Determinant Factors and Adaptation Features of Mobile Personalized Learning System

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Abstract. The mobile learning field is grown and enhanced to a more sophisticated platform for the last decades. It quickly becomes pervasive among educational stakeholders. Nowadays, both students and teachers are familiar with mobile devices to complete their tasks and assignments. A personalized system is one of the features contributing to the mobile learning system’s ease and effectiveness. This paper aims to identify the determinant factors and adaptation features from the previous works in this field. There are 30 papers to be included in the analysis using a coding strategy. The result elicits some determinant factors, including prior knowledge in using mobile devices, the ability to access the technology, and the existence of guidance from an expert. Also, several common adaptation features include user preferences, learning behavior, performance, and mobile-specific adaptation features such as device characteristics and content metadata. Study limitations and future directions are also discussed.

1. Introduction

Personalized learning is a type of knowledge where the learning activities and materials are customized and matched with students’ needs [1]. This type of experience is suitable for courses with a large class and attended by students from various backgrounds. It will also increase students’ motivation and engagement, which will improve their learning performance. The learning approach has been used in several areas such as language learning [2–4], computer programming [5–7], and life-long learning [8].

Nowadays, it is common to deliver personalized learning with mobile devices. Based on previous publications, mobile devices’ use enhances learning through immediate interaction and portability [1]. With their own mobile devices, students can access the learning material, receiving notifications, and communicate with their peers without depending on time and space. Moreover, the personalized interaction between the system and students will be more effective.

However, more research in this field must examine this kind of learning system’s factors and features. It may lead to the success of the system’s implementation. This study focuses on the determinant factors and the adaptation features of a mobile, personalized learning system.

This paper is structured as follows. Section two will discuss the methods of data collection and analysis. Section three will describes the result and discussion. Section four will end this paper with a concluding remark.
2. Related Works
Nowadays, the class has more diverse students. They may come from different cultures and backgrounds. Their level of knowledge is broadly diverse. Thus, a different learning approach should be delivered to manage these differences for effective learning to present. Personalized learning increases student engagement as it only shows the most suitable learning materials for students concerning their learning objectives. Simultaneously, implementing personalized learning in a mobile context also increases its usability regarding user interface, learning efficiency, and student satisfaction [9].

This learning can be adopted theoretical or practical knowledge acquisition [10]. Teachers can use the personalized learning system to customize the learning design based on students’ profiles. For example, in game-based learning, the teacher can select game elements based on gender and learning style [11].

While many studies have been done in developing personalized learning, fewer are discussing the implementation, impact, and effectiveness of the system. Moreover, the mobile affordances that might be affecting the system’s adaptive ability also need to be further explored. This study contributes to the system’s implementation phase by identifying determinant factors and adaptation features of this kind of system.

3. Methods
3.1. Data sources
Data was searched within three main databases in computer science namely Scopus, IEEEXplore, and ACM DL. The search keywords were the same among three databases, i.e. ”personalized learning” and ”mobile”. The result was limited to publications between 2016 and 2020 (5 years period). Moreover, only articles, not proceedings, being included in the analysis. The analysis uses coding techniques and NVIVO 12 was used to support the organization and analysis of the articles. Also, a treemap analysis is used to extract the most prevalent keyword terms. Table 1 describes the distribution of articles based on their sources. The inclusion criteria include the full article’s availability and discussion on the personalized system in the article.

| Databases     | # of articles | % of articles |
|---------------|---------------|---------------|
| Scopus        | 38            | 76            |
| IEEE Xplore   | 2             | 4             |
| ACM DL        | 10            | 20            |

3.2. Inclusion Criteria
Initially, 50 articles were found from the three main databases. Then, they were filtered based on the abstract section. Since this study focuses on the determinant factor and adaptation features in the mobile context, then the articles which are not discussing this topic, written in the abstract, will be excluded from the analysis. If there is no explanation about the abstract topics, then the article was skimmed through to search the discussion of the topics. Additionally, there should be a full article available. From this process, there were 30 articles selected for further analysis. The analysis is done by coding approach. It consists of three steps: open, axial, and selective coding.
4. Results and Discussion

4.1. Descriptive Results

Figure 1: The most common terms

To identify the main topics from selected publications, a treemap is being used. As depicted in Figure 1, there are two dominant keywords, i.e. mobile and learning. It can be concluded that these words have become the focus of research in the field of a mobile personalized learning system. In the case of learning, there are discussions regarding the students' engagement in the learning activities [12] as well as the learning outcome and performances [12], [13]. Moreover, learning motivation and preferences also becomes a popular topic [13–15].

