

A FRAMEWORK OF KNOWLEDGE PERSONALIZATION IN MOBILE LEARNING

SHEE YING TOH¹, NORRIS SYED ABDULLAH¹, SURAYA MISKON¹, AZIZAH ABDUL RAHMAN¹, HADINA HABIL²

¹Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia

²Language Academy, Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia

E-mail: ¹conanlan55@gmail.com

ABSTRACT

Mobile devices usage has grown significantly in the last decade. With the advent of mobile technology, mobile devices have transformed people lifestyle including learning style. Mobile learning uses mobile technologies to carry out learning process. Typically, mobile learning involved individual learning with less or without teacher's supervision and guidance. This means that the learners need to manage their knowledge on their own. However, not all learners have similar learning ability and behaviour. The ways they manage their knowledge are different. Hence, offering knowledge personalization to learners is needed to ease the knowledge management in mobile learning context of the learners. Motivated by the lack of research on knowledge personalisation in mobile learning domain, this paper proposes a framework of the knowledge personalization in mobile learning. The framework was developed based on literature analysis conducted on existing personalization research in e-learning domain or other similar domain. The resulted framework consists of three main elements, namely context, content, and learner. This framework can be used as guidance by mobile application developer to produce application that is tailored to learners' needs.

Keywords: *Personalization, Mobile Learning, Knowledge Management, Framework Development, Systematic Literature Review*

1. INTRODUCTION

Mobile devices such as personal digital assistants (PDA), laptops, smartphones, and others are emerged recently and evolved rapidly. Besides, mobile network and computing technology also emerged with the mobile devices. Then, a new form of learning emerged called mobile learning (m-learning). Qiang et al. [1] defined m-learning as a new form of learning where it uses mobile technology and devices to access to educational materials. On the other hand, Bo [2] viewed m-learning as a further development of e-learning that realized the true potential of e-learning as "anytime", "anywhere" and "adapted to the user". In addition, Gourova et al. [3] also viewed m-learning as e-learning that provided using mobile devices. Zhuang et al. [4] however viewed m-learning as a new field of distance learning that combined with mobile technology and education. In general, m-learning is a part of e-learning and distance learning that using mobile technologies to carry out learning process.

Any form of learning involves knowledge. Knowledge is the appropriate collection of information that is to be useful to learner. Information is data that has been given meaning by providing a context to the data while data is raw, discrete, objective facts about events. Knowledge usually is acquired through experience or education and comprises not only the ability to choose the appropriate course of action, but also the skills to execute it as well as help in making decision. However, knowledge is acquired by each people differently since every people have their own ability and behaviour in learning.

Recently, greater attention is given to personalization no matter in business or medical context as well as in learning context. When personalization is applied in learning context, learner's satisfaction, learning speed and learning effectiveness can be maximized. This is because personalization can give an experience that is tailored to individual's particular needs and personal characteristics.

When the knowledge is provided according to the learner's characteristics, abilities and

behaviours, it is called knowledge personalization. Every learner has their own characteristic, ability and behaviour. Providing knowledge according to their characteristics, abilities and behaviours can increase their learning effectiveness. However, there is very limited study on knowledge personalization in m-learning. Rapid change in mobile devices features has further intensified the challenges to incorporate the features in the application [5]. Therefore, not all the potential mobile devices features are incorporated into the application, in particular m-learning application. In this paper, the framework proposed is based on the systematic literature review conducted on personalization framework in e-learning and other learning domain.

From the personalization framework proposed in m-learning domain, different researchers have different focus on delivered the personalized content in m-learning. In our research, content personalization is similar with knowledge personalization. However, content and knowledge is different. Content is the information to be presented while knowledge is the content that is to be useful to learner. When the content is personalized to learner, it becomes the content that is to be useful to learner and hence content personalization is similar to knowledge personalization.

Zhang [6] proposed a generic framework for delivering personalized content to mobile users based on user profile. Sá and Carriço [7] however presented a framework which takes advantage of mobile devices' features to supports end-users in content personalisation. While, Tan et al. [8] presented a framework for location-based mobile learning system which means the focus is location.

