INTERNATIONAL STANDARD

ISO/IEC 29140

First edition
2021-11

Information technology for learning, education and training — Nomadicity and mobile technologies

Technologies de l'information pour l'apprentissage, l'éducation et la formation — Nomadisme et technologies mobiles

Reference number
ISO/IEC 29140:2021(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents) or the IEC list of patent declarations received (see https://patents.iec.ch).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html. In the IEC, see www.iec.ch/understanding-standards.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 36, *Information technology for learning, education and training*.

This first edition cancels and replaces ISO/IEC TS 29140:2020, which has been technically revised. The main changes are as follows:

— the list of definitions has been extended;

— the number of mobile learning applications has been expanded;

— recent references from the mobile learning literature have been included.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

Since ISO/IEC TS 29140-1:2011 and ISO/IEC TS 29140-2:2011 were published, there have been many technological innovations and increasing use of mobile technology in learning, education and training as indicated in many of the review and meta-analysis studies on mobile learning[1][2][3][4][5][6]. These two documents were updated and replaced by ISO/IEC TS 29140:2020, which has now been replaced by this document. The growth in active mobile-broadband subscriptions has increased significantly, with penetration rates increasing worldwide from 4,0 subscriptions per 100 inhabitants in 2007 to 69,3 in 2018.7 The number of active mobile-broadband subscriptions have increased from 268 million in 2007 to 5,3 billion in 2018[7]. In addition, almost the entire world population, or 96 %, now lives within reach of a mobile cellular network. Furthermore, 90 % of the global population can access the internet through a 3G or higher speed network[7]. This is placing a sense of urgency to revise the standards for the use of mobile technology in learning, education and training.

At the same time, the technology, and the application of the technology, is changing at a fast rate. For example, 3D glasses are being used for virtual reality, augmented reality and mixed reality; and voice input and output are being used for language training. In 2020, a bibliometric review of 450 articles was conducted on mobile earning in higher education research using bibliometric methods. The results indicate that use of mobile learning is increasing[8].

As schools, governments, organizations and businesses around the world design information for access by mobile devices, there is increased need to set standards for how information should be designed for delivery on mobile technologies to support learning, education and training. This increased need is heightened by demand for learning and training materials that can be shared easily between organizations and learners and made available to those in any geographical location. Mobile learning has the potential to provide learners with enhanced access to information and learning materials and guidance and support from anywhere rather than from a specific geographical location at a certain time. When mobile learning is implemented thoughtfully and well, it has the potential to increase efficiency and productivity for learning, education and training within different sectors (e.g. public, private, voluntary).

Mobile technologies, in addition to being a communication device, provide easy access to unlimited learning materials at any time and any place, which allows for student-centred learning and provides learning according to individual differences and needs[5].

Mobile learning has the potential to provide learners with new opportunities to connect with other learners, to interact with teachers and trainers, and to co-create collaborative learning environments. This is a critical issue for learners who live in remote locations lacking wired connections[9][10].

There are a number of research teams in organizations and communities who are working on mobile learning. Many research studies and projects have been completed on the use of mobile technology in education and training. Additionally, work is already in progress in various countries around the world on related topics such as learning in different contexts, learning while on the move and the use of hand-held computers in learning.

It is important that the design, development, implementation and evaluation of mobile learning within learning, education and training environments takes place in a manner that is seamless, flexible and integrated. In short, mobile technology needs to be seamlessly integrated into teaching and learning activities that are supported by information and communication technology (ICT) in general. A review of models and frameworks for designing mobile learning experiences described different learning strategies for using mobile technologies in learning[11]. These include:

a) context-aware learning where learners can learn in their own context using wireless connection, global positioning systems, satellite connection and mobile apps;

b) seamless and ubiquitous learning on the go and learning from anywhere because of the portability of mobile technologies; this learning strategy is important for the nomadic learners who move from one location to the next;

c) game-based learning where learners are presented with different scenarios and challenges during the learning process;

d) mobile computer-supported collaborated learning where students use mobile technologies to interact to complete learning activities in groups.

In the past, use of mobile technologies, because of their small size and portability, have been beneficial to nomads; however, the current mobile technologies are more powerful and they are being used in different locations and different contexts for learning. For example, mobile technologies can be used in a classroom to teach school-age children about disease transmission patterns; in medical education to support students learning about bedside clinical practice; in an industry to train employees how to maintain a piece of equipment; in a museum to give students a virtual presentation of a historical event; in a college to give students a virtual tour of an archaeological site, etc. The potential use of mobile technology is unlimited; its use will depend on the creativity of the instructional designer, teacher or trainer. An analysis of 113 global research studies on mobile learning in pre-kindergarten to Grade 12 levels found that 62 % of the studies reported positive outcomes, meaning that the majority of studies found that the use of mobile devices in a learning activity resulted in increased student learning[3]. It also reported that the majority of the studies (50 %) took place in formal educational contexts while a setting composed of both formal and informal settings accounted for 27 % of the educational contexts, and the remaining 23 % of the studies took place in informal settings.

Mobile devices have been around for many years but are becoming more sophisticated. At the same time, there remain limitations and challenges when using mobile devices. For example, some learners find that the screen size is small when reading information and the keyboard too small for entering information. To help with these limitations, researchers are developing mobile devices with virtual screens and keyboards and voice input and output options, which will help to overcome some of these challenges and limitations. In addition, 3D glasses have been developed to address the issue of screen size and data entry.

Information technology for learning, education and training — Nomadicity and mobile technologies

1 Scope

This document establishes a learner information model specific to mobile learning to enable learning, education and training environments to reflect the specific needs of mobile participants. It gives guidance on the use of a learner information model for mobile technology in learning, education and training (mobile learning).

