A Review on personalization in Mobile Learning

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Abstract

Over the last decade, several studies and researches showed the importance and the necessity to use mobile learning during the learning/teaching process. Mobile Learning (ML), nowadays gains more attention technically and pedagogically. This review of literature deals with the personalization issue in mobile learning, and how agents can be used to support solving this issue, the main objective of this study is to review recent and up to date studies on personalization in mobile learning and find if there are any gaps in the existing literature. The review process started with a primary search which resulted (200)articles, then preparing a checklist(Aims, Research Design, framework, and Justification of the findings), after that selecting the most relevant articles (27) according to some general questions, then the analysis process started and resulted some gaps in the existing literature. Results shows that most of the studies concentrate on one issue of the personalization such as (Device Capabilities, Student Level, Student's Preferences, Network Issues, Course "Subject", Device Operating System, and Location), also most of them assure that agents are a solution for personalization in mobile learning. So there is a need for more investigating on how to deploy agents more effectively to support more personalization in mobile learning.

Keywords: *Mobile Learning, Personalization, Context-aware, agents.*

1. Introduction

The purpose of this chapter is to review the state of the art and understand the issues and problems of the subject under study. And the questions that need to be justified in this chapter are:

a. What are the issues and problems related to personalization in mobile learning applications?
b. What are the limitations of the previous studies on personalization in mobile learning?
c. What are the existing methodologies being applied on development of personalized mobile learning systems?

Mobile learning is a widely accepted term for describing a learning process with mobile technologies. The purpose of this section is to present the literature review and theoretical foundation to show the ways that mobile technology and agent technology can be used in delivering personalization in mobile learning situations. The next section focuses on the emergence of mobile learning and the shift from e-learning to m-learning approach, after that there is section about personalization in mobile learning, followed by a section about the use of agents technologies in mobile learning systems to support personalization, finally, a further remarks on the existing literature.

Most of empirical studies investigated the importance of considering Personalized Mobile Learning Systems (PMLS) as an effective tool for the purpose of improving learning process. They provide scaffolding for constructing a teaching environment geared towards helping a student practice skills. There are different methods and techniques by which artificial intelligence (Agents) can be used to improve the performance of educational systems. In this section we would like to give an overview over some of those systems and their deployment of agents' technologies to accomplish personalization in a mobile learning system.

2. Mobile learning

2.1 Mobile Technology

With the expansion of mobile technologies, new qualities for media contextual use cases and ubiquitous computing arise. The mobility feature makes this technology revolutionary compared to other information technology devices and applications. People are using mobile devices as private storage tools and carry them as they would their watches, keys, or wallets. Mobile technology allows people remote access to services such as voice, messaging, controlling, Internet etc. In some cases mobile embedded systems make user accessibility easier. Today's youth welcome technology with enthusiasm and they are motivated to use it. Elliot Soloway says [26]:

"The kids these days are not digital kids. The digital kids were in the '90s. The kids today are mobile, and there's a difference. Digital is the old way of thinking, mobile is the new way."

The term "Mobile Technology" covers a huge range of mobile devices. Krannich classified the digital mobile electronic devices in three categories according to their transport ability, weight, form, components, capacity, and connectivity [27].

These categories are transportable devices, mobile devices, and wearable devices (Figure 1). This research predominantly focuses on handheld devices (except special single purpose devices) containing cell phones, smart phones, PDAs, mobile Internet devices, Internet tablets (e.g. iPad).

Mobile devices depend on the strength of their respective software and hardware features. These devices can be classified into three categories: mobile phones (cell phones and smart phones), special single purpose devices (usually with embedded systems), and handheld devices.

Mobile technology is playing an important role in new technologies. New technologies provide new designs, new interfaces, and new interactions. Mobile technologies and their devices are revolutionizing the computer use. Tablet PCs, and handheld devices let users perform tasks in flexible, mobile environments, work which used to occur only at the desktop.

