# Functionalities of Mobile Learning Apps and Potential for Data Integration in the Context of Higher Education: A Systematic Review

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## Abstract

The mobile device market has been steadily growing throughout the last two decades. Nowadays, most people own smartphones that support various applications. Many of these applications fall under the category of mobile learning. These apps have many exciting features which could potentially enhance the learning experience in higher education. If academic institutions decide to use such applications, they also need instructions on how to integrate these apps in a common learning portal, such as a learning management system. This research identifies six features of modern mobile learning applications - augmented reality, gamification, artificial intelligence, push notifications, personalization, and collaborative learning. Then, it describes them and their applicability in both educational and non-educational contexts, with the focus on higher education. Finally, two technologies, namely learning tools interoperability (LTI) and application programming interfaces (APIs), are presented for data and application integration.

## 1 Introduction

The mobile device market has been growing at an unprecedented rate. Defining characteristics of mobile devices, such as portability and ease-of-use, bring possibilities for learning anytime, anywhere. Consequently, new learning opportunities can be realised by using mobile applications.

Mobile learning applications constantly come into the market. Many of them gain traction quickly due to the way they setup the learning experience. For example, Duolingo, an interactive mobile platform for learning languages, counts around 40 million monthly active users (Blanco, 2020). Applications like this make use of many modern features to assist the learning process, such as gamification and personalized content. Naturally, academia may become interested in adopting similar applications in higher education by integrating them in learning environments.

### 1.1 Background

**Mobile learning and mobile applications**

Firstly, two key constructs need to be defined, namely, mobile learning and mobile learning applications. Mobile learning involves the usage of mobile technologies: personal digital assistants, cell phones, audio players, electronic books (Hamidi & Chavoshi, 2018), tablets, and smartphones. It can be defined as ”learning across multiple contexts, through social and content interactions, using personal electronic devices” (Crompton, 2013). As the mobile device market has grown remarkably in the last two decades, it became possible to effectively implement mobile learning in mobile applications.

Mobile applications are computer programs designed to run on mobile devices - such as a phone, tablet, or watch. These applications fall into many different categories - health, education, productivity, gaming, and others. This research is mostly concerned with Android and iOS applications since their prominence has grown remarkably throughout the past decade. Furthermore, the technological affordances of current mobile devices definitely give room for more usage possibilities.

**ML application functionalities**

Mobile devices become more and more advanced each year, and new applications and the features within are being constantly developed. For example, due to advances in mobile technology, it is now possible to use augmented reality technology on the go (Di Serio et al., 2013). Therefore, it is vital to keep track of the current state of mobile learning applications to spot new learning opportunities.

**Data integration**

Data integration can be defined as ”the problem of combining data residing at different sources, and providing the user with a unified view of these data” (Lenzerini, 2002). Mobile applications can collect valuable data (e.g., health applications can store user's weight) that can be used on other platforms. Consequently, it is essential for academic institutions to understand how helpful data can be integrated with their infrastructures. Nowadays, HE institutions make use of learning management systems that support diverse third-party content. For example, a popular LMS (Learning Management System) Blackboard supports many integrations, such as GoReact, Pearson, EdPuzzle, and many others (Sabo, 2020). This support enhances the learning experience by allowing the students to utilize useful third-party products.

Even though mobile learning has been researched for many years, various questions remain unanswered. Crompton and Burke (2018) identified five gaps in mobile learning literature. Some of the identified gaps include the usage of mobile devices in informal settings and how mobile learning is being used in the learning environment. Additionally, they concluded that there is a gap in the literature discussing the intervening variables that influence the learning outcome when mobile learning was applied. One of the intervening variables may be the features that mobile learning applications provide. Certain features may positively or negatively bias the learning outcome. That is why we provide the effect of utilizing specific features in HE settings.

Several researchers have already addressed the functionalities and technological properties of mobile devices. Mushtaq and Wahid (2018) stated technological affordances of mobile devices, such as touch screen, light weight and high speed, without mentioning the applicability of these specific affordances in HE. Other researcher, Vrana (2015), mentioned features of mobile devices, such as portability, social interactivity, without outlining the features of mobile learning applications. Notably, features of ML applications were not the primary focus of aforementioned researchers.