This document can be used as a reference by software developers, implementers, instructional designers, teachers, trainers, automated systems and learning management systems.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
adaptive design
creation of multiple versions of a web page to better fit the learner's device rather than a single static page that looks the same on all devices

3.2
artificial intelligence
AI
branch of computer science devoted to developing data processing systems that perform functions normally associated with human intelligence, such as reasoning, *learning* (3.4) and self-improvement

[SOURCE: ISO/IEC/IEEE 24765:2017, 3.234]

3.3
augmented reality
virtual objects superimposed upon or composited with the real world

Note 1 to entry: Virtual and real-world objects co-exist in augmented reality systems.

3.4
learning
acquisition of knowledge, skills or attitudes

[SOURCE: ISO/IEC 2382-36:2019, 3.1.1]

3.5
learner information
recorded information associated with learners and used by *learning technology systems* (3.6)

Note 1 to entry: Learner information may be created, stored, retrieved, used, etc. by learning technology systems, individuals (teachers, trainers, learners, etc.), and other entities.

[SOURCE: ISO/IEC 2382-36:2019, 3.7.1]

3.6
learning technology system
LTS
information technology system used in the delivery and management of *learning* (3.4)

3.7
mixed reality
display continuum in which both real and virtual images are combined in some way and in some proportion

Note 1 to entry: *Augmented reality* (3.3) and *virtual reality* (3.16) are considered to be on the mixed reality continuum.

3.8
mobile learning
m-learning
m-learn
learning (3.4) using information and communication technologies in *mobile contexts* (3.9)

3.9
mobile context
learning (3.4) that can occur in any location because of the portability of the *mobile technology* (3.10)

3.10
mobile technology
lightweight devices that learners can conveniently take anywhere to learn and mobile network that learners can access from anywhere

3.11
massive open online course
MOOC
free open online course that is available for anyone to enrol and complete

3.12
nomadic learner
learner who moves from one location to another with relative frequency

Note 1 to entry: The learner has to access the learning materials from different locations, varying time zones and within another environment during a single learning episode.

3.13
responsive design
method for web page construction to detect the user's screen size and orientation and dynamically change the layout accordingly

3.14
seamless learning
learning (3.4) in different contexts using multiple devices

3.15
ubiquitous learning
learning (3.4) that is stimulated and supported through diverse channels and always readily accessible

3.16
virtual reality
artificial environment presented using computer technologies

Note 1 to entry: Virtual reality has a high level of immersiveness, fidelity of information representation and degree of active learner participation compared with other forms of *mixed reality* (3.7).

4 Abbreviated terms

AI	artificial intelligence
ICT	information and communication technology
ITLET	information technology for learning, education and training
LMS	learning management system
LCMS	learning content management systems
MALL	mobile applications for language learning
MOOC	massive open online course
OS	operating system

5 Examples of mobile learning applications

5.1 Online student use of mobile devices for learning

A longitudinal and cross-sectional mixed methods study employing the community of inquiry (CoI) and framework for the rational analysis of mobile education (FRAME) models to examine the use of mobile devices among graduate students at one online North American university. See Reference [12].

5.2 Fluent speaking in English/fluent reading

Mobile learning applications can be used to train learners to improve their English-speaking skills. A recent meta-analysis study examined the overall effectiveness of using mobile devices on language learning. The meta-analysis was based on a synthesis of 84 separate studies from different sources. The medium-to-high overall effect size for mobile devices on language learning achievement confirms the positive benefits of using mobile devices in language learning. See Reference [13].

5.3 Digital textbook for innovative learning

The Ministry of Education in South Korea and the Korea Education and Research Information Service (KERIS) developed and implemented digital textbooks in an advanced form that overcome the limitations of paper textbooks, improve classroom lessons, and enable personalized teaching and learning. The digital textbooks can be accessed by mobile technologies. See Reference [14].

5.4 Mobile learning technology among final year medical students

A cross-sectional descriptive study conducted among final year undergraduate students at the University of Nairobi, College of Health Sciences. This study aimed to assess the use of mobile learning technology as well as exploring the challenges that impede adoption of mobile learning technology in the target population. See Reference [15].

5.5 Augmented reality training system

An augmented reality training program was developed by an augmented reality organization to train industrial sales and service workers on how to dismantle and re-assemble an accentuator valve. The trainee used tablets or augmented reality glasses, or both, with positioning markers to overlay holographic, step-by step instructional images on a real-world accentuator valve to dismantle and re-assemble the valve. The project was evaluated using a pragmatic mixed-methods approach. See Reference [16].

5.6 App for exam practice

Malezi exam practice is a mobile friendly web application that generates examination revision content for learning and testing readiness for final level exams in both primary and secondary school. See Reference [17].

5.7 Implementation of app for academic success

The University of Waterloo, Ontario, developed a tri-lingual (English, French, Chinese) mobile learning application designed to facilitate anywhere and at any time academic integrity training. The project is designed to improve student engagement with academic material by exploring mobile learning to better resonate with the university/college student population. The app has the capacity to provide an e-certificate and digital badge upon successful completion of the module lessons. See Reference [18].

5.8 Tutoring, games and applications for language learning

The purpose of the FirstVoices mobile applications for language learning (MALL) is to preserve and to promote First Nations languages. Over 60 Aboriginal languages are archived, some only available to members of that community. The resources are used by First Nations communities in Canada to teach, learn and document their words, phrases, songs, stories and other digital community resources. FirstVoices also serves as central language data platform for other applications. See Reference [19].

5.9 Evaluation of key factors that affect learner-empowered emergent technology integration

Wark's dissertation sought to determine what key institutional, curricular, instructional and contextual factors and, ultimately, what educational paradigm most enabled online graduate level learners to integrate emergent technologies for learning on demand. See Reference [20].

5.10 Other examples of mobile technology for learning

As the use of mobile technologies grows around the world, the infrastructure to support mobile learning is being improved to allow access anywhere and at any time to learning applications, services and content. In several countries, corporate, academic and government organizations are using existing learning management systems to implement and provide support for mobile learning. In some countries, connectivity is sufficient to allow learners to access learning resources and participate in teaching and learning activities through connecting to networks using mobile devices. There is a shift from wired to wireless connection that will facilitate the use of mobile technology in learning. Mobile learning is being used to improve access to learning materials and services that will facilitate individual learning, education and training from anywhere and at any time. Additional examples of mobile learning applications include the following:

— Educational organizations are making their digital learning materials available as open access so that the materials can be re-used at no cost providing the materials are used for education. In most cases, the materials can be accessed using mobile technologies.

