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A new definition of m-learning has been presented in the first chapter. It was modified from a definition presented by Sharples, Taylor, and Vavoula in 2007. In Chapter 1, Crompton, Muilenburg, and Berge defined m-learning as “learning across multiple contexts, through social and content interactions, using personal electronic devices” (Crompton, 2013, p. 4). This chapter departs from this definition and focuses on mobile applications (apps) and technologies in this context.

Mobile apps have come a long way in the past 2 years, especially in their applications for business, health, information, communication, and education. Most mobile devices are now capable of processing information in the same way as desktop computers. For example, many iPhones, iPads, and other similar smart devices are equipped with many functionalities and unique features that can be used for delivering learning content. However, mobile devices are considered as effective and efficient tools for teaching and learning, as mobile devices are being implemented as fusion devices that include some unique features and functionalities. Khaddage, Lanham, and Zhou (2009) listed some of these functionalities that are being implemented in one single mobile device, and they include the following (see Table 11.1).

Most of these features are already being used by students to help them during the learning process (Khaddage & Knezev, 2011). Currently, the rapid development of mobile apps for mobile devices is taking the educational world by storm.

The mobile-app sphere has grown tremendously in recent years and is showing no signs of stepping. The worldwide mobile-app market is expected to grow from US$6.8 billion in 2010 to US$25 billion by 2015 (Zedensk, 2011). A study by a mobile research

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Table 11.1 Functionalities of Mobile Devices (Khaddage et al., 2009)
specialist group confirmed that the mobile-apps market is moving rapidly, and this is affecting the world globally (Jahns, 2010). This fast penetration is due to open, easy, and direct access to app stores around the world, and it is due to the availability of tools and resources for developers to develop, manage, and maintain apps for any particular purpose. Currently, there are many stores worldwide, and mobile apps are spreading widely; there are apps for business, for health, and for music. However, there are only a few mobile apps in the area of higher education, especially at universities, and there is very little mobile support in the current online-course-delivery systems at most institutions (Selbu & Biju, 2008). With the advent of mobile technologies, such as smartphones, and the penetration of affordable flat-rate-based mobile connection, m-learning will become a major distributor of learning content to students at universities (Tatar, Roschelle, Vahey, & Penueil, 2003). It is a crucial fact that there is an urgent need to develop unique approaches that can form the base of new mobile apps for teaching and learning in higher education. This challenge could be made possible with the deployment of the emerging new, unique, cloud-based computing for teaching and learning via mobile apps. Cloud-based computing could form a foundation for a strong mobile-apps infrastructure; this is because there are few issues that still form a barrier for proper, effective mobile-device integration for education. These factors are listed in Table 11.2, along with the possible solutions to overcome the specific barriers.

Despite these rapid developments in mobile apps and devices, universities are yet to formally acknowledge and integrate apps for teaching and learning. The major issue claimed by universities is that there isn’t yet one standardized mobile device to be used by all students. Therefore, all students have different mobile devices. This fact is an issue for universities to implement interoperable mobile apps, as different devices have different interfaces and use different technologies. Some universities have overcome this barrier by using only one set of devices with the same interfaces, such as the iPhone or the iPad, to

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<td>Cost and charges</td>
<td>(Wi-Fi) hotspot access/(Chrome access); no Internet connection</td>
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<td>Privacy and security</td>
<td>Build access to apps via a secure private cloud</td>
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<td>Battery life</td>
<td>Current devices are equipped with longer battery life (10 hours)</td>
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<td>Screen display</td>
<td>Dynamic and interactive display</td>
</tr>
<tr>
<td>Data/text input</td>
<td>Touch screen for easy and direct interaction</td>
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<td>Connectivity &amp; communication options</td>
<td>Communication apps can connect and collaborate free, such as Viber, Skype, Facebook</td>
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<td>Processing power</td>
<td>Advanced operating systems within smart phones are constantly improving; Android/ISO</td>
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<tr>
<td>Application tools</td>
<td>Building apps on the cloud will create a device-independent platform</td>
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<tr>
<td>Audio</td>
<td>Voice-recognition input/recording</td>
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<tr>
<td>Development and implementation</td>
<td>Use already existing apps</td>
</tr>
<tr>
<td>Storage capacity</td>
<td>Most smartphones already come equipped with 32GB and external storage (memory cards etc.)</td>
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provide access to learning content. A good example of such integration is Abilene Christian University in the United States. It integrated the iPhnone for teaching and learning after a thorough investigation of students' and teachers' behaviors and demand and surveys on mobile technology and devices. The university was finally able to integrate the iPhone to promote m-learning from 2008 (Abilene Christian University, 2008).