New generations of mobile technology are moving towards optimization and improving previous versions shortcomings. In some cases Nanotechnology is part of some mobile technologies. Moreover, wearable computing systems are gaining in popularity and may one day be as a part of our everyday wardrobe. These types of devices are worn on the body and allow for interactions, modeling, monitoring systems, and personal independence. The convergence of wearable computing with mobile learning is expected in the near future; this may facilitate the learning process.

2.2 From E-Learning to Mobile Learning

Mobile learning inherits many features of e-learning although they have many differences such as knowledge input, output, memory capacity, application types etc. This overlap brings the basis of pedagogical learning theories from e-learning to mobile learning and even results in new learning theory implications in mobile learning. Ally points to mobile learning as a delivery of electronic context-based learning content on mobile devices [14]; however in e-learning solutions, content delivery is via personal computers.

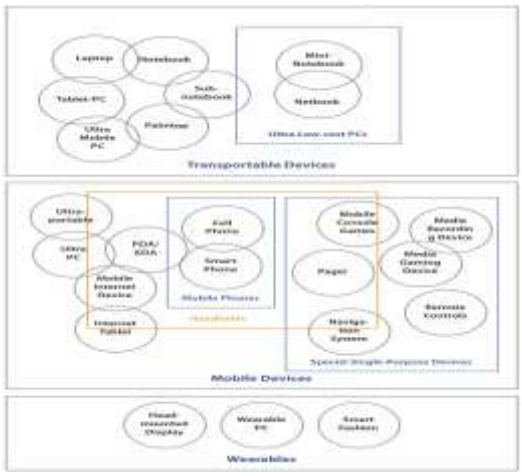

Figure 1: General classification of mobile devices [28].

By transforming learning content from e-learning platforms to mobile learning applications, the limitations in the presentation of content, processor performance and learning activities appear. To cover the limitations of small presentation screens on mobile technology, the learning strategies should be designed with consideration to aspects significant to individual learners. The mentioned considerations can have more complexity with different types of mobile devices as they have each different screen features.
E-learning applications have the possibility to be executed in multitask environments and learners can access different references and hyperlinks. With mobile devices, multitask functionality is still developing.

2.3 Mobile Learning

After the era of e-learning, we are converting to mobility, so is the need in the education process. Such a shift offers the opportunity of ubiquitous learning anytime, anywhere, so that learners do not need to wait for a fixed time and place for learning to take place. Kevin Walker says [29]: "Mobile learning is not something that people do; learning is what people do. With technology getting smaller, more personal, ubiquitous, and powerful, it better supports a mobile society. Mobile learning is not just about learning using portable devices, but learning across contexts" [29].

The success of mobile learning will ultimately revolve around a variety of rich converged experiences. These experiences will rest, in turn, on a foundation of converged network and device technologies, wireless services, content management, search management, and processing power [30].

The vision of mobile learning presented by the majority of authors currently searching in the field is that it seeks to enable 'anywhere, anytime, and any device' portable and personalized learning; it will facilitate communication, collaboration, and creativity among participants in authentic and appropriate contexts of use. In some respects, this is perceived as a revolution of 'just-in-time' and 'just-form' information delivery; however, the employment of mobile devices will be far from a panacea for the problems currently faced in education unless implementations of m-learning take heed of lessons 'e-learned' [30].

As with the implementation of any innovative scheme, significant technical and administrative challenges will be encountered. These will be met along with a more ill-defined challenge: 'How can the use of mobile technologies help today's educators to embrace a truly learner-centered approach to learning?' [31].

It is important to highlight that there still lack of complete and well-defined set of requirements for mobile learning environment, despite the efforts of some authors in this regard, such as, Nemesio Filuo and Ellen Barabosa, who tried to establish a requirement catalogue for mobile learning environment using systematic analysis of the existing literature in mobile learning, even they didn't validate or prioritize the requirements, it is a good start for more generalization of mobile learning [4] [24].