— Use of artificial intelligence (AI) to adapt learning to meet individual learner needs.

— Organizations are developing and delivering massive open online courses (MOOCs), which are free for anyone to participate. In some cases, learners can complete the MOOCs using mobile technologies.

— Countries and organizations are using mobile technologies to educate refugees who live in camps and cannot go to school, so that they can get the knowledge and skills to be integrated into society.

— In large geographically dispersed countries, mobile technologies are used to facilitate the delivery of information and learning materials to learners in any geographic location. Universities are developing digital repositories that have courses that link to learning resources, allowing learners to access course materials from anywhere and at any time using a variety of technologies, including mobile technology.

— Mobile learning is being used to train immigrants who require language instruction in a second language while they work at the same time.

— Organizations are converting courses for mobile delivery for the convenience of learning at a time and place that meets individual learners' needs.

Mobile learning applications are being used to in the following ways:

— Send daily information from schools and universities to students.

— Gather immediate feedback and response data from students using mobile phones as part of a classroom response system.

— Assess learner levels of understanding or skills, associated with rich media content.

— Browse videos of recorded lectures.

— Support problem-based or collaborative learning in real situations, such as exploring museums or cities to find out relevant information to solve a given problem.

— Support interactions with an intelligent software agent capable of adapting to the heterogeneous mobile computing environment. The agent can search for a conversion tool according to the desired format and convert the course materials automatically. The agent is able to understand mobile clients' device capabilities. In order for the server to know what type of course material the client wishes to receive, the client needs to provide information on the software and hardware capabilities of the device to the server. However, devices do not normally carry any information about their capabilities with respect to affordances available for learning, education and training activities.

6 Learner information for mobile learning

6.1 General

Information about the learner is used to determine how required learning materials infrastructure and support are all tailored for mobile learning. Learner information for mobile learning is similar to learner information for e-learning. Additional learner information is required to support mobile learning in different situations that may reflect contextual elements such as the mobility of the learner and the nature of the surrounding environment (e.g. infrastructure to support ubiquitous learning). The use of mobile devices to support mobile learning can be considered along different dimensions including the location and mobility of the learner and the embeddedness of the learner in the real environment or in context. In e-learning with desktop or notebook computers, the learner mobility and embeddedness are low. In mobile learning, learner mobility and embeddedness are high[15]. To adequately support mobile learners engaged in learning, education and training activities, information technology systems need to consider the specific context of the mobile learner with respect to dimensions such as mobility, embeddedness, learner preferences, content, device capabilities, connectivity and coordination.

Mobile learning provides flexibility for learning since it enables learning facilitated by a diversity of mobile devices. Mobile learning content is delivered in chunks and the mobile device can allow for synchronous, spontaneous interactions. In mobile learning, the learner is always connected and

learning is networked because of the connectivity of the mobile device[7]; however, the learner may connect for a short time to download an app and then learn using the downloaded app. Mobile learning provides learners with opportunities to learn outside of the classroom or workplace since the learner can learn from anywhere and at any time. Organizations use both e-learning and mobile learning; however, mobile learning provides more flexibility to learn and can allow for improved communications between learners and between learners and teachers.

6.2 Learner information model for mobile learning

Figure 1 shows a learner information model for mobile learning and the support systems for mobile learning. More information regarding learner interactions with mobile learning systems is provided in Clause 7.

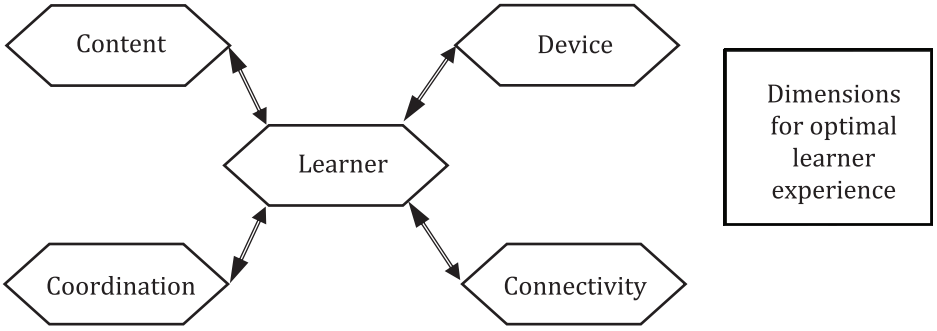

Figure 1 — Learner information model for mobile learning

The learner is at the centre of the mobile learning support systems model. Other aspects that are part of the model and impact on learner experience include content, device, coordination and connectivity. The minimum recommended elements are identified in Table 1 (see 6.3). Each minimum recommended element has been included under the relevant aspect of the learner information model for mobile learning. There are also optional elements included in 6.4 that have been grouped under the related aspect. It should be noted that the list of optional elements is not exhaustive and is further expanded in 6.5. Ideally, the elements within each aspect of the learner information model for mobile learning are viewed as dimensions that, when considered holistically, can assist in providing an optimal experience for learners engaged in mobile learning activities. It should be noted that mobile learning activities are inherently dynamic, connectivity can change during sessions, learner preferences for presentation can change depending on external factors such as noise in the surrounding environment or internal factors such as fatigue. Although in-depth details regarding privacy are beyond the scope of this document, several elements have been noted as possibly having potential privacy issues. Further discussion regarding possible technical solutions to these potential privacy issues is not included in this document.

