Educ Inf Technol (2017) 22:3081–3119
DOI 10.1007/s10639-017-9576-3

Blurring time and place in higher education with bring your own device applications: a literature review

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Received: 2 November 2016 / Accepted: 12 January 2017 / Published online: 24 January 2017

Abstract The use of mobile devices is increasing rapidly in society, and student device ownership is becoming more or less ubiquitous in many parts of the world. This might be an under-utilised resource that could benefit the educational practices of institutions of higher education. This review examines 91 journal articles from 28 countries published in the years of 2009–2015 with regards to the applications of Bring Your Own Device (BYOD) in higher education to take inventory of how it is applied where blurring of boundaries of time and place can be observed, and to observe problems or obstacles regarding these applications. Research interests do not seem to shift, as much as they are becoming more diverse. The five applications that were identified in 2009 were in discussion during all of the examined years, whereas the total number of applications in discussion increased to 12 in 2015. A methodological concern with regard to trend analysis is that more than half of the articles lack a stated year of data collection. As this can differ greatly from the year of publication, any trend analysis will be burdened with uncertainty. That said, a pattern that emerges is a shift away from distribution of content towards social networking applications. Much less focus has been placed on obstacles and problems in later years, but some areas that have been addressed are usability problems due to small screens and keyboards, with costs of devices and data plans making ownership unfeasible for certain activity types or groups of students.

Keywords Bring your own device · BYOD · Higher education · Mobile learning · Place · Review · Time

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1 Introduction

Regardless of how we feel about it, the use of personal and portable devices is increasing rapidly in society. This in itself is not an argument for its adoption for learning in higher education, but strong indications exist that educational practice can benefit from activities blurring the boundaries of time and place (e.g. Berge and Muilenburg 2013; Miller and Doering 2014; Shippee and Keengwe 2014; Traxler and Kukulska-Hulme 2016). When speaking of blurring time and place, several convergences are denoted, like those between distance and campus education, formal and informal learning, private and public spaces, all leading to learners potentially taking control of their learning and students thinking together with less effort.

This review seeks to take inventory of technologies that have been studied and used in higher education settings with the support of Bring Your Own Device (BYOD) applications.

The use of the Internet at large has moved from interaction with content towards communication between people, and the ability to support and maintain communication beyond the classroom through technology is transforming educational experience (Garrison 2016) This is a trend that is further strengthened by the ubiquitous access to mobile technology for educational purposes enabled by BYOD practices. The term BYOD was originally coined in 2009 (Johnson et al. 2015) and refers to "the practice of people bringing their own laptops, tablets, smartphones, or other mobile devices with them to learning or work environments" (Johnson et al. 2016, p. 36). The key aspect of it here is that of ownership. The device is outside of the education provider's control, thus requiring special considerations for the design and delivery of learning materials, and for the type of interactions that can be required of students. A strong argument in favour of a BYOD philosophy is that an institution that decides to produce materials that are dependent on a specific brand of device will require students without this type of device to either purchase the specified device, or opt out. This type of requirement placed on the student is simply not fiscally realistic for most public institutions (Caudill 2007; Koole et al. 2010).

Higher education is often discussed in terms of campus-based or distance education, or maybe as a middle ground termed blended learning, where components of distance education are brought into campus education. Still, two distinct locations are traditionally assumed: the campus classroom and the student's home. This notion is being challenged by the mobility and accessibility of modern mobile devices, which makes opportunistic learning (Hedin 2014) feasible. Opportunistic learning is the utilisation of short, otherwise unproductive snippets of time, like when commuting, mowing the lawn, or waiting in line. This brings the potential of blurring the traditional boundaries of time and place in education. A leap in usability could be observed when the modern touchscreen smartphone was introduced in 2007 (Grønli et al. 2014), and continuous improvements in screen sizes and performance since then have been beneficial for user experiences (Pegrum 2014), further improving the chance of blurring time and place.

Consciously or not, the concept of BYOD imbues many studies. Applications of BYOD are closely related to mobile devices, and thus to mobile learning. The latter is a term that is concerned with *aspects* of learning, more than pertaining to an entirely new *type* of learning. Many early definitions were created in terms of its hardware and technologies, e.g. Keegan (2005): "mobile learning should be restricted to learning on

devices which a lady can carry in her handbag or a gentleman can carry in his pocket" (p. 5). They are, however, "constraining, techno-centric and tied to current technological instantiations" (Traxler 2007, p. 4). Later definitions tend to emphasize communicative aspects, such as that by Pachler et al. (2010), which frames mobile learning as "the process of coming to know through [communication] across multiple contexts among people and personal interactive technologies" (pp. 6–7). For the purpose of this review, however, the only requirement is that the articles use the term "mobile learning" as a key concept.