Other researchers, Forment et al. (2009), directly addressed the issue of integrating third-party applications into LMS. However, the mobile application environment has changed significantly since then, and some of the technologies discussed in that research are already outdated. For example, the researchers mentioned Learning Tools Interoperability standard for integration purposes, but it has undergone multiple revisions since 2009 (IMS Global, 2021b).

Consequently, to address the identified gap in the literature, the following research question was identified:

> *What are the core functionalities of mobile learning apps and what kind of data integration takes place with existing infrastructures in higher education?*

In order to answer the research question in a structured manner, it can be divided into two sub-questions.

1. What are the core features and functionalities of mobile learning applications?
2. Which integration technologies can be used by HE institutions to integrate data between mobile learning applications and academic infrastructures?

## 2 Methodology

Qualitative systematic literature review was used to provide a thorough investigation of the research focus in this manuscript. This type of review can be defined as "a method for integrating or comparing the findings from qualitative studies. The accumulated knowledge resulting from this process may lead to the development of a new theory, an overarching 'narrative', a wider generalization or an 'interpretative translation'" (Booth, 2006, as cited in Grant and Booth, 2009). To facilitate this methodological approach, relevant search strategy, inclusion and exclusion criteria, analysis framework and coding were specifically identified.

### 2.1 Search Strategy

The research began with literature search by following PRISMA principles (Liberati et al., 2009). Articles were selected from the period of 2015-2021 to analyse the latest developments in mobile learning applications.

The search was limited to the years 2015–2021 for multiple reasons. In 2015, artificial intelligence got significant traction (Wang, 2016) and the mobile wearable technology market grew by nearly 172 percent (Richter, 2016). Furthermore, smartphones have been steadily and noticeably advancing in computing performance (Triggs, 2020), which allowed for the new features to be introduced each year. Interoperability standards have been steadily improving as well. For example, Learning Tools Interoperability, the standard reviewed in this paper, underwent significant changes with the final releases v2.0 in 2014 and v1.2 in 2015 respectively (IMS Global, 2021b). As a result, aforementioned technological advancements could be applied in academic institutions to improve the learning process.

This research made use of various sources to find the information. These sources included IEEE Xplore digital library, Scopus and Google Scholar.

**Search terms**

During the preliminary research it was observed that utilization of search terms directly derived from the research question (as shown in Table 1) resulted in a small quantity of papers. Furthermore, applying inclusion and exclusion criteria (Table 2) resulted in zero relevant papers. Therefore, it was decided to use another search terms (Table 1) to find the literature. The respective terms for data integration and features were identified as follows:

- **Data integration**. It was observed that **LTI** (Learning Tools Interoperability) and **API** (Application Programming Interface) can be used as the search terms for data integration. LTI is mentioned as one of the standards used for integration in documentations of two popular learning management systems: Brightspace and Blackboard (Blackboard, 2021; Brightspace, 2021). Likewise, API was chosen as another keyword since it is a well-known technology that accommodates data transmission between two software products. Many modern applications provide public APIs. For example, Fitbit, a popular fitness mobile application, provides an API which allows third parties to access data from the application, such as user's activities and goals (Fitbit, 2021).
- **Functionalities and features**. This aspect of the research also required additional insights in modern applications' traits to construct the search queries. Searching the web revealed many prominent characteristics of mobile learning applications. As computing power of mobile devices has been steadily growing, it allowed for new functionalities to be

| Initial search terms | Final search terms |
|---|---|
| "mobile learning", "m-learning", "interoperability", "data integration", "application(s)", "higher education", "functionalities", "features", "learning management system", "LMS", "app(s)", "mobile devices", "mobile application(s)" | "mobile learning", "m-learning", "interoperability", "data integration", "application(s)", "higher education", "functionalities", "features", "learning management system", "LMS", "app(s)", "mobile devices", "mobile application(s)", "adaptive learning", "push notifications", "gamification", "collaborative learning", "personalization", "augmented reality", "artificial intelligence", "chatbot", "LTI", "API" |

Table 1: Search terms.