There are different elements that can be considered in m-learning such as user profile, mobile devices' features, location, and others. In order to have a comprehensive understanding or conceptualization on the elements that can be included in m-learning domain, a general framework is needed. Hence, the framework proposed in this paper was developed by gathering the personalization elements considered by different researchers in m-learning domain. This framework can provide us a more general and comprehensive view on knowledge personalization in m-learning.

The remainder of this paper is organised as follows. The following section discusses the related research on knowledge personalization in learning domain. We then present the methodology for the

development of the proposed framework. In the following section we discuss the developed knowledge personalisation framework for m-learning. Finally, we conclude with discussion on limitation of the study, future work and conclusion.

2. RELATED WORK

Many personalization systems have been proposed in several domains such as digital libraries, e-commerce, e-learning, news recommendation, and search engine. Since our research domain is mobile learning, framework of personalization in e-learning or other learning domain are being reviewed.

Firstly, context element usually is being considered in personalization framework. Xu et al. [9] developed a conceptual model for personalised Virtual Learning Environment (PVLEs) and advocated that PLVEs should be modelled in terms of learning situations rather than in terms of knowledge structure. Context model also is being introduced in the proposed semantic e-learning framework of Huang et al. [10]. Furthermore, personalised delivery system proposed by Mittal et al. [11] presented course materials based on contextual information.

In addition, Ana et al. [12] introduced a semantic model of the student context in terms of an ontology network to detect the "current situation" of students when they are navigating into e-learning environments. The domains that being considered to conceptualize the context data are student domain, with information related to the student's profile and his/her preferences and behaviour in using the e-learning environment; learning domain, which describes the learning objects and the educational resources available to the students; and technological domain, with information related to the available devices and places (resources) that surround the student. Besides, Luna et al. [13] also represented context using ontology. The context ontology described the characteristics of the context such as context type, location, activities that can be performed, the kind of person who interacts in this context, registered users, courses offered, and others.

Secondly, personalization framework also includes content or learning object element. Carchiolo et al. [14] proposed a model for an e-learning system which allowed the construction of courses which are personalized in terms of both contents and teaching materials. One of the modules of the system is courses module. Biletskiy

et al. [15] also proposed ontological model of learning object for personalized search of learning objects on the web. The conceptual model used for learning object included: General (e.g. title, language, keywords); Life Cycle (e.g. version, status); Meta-metadata (e.g. identifier, contribution); Technical (e.g. format, size, location); Educational (e.g. interactivity level, semantic density); Rights (e.g. cost, copyright); Relations (e.g. kind, resource); Annotation (e.g. entity, date, description); Classification (e.g. purpose, taxon path).

Furthermore, Peter et al. [16] considered learning object in their proposed e-learning platform iLearn. The learning objects to be presented in iLearn are based on Fleming's VARK learning style. Cakula and Sedleniece [17] also developed a theoretical framework for a personalized e-learning model. It consists of four basic blocks; one of the blocks is course content which is responsible for structure of course material. In addition, Yang et al. [18] developed an adaptive learning system by taking multiple dimensions of personalized features into account. The system adjusted the content according to student learning styles (Felder-Silverman's learning style).

Thirdly, learner or user element is also being considered in personalization framework. Conceptual model for personalized Virtual Learning Environment (PVLEs) proposed by Xu et al. [9] is based on the learner such as learning plan, learning goal, and learner profile. Huang et al. [10] presented a semantic e-learning framework that including intelligent personal agents. By using intelligent personal agents, the framework could perform adequate personal trait information profiling and deliver personalized learning services according to the individual's personality and interests. Furthermore, the presentation style of the personalized delivery proposed by Mittal et al. [11] is based on user model.

In addition, Xu and Wang [19] developed a personalization model that demonstrated dynamic e-learning processes. Learner's model played an important role in the model. For instance, a learner's model is built in recognition stage and instructional actions are determined to match the individual's learner model in reaction stage. Other than courses module, the e-learning system model proposed by Carchiolo et al. [14] also included profiles module. Profiles module contains all relevant information about teachers and students.