A commonly promoted feature of mobile learning and BYOD that promotes blurring of boundaries is ubiquitous access and learning—the anytime, anyplace *access to content*. While easy information transmission has its advantages, a stronger case could be made for other models (Khaddage et al. 2015; Winters 2006), such as social connectedness with peers and teachers, as well as the added level of control and the possibility for self-regulated learning offered to the individual learner (Chayko 2008; Dron and Anderson 2014). The anytime, anyplace access is thus more about the learners being in control of the boundaries of time and place.

The above paragraphs are all examples of the blurring of historically rigid boundaries, and demonstrate why it is of importance in higher education settings. Thus, in summary, both general Internet use and definitions of mobile learning is moving away from a focus on content towards a focus on communication. Internet access has also become practically ubiquitous due to the rapid adoption of personal and privately owned mobile devices, making BYOD initiatives feasible on a larger scale. The improved usability of modern touchscreen devices compared to older feature phones (Pegrum 2014) might also have contributed to a shift in research focus, from the physical devices towards activities and possible uses these devices can support. These shifts in society at large raise the issue of whether the same trends can be discerned in the current research. Thus, this review sets out to explore the following research questions: How is BYOD applied in higher educational settings where blurring of boundaries of time and place can be observed? What problems or obstacles regarding these applications are observed?

This paper is structured as follows. First, some definitions of the technologies discussed are presented. In section 2 the research procedure and methodology is explained. Results at a general level are reported in section 3, examples of applications in section 4, followed by obstacles or problems in section 5. Finally, conclusions are drawn in section 6.

1.1 Definitions of technologies discussed

Some of the terms for technologies and applications that are discussed in this paper are sometimes used inconsistently; therefore a few quick definitions can be of value. A *podcast* (the word is a portmanteau of "iPod" and "broadcast") is an episodic series of digital audio files that a user can download automatically via web syndication to a local computer or portable media player, and unlike a radio broadcast it can be accessed anytime and anyplace, at the user's discretion. In this paper podcast strictly refers to audio recordings, and *Vodcast* (a portmanteau of "video" and "podcast") is used for the video equivalent. *Video streaming* is similar to vodcasts, but lacks subscription features and is typically referring to standalone recordings, and is often distributed via streaming

services like YouTube. *Social networking* refers to "websites which support networking activities amongst friends, families and colleagues in a branded environment through communication, file sharing and information exchange" (MacDonald and Creanor 2010, p. 117). A *blog*, short for web log, is a web site allowing easy web publication of discrete, often informal diary-style entries (called "posts") that readers typically can comment on. A *microblog* is a cut-down version of a blog with a limited number of characters per post (typically 140–200). Posts can be displayed publicly on a website and/or distributed to private or public groups of subscribers. A *wiki* is a website that allows collaborative modification of its content and structure directly from the web browser, typically using a simplified mark-up language ('Wiki" 2016). A *quick-response code* (QR code) is a type of matrix bar code that can be scanned with the camera of a mobile device that is equipped with a bar-code reader, e.g. a smartphone. It is typically used to store an Internet address for easy access.

2 Procedure

Although BYOD concepts are discussed in several studies, the term BYOD is seldom used to label them. This poses a challenge for any reviewer wishing to find as many papers as possible on the subject. As applications of BYOD are intimately connected with mobile devices and, hence, mobile learning (Johnson et al. 2016), the latter term has been used to maximize relevant returns from database searches. In this article, the term learning is used in its general, everyday meaning. However, in the presentation of results, terms for learning are being used as per the respective authors, leading to some sections signalling socio-cultural theories, whereas other segments signal cognitivist or constructivist theories for learning. This is intentional and is meant to indicate possible links between different applications of BYOD and different learning theories. A comprehensive search was conducted of the eight major online databases that Wu et al. (2012) used (ACM Digital Library, ERIC, Informaworld/Taylor & Francis Online, JSTOR, ProQuest, SAGE, Science Direct Online, and Wiley Online). The search was performed with the keywords "mobile learning" and "higher education". Only journal articles published from 2009 through 2015 with the full texts available were retained. A thorough examination of the resulting list of journals revealed some omissions, and the following journals not covered by the databases were individually searched: *American Journal of Distance Education, International Journal of Mobile and Blended Learning, International Journal of Mobile Learning and Organisation, Journal of Distance Education,*[1] and *Open Learning*. By examining abstracts, and by skimming the full texts in ambiguous cases, of the 380 articles matching the above criteria, 91 articles continued to meet the criteria of being concerned with higher education, BYOD, and the boundaries of time and place.