| **Common Inclusion Criteria** | **Common Exclusion Criteria** |
|---|---|
| Article was peer-reviewed and original | Article was not written in English |
| Abstract of the article included the search terms | Title of the article did not include any search terms |
| **Inclusion Criteria for Data Integration** | **Exclusion Criteria for Data Integration** |
| Discussed data integration approach was used in HE settings | Article proposed a new integration technology or framework that was not publicly available |
| **Inclusion Criteria for Features** | **Exclusion Criteria for Features** |
| Type of the mobile device was limited to smartphones, tablets and wearable electronics (e.g., smartwatches) | Article did not justify the feature's utilization outcome by any measuring instrument *(in the context of HE)* |

Table 2: Inclusion and exclusion criteria.

introduced. As a result, selected features for the review include: artificial intelligence, personalization, push notifications, gamification, collaborative learning and augmented reality. Utilization of these features as search terms on academic platforms gave relevant results.

## 2.2 Inclusion/exclusion criteria

We used the inclusion and exclusion criteria listed in Table 2. Since the research question of this paper was related to two domains, namely, features of ML applications and data integration, different criteria needed to be used for the literature selection. However, some of the criteria were shared, which is depicted in the "Common Inclusion Criteria" and "Common Exclusion Criteria" columns of the table.

Using combination of the final search terms (Table 1) with Boolean logic in 19 different search queries generated 10245 records from IEEE and Scopus, and 125910 search results from Google Scholar (Figure 1). Applying the aforementioned inclusion and exclusion criteria resulted in 27 studies for possible inclusion. These papers were thoroughly read to conclude the relevance based on the whole content. This resulted in selection of 18 articles for the review.

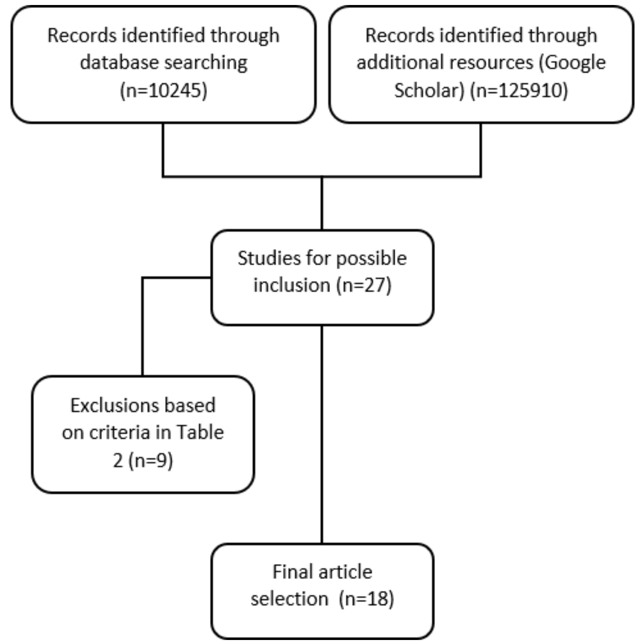


Figure 1: A representation of the literature search and review process.

## 2.3 Analysis framework

Five elements were identified for the analysis of the first research sub-question: 1) subject matter domain, 2) measuring instrument, 3) country of study, 4) utilization outcome, 5) feature. Consequently, three elements were identified for the analysis of the second sub-question: 1) data integration technology, 2) country of study, 3) integration purpose.

## 2.4 Coding

Coding can be used to analyze data in a more structured manner. The procedure of coding involves "examining a coherent portion of your empirical material - a word, a paragraph, a page - and labelling it with a word or short phrase that summarizes its content" (Linneberg & Korsgaard, 2019). In this review, each of the research elements received an individual coding. Since analysis frameworks are different for features and data integration, the respective codings are separate as well.