6.3 Minimum recommended learner information

Table 1 — Minimum recommended learner information model for mobile learning

Minimum recommended learner information	Description
Learner	
Geographical location of the learner[a]	Since the mobile technology allows the learner to learn from anywhere, it is important to know where the learner is located so that the learner can apply the information in the appropriate context, and in a manner that is consistent with the specific situation of the learner. Many mobile apps can access data regarding the geographical location of the learner and the learner's contacts. For example, turning on the flashlight of a mobile phone can provide the geographic location of the learner. Although access is supposed to be permission-based, learners do not always understand that they have the option of refusing to provide this information to third-party applications.
Learner history[b]	Previous learning activities of the learner and the learning levels that were attained.
Learning needs	The learning outcomes the mobile learning is intended to support and the learner would like to achieve.
Learner progress[c]	How the learner progressing in the learning process.
Language of the learner[c]	The learner should be able to access learning materials in her or his first language or the language that is being learned. If the learning materials are not available in different languages, ideally the system should enable translation of the learning materials to the learner's preferred language.
Device	
Type of device and operating system (OS) being used	The system shall know the type of mobile device and the OS the learner is using so that the information can be formatted for the specific device.
Connectivity	
Connection speed	The connectivity speed is needed so that information can be downloaded to the learner in an efficient manner. For example, if the learner has a slow connection speed, the learner should not be required to access large amounts of data. Or the learner should be able to download an app to learn offline if the connectivity is not adequate. This is important for augmented reality and virtual reality experiences.

[a] There can be privacy considerations regarding the recommended use of this element. Location settings can be used to determine surrounding infrastructure support for the purposes of coordination of information.

[b] There can be privacy considerations regarding the recommended use of this element. Learner history information is specific information relevant to support adaptive interactions between the learner and the IT system.

[c] There can be privacy considerations regarding the recommended use of this element. The information can be restricted to those who have specific roles within the IT system.

6.4 Optional learner information

There are optional learner information elements that can be considered in mobile learning systems to support learners (see in Table 2).

This list is not exhaustive. Additional optional learner information that contributes to optimal mobile learner performance is discussed in 6.5.

Table 2 — Optional elements of learner information model for mobile learning

Optional learner information	Description
Learner	
Learning preferences of the learner[a]	Activities based on the learner's learning preferences can be suggested if they are known to the mobile learning system.
Learner academic background[b]	Knowing the learner's academic background can help to ensure that the appropriate content is presented to the learner at the right time and level.
Learner display preferences	Before the correct mobile device is given to the learner, the learner display preferences shall be known. For example, if the learner requires that text is presented on a high contrast background, then the mobile device shall meet the display and delivery requirements of the learner.
Motivation level of the learner	The motivation level of the learner to learn in a situation that requires mobility or the use of a mobile device.
Connectivity	
Electrical capabilities	The electrical capabilities of the geographical location of the learner shall be known so that the appropriate device can be given or suggested to the learner to access the information.
Coordination	
Coordination of other access (e.g. tutor, peer, instructor)	Provides the learner with access to tutors, peers or educators for help while learning if needed.
Learning group	Identification of the group to which the learner belongs so that communities of learners can be formed.
[a] The information can be restricted to those who have specific roles within the IT system.	
[b] There can be privacy considerations regarding the optional use of this element. The information can be restricted to those who have specific roles within the IT system.	

6.5 Dimensions for optimal learner experience

6.5.1 General

The information about the learner is used to determine how learning materials are developed, delivered and rendered for mobile learning. As noted in 6.3, it is the learner and the learner experience that is key to the success of mobile learning activities. Subclauses 6.5.2 to 6.5.6 provide additional details and describe how mobile learning materials should be designed and developed based on the learner information and to meet the needs of the learner. All of the aspects of the learner information model for mobile learning are discussed and suggestions are provided to ensure an optimal learner experience. The information is organized using the dimensions proposed in Reference [10].

The following design elements should be considered when designing learning materials for mobile learning:

— learning is self-directed where the learner controls the speed of the learning;

— learning is ubiquitous where learning can take place anywhere and at any time;

— learning, education and training activities need to be supported reliably and with seamless connectivity;

— build a learning community to support the collaborative work of learners who feel comfortable working in groups.

6.5.2 Learner dimension

As noted above, there are certain minimum recommended learner elements that should be considered by designers, implementers and others.

— Learner identification: This is used to uniquely identify the learner so that appropriate access is provided to learning resources. It includes a username and password.

— Geographical location of the learner: It is important to know the geographical location of the learner so that the appropriate learning activities can be presented in the current context of the learner who is mobile and who can be in different geographic locations at different times.

— Learner history: This involves the previous learning activities of the learner and the learning levels that were attained.

— Learning needs: The learning outcomes the mobile learning is intended to support and the learner would like to achieve.

— Learner progress: Information regarding how the learner is progressing in the learning process.

— Language of the learner: The learner should be able to access learning materials in her or his first language or in the language that is being learned. If the learning materials are not available in different languages, ideally the system should enable translation of the learning materials to the learner's preferred language.

Additional optional learner elements are provided below.

— Learning preference of the learner: It is important to know the learning preference of the learner since different learners have different learning preferences and some learners are more visual while others are more verbal[16]. The right learning content and services that are provided to the learner in mobile learning depend on the learning preferences of the learner. For example, if the learner has a reflective style, then the mobile learning delivery system should use asynchronous communication to allow learners to reflect before they respond to comments and questions.

— Learner academic background: Before the appropriate content is provided to the learner, it can be helpful if the content is provided at the right level. Having information related to learner academic background can help to determine the right level of information to provide to the learner.

— Learner display preferences: Individual learners have specific preferences that should be considered during the learning process. For example, if the learner requires that text is presented on a high contrast background, then the mobile device shall meet the display and delivery requirements of the learner.

— Motivation of the learner: Learner motivation can impact positively or negatively on learning outcomes. Technologies need to support learner motivation to impact positively on learning outcomes. Hence, mobile learning materials shall use strategies to continually motivate and engage learners.

6.5.3 Content dimension for individual learner needs

The content dimension suggests that the system shall have capabilities for organizing and selecting the appropriate content and for delivering content according to the learning situation so that learner needs are met.

Optional information elements for content that support learners in mobile learning situations are as follows.