Coding of the full-text articles was conducted using a general inductive approach (Thomas 2006). To aid in this process, the qualitative data analysis software package Atlas. Ti was used for document and code management and analysis (*Atlas.Ti* 2015). The primary coding of the research themes was guided by the author-identified

[1] This journal changed its name to *International Journal of E-Learning & Distance Education* in January 2015

keywords from the articles, as well as by the analysis of the major implications for theory and practice reported in the conclusion sections, as demonstrated by Wickham et al. (2012).

A separate round of coding was performed with an attempt to determine the years of data collection. The difference between the year of publication and the year(s) of data collection was found to vary between zero and six years ($n = 48$, $\bar{x} = 2.1$, $s = 1.2$) for articles that did declare the year of data collection. This variation demonstrates the importance of using the year of data collection for any correlational analysis between technological generations/platforms and research themes to be valid.

3 Results

The 91 articles retained for analysis are distributed between years of publication according to Fig. 1. Previous reviews have observed a trend indicating an increase in the number of publications over time (Hwang and Tsai 2011). There appears to be an increasing number of publications year over year. This is supported by a regression analysis, showing a regression coefficient of 2.54 and an adjusted R^2 of 0.27 but the uneven distribution urges a cautionary interpretation of these values.

Out of the 91 articles, 86 are empirically oriented studies, three have a theoretic, and two have a method developing focus.

Of all of the articles, 48 explicitly stated the years of data collection. This leaves 43 articles (47%) where years of data collection could not be determined (see Table 1). Data collected during 2007 or earlier can by necessity not be affected by smartphone use, as touchscreen smartphones did not gain market impact until 2008 (first iPhone released mid-year 2007, first Android phone fall 2008). When comparing data collection with the year of publication, 2012 was the first year without articles collecting data in the pre-smartphone era.

The geographical distribution of the articles, based on the first author's affiliation (see Table 2), is heavily skewed towards English-speaking countries with the most publications coming from the United States of America (USA) (15 articles), followed

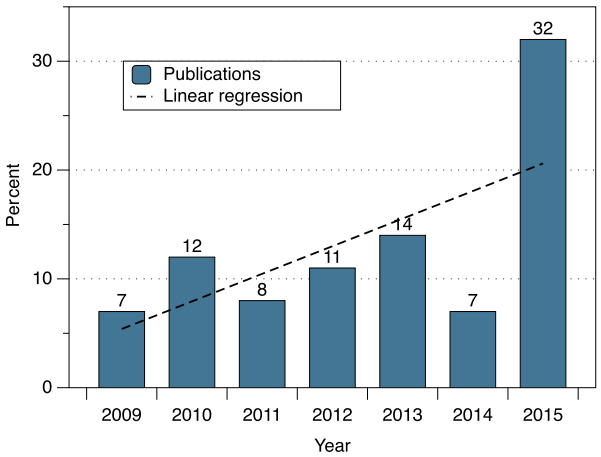

Fig. 1 Publications per reviewed year

Table 1 Articles per era of data collection

Period of data collection	Frequency
Pre-smartphone era (2007 and earlier)	8
Undisclosed	43
Smartphone era (2008 and later)	40
Total	91

by the United Kingdom (UK) (12), Australia (12), South Africa and Taiwan (both 7). Europe accounts for 28 publications, Asia 25, North America 18, Oceania 13 and Africa 7. Worth noting is that all African publications have a South African affiliation, and that South America lacks affiliated first authors altogether.

A condensed summary of all articles in this review can be found in the appendix Table 5. The summary includes (a) author names, (b) article title, (c) publication year, (d) stated year(s) of data collection, (e) country affiliation of the article's first author, (f) types of respondents and (g) stated purpose of the articles.

