed for mobile devices. In the light of this paper, each microlearning unit can be seen as a "short, focused learning chunk of information on a topic that is designed to fulfil a specific

learning objective" (Zhang & Cristol, 2019). This paper will use the term microlearning by itself to refer to mobile microlearning.

Recent empirical research shows that in a multi device environment, mobile technologies like microlearning can enrich the learning experience of students (Gruber et al., 2015) and the increase in smartphones ownership around 2010 is beneficial for this multi device environment. Other works indicate the benefits of microlearning to increase student test results compared to regular e-Learning methods (Polasek & Javorcik, 2019) and the potential to support learning by making the content more appealing to the learner (Lee et al., 2021). Microlearning is also considered to play are role in learner engagement for Massive Online Open Courses (MOOCs) (Leach & Hadi, 2016). Related research is performed to mitigate the current low completion rates of MOOCs by using microlearning (Sun et al., 2015) and making the learning experience more personal (Sun et al., 2018).

Multiple stakeholders are involved in effectively using microlearning tools to benefit education. This work considers the main stakeholders to be teachers, students, tool developers, and the higher education institution. These stakeholders will be discussed in later in this work and will be linked to the main findings.

Designing microlearning content to fit in the current educational setting can take effort. In the context of digitalization, much learning material is available in digital form. However, these learning sources cannot be directly used for microlearning as they are usually not small bite-sized learning activities and are not particularly focused. Bite-size and focused content are two features of microlearning content given by Buhu and Buhu (2019) alongside compactness, relevancy, and immediate reward of the material. These are only some of the features of microlearning found in literature and different views on microlearning exist (Díaz Redondo et al., 2020). The duration of 'bite-size' content for instance is not commonly agreed on in literature.

Insightful work is done by (Jahnke et al., 2020) which looked at design principles of microlearning tools. Identified themes are mostly in line with previously mentioned features including chunked courses, interactive micro-content, and focus on learner needs. The work also indicates various design principles following from these themes, which include interactive content, instant feedback, engaging instructional flow, and tracking learning progress.

The choice of delivery tools is also important for how the material is made available, this can involve the existing Learning Management System (LMS) of the higher education institution for instance. It is especially important for microlearning delivery tools to understand the dynamics of cross-contextual learning like location and time as this forms the core of the mobile learning experience (Glahn & Gruber, 2020). Microlearning together with current mobile devices enable learning across different contexts enriching traditional formal learning by providing the possibility to learning anytime and anywhere. This learning across different contexts is captured by the overall definition of mobile learning: "learning across multiple contexts, through social and content interactions, using personal electronic devices" (Crompton, 2013, p. 1).

The features, themes and design principles are useful in understanding microlearning tools and characteristics of the content they create and deliver. However, without explicit evaluation criteria, evaluating microlearning tools to identify their potentials and shortcomings can be difficult. This work aims to provide these core evaluation criteria such that evaluating microlearning tools becomes easier. This work provides these criteria in the light of digitalization and higher education.

The focus of current literature is on features and design principles of microlearning tools rather than evaluation criteria. Without explicit evaluation criteria it can be difficult

to evaluate microlearning tools for designing and delivering microlearning content. Thus, the purpose of this work is to conceptualise an evaluation framework for microlearning tools. The core criteria of the framework can be used to understanding the potential and shortcomings of the tools in the higher education and digitalization contexts. The potentials and shortcomings are studied by looking at current challenges the microlearning tools face in the two contexts.

Putting it all together, this study is guided by the overarching question: *What are the potential and shortcomings of the current mobile learning tools for designing and delivering microlearning content and what would be the core criteria of an evaluation framework for mobile learning tools of microlearning content in the context of digitalization and HE?*

To better understand and answer the main research question the following two sub-questions are formed:

1. What are the potential and challenges in designing and delivering microlearning content?

2. What would be the core criteria for an evaluation framework for designing and delivering mobile learning content?

2 Methodological Approach

To answer the sub-questions, existing literature is systematically studied. This concerns choosing specific search terms close to the core constructs in the research questions to guide the search. Inclusion and exclusion criteria are defined used forto filter choosing relevant literature and together with a framework for analysis is constructed to code the literature. of the found literature.