Furthermore, Biletskiy et al. [15] developed ontological model of the learner in the domain of personalised search of learning objects on the Web. The conceptual model used for learner included: Identification (e.g. name, address, demographic, agent); Accessibility (e.g. language, disability, preferences, eligibility); Goal (learning, career and other objectives and aspirations); Qcl (qualifications, certifications, and licenses); Activity (e.g. educational program); Competency (acquired learning competencies e.g. awards); Transcript (summary records of academic performance); Interest (hobbies and recreational activities); Affiliation (membership of learned, professional, civic and recreational organizations); Security key (e.g. passwords, public key); Relationship (the relationship to be established between the other core data structures); Extension (the extension facility for top-level "learner information").

Peter et al. [16] considered learner in their proposed e-learning platform iLearn. Kaya and Altun [20] proposed an ontology based learner model for e-learning systems. Learner's demographic information, current learner status, expectations, individual attributes, performance and the context attributes are the essential data that are kept about the user embedded in that model. Cakula and Sedleniece [17] developed a theoretical framework for a personalized e-learning model. The framework consisted of four basic blocks; one of the blocks is student personality which stored information about student learning style and previous knowledge level. Luna et al. [13] also represented user profile using ontology. The user profile ontology described the characteristics of the user such as personal information, demographic information, preferences, interests, skills, current position, enrolment, academic degree, laboratory adscription, academic interests, and others.

Table 1 shows the elements considered in personalization in learning domain.

Table 1: Elements Considered in Personalization

Sources	Element considered in personalization in learning domain		
	Context/ Situation	Course/ Learning object/ Content	Learner/User
Xu et al. [9]	/		/
Huang et al. [10]	/		/
Mittal et al. [11]	/		/
Xu and Wang [9]			/
Carchiolo et al. [14]		/	/
Biletskiy et al. [15]		/	/
Peter et al. [16]		/	/
Kaya and Altun [20]			/
Ana et al. [12]	/		
Cakula and Sedleniece [17]		/	/
Yang et al. [18]		/	
Luna et al. [13]	/		/

Although the personalization framework in the domain of m-learning is limited, the available frameworks for mobile device or mobile user are being reviewed to serve as reference for the development of our framework. Zhang [6] proposed a generic framework for delivering personalized and adaptive content to mobile users. It consists of user profile which is used for content personalization. The user profile may include (a) user information including user ID, background information, personal interest represented by either keywords or information/service categories, preferences (e.g. media preference, summarization method, and priorities among data items); (b) target device information such as screen size, screen resolution, network, battery, memory; (c) service profile including service restrictions and user availability; (d) wireless network information such as network ID, topology, and configuration.

Sá and Carriço [7] presented a framework which takes advantage of mobile devices' features to supports end-users in pervasive learning and content personalization. To provide access to different students with different disabilities, the framework included elements that allow teachers to create accessible artifacts. The accessibility elements included the various configurations and common interaction options that can be used to interact (e.g. text input, multiple-choices) or to visualize the content (e.g. images, video); text-to-speech features which recreate the content (text, image) through audio output; gesture-based navigation; voice-based navigation; the customization of the artifacts' behaviour.

Chen et al. [21] presented ontology in the mobile phone domain for the construction of knowledge base. The concept of mobile phone is divided into seven parts: model, hardware, software, standard, brand, shape and colour. Tan et al. [8] presented a 5R adaptation framework for location-based mobile learning system. Its concept is at the right time, in the right location, through the right device, providing the right contents to the right learner. The time indicated two factors, the date-time and the learning progress. The location indicated the learner's current geographic location. The device referred to the learner's mobile device that is used to conduct mobile learning. The contents included learning objects, learning activities, and leaning instruction. The learner is the person who conducts learning through mobile device in the mobile learning environment.

Al-Hmouz [22] presented Adaptive Mobile Learning Framework that depicts the process of adapting learning content to satisfy individual learner characteristics by taking into consideration the learner's need; Mobile Learning Content Framework that describes the factors that play an important role in delivering learning content to mobile learners, and their relationship with each other; and Enhanced Learner Model that focuses on how to model the learner and all possible contexts in an extensible way that can be used for personalization in mobile learning.