4 Examples of how BYOD is applied

Some research suggests that the use of mobile devices can challenge traditional interpretations of place, for instance what constitutes a public and a private place. Bradley and Holley (2011) finds that "mobile devices are reconfiguring the relationships between public and private spaces" (p. 50) as they give students greater flexibility in choosing places for learning. An illustration of this blurring of place is the observation by Ilic (2015) where mobile devices allowed students to create a private space even in public places, such as on a crowded train, and that the "role of the smartphone as an essential communication tool and its ability to switch effortlessly between the private websites and the public homework site places the device as a bridge between public and private life" (Ilic 2015, p. 29). The dominating application of BYOD is the use of various social media and communication technologies. In Table 3 the number of

Table 2 Articles per first author country affiliation

Country	Articles per country (total)
USA	15
UK	12
Australia	12
South Africa	7
Taiwan	7
Germany	4
Canada, Malaysia	3 (6)
Iran, Israel, Jordan, Oman, Serbia, Spain, Switzerland, United Arab Emirates	2 (16)
Belgium, Finland, Greece, Hong Kong, Ireland, Japan, Netherlands, New Zealand, Saudi Arabia, Singapore, South Korea, Turkey	1 (12)
Total	91

Table 3 Articles mentioning application per year of publication

	Year							
Application	2009	2010	2011	2012	2013	2014	2015	Total
LMS	2	3	4	5	9	4	14	41
SMS	4	7	3	2	7	3	8	34
Podcasting	4	4	3	5	7	2	8	33
Social Networking		2	3	4	7	2	14	32
Instant Messaging	3	4	3	1	7	3	9	30
Blogging	1	2	2	3	5	4	9	26
Facebook		2	3	3	6	2	8	24
Microblogging		1	2	2	4	2	8	19
Wiki			1	1	1	1	9	13
QR					1	1	4	6
3D							4	4
Augmented Reality					1		2	3

articles mentioning various popular applications of BYOD is listed in order of occurrences. Note that the presence of a topic in an article does not mean it is the focus of the article's empirical examinations.

The occurrence of sentences in an article mentioning the subject in question can vary from 1 to nearly 200. It is therefore obvious that the above method does not reflect the extent to which a certain subject was discussed. To better estimate the amount of interest in a certain application, the number of sentences mentioning it has been counted. In Fig. 2 the percentage of sentences containing these subjects per year is displayed. This aids in painting a picture of how interest in different areas changes over time. As the number of publications per year varies greatly, frequencies are less suitable for comparison.

Some observations can be made from this. The number of different applications discussed increases year over year, starting with five in 2009 and increasing to twelve in 2015 (Fig. 2). The most common application in these articles is podcasting, drawing a fairly even amount of interest over time. Also, interest in the early applications has not decreased substantially as other applications appear; new applications are just added to the palette. One possible exception is text messaging. There is a tendency that interest is shifting away from short message service (SMS) towards instant messaging (IM). SMS and IM applications are similar in function, but the latter has higher requirements for Internet access and access to app-capable devices, possibly reflecting improving device standards among students. Social networking applications are generally on the rise, such as Facebook, microblogging and instant messaging. Two applications entered in 2015, 3-D and augmented reality (AR). As both require high performing graphics this indicates that some critical performance threshold for mobile devices have been reached.

A similar analysis as above was performed regarding perspectives on learning. The occurrence of sentences mentioning constructivism and socio-cultural perspectives was counted and the results are reported (see Table 4) for two periods, 2009–2011 that contains articles collecting data in the pre-smartphone era (Table 1) and 2012–2015 that does not contain articles stating data collection in that era.