2.1 Search strategy

This paper makes use of the PRISMA (Liberati et al., 2009) principles to guide our search of the literature. As literature on microlearning design and delivery characteristics is scarce, a wide search space is chosen by choosing popular scientific databases with only applying a year boundary for the search. This is done in order to achieve a broad sense of the microlearning field and to address the scarcity of literature.

Databases used for literature search are Springer, Science Direct, IEEE, ACM, and Willey together with the search scientific engine Google Scholar. The following search terms are used: "mobile learning", "microlearning", "digitalization", "higher education", "evaluation", "design", "delivery", "push notification", and "micro MOOC". Representing different variations on writing design and delivery aspects is achieved through wildcards in the search terms given to the databases. These terms are chosen to closely reflect the different sub-questions and to capture the overarching mobile learning theme. The "micro MOOC" search term was used as microlearning is often coupled with Massive Online Open Courses (MOOCs), which could provide valuable insights in the design and delivery of learning material.

2.2 Study selection

Mobile learning exists for some time now, however mobile learning combined in the digitalization setting is relatively new. To capture the digitalization context more closely, the

Table 1: Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Smartphones and/or tables are used for microlearning.	Study does not use laptops as microlearning devices.
Study is performed in the higher education setting or is applicable to this setting.	Microlearning must not be limited to the formal (classroom) context, i.e. microlearning should provide informal learning possibilities.
Article should be peer reviewed.	
Article addresses microlearning content design characteristics.	
Article addresses microlearning content delivery characteristics.	

search is performed by looking at articles after 2010. This also is the year where smartphones became more mainstream which is beneficial for mobile microlearning. Searching the databases mentioned above resulted in a total of 176 articles.

2.3 Inclusion/exclusion criteria

For the selection process of literature, the inclusion and exclusion criteria in Table 1 are used. The papers articles need to adhere to the first three inclusion all inclusion criteria listed in the table and adhere to at least one of the last two inclusion criteria. The articles and must not fall under the exclusion criteria listed in the table. An important inclusion criterion is that all articles should be peer reviewed. The databases used for the search mentioned in section 2.1 indicate that as all their articles are peer reviewed. This work only uses databases for which their articles are peer reviewed.

Reviewing the 176 articles resulted in removing 115 articles which where not applicable to the higher education setting or microlearning. From the resulting 56 articles, 28 were removed based on the inclusion criteria. This results in a total 28 articles to be used for analysis. The PRISMA diagram indicating the search process is depicted in Figure 2.