More contribution in the field of mobile learning came from a research on a framework for lifelong learning using mobile learning, adding mobile learning theories to the content of the previous frameworks [31], hoping to provide forwarding engineering support for the successful design of the future mobile lifelong learning [1].
So, mobile learning and expert systems can employ their aptitude to adaptively adjust the training for each particular learner on the bases of his/her own rapidity of learning which allows students to gain deep understanding of fundamentals to be able to follow the more advanced topics [8] [32]. So expert systems will provide excellent alternative to the private tutorial and individual training.

Since, mobile learning applications support traditional indoor and outdoor activities using mobile devices. From former practical experiences we can notice that GPS can be used to deliver resources for mobile applications, but we cannot guarantee the required level of GPS accuracy. So we can enhance this by adding a new layer to the existing applications (Self adaption layer" Agent"), making the system more robust to degrading GPS accuracy [7].

Moreover, mobile learning can provide learners with characterized learning services according to their performance and records. Also, it can support intelligentization through automated task without users instructions, to achieve some goals, but it needs more concentration on GUI, which need to be user friendly and easy to use [5]. Assessment or testing learners' abilities or achievement is a key element of the educational process, which should be included in a mobile learning system. That can be utilized to enhance more traditional learning practices, or for sure provide an important tool to support distance learning [6] [33].

Finally, mobile learning system should contain the main component of the traditional teaching system, and one of the main components of the traditional system is the teacher, so there should be one component in the mobile learning system to act as the teacher (an agent) that will be the main reference point for the course, which is responsible for allowing entry to the course, provide relevant course materials, and setting testing process [34] [13].

2.4 Significant Advantages and Highlights of Mobile Learning

- Can provide the learning process in real context.
- Can enhance the motivations for learners to be engaged more in learning process.
- Helps the learners to feel their autonomy and self-confidence in learning. Inherit the advantages of e-learning.
- Covers the restrictions of time and place of learning.
- Can support personalized learning.
- Can be used in two forms of individual or collaborative learning as well as social communications.
- Can be used as learner-centered content.
- Helps the situated learning on workplace (Just-in-time learning).
- Can be used as a tool for mobile assessment and surveys.
- Can provide new and different types of interactions.
- Can facilitate the communication during learning process.
- Can support easy learning material administration and updates. [14] [35]

Despite the many advantages of mobile learning, these potential "wins" do come with challenges.

2.5 Challenges of Mobile Learning:

- Small screens and limited amount of information on screen.
- Limited storage capacity.
- Lack of operating system (in many cases).
- Can make the sense of isolation from other colleagues or classmates.
- Can cause cheating in learning process.
- Can make problem in different learning platforms and devices.
- Limitation in publishing learning materials in different devices.
- Mobile devices can be out of date very quick (fast moving market).
- Wireless connectivity reception problem.
- Problem in multi-device capabilities. [14] [35]

Mobile learning can be used in the following situations based on the requirements and needs [14] [35]:

- Attending in virtual learning environments for training or teaching.
- Access to different digital libraries and archives.
- Access to different learning material pools (Quiz, test, interactions…).
- Live broadcasting and podcasts.
- Bringing the possibility of "Fun in Learning" as well as "Joy of Use".
- Facilitate offline-learning content.

3 Personalized Learning

According researches in software design, the analysis finds that models tend to associate personalization with individualization [36]. Clarke clarifies the difference between personalization and individualization; it lies in the end-user's ability to control the device and its related data [36]. According to this expert, individualization lets teachers and learning software designers tailor materials to match scaled assessments of learner's interest whereas personalization lets the learner interact with the material on the device. In other words, individualization is a one-way process from teacher to learners while personalization is two-way. Personalization means fitting specific content or presenting information according to an individual learner's needs. It is the capacity to tailor learning content and interactions to match learner abilities and needs that make the use of mobile technologies unique.

Figure 3 depicts the differences between personalization, individualization, and customization. In customization, the control of process is from the learner side and learners select material and leaning processes according to their own interests.