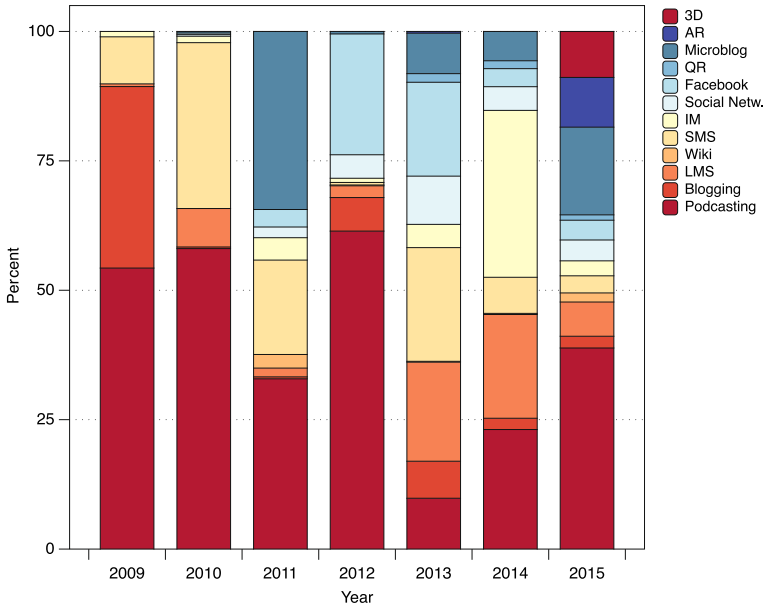

Fig. 2 Sentences mentioning specific applications, in per cent of occurring sentences per year

There is no mention of socio-cultural perspectives in the first time period, only in the second. The numbers above indicate that interest in constructivist and socio-cultural perspectives are increasing over time.

4.1 Podcasting

Podcasting is the most thoroughly studied application of BYOD, with 33 articles mentioning the term and 24 articles having it as the primary focus and examining its use in a wide selection of academic subjects. Interest in this area was relatively constant during the period of study. Ng'ambi and Lombe (2012) proposed a classification scheme for podcast types, where the four podcast types are: a) replicating lectures, b) supplementing lectures, c) replacing lectures, and d) student produced podcasts. The time- and place-shifting of lectures is the dominating example in the reviewed articles, e.g. podcasts of type "a". A few studies deal with podcasts of type "b", and one study is of type "d", but none of the examined empirical studies examined is of type "c". The first category "a" can be further subdivided into direct recordings of lectures, and summaries of lectures recorded at separate occasions. The first subtype has the

Table 4 Number of articles and number of sentences containing constructivist or socio-cultural perspectives for pre-smartphone era articles and smartphone era articles respectively

Publ. Years (n)	Articles	Sentences	Per cent of Articles
2009–2011 (27)	4	7	15%
2012–2015 (65)	26	114	40%
Total (92)	30	121	33%

advantage that it takes almost no extra time for the teacher to produce, but the pace of the recording is often poorly suited for listening as the teacher naturally focuses on the live audience, and sound quality can be lacking. The second type has the advantage of being better adapted to the distribution form, usually being better paced and of higher audio quality. A disadvantage is that it consumes a lot more teacher time in terms of preparation, actual recording time and post-recording editing. An interesting variety of type "b" is primer podcasts, approximately five-minute recordings that each consist of an introduction to theories and summary definitions of core concepts from the upcoming lecture, ended with epistemic questions meant to stimulate deeper learning. Popova, Kirschner and Joiner's study (Popova et al. 2014) found positive effects on student engagement with this intervention, although no change in learning outcomes could be observed. Pegrum et al. (2015) examined student-produced podcasts (type "d") and found positive learning outcomes for some of the tasks. They concluded that, as there were no negative effects from student creation of podcasts, instructors should be encouraged to consider adopting creative approaches. Several reasons have been given for why podcasts would augment the teaching and learning practice. One is the supposition that podcasts can be used to take advantage of otherwise unproductive snippets of time, so-called opportunistic learning (Hedin 2014). With podcasts and portable technology it could be possible to access course material during commuting, while gardening, when training etc.:

> podcasting is commonly seen as a way of supporting m-learning since it enables learners to access course material on portable devices in any location. This opens up possibilities of accessing the material at opportune times such as during commuting. (McGarr 2009, p. 318)

The reasons mentioned for time- and place-shifting lectures through podcasts are potentially better retention through the possibility of repetition, and handing more control of the learning process over to students. The continuing interest in researching podcasting might be somewhat surprising, since there exists a perception in the research community that this is a technology that is becoming out-dated (Sundgren and Jaldemark 2016).