— Course module: Courses can be delivered in the form of modules. The modules are then broken down into smaller chunks based on the learning objectives in the modules. Modularizing courses can allow learners to complete a small segment of a course before moving on to other segments.

Identifying content with course modules can help with monitoring learner progress through content and with delivery of appropriate content.

— Granularity level: Mobile learning materials can be developed in chunks to allow for flexibility in delivery for the learner. Learning materials are often packaged in manageable interconnected chunks to allow learners to access a small segment of a lesson at a time. This can make learning easier on mobile devices and learners may get a sense of accomplishment after completing each linked segment of a lesson. Information should be chunked in segments of appropriate and meaningful size to facilitate cognitive processing.

— Sequencing: Mobile learning materials need to be sequenced appropriately in order to provide access to materials in a manner that is consistent with the needs of the learner.

— Multimedia: Mobile devices shall have multimedia capabilities to meet the needs of those with different learning preferences and accessibility requirements. Recent research studies have shown the benefits of the use of mobile phones with multimedia capabilities in language learning. Additionally, the use of voice input for mobile devices can improve efficiency when inputting data into mobile devices. For example, voice input can be supportive for use in learning activities related to field work in engineering and science and in a range of learning situations, especially language learning. Learning materials should be presented in multimedia formats to capitalize on the capabilities of the mobile device. For example, video segments can be presented to deliver rich information segments and audio will allow learners to listen to information anywhere and at any time. As more organizations start to use augmented reality and virtual reality, there will be increasing use of mobile devices such as smart phones, 3D glasses, ubiquitous technologies, etc., which shall have multimedia capabilities.

— Pedagogy: Identification of the pedagogical basis for content can help in the delivery of content to meet learning needs of mobile learners. Use of AI techniques, such as that used in the learning cell framework, will help to customize the learning resources for individual learners. For example, pedagogical considerations can involve structuring of learning content to support social constructivist approaches to learning activities. Alternatively, a behaviourist approach can be used to reinforce the development of fundamental knowledge required for application in an activity. Cognitive approaches can be used to develop learner metacognitive skills.

6.5.4 Device capability dimension to maximize the use of the mobile device

The device capability dimension suggests that the adaptation framework should have the capability for identifying and utilizing some or all of the device capabilities.

The minimum recommended information for a device is as follows.

— Type of device being used: The system shall know the type of mobile device the learner is using so that the information can be formatted to the specific device. This recommended information can be linked to other optional elements listed below to provide an optimal experience for the mobile learner.

Suggested optional information elements for a device are as follows.

— Presentation capability: Designers of materials for mobile devices shall use presentation strategies to enable learners to mentally process the materials efficiently. Of primary concern are questions regarding presentation capability to support content being used. Does the device have the presentation capability to support the display of the size and portability of the content being used? Due to the small input and output components of mobile technology, there are design implications for learning materials for mobile learning. For example, rather than scrolling through information on the screen, users of mobile technology shall be able to go directly to the information and move back and forth with ease. To compensate for the small screen size on mobile technology, learning strategies shall use rich medium to convey the message to the learner. For example, rather than present information in textual format, graphics and pictures can be used to convey the message using the least amount of text. To present procedures and real-life situations, video clips can be

used to present real-life simulations to the learner. Pictures and graphics can be used as overviews to give learners the big picture before they go into the details.

For active learners, information can be presented on the mobile device and then the opportunity given for the learner to apply the information. For creative learners, there shall be opportunities to apply the information in real life applications so that they go beyond what was presented. When designing learning materials for access by mobile devices, educators and trainers need to move away from presenting information in a linear, textual format to a more graphical and hypertext format. The information can be presented in the form of a concept map or network diagram. A concept map or a network diagram can be used to show the important concepts in the information and the relationship between the concepts rather than present information in a textual format. In addition to these design strategies, trainers need to design learning material for just-in-time access and immediate application, since it is possible that learners on the job need to acquire knowledge and skills for immediate application. Also, responsive design principles should maximize the use of different types of mobile technologies for learning since different learners can have different types of devices. For example, MOOCs usually have large enrolment with learners from different parts of the world who have different types of devices. They shall be able to use their existing devices while taking the MOOCs. In some cases, learners have more than one device which they will use while completing the MOOC.

— Interface: The interface for mobile devices shall adapt to the learner rather than requiring the learner to adapt to the interface through adaptive design. The interface can be graphical and should present limited information on the screen to prevent information overload. The mobile learning system shall have some built-in intelligence to anticipate what the learner will do next and then provide the appropriate information and interactive activities. A good interface for learner access should reduce information overload by presenting fewer concepts on one screen or organizing the information in the form of concept maps to give the overall structure of the information and then presenting the details by linking to other screens. At the same time, the interface shall also use good navigational strategies to allow learners to move back and forth between displays. The interface to the mobile technology shall be appropriate for individual learners and intelligent software systems should be developed to customize the interface for individual learners.

— Privacy: The mobile learning system shall protect the privacy of learners since the system can have the capability of monitoring where the learner is located as the learner moves around and what the learner is doing without the learner being aware of being monitored[12]. The transfer and storage of information can need to support adaptive interactions intended to enhance learning. At the same time, the transfer and storage of this information needs to respect the privacy of the learner. The use of security and authentication in order to protect privacy is beyond the scope of this document; however, items that require consideration with respect to privacy have been noted in Tables 1 and 2. Proper security and authentication shall be provided by the learning system to prevent unauthorized access to information.

— Operational capability: Learners should be able to access learning materials in context in both formal and informal learning settings. For example, if a learner is using a piece of equipment in a remote geographic location and would like to learn more about the equipment, the learner should be able to access information relating to the equipment. The operational capabilities of the mobile device can impact on the experience and outcomes experienced by the learner. Additionally, it is helpful if the operational capability minimizes typing required by the learner because the keyboard on mobile devices is very small. To make input more user-friendly, pointing or voice input capability can be used to minimize typing.

6.5.5 Connectivity dimension to perform at different connection speeds

The connectivity dimension requires that the system shall have the capability of deciding which mode of operation is best suited for the connectivity condition.