2.4 Framework for analysis and coding approach

The sources found will be open coded to identify the important constructs and groupings of central terms in the papers. Based on the research question, two core elements were identified for analysis. These elements are microlearning content design and microlearning content delivery. The design and delivery elements were open coded based on identified key words or word groupings frequently used with these two constructs in the 28 articles found. The results of this open coding is found in next section where they are linked to the identified digitalization and higher education characteristics. An overview on the research methodologies of the 28 articles is shown in Table 2.
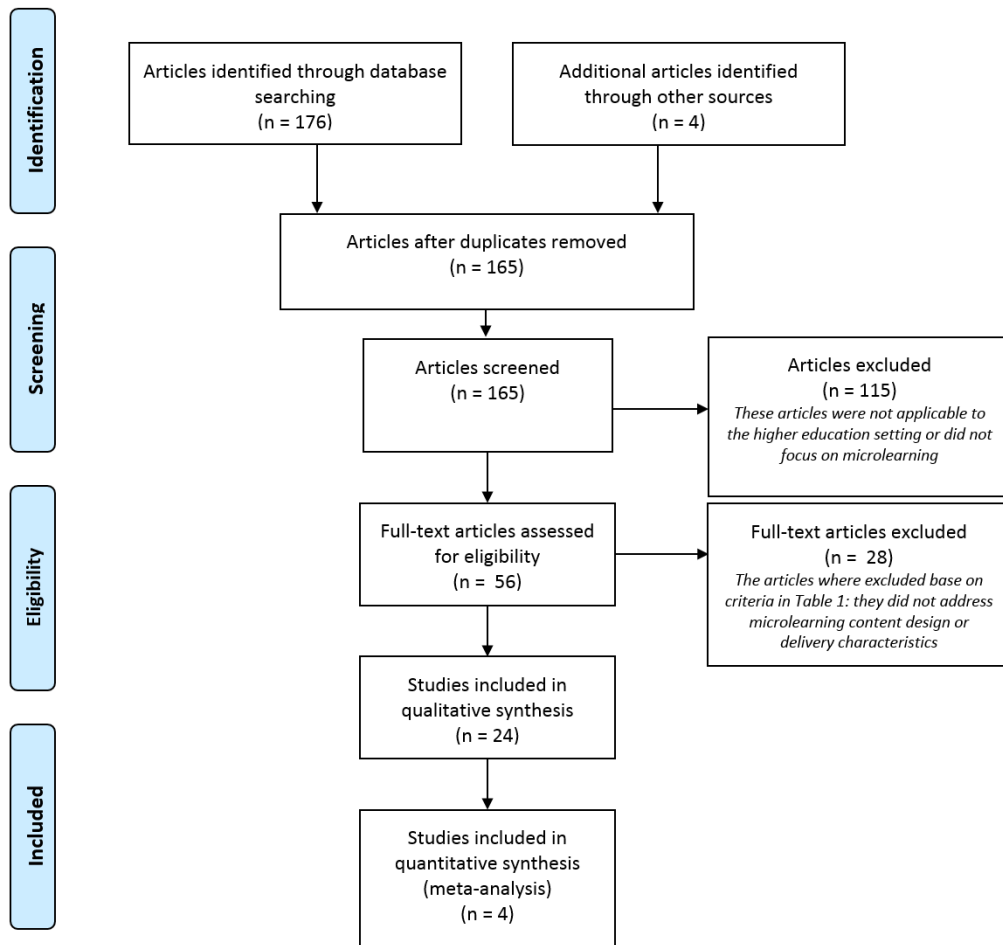
Figure 1: PRISMA systematic literature search

Table 2: Research methodologies of articles

Research methodology / strategy	Number of articles
Action research	9
Design science	8
Quantitative	4
Literature review	4
Mixed Methods	1
Case study	1
Experimental	1

Table 3: Description of design coding

Code	Description
Content development	This code includes the studies that focus on microlearning content creation and content organizing.
Content engagement	This code includes the studies that focus on aspects that make the microlearning content engaging for students.
Content adaptation	This code includes the studies involving microlearning tools that can adapt the learning content to the learning style or situation of the learner.

3 Findings and Discussion

The following sections presents and discusses the findings. These findings will be presented per research questions. The first section addresses the potential and challenges of designing and delivering microlearning content. The second section discusses the findings related to the evaluation of mobile learning tools in the context of digitalization and higher education.

3.1 The potential and challenges of designing and delivering microlearning content

3.1.1 Microlearning content design

From the coding of the microlearning design stated in section 2.4, three final codes follow which are listed in Table 3 and the final overview of the number of articles in each group can be seen in Figure 2. Content development focus developing the microlearning material, like reusing existing e-Learning material (Pajarito & Feria, 2015) and looking at content learning organization (Corbeil et al., 2021). Content engagement focuses on how to make microlearning more engaging for the student, looking at aspects like progress tracking (Ohkawa et al., 2019) and using gamified elements Díaz Redondo et al. (2020). Content adaption is about adapting the learning content for the learner based on learner characteristics (Sun et al., 2018). A total of 26 articles looked into microlearning content design.

Microlearning content development

Of the 26 papers that discussed microlearning content design, ten papers discussed content development. The literature for content development focusses on technologies and characteristics for developing microlearning content. This involves adhering to the design principles of the microlearning content like small bite-sized and focused content.