From the reviewed personalization framework in m-learning domain, we can found that there are different elements that can be considered in m-learning domain. Zhang [6] proposed a generic framework for delivering personalized content to mobile users based on user profile. Sá and Carriço [7] presented a framework which takes advantage of mobile devices' features to supports end-users in content personalisation. Tan et al. [8] presented an

adaptation framework for location-based mobile learning system. From these authors' research, we can conclude that user profile, mobile devices' features, and location are needed to offer knowledge personalization in the domain of m-learning.

Besides, Al-Hmouz [22] proposed an adaptive framework to provide personalisation for mobile learners based on three aspects which are context based (Adaptive Mobile Learning Framework), content based (Mobile Learning Content Framework), and learner based (Enhanced Learner Model). It is clearly that three elements can be included in the domain of m-learning which are context, content, and learner to provide personalisation for mobile learners.

Since there are different and lots of elements that can be included in m-learning domain, a general framework is needed to have a comprehensive view on knowledge personalization in m-learning. A consensus understanding or conceptualization on the knowledge personalization in m-learning domain can be gained. This framework can also be used as guidance by mobile application developer to produce application that is tailored to learners' needs.

3. METHODOLOGY

Systematic literature review approach proposed by Bandara et al. [23] is utilized to develop the framework. Three phases of Bandara et al. [23] approach are adapted.

Identification and extraction of articles: In this study, articles about personalisation are found from three databases which are ProQuest, ScienceDirect, and Wiley Online Library. The search terms that are used during extraction process are "Personalization" or "Personalized" and "conceptual model" or "ontology". These databases are used for searching relevant articles based on the keyword found either in title, abstract and keywords. The search publication time is from year 2000 until 2015. There are about 2855 papers of book chapters, journals and conference papers have been found.

Preparing for analysis: Next step, the extracted papers are filtered. The filtration is done by reading the abstract and selected papers that related with personalization framework of learning or mobile learning only. This process yielded 113 papers. Microsoft Excel 2010 is used to capture the information needed for this study. The needed information includes all the personalization

elements considered by each paper in the learning domain. These information are copied and pasted in Microsoft Excel 2010.

Analysis and write-up: Finally, the information is analysed and the finding is presented in a useful manner such as in table form. The similar content is put together while the different content is compared.

After analysed the information, the most frequently emerged personalization elements are considered as the main elements in the proposed framework. The elements are context, content, and learner. Then, each of them has several sub-elements. Each paper considered some similar and some different sub-elements. Since there are many sub-elements, we set a constraint for the selection of sub-elements to narrow down our study. The main constraint is we focus on mobile learning which means that the sub-elements must related to mobile devices. The exclusion criteria of the sub-elements is any sub-elements that are not related to mobile devices and mobile learning such as academic degree of learner as usually appear in e-learning system, transcript or academic performance, affiliation, and others.

The selection criteria of the sub-elements of each of the main elements are as the following:

- *Context:* it should include the information related to mobile devices and location or time of the usage of mobile devices.
- *Content:* it should include the information about the content to be presented in mobile devices such as their format, structure, presentation style or classification according to learning styles.
- *Learner:* it should include the information about the learner and it can answer the questions such as what the learner do when using mobile devices; how the learner use the mobile devices; who the learner use the mobile devices with; and why the learner use the particular feature of the mobile devices.

4. RESULTS

Knowledge personalization in mobile learning aims to provide knowledge that is personalized to learners in the domain of mobile learning. Every

learner is different. They have different ability in learning or absorbing knowledge. Given the same knowledge, some learners may easily understand it by reading but some learners may need illustration or example to understand it. Besides, every learner has their own preference in learning such as leaning at quiet environment, learning by playing games, learning by communicate or cooperate with other people, and others. When the learners carry out learning process with their own preference, they will understand the knowledge easily and may extend or apply the knowledge they have learned. Hence, knowledge that is personalized to learners is needed to enhance the learning efficiency and effectiveness of the learners.

In this paper, a framework of knowledge personalization in mobile learning is developed. From the literature that has been reviewed, there are three elements are frequently found in the research of personalization in learning domain which are context, content, and learner. In our framework, context, content, and learner are included and tailored in the domain of mobile learning. Mobile learning is a part of e-learning and distance learning that using mobile technologies to carry out learning process. In other word, mobile technologies are the main criteria that differentiate mobile learning with other type of learning. Hence, this framework is mainly based on the feature of mobile device. The mobile device considered in this framework will be the smartphone and tablet device.