The minimum recommended connectivity information to support optimal learner experience is as follows.

— Connection speed: The speed of the connectivity so that information can be downloaded to the learner in an efficient manner. For example, if the learner has a slow connection speed, the learner should not be required to access large amounts of data.

Optional information elements to support optimal learner experience are as follows.

— Electrical capabilities: The electrical capabilities of the geographical location of the learner shall be known so that the appropriate device can be given to the learner to access the information or the learner shall be informed of the electrical capabilities of the location so that they can plan how to use their mobile devices.

— Real-time or online mode: The mobile learner may access content or participate in learning activities either in real-time (synchronous) or in an online mode that is asynchronous, or the learner may download an app on the mobile device and learn offline. The learner only needs to go online to download the app.

— Integration with other technologies: Mobile technologies need to interoperate with other technologies to enable the seamless provision of learning resources to the learner.

6.5.6 Coordination

The coordination dimension requires that the system shall have the capability of allowing the learner to interact and obtain feedback from others involved in the learning process and efficiently isolate the content, presentation, navigation and interaction components and subsequently integrate them seamlessly and effectively.

The optional coordination elements to support mobile learners are as follows.

— Coordination of other access (e.g. tutor, peer, instructor): Provide the learner access to tutors, peers or instructors for help while learning if needed. In ubiquitous learning, there should be ways for identifying the specific learning collaborators, appropriate learning content and required learning services in the right place at the right time[18][19]. AI techniques can be used to match the learner to the appropriate tutor and learning resources.

— Learning group: Identification of the group to which the learner belongs so that communities of learners can be formed.

— Presentation integration: Mobile learning materials shall be integrated for delivery on the specific mobile device being used by the learner. The system should check the type of device and then format the learning materials for learners' specific devices.

— Interactivity: The content and learner activities need to be coordinated to provide the appropriate level of interactivity for the individual learner and others involved in the learning process.

— Navigation: Seamless navigation for the individual learner requires coordination of content and learning activities in a manner that respects the different levels of learner background experience and expertise. Alternative navigation pathways sometimes need to be provided to the same content and learning activities, depending on the individual learner elements (learner display preferences, etc.).

7 Learner interaction with mobile learning system

7.1 General

Where ITLET systems are designed to support nomadic learners who are in motion from one place to another, it is important to consider the range of typical or likely requirements to enable learning. Learners need to be supported by technologies so that they can improve their learning in an efficient

and effective manner. The underlying role of technologies is to support learners by enhancing communication, convenience and connection. There are several components that are essential to supporting learners' requirements within nomadicity contexts, as given in Figure 2.

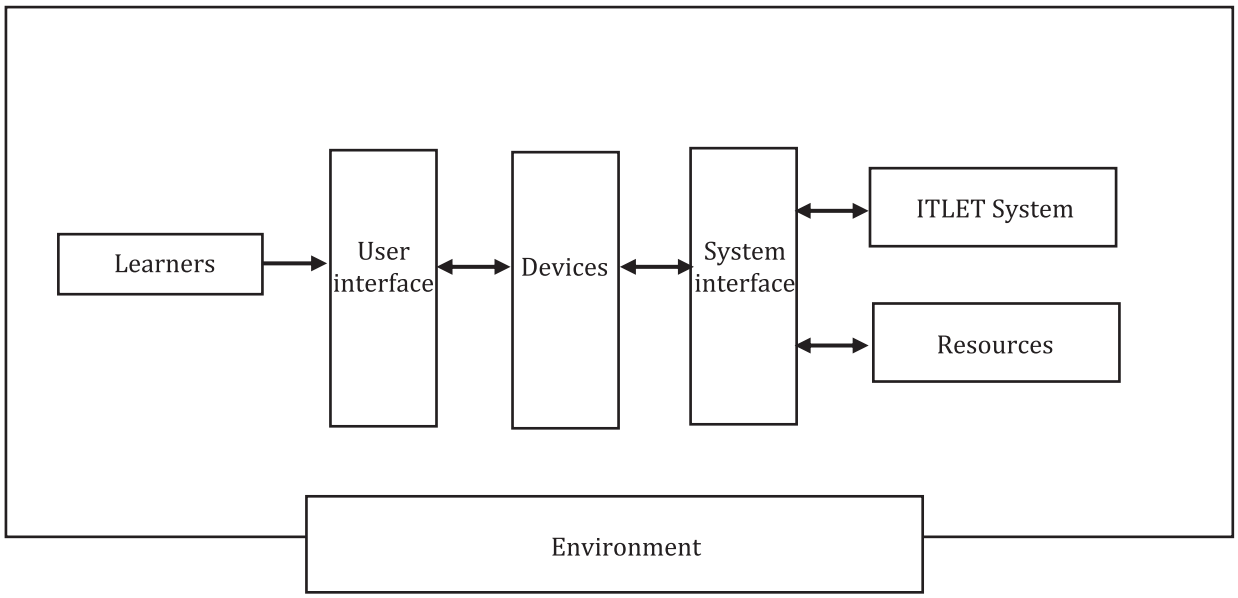

Figure 2 — Learner interaction with the mobile learning system

7.2 Learners

As noted in Clause 6, specific contextual information can allow for seamless and straightforward delivery of learning, education and training information. For learners who are on the move, this may include information such as current location, estimated geographic coordinates based on mode of transport, and specific preferences for display.

7.3 Resources

Resources include items or information about items that are required to support learners who are participating in learning, education or training activities, and can be divided into the following:

— Content refers to the actual digital items themselves such as text, image, audio, video and others.

— Content can also involve information produced to improve findability of digital items for educational purposes or to support education in nomadicity environments (metadata for learning resources, pedagogical information, social tagging, etc.). Resources need to be provided in a manner that is consistent with learner requirements given the learners' contexts and surrounding environments including elements such as current network condition, interface characteristics, device functionality and state, etc.