When designing any learning material, it is important to keep didactical design principles in mind for developing the course content. Park and Kim (2018) state a method for efficient microlearning production based on existing e-learning material. They state that the learning units should be developed following a goal-based approach by representing a learning goal and evaluation as a single learning object, with evaluation focussing on student participation. All the material that is not necessary for a particular learning unit should be excluded, in line with the focus characteristic of microlearning. Developing microlearning content is a task usually devoted to the teacher. Therefore, many sources in this group look at microlearning from a teacher's perspective. Throughout literature, e-learning courses are often used as a
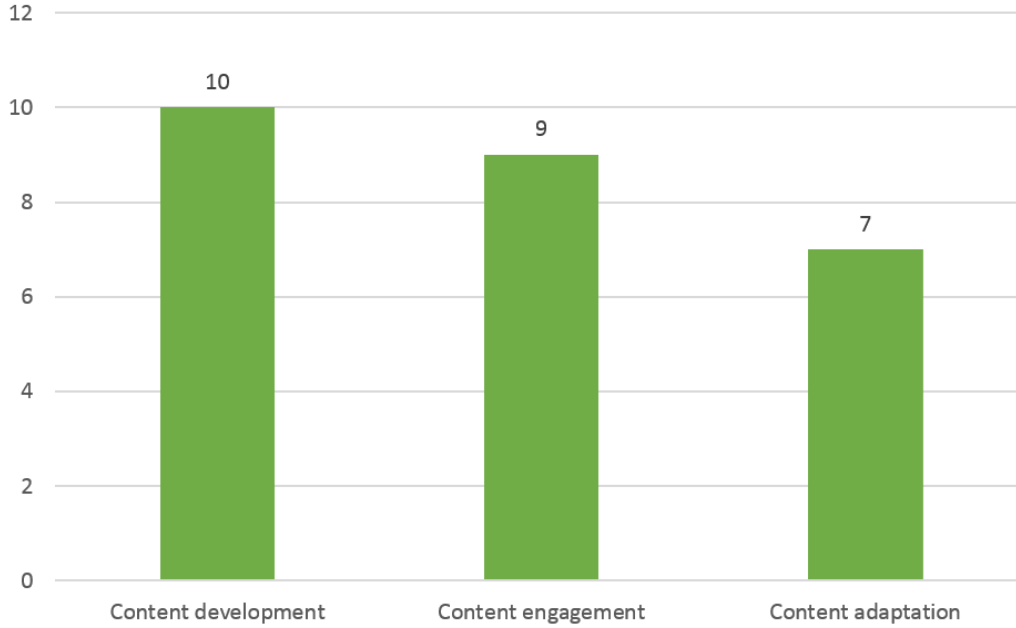
Figure 2: Number of articles on microlearning content design

basis for microlearning courses (Park Kim, 2018; Pajarito Feria, 2015; Polasek Javorcik, 2019).

According to Corbeil et al. (2021), the ability to share microlearning content is one of the benefits of microlearning. The authors state that developing and sharing of microlearning content thought the so called Open Educational Resources (OER) library can greatly benefit creators like teachers and learning professionals, while at the same time taking factors like copyright over development and sharing into account. However, the process of developing, evaluating and organizing the microlearning process for content creators can be challenging and forms one of the major challenges of microlearning (Corbeil et al., 2021). To address these challenges, integrating content creation tools with traditional LMSs of higher education institutions seems promising (Diaz et al. 2021). This methods allows for valuable data exchange between the microlearning tools and is a means to facilitate the learning process organization in the higher education setting. Learner feedback data can give teachers and other content designers insights in how the microlearning material is received which allows for further improvement of learning content development (Wen and Zhang et al., 2014).

Thus, existing e-Learning material is often used for microlearning content development and researchers indicate the potential of sharing existing microlearning content though OER libraries. Following from this, content organization becomes an important challenge. Integrating microlearning tools with traditional LMSs of higher education institutions could solve this challenge and provide further means to improve content creation.