The coding of the subject matter domains was based on the academic areas, e.g., Anatomy, Business, English. The measuring instruments were coded by the method for confirming the utilization outcome. The utilization outcome was coded by three keywords - either "positive", "negative", "neutral", or "mixed". A "positive" utilization outcome would mean that using a certain feature had a positive outcome on student's learning, or that the feature increased user's engagement while using an application. On the other hand, a "negative" outcome would mean that the user's engagement or motivation declined or that the feature harmed the student's learning. A "neutral" outcome signified a neutral effect on user's engagement, motivation, or learning. A "mixed" outcome signified the occurrence of either positive, negative, or neutral outcomes based on the experimental setup. Lastly, features were coded into six distinct labels, namely: "artificial intelligence", "personalization", "push notifications", "augmented reality", "collaborative learning" and "gamification". Each of these features can be described as follows:

- **Push notifications**. Push notifications are messages that can pop up on mobile devices. They contain small pieces of text and usually serve an informative purpose. They are an essential and highly used feature of modern mobile applications.
- **Personalized and adaptive learning**. Personalization is a very common feature in modern ML apps. Usually it is implemented as personalized learning tracks, settings, lessons or content. Adjustments to settings may include "changing the font size or colour scheme to improve readability, or changing the language to facilitate typing in a different character set" (Kukulska-Hulme, 2016). Content can be personalized by taking into account students prior knowledge and preferences. For instance, ML application for learning English can provide reading recommendations specifically adapted for the user (Kukulska-Hulme, 2016). Furthermore, ML applications are capable of providing feedback, hints and dynamically adapt the learning material based on user's progress (Hermawan et al., 2018).
- **Artificial Intelligence**. Application of AI techniques can be found in many apps today due to the technological advancements of modern mobile devices. For example, modern applications utilizing AI can provide features for monitoring user's health and receiving personal assistance (Deng, 2019). However, AI can also be presented more visually, e.g., in a form of a chatbot, that can answer the questions that users may have.
- **Gamification**. Gamification is the application of game elements as an effort to improve user's engagement (Rosmansyah & Rosyid, 2017). It can be found in many modern ML applications. For example, a popular language learning app "Duolingo" uses daily goals that the user needs to reach and awards experience points for performing learning activities (Karjo & Andreani, 2018). Another application, "Kahoot!", uses gamification to make engaging quizzes where students can anonymously participate in real time (Tan et al., 2018).
- **Collaborative learning**. Collaborative learning is used for denoting situations where learners group together to solve complete certain tasks, problems, or create a product (Laal & Ghodsi, 2012).
- **Augmented Reality**. Mobile augmented reality is a "technology that combines real and virtual objects in a real environment" (Chatzopoulos et al., 2017). Additionally, it works interactively in real time and the augmented view is displayed on a mobile device (Chatzopoulos et al., 2017).

The analysis of data integration required a different coding. Integration purpose was coded by the reason of using a certain technology - learning a subject, gathering particular type of data, and others. The data integration technology was based on two labels, namely, "LTI" and "API". These two technologies can be identified as follows:

- LTI is the standard that "aims to deliver a single framework for integrating any LMS product with any learning application" (IMS Global, 2021a).
- API is a well-known technology that accommodates data transmission between two software products.

## 3 Findings and Discussions

Several significant findings were identified during the literature review. They are tied to the sub-questions of the research paper and are presented in different subsections below.

### 3.1 *Core features of mobile learning applications*

The search resulted in 14 papers related to the features of mobile learning applications. Six of them mention usage outcome of a particular application or a direct effect of utilizing a specific feature of a mobile application (not necessarily an ML application) in a non-academic context (Table 3). These papers are examined in the first subsection. The remaining papers (eight) investigate the effect of integrating a mobile application with a specific feature in higher educational process (Table 5). These papers are discussed in a second subsection respectively.

**Effects of utilizing mobile learning apps with certain core features outside the HE context**

- **Push notifications**. The search resulted in three papers discussing this feature. X.-L. Pham et al. (2016) outline that push notifications increased the time spent in application for learning English (in most cases). They also note that notifications should be properly designed (i.e., less annoying and more informative) to achieve the positive outcome. Other researchers, Stroud et al. (2020), report greater usage of a news application with push notifications enabled. Freyne et al. (2017) studied the effect of using push notifications in a diet app. They state that push notifications are a valid mechanism for capturing users' interest in the short term, while it is noted that the effect tends to wear off with time, as users become less engaged with the application.
- **Personalized and adaptive learning**. The search for this specific feature resulted in one paper. Hermawan et al. (2018) analyzed the implementations of adaptive learning and stated that "the development of adaptive

mobile learning applications is necessary" since adaptive systems are tailored to user's characteristics and learning skills.