In addition, resources that are time sensitive, such as tests at specific times, are not always suitable if the learner is in another time zone. The same applies to resources required for learning, education and training activities that are based on collaborative learning efforts or require real time communication between learner and another role-player in the learning process. Resources that require certain bandwidth or specific data speed are not always suitable in specific contexts. In some cases, there can be restrictions on the timeslots available by the nomadic learner. For example, students, professional sportspersons participating in a contest or a show event, or military people serving abroad can have strict schedules. Therefore, the duration of a learning unit does not always exceed the duration of these timeslots. Additionally, it can be helpful if interactions can be resumed at the same point where learners had to discontinue their activity at a previous point in time. Another restriction can be that the resources the learner needs are available only at given times by the supplier in the specific environment

(open or business hours, etc.). Resources that require specific input or output (e.g. for technical subjects or language training) can be more challenging or are not always transferable over different points in time and from different locations. Resource developers and delivery systems for nomadic learners need to consider these implications and specific solutions can be necessary.

7.4 ITLET system

These include information technologies that are specifically designed to support learning, education, training and where learning takes place, e.g. learning management systems (LMS), learning content management systems (LCMS), numerous web applications and services that can be harnessed for learning, education and training purposes.

Participant information data should include the nomadic aspect. Schedules that provide logistical information regarding the participant can vary over time and this information can be very useful. For example, mobile phone connections can require phones that follow a regional standard or the use of another phone number. Roaming is very expensive, so the use of a local network can be advisable for the learner.

Participant information can be even more important when considering collaborative forms of learning are being used more frequently and can require specific information related to nomadicity. Information on the location of a learning partner can also be made public to other learners. In this case, privacy can be a concern that needs to be addressed; however, specific implementation recommendations related to privacy are outside the scope of this document.

NOTE For the growing importance of collaborative learning, Reference [21] provides a blog on developments in e-learning.

The participant can be forced to use devices or user surfaces that he or she has not used before (e.g. Qwerty or Azerty keyboards, signs, foreign language instructions). This can hamper learner interactions when the learner engages in learning, education or training activities.

The ITLET system such as an LMS has to record the technical context, where the participant is working from, and has to deliver the resources in a didactical and technical format, so the learning process is not interfered with.

The inclusion of the student in collaborative forms of learning (e.g. in a virtual classroom) can depend on factors such as the learner's time zone, learner's availability at a given time, etc. The ITLET system, such as an LMS, has to store the resources that were not delivered due to the restrictions of learning within nomadicity, and should offer them automatically, as required by the learner (either at the same point where the learner left off or at a point chosen by the learner) when the context allows.

7.5 Devices

Devices are tools that are used by learners to access resources and ITLET systems. Learners can use devices to access learning services and to manage their learning information and personal information. Devices have to support various functions for learning, education and training in environments that involve nomadicity. This means that they can be used as input or output devices, as well as appropriate storage devices for offline services.

7.6 Interface

As noted in Figure 2, an interface can involve interactions between the individual learner and the device(s) (user interface) and interactions between the device(s) and the ITLET system or resources (system interface). Both the user interface and system interface involve technologies and tools that are used to connect learners to resources and other systems such as LMS. User interface characteristics can include interactions defined by personal preference profiles, optimal use of device screen size, audio and video capability, and other functionalities. System interface characteristics enable interactions between device and resources (e.g. identification and search functionality for the use of resources that are appropriate or required for an activity), and interactions between device and ITLET system

(recording of test responses, delivery of feedback, etc.). Both user and system interface have to support various functions for learning within nomadicity. The interface components should (where possible) incorporate the most current information related to human factors research. In addition, accessibility approaches (as suggested in International Standards such as ISO/IEC 24751) can be integrated within interface components.

To connect the learner to his or her changing environment, specific interfaces are used. The purpose of the interface is to close the gap between the environment, the ITLET system used and the specific device the learner is using or has to use.

a) Administrative interface: This has to provide the necessary data to login within the specific environment and involves:

   1) connectivity;

   2) encryption information;

   3) device identification;

   4) necessary identification systems and data-support systems;

   5) integration into the local ITLET system (e.g. LMS system) (if necessary) – localization data;

   6) content management system (resources) to build learning units.

b) User interface:

   1) easy installation wizard;

   2) software check (to ensure all necessary software is available to perform the learning, education or training activity);

   3) online and offline routines so that it is possible to get access to learning units for situations where internet access is not available;

   4) learner data, such as learner's progress, schedule, tests and other tasks to perform and group integration;

   5) download of bandwidth intensive resources such as films and large images;

   6) providing a comfortable platform to choose learning units out of a "catalogue", etc.

7.7 Environment

This includes all information on the location, such as time zone, geographical information (if needed), applicable norms and standards for telecommunication. Information is required regarding technical implementation (firewalls, usable or allowed ports, bandwidth and any restrictions regarding file size and extensions, etc.). This also includes the technical environment such as wireless environment that is required to support nomadicity. Without adequate infrastructure support, all learning, education and training activities that the nomadic learner tries to engage in will be impossible. This means that the environment is a key consideration for learning within nomadicity. Some characteristics that need to be considered for environment include infrastructure support and availability in current and projected locations. Other considerations include current noise levels and other environmental factors that can impact on delivery modes required by the learner.

Existing and emerging information technologies can be used to make the learning environment ubiquitous and to support learners within nomadic contexts. Currently, implementations of these environments are being studied or researched in different countries. For example:

— information can be used to identify or track items (landmarks, art, products, etc.), and the information can be stored and retrieved remotely [radio frequency identification (RFID), navigation app for mobile, 3D glasses, etc.];

— environments can be developed to support the use of high-speed internet from anywhere at any time to offer various functionalities, such as telephone broadcasting, internet, educational resources, games and email, when needed by the learner;

EXAMPLE 1 Wireless broadband (WiBro), which is being developed by the South Korean telecom industry, offers telephone broadcasting, internet by TPS (triple play service).