As mobile devices and app technologies can provide an efficient delivery mechanism of learning content, universities should implement methods to integrate this technology. In the next section, mobile apps and technologies for teaching and learning are discussed, and cloud-based computing is described as an alternative and effective approach for successful mobile-app integration.

**MOBILE-APP TECHNOLOGIES**

Mobile apps, if integrated properly, can provide an efficient delivery mechanism for learning content. In this section, we investigate app integration, methods, and approaches that can be adapted to meet today's students' needs.

Oblinger (2003, 2004), Oblinger and Oblinger (2005), and McMahon and Posspil (2005) describe today's learners as digitally literate, "always on," always connected and reachable. They want to stay connected and reachable, they also want to experiment and have community-oriented personalities and characteristics. They are collaborative and multitasking learners who like to study in a group-based environment (McMahon & Posspil, 2005).

Khaddage, Lattenmann, and Bray (2011) also stated that the methods of communication among students have changed over the years, and, these days, students stay connected with their peers via social media and Web 2.0 technologies, such as Facebook, Skype, Twitter, YouTube, blogs, wikis, etc. They belong to the new, digital mobile world. Universities and educators, on the other hand, are often still reluctant to use these technologies and, in particular, mobile apps for teaching and learning; they view these technologies as a distraction for students (Khaddage et al. 2011).

**Mobile Apps for Teaching and Learning**

There are many methods and approaches that can be adapted to integrate mobile apps, and this could make learning and teaching an easy task for students, as well as for teachers. Apps can be used for test preparation, study guides, and as new types of instructional material in the classroom environment. We believe that mobile apps can offer the following three "Ss" to the access of learning content in a university environment: "speed, security, simplicity." Figure 11.1 is an illustration of the three Ss:

- **Speed**: Apps are designed to be fast and efficient; they are very quick to load and start up remotely from any mobile device, regardless of how complex the query.
- **Security**: Apps are designed to keep users safe and more secure when using their mobile devices; they can be developed with built-in malware and phishing protection, and the auto-updates feature is an important feature to make sure that the app's functions are up to date with the latest security updates.
- **Simplicity**: Apps can be streamlined, clean and simple, efficient, and easy to use. Users can access and perform a search and navigate action via the same box and the same interface very easily.
There is also an important new feature of most of the Google apps that can be used for teaching and learning, such as Google Doc and Gmail. Since August 2011, Google has offered offline access to its web apps such as Gmail, Google Calender, and Google Docs (Geron, 2011). Google has provided this option to support the use of Google apps for business and education. Therefore, universities can take this challenge now and try to integrate app technologies to provide learning content to students. This feature can eliminate the costs and charges normally acquired by internet service providers (ISPs); this has been a major concern, in particular when accessing apps via a mobile phone using 3G networks. Hence, when the same access is offered free of charge and offline via Google Chrome technology, users will be encouraged to integrate this technology into their daily life and will use it to access learning content. With this offline access, users can interact with the mobile apps and their Gmail and communicate with their student peers or teachers.

Also, both the iOS and Android platforms provide development tools for making the app-development process easier and more coherent. This has helped in the development of a variety of apps that are freely available online for teachers and students to download, use, and adapt. It is also a crucial factor for developers to be knowledgeable about the platform-centric application programming interfaces and development tools provided by the platform being used by the particular institution, so that they can design and build apps according to their special requirements. Currently, Apple and Google are dominating the app market for business as well as for education; already some universities, such as Deakin University, are conducting an investigation into iPad (Apple) integration via apps for teaching and learning (O'Loughlin, 2011).

Research has suggested that the early 21st century is like the early 20th century, in that we are at the beginning of a new educational paradigm, and the engine of growth is communication and information (Daniels, 2009). As mobile technologies and tools
are becoming more affordable, connectivity is becoming more ubiquitous, and ownership of mobile devices is constantly on the rise; hence, mobile apps will make their way into the mainstream of the educational environment. Currently, there are a growing number of m-learning apps that can be used for teaching and learning, and here are a few that we recommend:

- Mental Note (type, draw, add notes to pictures);
- iStudiez Pro (built-in planners for input and schedules, track workload);
- InClass (organize, share notes, save .doc files and Ace classes);
- Audio Note (write notes, set up recording, audio recording with time stamp);
- Kindle (reading, downloading books, etc.);
- PenUltimate (store information in a separate note; students can e-mail it and share it);
- Pages (word-processing program, sync docs. or create new ones);
- Some Google apps for educational use:
  - Gmail & Calendar: communicating and sharing schedules;
  - Talk: synchronous (IM and video) communication;
  - Doc: real-time collaboration for Docs;
  - Group: form teams;
  - Sites: create their own sites.