- **Artificial Intelligence**. The search for this feature resulted in one paper. X. L. Pham et al. (2018) investigated the usage of a chatbot in the mobile application for learning English. With the help of the chatbot, the users could start conversations about vocabulary, lessons, and other topics. The researchers reported that the users "interacted positively with chatbot".
- **Gamification**. One paper mentioning this feature could be found. Heryadi and Muliamin (2016) gamified the learning of Mandarin in college, which resulted in improvements of learners' skills, concentration, and immersion.

**Effects of using mobile learning apps with certain core features in HE context**

The study found eight research papers investigating the effect of applying a mobile application with a specific feature in the higher educational process. However, only papers discussing collaborative learning, gamification, and augmented reality could be found.

Overall, the conducted literature review shows six diverse subject matter domains (Figure 2), with English and multiple academic disciplines being the most frequent. Additionally, students were given new learning opportunities in every study. These opportunities included: leaving live notes on the recorded lectures for collaborative learning (Ukelson, 2015), viewing the human body with augmented reality for studying anatomy (Khan et al., 2019), competing with fellow students via online quizzes (Tan et al., 2018), and others.

Importantly, every paper out of the eight stated an overall positive usage outcome. Some articles (Situmorang et al., 2021; Zhang et al., 2019) stated the increase in learning outcomes (grades), based on a comparison of the results before and after using an application. Most articles described learners' experience as primarily positive, with some mentioning an increase in learners' satisfaction (Khan et al., 2019; Yoon & Kang, 2021). Students described their learning experiences as "engaging" (Tan et al., 2018; Zhang et al., 2019), "fun" (Perry, 2015; Tan et al., 2018), "effective" (Situmorang et al., 2021; Tan et al., 2018). The positive learning outcomes were substantiated by different measuring instruments listed in Table 5.

Overall, one pattern can be observed - users viewed the discussed features positively. The applications featuring gamification, collaborative learning, and augmented reality enhanced the learning experience, which was substantiated by the corresponding measuring instruments. That is why, based on the perceived usefulness and potential, the aforementioned features can be identified as "core" features of modern ML applications. On the other hand, while push notifications, personalized learning, and artificial intelligence show promising utilization results, their effectiveness is yet to be determined in HE context.

Additionally, perceived usefulness is not the only metric that can support a certain feature being focal. Features and functionalities can also be described as "core" if the relative number of applications having them is prevalent. Hence, further research should be conducted based on other metrics as well.

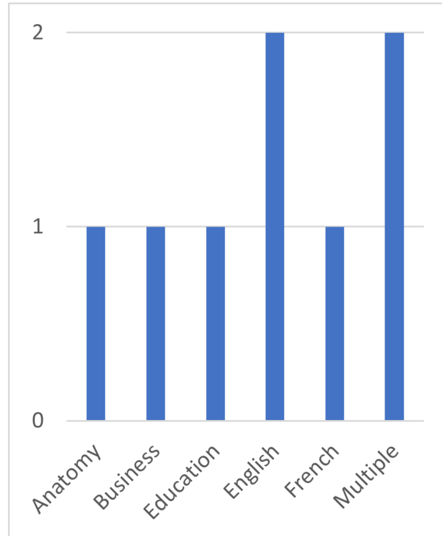


Figure 2: Number of papers for each identified subject matter domain.

## 3.2 *Integration of mobile learning applications into HE infrastructures*

The literature review aimed to find the data integration techniques that are used between ML applications and HE infrastructures. In the end, four relevant papers were identified (as can be seen in Table 4). Each of these papers used LTI or API with a distinct integration purpose.