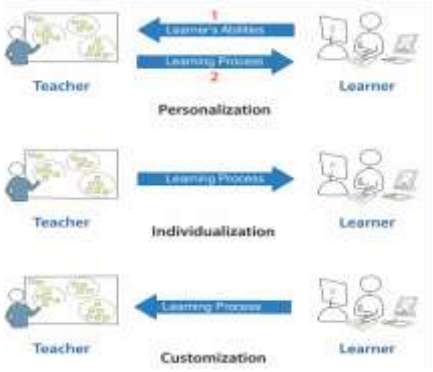

Figure 2: Personalization, Individualization, and Customization.

Personalization is one of the principles in the design of this study. Personalized learning usually occurs in traditional learning in informal ways. Traditionally, successful trainers using this method by differentiate between a learner's attitude and behaviors and through receiving learner feedback. The report of the teaching and learning in 2020 review group (Vision 2006) argues personalization serves a moral purpose and social justice and stating:

"Put simply, personalizing learning and teaching means taking a highly structured and responsive approach to each child's and young person's learning, in order that all are able to progress, achieve and participate. It means strengthening the link between learning and teaching by engaging pupils – and their parents – as partners in learning."

John Traxler in his book "Mobile Learning" points to diversities, differences and individualities, which can be recognized by personalized learning and adapted to the user [37]. Ally claims that productive and meaningful processes for the learners in enhancing their abilities according to their own autonomy can be supported by mobile technologies [14].

Hawkridge and Vincent's discussions about the use of digital media and computers by people with learning disabilities further determine the limitations and lack of this kind of personalization for learners [38]: "Computers can ease learning difficulties. They can help learners to overcome their difficulties. They cannot work magic. They are not necessarily the best solution. Because each learner's needs are slightly different, there are few standard rules."

In 1992, Hawkridge and Vincent's citation was revolutionary. They looked toward the possibilities that digital media could help people with learning difficulties.

At that time the graphical user interface (GUI) technologies were not intuitive and interactive functionalities had not been developed. However, they saw certain use cases for the disabled where the computer might be helpful.

Interface limitations and hardware interactions made the early e-learning tools a less appropriate choice for educators looking for helpful learning aids. Since that time, there have been tremendous advancements in computer technologies including: hardware, software, user interface, database, web technologies and audio-visual capabilities. Nowadays intelligent learning systems implemented on client-server solutions, based on fully developed interactive patterns enable us to focus on personalization and individualization. At the meanwhile, developers still facing challenges in building fully personalized functionalities in the core of a learning system.

Figure 3: Learner central to a personalized learning system.

Most of the research agreed on that Personalization means Fitting specific content or presenting information according to an individual learners needs. It is the capacity to tailor learning content and interactions to match learner abilities and needs that make the use of mobile technologies unique [8] [9]. Personalization came to the surface through the need for more specific materials according to learners' preferences to increase learners' performance [11]. New methods and framework proposed to achieve personalization especially in English education, and their results were encouraging and promising for a good future mobile learning as a tool to enhance learners' performance [11].

Most of learning contents in mobile learning are designed for desktop platforms, which is not suitable for hand-held devices [19], also some materials irrelevant to learners preferences or contextual environment, which may affect learning efficiency [12]. So, there is a need for more concentration on mobile learning applications design process [39], to be suitable for these devices and responds to users' needs and preferences [7] [8] [19].

The advancement of mobile learning in 2007 was the main point of many researches, one of them was conducted by Luvai Motiwalla on a new framework for mobile learning and its evaluation, her study results showed that mobile learning system is useful and good complementary tools for the classroom, providing flexible access from anywhere and anytime. Also, students perceive an important supplementary role for wireless handheld devices in e-learning, and are effective in delivering personalized content [25]. A theoretical foundation (AGORA) that can be used to model a city mobile learning founded by Basit Khan, in which there are two important aspects of learning-experiences that need to be represented. First, it is important to represent the experience of a place. Second, it is also important to consider the technological factors involved [2].
Learning styles is another issue should be addressed when dealing with personalization; many researches have been conducted regarding this issue but in e-learning content [40]. One of them conducted to design architecture for an intelligent tutoring system that considers learning styles of the student and the competency-based education. This architecture incorporates a selector agent, which will choose the content to show, considering the learning strategies that support the students learning style [41].