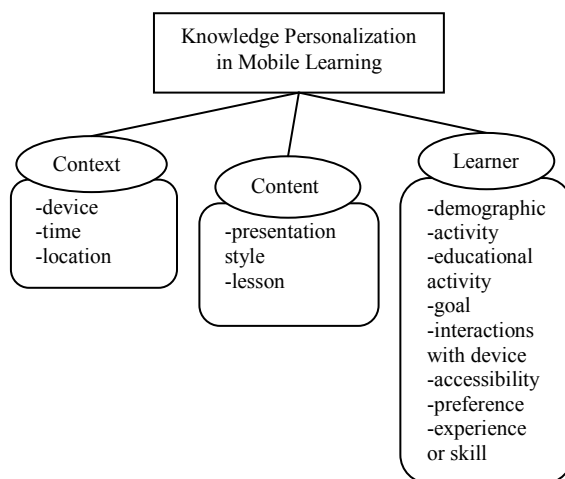


Figure 1: Framework of knowledge personalization in mobile learning

Figure 1 shows the framework of knowledge personalization in mobile learning. Three elements which are context, content, and learner build up the framework. Each element has their sub-elements

which will be related with the feature of mobile device.

The three main elements, context, content, and learner are adopted from the study of Tan et al. [8] where the time, location, and device are combined as context. The study of Al-Hmouz [22] which separate personalization framework into three aspects such as context, content, and learner also contributed to the development of our framework.

For the sub-elements, some personalization studies in e-learning, m-learning or other learning domain have proposed it as their framework elements. These elements are adopted in our study to develop the framework of knowledge personalization in m-learning. Table 2 shows the studies which already propose the same element that have been adopted in this framework.

Table 2: Studies which already propose the same element

Author	Studies
Biletskiy et al. [15]	An ontological model of the learner in the domain of personalised search of learning objects on the Web is introduced. The conceptual model used for learner included: Accessibility; Goal; Activity; Interest; ... <i>Elements adopted:</i> Accessibility; Goal; Activity; Preference
Sá and Carriço [7]	A framework which takes advantage of mobile devices' features to supports end-users in pervasive learning and content personalization is presented. To provide access to different students with different disabilities, the framework included elements such as text input; text-to-speech features; gesture-based navigation; voice-based navigation... <i>Elements adopted:</i> Accessibility
Peter et al. [16]	An e-learning platform iLearn is proposed. The learning objects to be presented in iLearn are based on Fleming's VARK learning style.

	<i>Elements adopted:</i> Presentation style		four main components: Learner Status, Situation Status, Knowledge and Shared Properties Status, Educational Activity Status. <i>Elements adopted:</i> Content; Learner
Kaya and Altun [20]	An ontology based learner model for e-learning systems is proposed. The essential data in the model included: learner's demographic information, learning goals, achieved gains and other results which emerge in the interaction of system and learner... <i>Elements adopted:</i> Demographic; Goal; Interactions with device	Mohamad [24]	An implementation strategy for introducing English Language learning through mobile phones is developed. Their document is divided into ... "mobile technology integration into the curriculum" ... <i>Elements adopted:</i> Lesson
Chen et al. [21]	Ontology in the mobile phone domain for the construction of knowledge base is presented. The concept of mobile phone is divided into seven parts: model, hardware, software, standard, brand, shape and colour. <i>Elements adopted:</i> Device	Luna et al. [13]	User profile is represented using ontology. The user profile ontology included demographic information, preferences, skills... <i>Elements adopted:</i> Demographic; Preference; Experience or skill
Tan et al. [8]	A 5R adaptation framework for location-based mobile learning system is presented. Its concept is at the right time, in the right location, through the right device, providing the right contents to the right learner. <i>Elements adopted:</i> Time; Location; Device; Content; Learner		
Ana et al. [12]	A semantic model of the student context in the e-learning environments is introduced. The domains that being considered to conceptualize the context data are ... technological domain, with information related to the available devices and places (resources) that surround the student. <i>Elements adopted:</i> Device; Location		
Al-Hmouz [22]	The proposed Mobile Learning Content Framework consists of three stages: Learning Content (Raw Content), Learning Content Structure, Content Classification. The proposed Enhanced Learner Model consists of		

Finally, the following subsection will give detail description on the elements and sub-elements included in this framework. How the elements and sub-elements are adapted in this framework will also be discussed in the following subsection.