— buildings (residential, commercial, industrial, etc.) can be provided with ubiquitous networking systems that are designed and developed to enable data transfer between devices as needed to increase efficiency, effectiveness and convenience;

— specific regions (such as cities and regional corridors) can have enhanced services that provide appropriate data and information automatically dependent on user-determined preferences);

— a suite of specific technologies and devices can be provided in order to perform specific functions;

EXAMPLE 2 An “e-bag” used by children from nomadic families is equipped with devices that detect the learning environment via wireless technology to automatically connect the students to the needed resources such as access points, printers and libraries.

— mobile context aware hyper media systems can provide enhanced and augmented experiences to support learning, education and training (information can be supplied on any enabled device to support learner interactions with museum displays, etc.).

8 Additional considerations

At the same time, the learning materials developed for delivery on mobile devices should be suitable for different cultures and contexts. For example, standards developed for mobile devices should apply to different cultures since wireless mobile technology allows anyone from anywhere to access learning materials. Also, there should be consideration of mobile learning that applies in different contexts. For example, it can be helpful to have guidelines or standards regarding the design of information for access while working off-site in the field.

As learners move from one place to the next, they should be able to use computing devices and communication technology to access information and learning materials from anywhere and at any time. The use of mobile computing devices to access learning materials shall be transparent to the learner and at the same time support their specific learning needs. For the nomadic learner, the infrastructure shall be in place to make sure there is access to learning materials and support as learners move from one geographic location to the next.

Bibliography

[1] Ally M., Prieto-Blázquez J. What is the future of mobile learning in education? *RUSC. Universities and Knowledge Society Journal*. 2014, 11(1) pp.142–151. DOI:10.7238/rusc.v11i1.2033

[2] Chee, K.N., Yahaya, N., Ibrahim, N.H., Noor Hassan, M. Review of Mobile Learning Trends 2010–2015: A Meta-Analysis. *Educational Technology & Society*. 2017, 20(2), pp. 113–126

[3] Crompton, H., Burke, D., Gregory, K.H. The use of mobile learning in PK-12 education: A systematic review. *Comput. Educ*. 2017, 110, pp. 51–63

[4] Fu, Q., Hwang, G. Trends in mobile technology-supported collaborative learning: A systematic review of journal publications from 2007 to 2016. *Computers & Education*. 2018, 119, pp. 129–143

[5] Talan, T. The effect of mobile learning on learning performance: A meta-analysis study. *Educational Sciences: Theory and Practice*. 2020, 20(1), pp. 79–103. Available from: https://dx.doi.org/10.12738/jestp.2020.1.006

[6] Sung, Y., Chang, K., Liu, T. The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Comput. Educ*. 2016, 94, pp. 252–275. Available from:https://dx.doi.org/10.1016/j.compedu.2015.11.008

[7] International Telecommunication Union (ITU). December 8, 2018. Press release: ITU releases 2018 global and regional ICT estimates. Available from [27 December 2018]: https://www.itu.int/en/mediacentre/Pages/2018-PR40.aspx

[8] Sobral, S.R. Mobile Learning in Higher Education: A Bibliometric Review. *International Journal of Interactive Mobile Technologies*. 2020, 14(11) pp. 153–170. Available from: https://doi.org/10.3991/ijim.v14i11.13973

[9] Ally, M., Tsinakos, A. *Increasing access through mobile learning*. Commonwealth of Learning, Vancouver, Canada, 2014

[10] Lai, C.L. Trends of mobile learning: A review of the top 100 highly cited papers. *British Journal of Educational Technology*. 2020, 51(3), pp. 721–742. doi:10.1111/bjet.12884

[11] Hsu Y., Ching Y. A Review of Models and Frameworks for Designing Mobile Learning Experiences and Environments. *Canadian Journal of Learning & Technology*. 2015, 41(3) pp. 1–21

[12] Ally, M., Wark, N. Online Student Use of Mobile Devices for Learning. In: Parsons, D., Power, R., Palalas, A., Hambrock, H. MacCallum, K. (Eds.) *Proceedings of 17th World Conference on Mobile and Contextual Learning*. Concordia University Chicago, Chicago, IL, USA, 2018, pp. 8–13. Available from: https://www.learntechlib.org/p/184917/

[13] Chen, Z., Chen, W., Jia, J., An, H. The effects of using mobile devices on language learning: a meta-analysis. *Education Tech Research Dev*. 2020, 68, pp.1769–1789. Available from: https://doi.org/10.1007/s11423-020-09801-5

[14] Kim, H., Shin, A., Kye, B. Evaluation of a digital textbook program in terms of implementation fidelity. *KEDI Journal of Educational Policy*. 2018, 15(1), pp. 3–20

[15] Masika, M.M., Omondi, G.B., Natembeya, D.S., Mugane, E.M., Bosire, K.O., Kibwage, I.O. Use of mobile learning technology among final year medical students in Kenya. *Pan Afr Med J*. 2015

[16] Ally, M., Wark, N. Distributed augmented reality training to develop skills at a distance. *World Conference On Online Learning Teaching In A Digital Age – Re-Thinking Teaching & Learning*, 16-19 October 2017

[17] Malezi Exams. Available from [8 August 2021]: https://exam.malezi.co.ke/

[18] HANBIDGE, A.S., TIN, T., TSANG, H.H. Academic Integrity Matters: Successful Learning with Mobile Technology. In: AUER, M., TSIATSOS, T. (Eds.) *The Challenges of the Digital Transformation in Education. Proceedings of the 21st International Conference on Interactive Collaborative Learning (ICL2018) – Volume 1*. Springer International Publishing, 2020, pp. 966–977

[19] FirstVoices. Available from [8 August 2021]: https://www.firstvoices.com

[20] WARK, N. *Shifting paradigms: A critical pragmatic evaluation of key factors affecting learner-empowered emergent technology integration*. Dissertation, 2018. Available from: https://dt.athabascau.ca/jspui/bitstream/10791/274/4/NorineWarkFinal.pdf

[21] TUCKER, C. *Experiencing elearning* [online]. Available from: https://christytucker.wordpress.com/

ICS 35.240.90

Price based on 18 pages