Microlearning content engagement

Content engagement was the second most studied topic for researching microlearning content design with nine studies found. Indeed, the idea behind microlearning is to make learning easier and more enjoyable by using small learning units which can be learned from anytime and anywhere. As a result of a large topic subdivided in smaller units, it can be challenging for the student to keep an overview of what is already learned. Especially in a microlearning setting, which is characterised by learning across different contexts, its is important that students can interrupt and resume their learning while keeping track of their progress. This ability forms a great potential for microlearning tools, as providing this flexibility with a clear overview of the learning progress for each student has shown an increasement in study time of microlearning content while decreasing the feelings about learning as burdensome for the students (Ohkawa et al., 2019). Another positive aspect that can increase microlearning content engagement is using microlearning with gamification elements according to Diaz et al. (2020). The researchers indicate that in this setting, letting the students earn badges and having leaderboards in the learning tool can provide social aspects to microlearning. These social aspects then motivate the student to follow certain learning objective which in turn provides the more social recognition among peers and increases learner engagement.

Besides flexibility and being able to use gamified elements, the small microlearning units have more positive effects. Due to the compact nature of the microlearning, only the information that is needed for a certain learning activity is provided. This exclusive focus of the content reduces the chances of falling behind and reduced dropouts according to Díaz Redondo et al. (2021) The researchers also stated that microlearning allows for spaced repetition, which benefits the cognitive process when adopted regularly. Their survey, conducted with higher education professors, indicated that university lectures are seen as a favourable fit for microlearning. The majority of the participants of the survey would use microlearning activities at the end of their lessons as they see it as a valuable addition in increasing motivation and engagement of the student by reinforcing what is learned and receive feedback on the lecture. Due to its benefits, spaced repetition is seen as an important strength of microlearning (Corbeil et al., 2021).

Thus, spaced repetition is considered to have potential and is considered to be a great purpose from microlearning. In a formal classroom setting microlearning tools have the potential to reinforce the learning content thought in class and can receive feedback from the student on the material. Also gamified element have the potential the increase microlearning engagement. However, despite its engaging factors, many researchers agree that microlearning is not suitable or is challenging for learning more complex and abstract learning concepts (Díaz Redondo et al., 2021; Lee et al., 2021).

Adaptive microlearning content

Adaptive microlearning accounted for seven studies within the microlearning design construct. Adaptive microlearning refers to the to the property of microlearning tools to adapt the learning content for learner by making use of learner characteristics. Microlearning tools capable of adapting for the learner have great potential for microlearning, as they can achieve personalization of the learning content making and it more attractive. Adapting content to achieve personalization is linked to engagement, as personalization can make the learning more enjoyable for the learner.

There are different ways how one can adapt the learning content for providing a personal learning experience. In order to adapt for the user, microlearning tools should have a

Table 4: Description of delivery coding

Code	Description
Delivery system	This code includes the studies which focus on the delivery system of the microlearning content.
Context depended delivery	This code includes the studies which look at delivering learning content depending on contextual factors of to the learner.
Notification methods	This code includes the sources that look at different ways of notifying the learner to use the microlearning tool.

model of the learner to understand its characteristics. This requires collecting data about the learner and analysing this data. In literature, there is a link between adaptive content and context awareness. In order to adapt and recommend learning content, Lin et al. (2019) indicate that both the material and the learner need to be analysed. According to the researchers this is done in three stages, namely segmentation, annotation, and recommendation. Segmentation and annotation are related to the learning content itself and recommendation is combined with knowledge about the learner. Segmentation referees to the separation of learning content in microlearning units. After the content is segmented, the units need to be annotated to make these learning resources machine and human understandable. This is needed, as achieving adaptive content for personalization requires the computer system to understand the characteristics of the content. The next step is having an accurate learner model such that the system can provide personal learning content.