Social aspects also get the attention in mobile learning field through using social aspects agent to the system, leading to improve the added value of the mobile learning system, making students more comfort and satisfied when dealing with the system [42] [43].
Learners mobility increase across formal and informal con- text is a positive response to global economy and work- force. TEALE (Technology-Enhanced Autonomous Learning Environment), which is a framework that consists of three components [9]:
1. Learner agent objects (LOA): individual academic portfolios elements in a collection of evidence based multimedia proxies and artifacts representing a learner's formal and informal academic experience.
2. Meta-data system that provide automated learning assistance by employing algorithms from learning sciences to influence, anticipate, evaluate and manage individual learning activities.
3. The communication interface that interacts with other TEALEs, remote labs, and external learning resources libraries. And they found that using TEALE increased the interaction between faculty and students, and fostered the collaboration among the students, also an indication that TEALE framework has implications on different levels in teaching and learning process.

4 Agent Technologies

The agents' abilities may vary significantly depending on the roles that they take in their deployed environments.

However, still we can identify necessary and widely agreed on properties of agents, namely: autonomy, pro activeness, responsivity, and adaptivity. Additionally, agents should also know users' preferences and tailor their interactions to reflect these [20]. It is generally accepted that an agent is an entity that is capable of carrying out flexible autonomous activities in an intelligent manner to accomplish tasks that meet its design objectives, without direct and constant intervention and guidance of humans.

Multi-agent systems contain many agents that communicate with each other. Each agent has control over certain parts of the environment, so they are designed and implemented as a collection of individual interacting agents. Luck et al. remark that, "Multi agent systems provide a natural basis for training decision makers in complex decision making domains [in education and training]" [23]. Furthermore, multi-agent systems can substantially contain the " spread of uncertainty", since agents typically process information locally [14].

There are many definitions of agents one most agreed upon is that one presented by Wooldridge and Jennings [10]: Agent is a computer system (software/hardware) that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives. Deploying intelligent tutor in on-line education emerged in the 90s of the last century, Sherman Alpert and his colleagues conducted a research in 1999 on the shift of using standalone Intelligent Tutoring System (ITS) to one that operates on the World Wide Web, showing that both architecture and features of the system support students problem solving activities [44]. Another research conducted by Marcia Mitchell proposed a framework for an intelligent tutoring system that support Distance Learning (DL), (CHARLIE) which is high level software based tutoring that has the ability to encompass a wide variety of current DL technologies in a single DL session [45].

The term agent technologies for mobile devices started to get attention because of the advancement in mobile technologies early this century. Mobile agent technologies provide an attractive solution to implement and improve mobile learning environments. Still mobile learning agents at that period need more improvements [46]. There are many design consideration should be considered when dealing with mobile devices as a media of delivering learning materials, such as, software portability, limited computing capabilities, limited display properties, development costs, design flexibility and scalability, limited memory resources, and software agent support. So some intelligence features is needed through an agent that is capable of adapting to the heterogeneous mobile computing [20]. Yani-Lei and his colleagues introduced an intelligent tutoring system in mathematics, which uses some advanced algorithms for mobile learning, and their project emphasis on generating questions automatically, and guided learning aspects [18].

Emotion also plays an important role in learning process, it is important to consider emotional state of the student, which is equally important to the cognitive level. Psychological researches indicated that emotions have deep influences. Although several approach have been constructed for ITS, enhancing students emotional intelligence has not been considered so far, PANDA.TUTOR one of the e-learning ITS introduced by Heba Elbeh in 2012, that incorporate an emotional agent, that predict the student emotional state and choose the appropriate scenario, learning strategy, and learning style in order to regulate with current emotional and motivational state of the student [3]. The need for enhancing mobile learning is one of the most important issues raised nowadays according to the students and faculties viewpoint [16]. Video streaming is very important and effective factor, but the bandwidth of the wireless networks is hardly sufficient enough to enable video streaming, so some agents are needed to manage this issue [16].