Table 2 depicts the distribution of publication year for all papers. It shows a gradual increase from 2015 until 2018. The increasing trend denotes the interest of researchers in this field. Also, it reflecting that more various topics are being studied.

| Year | # of articles | % of articles |
|------|---------------|---------------|
| 2016 | 6             | 20            |
| 2017 | 4             | 13            |
| 2018 | 9             | 30            |
| 2019 | 6             | 20            |
| 2020 | 5             | 16            |

4.2. Determinant factors

Several factors determine the effectiveness of the use of a personalized learning system in a mobile environment. First, previous knowledge is useful to increase awareness about the system
features and what it means to users, which will increase the system’s usage [2]. Also, the system’s lack of knowledge could be a barrier for the user to access the system [16]. Previous knowledge is also required for users to interact more fluently with the application [11]. The next factor is the existence of guidance. This is required to help the user maximize the system affordances by reducing the user’s cognitive overload during the system usage [3]. Lastly, it is also essential to consider the system’s characteristics such as the type of communication, resource capacity, and ease of use of the system [17].

4.3. Adaptation features
A personalized system means the system can adapt to the user or context. The system can deliver content based on the user’s needs. Students can be supported by providing learning materials and activities suitable for their current knowledge and performance in learning. On the other hand, mobile devices have several characteristics that differ from desktop-based devices such as the size of the screens, battery power, cameras, connection, and other types of sensors. It is possible to take advantage of these characteristics to better adapt the learning context, for example, by delivering quizzes while the students are in campus and reading material while they are at home. The complete list of features identified from previous publications is described in Table 3.

| No | Dimension     | Code | #  | %    | References       |
|----|---------------|------|----|------|------------------|
| 1  | Learner       | Activity | 2  | 5.26 | [18, 19]         |
|    |               | Behavior | 3  | 7.89 | [20–22]         |
|    |               | Competency | 1  | 2.63 | [23]             |
|    |               | Demographics | 1  | 2.63 | [24]             |
|    |               | Expectations | 1  | 2.63 | [25]             |
|    |               | Genders | 1  | 2.63 | [11]             |
|    |               | Knowledge | 5  | 13.16 | [9, 25–27]     |
|    |               | Literacy | 1  | 2.63 | [24]             |
|    |               | Misconceptions | 1  | 2.63 | [6]              |
|    |               | Needs | 2  | 5.26 | [9, 28]         |
|    |               | Outcome | 1  | 2.63 | [22]             |
|    |               | Performance | 2  | 5.26 | [17, 29]       |
|    |               | Preferences | 1  | 2.63 | [5]              |
|    |               | Profile | 1  | 2.63 | [6]              |
|    |               | Progress | 1  | 2.63 | [26]             |
|    |               | Skills | 1  | 2.63 | [25]             |
|    |               | Styles | 2  | 5.26 | [11, 30]        |
| 2  | Learning      | Metadata | 1  | 2.63 | [5]              |
|    |               | Environment | 1  | 2.63 | [18]            |
|    |               | Institutional characteristics | 1  | 2.63 | [24]             |
|    |               | Location | 2  | 5.26 | [19, 21]       |
|    |               | Time | 1  | 2.63 | [19]            |
| 3  | Technology    | Networking parameters | 1  | 2.63 | [5]            |
|    |               | Device capabilities | 2  | 5.26 | [5, 18]        |
|    |               | Transcoding strategies | 1  | 2.63 | [5]          |
|    |               | Platform | 1  | 2.63 | [18]           |
Figure 2: Determining factors on the personalized learning system

The features are grouped into three categories based on mobile learning’s dimension [31]. There are three dimensions namely technology, learning, and learner. While it is found that mobile learning research topics commonly focusing on technology [32], this study found that most of the features were being focused on learners and less focused on technology. This is not surprising since the learner, to which the system adapts, is the most complex component and the central element in designing a personalized learning system. The features of learner span from cognitive to metacognitive characteristics.

5. Conclusion
Delivering personalized learning in a mobile context could benefit students as it allows them to learn at their own pace. Identifying driving factors and adaptation features could be beneficial to increase the effectiveness of learning. There are five factors to be considered in this context, i.e., prior-knowledge, guidance, type of communication, resource capacity, and system usability. Also, several adaptation features in learning activities are enhanced by personalized systems such as learning behavior, goals, and performances.

Designing a system that focuses on the user requires a different approach. In this regard, either user-centered design or participatory design could be used to elicit user requirements. This study is limited to the number of articles to be analyzed. However, personalized learning in a mobile context is a growing research area, and many research opportunities can be done in this field. Future research could be directed in exploring new learning strategies based on existing learning theory such as collaborative learning, connectivism, and experiential learning [33], proven to enhance learning in a mobile context.

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