However, making a good learner model is challenging and requires knowing a number of features. According to Sun et al. (2018), the personal factors for adaptive learning can be subdivided in two categories. These are personal non-intelligent factors and personal intelligent factors. Under each of these categories fall certain characteristics. For personal non-intelligent factors, these include the factors: learner types, time availability, progress identification, and learning preference. This is data can often be received from the systems the learning is getting the learning content from or can be asked for through the learning process. Data like learning preferences, need to be asked to the learning in order to know. Personal intelligent factors like learner pre-knowledge assessment, learning styles, and memory ability of the learner enrich the learner model. These characteristics differ from non-intelligent factors in the sense that they cannot be directly asked to the user and need to be learner though analysis historical learning data. Combining this data with external factors like location and degree of disruption for learning, Sun et al. (2018) make a model that can adapt the content for the learner in terms of activity sequencing and duration to fit to the available time and context of the learner. Learning from this data to build a learner model is knows as Educational Data Mining (Sun et al., 2018). Knowing the context of the learner is especially valuable for delivering the chunked learning content which is addressed in the next section.

3.2   Microlearning content delivery

The microlearning delivery construct stated in section 2.4 has three codes which can be seen in Table 4. A total of 25 studies investigated microlearning content delivery. The final overview of this coding can be found in Figure 3.
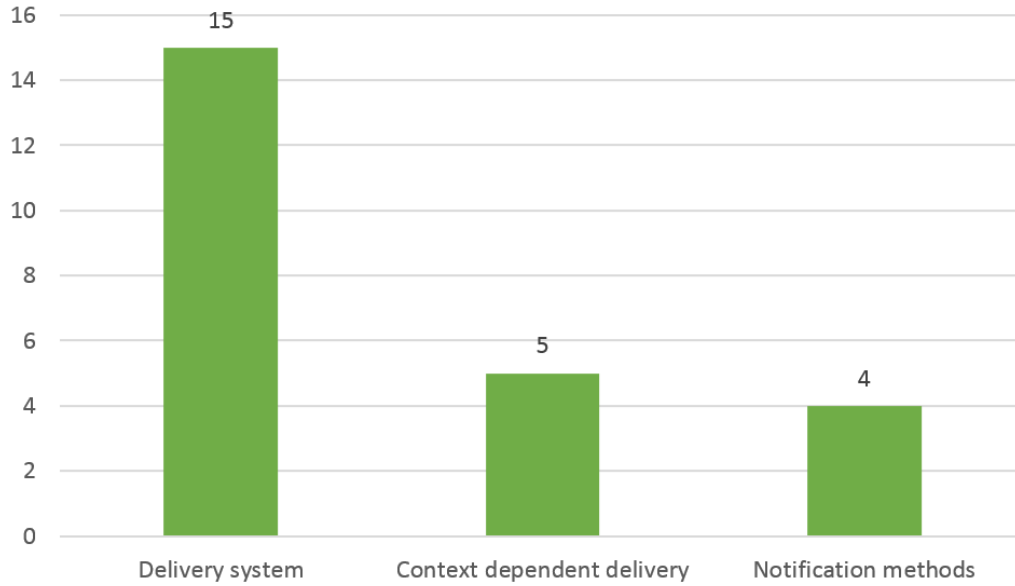
9

Figure 3: Number of articles on microlearning content delivery

Delivery system

Literature for studying the microlearning delivery system accounted for fifteen studies. In literature, tools have been proposed in the literature that are capable delivering microlearning content. These tools have the responsibility to delivery the developed content by the teacher to the student's mobile devices. Learning Management Systems that are already in place for existing e-learning courses can provide delivery capabilities for microlearning content (Skalka & Drlík, 2018). However, as identified in section 3.1.1 under content development, microlearning content requires a specific structure and format for which specific tooling for microlearning can be useful. However, the wide variety of tools proposed in literature which achieving the same goal of providing microlearning content can form a digital divide of these tools (Glahn et al., 2015). If these tools are incompatible with each other, making use of the benefits of sharing and reusing microlearing content as discusses in 3.2.1 can become difficult. Integrating these learning tools in the existing LMS of the higher education institutions could overcome this. The advantages of this approach is that both technicians of the teachers know how to use the existing LMS (Díaz Redondo et al., 2021).