4.2 Social networking

The second most researched application of BYOD is social networking, with Facebook being the most common platform used. The publication dates for articles concerning social networking are distinctly skewed towards later years. A typical example of a studied area is a social networking site (usually Facebook) used as a platform for communication between faculty and students as well as between students only. The latter includes the exchange of learning material (de Waard et al. 2012) and the facilitation of group work (Bradley and Holley 2011). This in some respects replicates the functionality of a learning management system (LMS). There have also been examples of social networking uses occurring among students that were not initiated or explicitly encouraged by the educational institution. For instance, informal learning clusters "often merged discursive practices like tweeting, Facebooking, and general communications to ensure more enriched social practices" (Rambe 2012, p. 55). In

another example, a group of students started a Facebook group for exchange of work and ideas just before a holiday. Due to volcanic ash's affecting the European airspace, some students were unable to return in time for the completion of a group assignment but could continue to participate in the Facebook group to finish the project: "[w]hat was started as a means of communicating turned into a 'life saver' for these students" (Bradley and Holley 2011, p. 47). A less common example is students accessing an expanded community of external professionals in their subject area, as in Pimmer et al. (2012) case study of medical education where many students participated in Facebook groups dedicated to medical education purposes.

4.3 Text messaging

Text messaging, or SMS communication, is the focus of eleven articles. The distribution of articles over time is fairly uniform, with a possible drop in the last year. Examples of use range from administrative access and support, to formative assessment, collaborative learning tasks, and teacher guidance. Young et al. (2010) used SMS as a means of providing support to health students while in practice placements. They found that students experienced an enhanced sense of support with this system in place, even the students who did not use it:

> "The fact that texting enhances a sense of support even where students do not use it make the facility very attractive. It can be seen a means of enhancing students' experience on placements with very low costs to the University in terms of finance and staff energy" (Young et al. 2010, p. 123).

Opportunistic and bite-sized learning via text messaging was tested in English learning in two different studies. One compared the learning of English idioms through classroom instruction, self-studies, and SMS distribution. Four idioms were sent per day in three-hour intervals. The SMS treatment group was found to have significantly higher learning outcomes (Hayati et al. 2013). A similar study using SMS to teach English vocabulary via the SMS-distribution of English words and definitions every 30 min during office hours also reported positive learning results, although no control group was part of the research design (Cavus and Ibrahim 2009). Morris (2010) combined podcasts with formative feedback via SMS. Each podcast episode contained five multiple-choice questions. Students responded to a question by sending a specific code in a text message, generating an automated response. Students using the podcasts and mobile formative assessments experienced a significant improvement in examination performance.

4.4 Blogging

Blogging has a relatively long history of use in education. With this background it is somewhat surprising that most articles were published in the latter half of the studied period – eight articles compared to one article in the first half – but this might be a result of improved usability on mobile devices for content production. Some blog implementations were motivated by the possibility of

facilitating opportunistic learning. Vuojärvi et al. (2012) implemented learning diaries for students during their apprenticeship period. With mobile access to blogs, students could take advantage of breaks or periods of waiting for customers. Another take on the opportunistic learning is the use of blogs for medical students posting questions and asking for assistance on subjects or situations encountered while treating patients, thus placing emphasis on student-to-student communication (Wilson and Bolliger 2013). A similar argument for blogging is the support for situated learning it could provide. Gikas and Grant reported on the affordance of mobile devices in combination with blogs, making it possible for students "to collect data and interact with content as they immediately came across it in their daily lives" (Gikas and Grant 2013, p. 22). Students perceived blogging as promoting meaningfulness and as linking instructional content and authentic contexts in important ways. Most examples were of student use, but one example of blogs was for faculty use. In this case, the blog was employed for information exchange within a teacher community of practice (Cochrane et al. 2013). This study also found that a blog as a reflective student discussion area benefited students who otherwise were reserved in face-to-face debate and that it helped students to discover beliefs and motivations of others. To conclude, this technology is making its way onto the mobile platform, demonstrating that production of content, and not just consumption of content, can be viable on mobile devices in spite of their small screens and keyboards.

4.5 Microblogging

Microblogging is a service influenced by the ubiquitous access to SMS messaging via mobile phones, as well as the distribution model of Internet Relay Chat (IRC) and its status messages. The dominant platform is Twitter and that is also the only microblogging platform examined in the reviewed articles. Academic applications of Twitter range from use as a channel for administrative announcements in a library context (Cassidy et al. 2014), as a virtual community building tool (Cochrane et al. 2013), for sharing content between students (de Waard et al. 2012; Rambe 2013), to gain access to an extended community and interact directly with subject matter experts (Gikas and Grant 2013), and as a communication platform (Rambe 2012). Tweeting is furthermore, under the right circumstances, assumed to help improve social presence and to stimulate the students' desire to learn (Menkhoff et al. 2015). In conclusion, although microblogging can appear to be a one-way distribution channel for content, it could be implemented to support aspects of the Community of Inquiry model (Garrison 2017; Garrison et al. 1999) to improve both social and teaching presence.