4.1 Context

Context is the circumstances of learner learning particular knowledge using mobile device. It has the following sub-elements:

- *Device* [8, 12, 21]: The information related to the learners' mobile device that is used to conduct mobile learning. For instance, network connectivity and functionality.
 - *Network connectivity*: The type of the network that used by the learners to connect to the internet in their mobile device. It includes Wi-Fi and packet data (3G/4G/LTE). Knowledge can be personalized according to the device's network connectivity. For example, some learner may not prefer learning with packet data as it spends data and money. Then, the content provided can be designed as not spend lots of data like excluded video.

- *Functionality*: The range of functions that the learners' mobile device can perform. Knowledge can be provided according to the functionality or feature of mobile device. For example, the content can be designed based on the location detected by GPS.
- *Time* [8]: The time when the learners are conducting mobile learning. Knowledge can be provided according to the learning time of the learners. For example, if the learner prefers study at the early of the morning, the content will be provided to learner on morning section. Time can be divided into three types: day, time section, and action.
 - *Day*: The time that is measured in days such as weekdays (Monday, Tuesday, Wednesday, Thursday, Friday) and weekend (Saturday, Sunday).
 - *Time section*: The time that is measured by dividing the whole day (24 hours) into several sections such as morning, afternoon, evening, night, and midnight.
 - *Action*: The time that is measured by the action of the learners such as waiting for public transport, class exchange or food; eating; travelling; before sleeping; and after awake from sleeping.
- *Location* [8, 12]: The geographic location of the learners when they are conducting mobile learning such as within home, on transportation (e.g. buses, trains, cars), at class, at library, at restaurant, at park, at shopping mall, etc. Knowledge can be provided based on the location. For example, English vocabulary of the items that may exist in the classroom can be provided if the learner's location is at class.
- *Form*: The type or variety of the content which are text, image, video, and audio.
- *Orientation*: The direction in which the content to be displayed which are portrait and landscape.
- *Colour*: The appearance of the content such as colourful; black and white.
- *Font size*: How large or small the font of the content is.
- *Length*: The measurement of the content from one end to the other.
- *Hiding*: The content is being covered so that it cannot be seen.
- *Animation*: The content seems to move.
- *Illustration*: The image style of the content which are cartoon/ drawing; real/ photo.
- *Voice*: The type of the sound produced through the mouth by a person about the content such as male or female voice.
- *Quality*: How good or bad the content is.
- *Structure*: The arrangement of the content.
- *Lesson* [24]: The content that is intended to be learned by the learners when they are conducting mobile learning. Knowledge can be provided according to the learners' preference of lesson number per day, difficulty, and review method.
 - *Number*: The number of the lesson provided per day.
 - *Level*: The difficulty of the lesson provided which are beginner; intermediate; advance.
 - *Review*: The way of studied again the lesson that has learned which are either automatic/ periodic or by request.

4.2 Content

Content is the detail of particular knowledge to be displayed on mobile device. It has the following sub-elements:

- *Presentation style* [16, 22]: The way of the content to be displayed when the learners are conducting mobile learning. Knowledge can be provided according to the learners' preference of presentation style. For example, a visual learning style learner may prefer the content displayed as image or video. Some of the examples of presentation style are form, orientation, colour, font size, length, hiding, animation, illustration, voice, and quality.

4.3 Learner

Learner is the person who is learning particular knowledge using mobile device. It has the following sub-elements:

- *Demographic information* [13, 20]: The data related to the learner is gathered to identify and categorize each different learner such as age, gender, language, knowledge level, competency, etc.
- *Activity* [15, 22]: The activities carry out by learner using mobile device such as phone

calling, text messaging, picture messaging, e-mailing, social networking, getting directions, taking photo, searching and downloading applications, listening music, watching videos, playing games, gathering product information on potential shopping items, browsing or “surfing the web”, reading, completing coursework, participating in lectures, etc. Knowledge can be personalized according to the activity frequently done by learner on mobile device. For example, knowledge can be designed as game for those who always playing game.