Context dependent delivery

Context dependent delivery was researched by five studies for studying microlearning content delivery. Context dependent delivery refers to a tools ability to deliver learning content based on various contextual factors. Knowing these contextual factors is formalized in literature as "context awareness" (Vallejo-Correa et al. 2021) and its link with content adaptation was indicated under Adaptive microlearning content in the previous section. According to Glahn and Gruber (2020) many educational design models only consider context passively through the learning environment. In this passive view, this environment is seen as an

educational design element which structures learning resources. The increasing possibility of mobile technologies to sense various contextual factors related to learning questions the passive perception of context according to Glahn and Gruber (2020). In other words, the potential that mobile technologies have for context aware learning in not enough utilized according to the researchers.

Taking into account these various contextual factors is important in a mobile learning setting which is characterised by learning across different contexts (Crompton, 2013). Depending on time, location, social context and device context for instance, the learning preferences of the learner can differ stated by Lin et al. (2019). To illustrate, the type of microlearning content to deliver can vary based on the device context the researchers state. Reading texts can be more effective on a tablet due to its screen size rather than them reading on a mobile phone. To know these contextual factors, information about of the mobile devices is needed to define the capabilities, features and limitation of a mobile device (Sun et al., 2018).

Notification methods

Notification methods was accounted for four studies for researching microlearning delivery. for Whereas the previous section focused on when and in which context to engage the learner with learning content, in this section the focus lies on how to notify the learner. In literature, a couple of methods have been proposed which aim to effectively notify the learner to engage with the microlearning content.

Kljun et al. (2019) focus on how triggering of the learning can impact the engagement. Their study involved focus group to understand the effects and potential of notification methods by using focus groups for no triggering, regular triggering, and so-called adaptive triggering. Their results show an increase in course completion rates and learner engagement when using adaptive triggering. When the microlearning application sees that a learner is less engaged with the learning content the system provides personalized notification triggers, hence the term adaptive. The researchers also acknowledged the importance of elements like content design and social modelling to be important for engagement.

Dingler et al. (2017) look into the effect of notification methods on learning interaction rates in their language learning app which uses microlearning as its learning sessions. Using smartphone usage data of the learner like lock and unlock patterns, the tool the researchers developed provided different types of notification like learning reminders. The researchers found that when using such notification, quick microlearning learning sessions and learner engagement increased.

3.3 Evaluation framework and multi-stakeholder perspective for microlearning tool development

3.3.1 Core criteria for an evaluation framework for designing and delivering mobile learning content

Evaluating higher education mobile learning tools for microlearning content involves understanding the dynamics that play in designing the content and delivering the content. These dynamics have been examined in the previous sections identifying key potentials and challenges in the microlearning design and delivery. In the context of digitalization there are a couple of key focus points, namely using the potential of learner data for personalized

learning experience and enhancing learning engagement through context awareness delivery methods like adaptive notification.

The core criteria this work proposes to evaluate microlearning tools for designing microlearning content are 1) content development facilities, 2) content engagement methods, and 3) content adaptation techniques. These core criteria are grounded on the central themes found in the section 3.1 and represent the three important perspectives involved in microlearning, namely the teacher's perspective, the student's perspective and the systems perspective respectively. The core evaluation criteria for content delivery this work proposes are 1) delivery system integration, 2) context aware delivery methods, and 3) learner notification methods. These criteria follow from three central themes found in section 3.2.