Some papers (Queirós et al., 2016; Tran & Meacheam, 2020) showed how LTI was applied for integrating data between self-developed mobile learning applications and learning management systems. Additionally, one of these studies showed integration of ML applications with different learning management systems to check if the integration was consistent across the platforms (Queirós et al., 2016). Only two systems could fully support the application, namely Moodle and Sakai. Other papers (Costello et al., 2019; Kimmons et al., 2017) showed the usage of Twitter's and Google Books APIs for data extraction. For example, Twitter's API was used for the extraction of 5.7 million tweets. This data was gathered by the researchers and then used for analyzing the institutional uses of Twitter as a platform.

To summarise, performing data integration with LTI shows that such standard can be used for application integration, even though it may not fully work on some learning management systems. Nevertheless, this standard can be considered for integration purposes.

On the other hand, implications regarding the usage of APIs for data integration are not immediately apparent. As the two papers show, they can be used for data extraction by the researchers (outside the context of mobile learning).

| Authors & Year | Title | Feature | Country of study | Measuring instrument | Utilization outcome |
|---|---|---|---|---|---|
| X. L. Pham et al. (2018) | Chatbot as an Intelligent Personal Assistant for Mobile Language Learning | artificial intelligence | Many | analysis of data collected from the application | positive |
| Hermawan et al. (2018) | Adaptive Mobile Learning in the Nearby Wisdom App | personalization | China | n/a | positive |
| X.-L. Pham et al. (2016) | Effects of push notifications on learner engagement in a mobile learning app | push notifications | Many | analysis of data collected from the application and mobile devices | positive |
| Stroud et al. (2020) | The Effects of Mobile Push Notifications on News Consumption and Learning | push notifications | USA | survey | positive |
| Freyne et al. (2017) | Push Notifications in Diet Apps: Influencing Engagement Times and Tasks | push notifications | Australia | live user evaluation | mixed |
| Heryadi and Muliamin (2016) | Gamification of M-learning Mandarin as second language | gamification | Indonesia | questionnaire | positive |

Table 3: Overview of articles discussing utilization of ML apps with specific features **(outside of HE).**

| Authors & Year | Title | Technology | Country of study | Integration purpose |
|---|---|---|---|---|
| Queirós et al. (2016) | Integrating Rich Learning Applications in LMS | LTI | Singapore | learning Mathematics |
| Tran and Meacheam (2020) | Enhancing Learners' Experience Through Extending Learning Systems | LTI | Australia | introduction of flipped learning in the classroom |
| Kimmons et al. (2017) | Institutional Uses of Twitter in U.S. Higher Education | API | USA | data mining |
| Costello et al. (2019) | Determining textbook cost, formats, and licensing with Google books API: A case study from an open textbook project | API | USA | querying information about the books |

Table 4: Overview of articles discussing integration of ML applications in HE infrastructures.

| **Authors & Year** | **Title** | **Feature** | **Country of study** | **Measuring instrument** | **Utilization outcome** |
|---|---|---|---|---|---|
| Khan et al. (2019) | The Impact of an Augmented Reality Application on Learning Motivation of Students | augmented reality | South Africa | questionnaire | positive |
| Yoon and Kang (2021) | Interactive learning in the classroom: A mobile augmented reality assistance application for learning | augmented reality | South Korea | questionnaire | positive |
| Situmorang et al. (2021) | Entrepreneurship Education Through Mobile Augmented Reality for Introducing SMEs in Higher Education | augmented reality | Indonesia | questionnaires and comparison of students learning outcomes | positive |
| Zhang et al. (2019) | Crossing boundaries: lecturers' perspectives on the use of WhatsApp to support teaching and learning in Higher Education | collaborative learning | South Africa | interviews | positive |
| Gachago et al. (2015) | A Case Study of Collaborative Mobile Learning in Large-size Classes | collaborative learning | China | survey, data collection from the platform, classroom observation | positive |
| Ukelson (2015) | Lecturemonkey - a platform for collaborative mobile lecture capturing and e-Learning publishing | collaborative learning | n.g. | analysis of users' and teachers' feedback | positive |
| Perry (2015) | Gamifying French Language Learning: A Case Study Examining a Quest-based, Augmented Reality Mobile Learning-tool | gamification | Canada | questionnaire and analysis of audio recordings | positive |
| Tan et al. (2018) | Kahoot! It: Gamification in Higher Education | gamification | Malaysia | questionnaire | positive |

Table 5: Overview of articles discussing utilization of ML apps with specific features.