- *Educational Activity* [22]: The learning tasks that carry out by learner using mobile device. For instance, revisiting lessons materials, listening to audio recordings, internet research, creating concept maps, playing learning games, word processing, reading, discussion, record or video a teacher lecture or class lab, taking photo of the learning materials (e.g. lecture notes, assignments), download and store learning materials from internet, etc. It is the same as the activity sub-element. Knowledge can be personalized according to the educational activity frequently done by learner on mobile device.
- *Goal* [15, 20, 22]: The learning goal of the learner such as understand English essay, can speak English language, cooperate with classmate in completing coursework, etc. The learning goal decided which type of knowledge should be provided to the learner.
- *Interactions with device* [20, 22]: The measurement for the interaction between the learners and their own mobile device. Interaction of the learners indirectly can predict the preference of the learners. There are two types of measurement: frequency and number of times.
 - *Frequency*: The unit for the measurement of interaction with device such as never, rarely, sometimes, frequently, and always.
 - *Number of times*: The unit for the measurement of interaction with device either per day, per week or per month.
- *Accessibility* [7, 15]: Accessibility in other word is the ability to access, in this framework, the content presented or functionality of mobile device. This is about making things accessible to all people (whether they have a disability or not). Different learners have different ways of

accessibility. Their preference accessibility needs to be considered in knowledge personalization so that the knowledge is tailored to learners’ needs. There are two types of accessibility which are text input and navigation.

- *Text input*: The way of the learners enters text on their own mobile device such as by using on-screen keyboard, trace/ swiped-based keyboard, stylus, handwriting, and autocorrect/ predictive text feature.
- *Navigation*: The way of the learners navigates functionality on their own mobile device such as by using touchscreen or voice recognition software.
- *Preference* [13, 15, 22]: The preference of learner in certain aspects such as the context of learning, the content displayed on mobile device, the activities carried out using mobile device, the social networking site, the accessibility, etc. Preference of learners needs to be taken into consideration so that the knowledge provided is tailored to learners’ needs.
- *Experience or skill* [13, 22]: The data related to the experience of learner on some features of mobile device is collected such as novice, intermediate or expert. Experience of the learner will decided which ways the knowledge can be provided. For example, the learner who is expert in voice recognition software can navigate the content displayed by voice.

5. DISCUSSION AND CONCLUSION

Mobile learning is a part of e-learning and distance learning that using mobile technologies to carry out learning process. It is usually done by learners individually because of the lack of teachers’ supervision and guidance in mobile learning context. This means that the learners need to manage their knowledge by their own. However, every learner has their own learning ability and behaviour. The ways they manage their knowledge are different. Hence, offering knowledge personalization to learners is needed to ease the knowledge management in mobile learning context of the learners.

Knowledge personalization is the knowledge provided according to the learner’s characteristics, abilities and behaviours. However, there is very limited study on knowledge personalization in mobile learning. In this paper, a framework of the

knowledge personalization in mobile learning is proposed. The framework is developed based on the literature of the personalization in the e-learning domain or other learning domain. The resulted framework consists of three main elements which are context, content, and learner. Each element has their sub-elements which will be related with the feature of mobile device.

Different people have different focus on personalization in the m-learning domain. Some of them may focus on learner aspect [6]; device's features [7]; or location based [8]. It is difficult for m-learning developer to have a consensus focus or view when developing m-learning application. The proposed framework in this study hence can provide a general and comprehensive view on the knowledge personalization in m-learning domain.

Finally, the proposed framework has not been validated. Hence, future work can be done to validate the framework. In addition, the framework can be extended to bigger focus such as includes the element of learner's learning styles. There are different types of learner's learning styles models such as Felder-Silverman's learning style, Fleming's VARK learning style, and so on. Choosing the most suitable learning style model for knowledge personalization in mobile learning as well as adapting the learning style model into the proposed framework can be done in the future. Furthermore, this proposed framework can be adapted to the development of mobile learning application. Ontology for the knowledge personalization in mobile learning can be developed based on this proposed framework so that m-learning developer can utilize the ontology as guidance in m-learning application development.

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