Device independency is one of the raised issues when dealing with mobile learning because of the different operating systems and platforms, there were some attempts to resolve this issue, Xinyou ZHAO in 2008 proposed a device independent system architecture for mobile learning, in which there is a device detector (agent) that take responsibility for detecting the capabilities (memory, screen size,...etc) of the mobile device and then sending capabilities to Adopted Content Model, and its adapts the WURFL model to detect the device, which collects the features of device and mobile browsers in the wireless world [23]. In 2012 new trend initiated, which concentrate on deploying agents in game-based mobile learning applications [33] [22]. Two studies conducted separately on language learning through game- based mobile learning which employs agents, one for English language and the other for Chinese Hanzi and Japanese Kanji, and the results showed positive response towards the use of the proposed frameworks which is similar to multimedia world in that we need to Pictionary in designing the game in learning. Also it makes learning more fun and interesting [47] [48].
Using agents in mobile learning will allow users to choose interrupted or uninterrupted learning, also user should be able to choose the suitable assessment

methods (Self-test or Normalized test). At the same time the system should keep track with the users operations and advancement. Since the mobile portal constructs the ubiquitous mobile intelligent learning environment, which should provide the user(s) with more flexible learning method at anytime and anywhere [49].

5. Summary of the Literature

From the literature, Table 1 show the related article on personalization organized according to the publication year, their number and percentage, and from that table we can figure that year 2013 got the highest percentage of related article (39%), and 2011 is the least (2%), taking in consideration that the number of related article in 2014 is expected to increase. This means that most of the articles included are up to date (55%) from 2013 and 2014.

Table 1: Percentage According to Publication Year

Year	No.	Percentage of 38
2009	5	13%
2010	3	8%
2011	2	5%
2012	7	18%
2013	15	39%
2014	6	16%

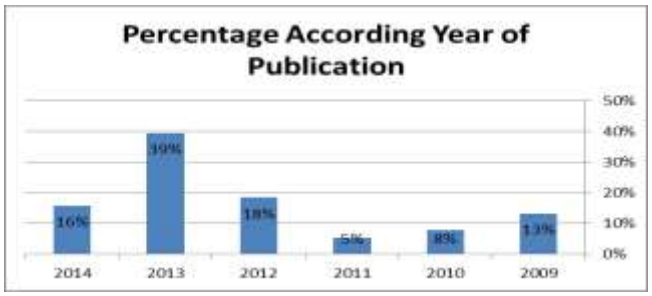

Figure 4: Percentage of Related Articles and Publication Year

According to the searching process, Table 2 summarizes the references according to three search keywords and supplementary materials (Mobile learning, Personalization, Agent technology, and others). We can see that out of a total of 58 articles reviewed in this review, 55 articles related to mobile learning in general, 38 related to personalization in mobile learning systems, 30 articles were related to agent use in achieving personalization in mobile learning applications using agents technologies, and 5 supplementary articles used to support the preparation of the report in (Literature Review, methodology, and Experiment Design).

Table 2: List of Keywords and Correspondent Studies

Aspect	No.
Mobile learning	53
Personalization	38
Agents Tech.	30
Others	5

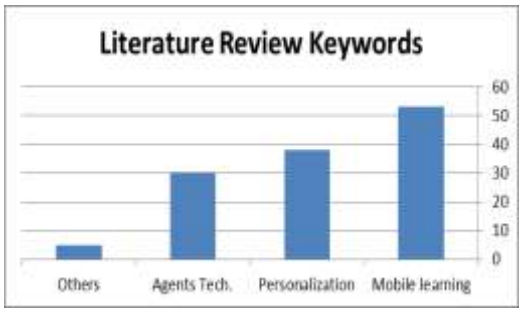

Figure 5: Number of Articles according to the research keywords

And Table 3 show the trends in personalization of mobile learning systems and the studies related to trend.