These criteria together with their links to the higher education and digitalization context are depicted in Figure 4.
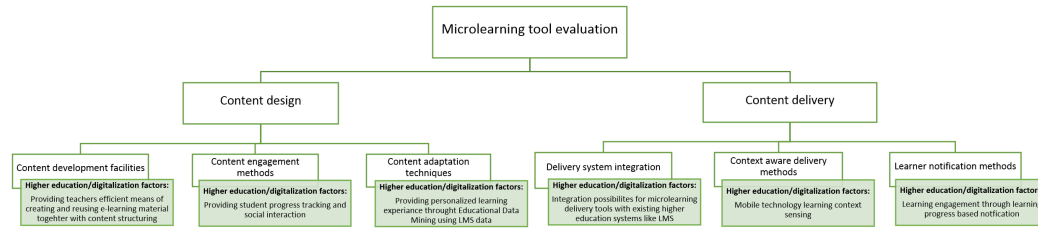

Figure 4: An Evaluation Framework for microlearning tool evaluation in the context of digitalization and higher education

3.3.2 Microlearning tool development from a multi-stakeholder perspective

Developing microlearning tools involves various stakeholders. This work identifies the main stakeholders to be teachers, students, tool developers, and the higher education institution. Each of these stakeholders is important to consider in making an effective microlearning tool. Form the findings of the previous section, microlearning content development can be a challenging task (Corbeil et al., 2021). Therefore, good tooling which can support teachers in making microlearning content is important. This involves the tool developers to know the requirements of microlearning design and delivery. Besides user studies to identify important requirements, tool developers can use this work to inform themselves about the potentials and challenges of current microlearning tools as well as to evaluate their tools with the framework. In this context, the higher education institution is mostly responsible for funding the integration of the tools in existing system infrastructures.

4 Responsible Research

This work states that all studies used for this work are peer reviewed articles. This claim is based on the requirement of the selected databases in section 2.1, which states that all work in their databases is peer reviewed work. Work found outside those databases is individually verified to be peer reviewed. Every scientific insights this work used is referenced with the respective author(s) and included in the reference list. The selection of scientific work is motivated by the inclusion and exclusion criteria in Table 2 which are constructed to closely represent the main research question.

5   Limitations

This work uses literature resulted mainly from the databases the section 2.1 given the stated year range. Literature outside these databases mostly remain is unstudied as well as literature written in other languages than English. These other sources can contain insights not covered by this paper and therefore remain unused in the proposed evaluation framework.

6   Conclusion

This paper investigates the designing and delivering of microlearning content in the context of digitalization and higher education and proposes an evaluation framework to evaluate microlearning tools. A total of 28 studies were analyses in this review to gain an understanding regarding the characteristics content design and delivery. To understand the microlearning content design construct of the main research question, this work looked at the development of the content, the student engagement and ways of content adaptation to the student. The findings show that existing e-learning content has a potential to be used for microlearning content development. A shortcoming of microlearning is that it is difficult to learning more complex learning material. Microlearning also has the potential to be easily reused through the use of Open Education Resources. Content engagement though progress tracking, gamification and reminder notifications was also found. Likewise, adaptive microlearning content has the potential to provide a personalized learning experience also increasing learner engagement.

The final evaluation frameowork uses the following evaluation depicted in Figure 4: 1) content development facilities, 2) content engagement methods, and 3) content adaptation techniques. These core criteria are grounded on the central themes found in the section 3.1 and represent the three important perspectives involved in microlearning, namely the teacher's perspective, the student's perspective and the systems perspective respectively. The core evaluation criteria for content delivery this work proposes are 1) delivery system integration, 2) context aware delivery methods, and 3) learner notification methods.

7   Implications and Future work

This work delivered core evaluation criteria based on recent research on the microlearning field in the light of digitalization and higher education. Findings include the importance of having easy to use tools that enable the design of adaptive learning content which is subsequently used for context aware delivery. As the system behind this functionality can be complicated, the tools play an important role for the content creation perspective. The various proposed tools in found this literature review were different tools each providing design and delivery characteristics in their own way. Form a systems perspective, this results in incompatibility of the material created for these tools or platforms making one. Future research in standardising microlearning content creation would make the content more portable across different tools which can save time and effort for microlearning content creators wanting to use created content across different tools. With the proposed framework, the multiple stakeholders mentioned for microlearning tool development can evaluate current and future microlearning tools and test the effectiveness of the framework with future research.

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