However, the construction of public APIs, such as REST API, is not limited to an application's domain. Mobile learning applications can also provide public APIs, which can be used by higher educational institutions for data extraction. For example, Google Classroom is an application for performing learning activities outside a real classroom, such as doing assignments. It provides an API for managing topics, courses, and classwork. Valuable data, such as students' submissions, can be retrieved by teachers for grading (Google, 2021). That is why APIs may serve as a relevant tool for data integration in the context of mobile learning as well.

## 4 Limitations

This systematic review faced certain limitations. The main limiting factor was the lack of recent literature concerned with the research question of this study. That is why additional search terms were derived to extend the search space. Utilization of the final search terms resulted in 18 papers selected for the review. Out of 14 papers related to the features, only eight discussed their applicability in HE. Hence, further research is needed to confirm the appropriateness of personalization, artificial intelligence and push notifications in an academic context. Likewise, findings from four papers linked to data integration were not enough to draw definite conclusions about the interoperability options. However, these papers still present the relevant scenarios of using data integration technologies. The other limiting factor was the selection of the literature written in English only. Hence, literature written in other languages is not represented by our research paper.

## 5 Responsible Research

The research was conducted responsibly and was based on the following premises:

- **Interest**. There was no financial interest, conflict of interest or belief that biased this study.
- **Funding**. No funding was provided for this research.
- **Reproducibility**. The issue of reproducibility did not directly apply to the chosen methodology (systematic review). However, interested parties can come to similar conclusions after analysing the articles mentioned in this research and following the methodology of this paper. All of the articles are open access and can be checked if needed.
- **Methodological considerations**. Literature search resulted in many academical records. Consequently, relevant papers were collected by applying inclusion and exclusion criteria. This resulted in a better selection of the literature by including only original and peer-reviewed research. Lastly, reviewed studies were thoroughly read to accurately derive the conclusions.
- **Acknowledgement** All of the paraphrases and citations in this paper mention the source to avoid plagiarism. Additionally, all of the scientific work used for our manuscript is mentioned in the reference section and follows APA-7 guidelines.

## 6 Conclusions and Future Work

This systematic literature review aimed to identify the core features of mobile learning applications and the interoperability technologies that accommodate data transmission with HE infrastructures. Consequently, the review resulted in eighteen papers - four for data integration and fourteen for the features. Eight studies revealed that the students' perception of utilized mobile learning applications was positive, and the learning experience could be described as "fun", "engaging" and "effective". Importantly, these studies had diverse subject matter domains and countries of research. Additionally, two articles showed improvements in students' learning outcomes. Six other studies have shown push notifications, personalized learning, artificial intelligence, and gamification being practical instruments for increasing engagement or learning motivation. However, the applicability of push notifications, personalized learning and AI in HE is yet to be researched.

Lastly, four papers revealed the use cases of LTI and API in higher education. Two of these studies showed the integration of self-developed mobile learning apps in learning management systems using LTI. Two other studies showed APIs of Twitter and Google Books being used for data collection. Likewise, APIs of mobile learning applications can also be used for integration purposes. While the selection of literature was limited, API and LTI can be proposed for integration with the infrastructures in HE.

There are several prospects for further research related to the research question of this paper. Firstly, six identified features were largely analyzed by their perceived usefulness. However, core features can also be identified by collecting the data about mobile learning applications in the market and analyzing most frequent mentions. This requires a different methodological approach, as well as access to the data regarding ML apps and their respective functionalities. Secondly, APIs applicability in higher education is yet to be determined. Hence, case studies can be conducted by using ML applications' APIs for integrating students' data - such as grades, submissions, and more. Finally, since mobile application landscape is steadily evolving, the question of this research should definitely be visited once again in the future to identify new features or data integration technologies.

This review is beneficial for academia to learn about the features of mobile learning applications, as well as their advantages and applicability in both educational and non-educational contexts. Lastly, interested parties may consider using LTI for integrating mobile learning applications with learning managements systems and APIs for extracting data from these applications.

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