Table 3: Aspects of Personalization and Related Studies

Personalization TREND	No.	Percentage of 38
Device Capabilities	6	16%
Student's Level	9	24%
Student's Preferences	9	24%
Network Speed	4	10%
Subject	8	21%
Location	2	5%

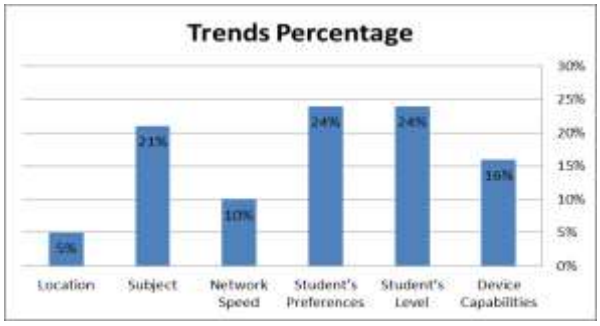

Figure 6: Aspects of Personalization and Related Studies

Table 4: Research Methodology Used and Percentage

Methodology	No.	Percentage of 38
Experimental	17	45%
Case Study	9	24%
Descriptive	7	18%
Literature review	3	8%
Formal Proving	2	5%

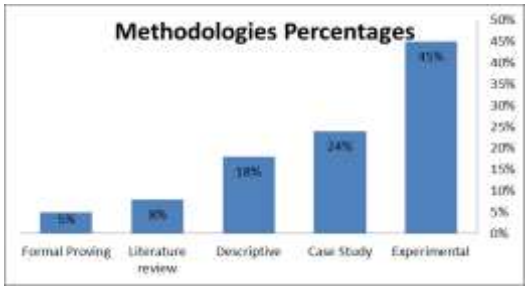

Figure 7: Research Methodology Used and Percentage

6. Conclusions & remarks on the existing literature

The analysis of the related articles about personalization (38), To answer the first question, what are the issues and problems related to personalization in mobile learning applications?
From earlier sections that most of the existing literatures concentrate on one issue in personalization; those issues can be categorized as:

1. **Student level:** In those studies personalization occurs according to the student level and achievement, so the material delivery will be from an agent, according to some academic levels of intended out comes (ILO's) of those materials and their suitability to the student level.
2. **Student Preferences:** The learning materials are sent to the student according to his preferences (Graphics, Video, Audio, and Text).
3. **Network Speed:** Here an agent is deployed to measure the network speed (line speed of the connection) according to the network speed the agent select the suitable materials to be viewed by the students according to their size.
4. **Subject Specific:** The ML application was designed to a specific course, which (the design) may not be suitable for other subjects.
5. **Location:** that means that there is an agent that predict and somehow find the location of the student (university, cafeteria, library, ...) then it send the materials that are suitable for the specific place.

Regarding the second question, "What are the limitations of the previous studies on personalization in mobile learning?", from the analysis of the projects listed in the literature review, we can conclude that mobile learning is one of the new important tools in educational institutions, but also more research is needed to stabilize, standardize, and formalize mobile learning, so it can deliver more personalized materials according to the students' needs and preferences.
The main gap in the literature is that they didn't investigate the personalization from different perspectives; most of them deal with one perspective (educational or technical), some of them try to solve educational issues (students' learning styles and preferences) neglecting the technological issues and capabilities, while the others try to deal with technological issues (device capabilities, network properties, … etc) without taking into consideration the educational issues.

To answer the question "What are the existing methodologies being applied on development of personalized mobile learning systems?", the analysis of the literature in 38 study regarding the personalization resulted five main methodologies as shown in table 4, and from the table we can notice that the most and commonly used methodology is experimental with 45 percentage, then the case study methodology 24 %.
Therefore, more investigation is required to fill in the gaps of enhancing mobile learning applications towards more generalized and standardized architecture or framework that contain some intelligence features (Agents). Since most of the conducted researches where limited to specific course, group of users, or specific goal, such as mobile capabilities, connection speed, location … etc.

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