Cloud Computing for Mobile-App Integration
Currently, with the development of cloud-based computing, developers of mobile apps are able to create cross-platform mobile applications using traditional Web technologies. Cloud-based computing is considered an innovative solution in relation to mobile-apps development. Recently, the development of cloud-based computing and its application and tools have become very popular for teaching and learning and are considered a step forward for educational institutions. Therefore, developing a shared, m-learning environment may now be possible through this advanced, emerging technology (Hamm, 2009).

Cloud-based computing consists of three layers, which form the three building blocks of cloud computing: the infrastructure as a service (IaaS), the platform as a service (PaaS), and the software as a service (SaaS). This gives the user flexibility in selecting the appropriate service of their choice (Creeger, 2009).

Khaddage and Knezek (2011) stated that the combination of the three layers allows users to run and access apps from anywhere and at anytime, and store information and content online. The three layers can be identified as follows:

- The IaaS is the major foundation layer, where everything is built; it is responsible for the cloud-hosting applications, and users can run any app of their choice, or any existing apps can be migrated to the cloud using the cloud hardware.
- The PaaS allows users to develop and implement their own apps using certain tool resources. A good example of this is Google App Engine: It allows users to develop their own app, tailored to their needs.
- The SaaS allows users to access and run existing online apps, such as Google apps. The advantages of these apps are their excellence for global collaborative work. Furthermore, they are free of charge (Khaddage & Knezek, 2011).
Cloud-based computing can enhance the process of developing cloud-based apps that work on multiple devices, such as mobile, desktops, browsers, and apps within the cloud-based environment (Khaddage & Knezek, 2011). Figure 11.2 is an illustration of this process.

The apps are stored in the cloud, and users can have fast, secure, remote or local access from just about any client device or operating system. The plug-and-play feature within the cloud-computing technology is responsible for publishing the apps onto the network or the Web. Tools such as cloud-based e-mail systems, calendars, chats, and forums, to improve messaging, as well as interaction capabilities and shared resources, data, and information, can all be integrated. The students can make multiple copies of the learning content, viewable on a variety of devices that can be synchronized, and, hence, all users within the same field can have access to share and use the information in their account. Cloud-computing applications should be designed for scalability to support large numbers of students and surges in demand. Universities can develop and remotely host custom-built educational applications within the cloud, and this can reduce costs and time spent, thus providing benefits to students as well as to the university. In order to create such apps, it is necessary to develop these applications on the underlying platform in order to cover different mobile devices, such as iPads, Blackberries, iPhones, Windows Mobiles, etc. There are many good examples of cloud-based mobile applications, such as Gmail's mobile provided by Google, Google Documents, etc., and they are all accessible via the mobile-app technology. These technologies may take universities toward a more open and global educational environment, and ensure greater future prospects for today's students, as they strive to reach out to an open-access, global learning environment via mobile apps.

**The Future of Mobile Apps for Teaching and Learning**

In the near future, we may see that Apple follows the Kindle model of cloud-synced books. Kindle and the iBooks app allow students to share their notes and bookmarks. Interoperability between applications and devices is given, and data can be synchronized.
Universities should implement an education strategy that can merge the tools and technologies, apps, and pedagogical factors. Therefore, we may see that educational institutions start to acknowledge and formally recognize informal learning (learning that happens outside a classroom environment), as mobile-app technologies and methods of communication are already enforcing this push into the curriculum, hence giving mobile apps capability to bring together informal and formal learning approaches (Knezek, Kwok-Wing, Khaddage, & Baker, 2011).

A framework to evaluate how this technology can improve learning should be implemented in the near future, as technology keeps evolving rapidly, and changes should occur along the way. It is also believed that iPads/iPhones/iPods and their apps will be real winners in the teaching and learning environment. Although making textbooks digital won’t revolutionize education, it will improve the medium that can offer the three Ss mentioned earlier (speed, security, and simplicity), and, therefore, a change in teaching methods and a focus on social factors are what are needed to change education for the better. Today’s society needs critical thinkers, inventors, creators, and not just ordinary students who acquire one-way, static education, and mobile apps could provide this dynamic, collaborative method of learning.

Mobile cloud computing holds great promise for delivering cloud-based mobile apps by enabling access from anywhere, but there may still be several barriers that need to be addressed to elevate its usefulness and capabilities. For mobile cloud computing to reach its full potential, the following three critical challenges need to be addressed, as stated in a recent article by Betts (2011):

- lowering network latency to meet application and code offload interactivity;
- increasing network bandwidth for faster data transfer between the cloud and devices;
- providing adaptive monitoring of network conditions to optimize network and device costs against the user’s perceived performance of cloud applications.

None of these is easy to accomplish, but service and network providers, in cooperation with educational institutions, are already making important steps to improve the mobile-cloud experience.

In the following section, an analysis of student perceptions of mobile apps for teaching and learning is described to support the integration and the acknowledgment of this unique type of access and delivery of learning content.

**ANALYSIS OF STUDENT PERCEPTIONS OF MOBILE APPS FOR TEACHING AND LEARNING**

From a didactical, methodological, and technical perspective, mobile apps seem to be an efficient means for teaching and learning purposes. Mobile devices such as smartphones provide the technological platforms for access and transfer of information. The open-source idea of the Android operating system pushes the development of educational apps. The majority of mobile devices and smartphones are easy to use and are seen as efficient tools for collaboration and data sharing. Didactical concepts derived from a constructivism perspective show ways to manage dispersed and self-organized work or group-work processes.
The survey was conducted to explore and analyze students' perceptions of mobile apps for teaching and learning. Student perceptions of mobile apps may be influenced by specific individual variables, such as gender and attitude toward technology, environmental variables, such as access to the Internet and supply of applications, as well as social variables and network effect, which may be based on groups' cohesion (Kaasinen, 2005).

**Methodology**
In order to study the attitudes of students toward the effectiveness of m-learning, a questionnaire with 20 items was developed, designed to measure students' attitudes toward, and perceptions of, the effectiveness of mobile apps for teaching and learning. The study was conducted between August 2010 and September 2011. A convenient sample of about 240 students in Japan, 80 in Germany, and 40 in Australia was taken. The students come from different academic fields, have different cultural backgrounds, and come from different universities in Australia, Japan, and Germany.

**Results and Discussion**
Our findings show that 90 percent of the surveyed students in Germany, 95 percent of the Japanese, and 98 percent of the Australian students use smartphones (iPhone, Blackberry, Samsung Galaxy/Wave, etc.). The analysis indicates that, although computer use is still dominant, a large number of university students use their mobile phones to access content, communicate, and share information. For example, 41.2 percent of the Japanese students reported connecting to the Facebook app via smartphones. Only 15 percent of the German students use Skype or Viber on their smartphones. All smartphone users use mobile apps, but only 20 percent are willing to pay for them.

About 70 percent of all surveyed German students perceive smartphones and mobile apps as useful for distance learning. This ratio was even higher among Australian students (85 percent). The following fields—where mobile phones can contribute to learning—were mentioned: collaboration and communication among students (perceived as useful by 50 percent of the students); communication with the teacher (perceived as useful by 30 percent of the students); quizzes (perceived as useful by 21 percent of the students); and uploading and downloading of content (perceived as useful by 30 percent of the students). Gender-specific differences are not significant.

The most commonly used apps on a mobile device are language programs (such as the Chinese App or Spanish for Dummies) and apps for quizzes and tests (e.g., SAT test). The surveyed students complained that they do use mobile apps in an informal way and outside their learning context and their university, as this type of learning is still unrecognized and not formally acknowledged, and, thus, teachers and administrators are yet to formally integrate and implement these apps to help their students learn. Hence, it is not surprising that the adoption rate of this technology for teaching and learning in higher education is still low.

For now, the general sense gained from this preliminary analysis is that, in Japan, as well as in Australia and in Germany, the convenience of being able to connect to the Internet via apps, using mobile devices, is very appealing to students, but not so much to teachers yet. As mobile-computing technologies are currently being led by hi-tech mobile devices such as the iPad, iPhone, Samsung Galaxy/Wave, and Blackberry, and operating systems such as Android and iOS, and an increasing number of apps, the
movement toward the use of mobile devices in education is on the rise. Not only is this trend likely in educational settings, but also for different organizations (Lahns, 2010). Apps are being developed on a daily basis and are ready to be used, and this rapid development can simplify the process of apps integration for teaching and learning for nontechnical users from all different educational backgrounds, as they would only be required to integrate a particular app and use it, without worrying about the technological aspect behind its development and implementation.

CONCLUSION

Mobile apps will soon reshape the future of the current learning settings at universities. Smart mobile devices such as smartphones, iPads, tablets, and e-readers are now surpassing laptops and desktop computers. The time has come for universities to integrate this technology into the curriculum and use it effectively. Mobile apps, along with cloud-based computing for teaching and learning, will soon become the future of higher education. Decision-makers, developers, teachers, administrators, and researchers will soon see that these technologies and applications will increase productivity among students, reduce paperwork, and grant immediate access to content. This can be achieved in a unique way that other devices simply do not offer.

REFERENCES