4.6 Instant messaging

Several providers/platforms exist for instant messaging services. Allagui (2014) examined whether using the WhatsApp platform in English learning could improve students' motivation to write, and a positive effect on motivation could be established. Other effects were that vocabulary and spelling skills in language classes improved, but grammar, idea development, and organisation were lacking. In Antonenko et al. (2013)study of attitudes towards mobile LMS

features, females were significantly more inclined to find instant messaging features useful, and students in general perceived instant messaging to be more important than what faculty did. Because many different services are coming together in a single device, the blurring of boundaries between them is starting to emerge. SMS and instant messaging are becoming less and less distinct, which might lead to SMS becoming an outdated form of communication (Brett 2011). Similarly, traditionally computer-based tasks, such as instant messaging, are showing a large increase in use on phones (Cassidy et al. 2014).

4.7 Video streaming

Video streaming refers to videos made available to students online, typically via video sharing sites such as Youtube, or directly through an LMS, What separates video streaming from vodcasts (video podcasts) is that the videos can be accessed directly, without the need for subscribing to feeds. Some concern has been raised that recorded lectures might lead to decreased attendance in class (McGarr 2009). An experiment with video vignettes as a preparatory tool for practical classes, however, led to an increase in attendance and an improvement in the perception of the relevance of the subject for students' future professions (Ernst et al. 2012). Another critique against video lectures is their unidirectionality, not lending themselves to communication and dialogue. By supplementing videos with a commenting function through the development of a platform (MOBILect) this problem was addressed in two studies (Boyinbode et al. 2013; Boyinbode and Ng'ambi 2015). The results indicated that this tool encouraged students to ask questions they would not dare to ask in class, benefited shy students, and allowed students to gain a deeper understanding of the lecture by exposing them to other people's ideas and opinions. Sadik (2015) investigated student preferences for video lecture formats. Comparing full-length lecture captures with supplemental and shorter screencasts covering the same subjects, students were found to be in favour of the latter format.

4.8 QR codes

Quick Response (QR) codes are intimately associated with modern smartphones, as they depend on three key features: a camera to scan the code, a live Internet connection, and an app to process it. Still, only six articles mention QR codes. This could be because the code is a same-place technology—physical presence at the same location as the QR code is a requirement for scanning it—and therefore it might not be of interest in scenarios exploring flexible place. Furthermore, Cassidy et al. (2014) found that students reported low familiarity with QR codes as a concept, and those familiar with it used it quite infrequently, not matching the recent hype surrounding the technology in the library science field. Cochrane et al. (2013) explored QR codes in a journalism course, with the initial student response that it was a "gimmick", but after some exercises raising awareness about QR code use in local news publications, students started to explore its potential. Yin and Fitzgerald (2015) did see

positive attitudes towards the use of QR codes, but it was mostly used to simplify a login process.

4.9 Wiki

Wikis were discussed in two articles, but just one treated the subject with any detail. In that article, students were required to use a wiki for a group assignment where participants could be in different time zones. The benefits that were mentioned for using a wiki were twofold, the most obvious being the ability of students to work at a time and place of their convenience (Soon 2011; Wilson and Bolliger 2013). The second benefit was the teacher's ability to track and follow individual students' contributions to the assignment through the wiki's history feature: "Wiki's history helped the instructor to monitor both the students' activity and their levels of contribution to the project and therefore made the assessment of individual members easier" (Soon 2011, p. 49). Students were mostly positive towards using the wiki, but many were not familiar with how to use it, and a majority "described a need for more time for Wiki training before embarking on their required group assignments" (Soon 2011, p. 47). The functionality described above can also be found in collaborative office suites online, such as Google Drive/Docs and Microsoft Office 360. As usage of these services does not require as much specialized knowledge, it is likely that they will replace wikis to some extent in the future.

4.10 LMSs and mobile access

Mobile LMS access seems to be increasing, as exemplified by data from New Zealand where mobile access quadrupled during the last year of the study (Ernst et al. 2013). Some studies have been made to develop/integrate mobile services into existing LMS platforms. In an examination of expectations for an LMS, where both students and faculty responded, some differences of opinion emerged. Students expressed a stronger interest in accessing grades, feedback, assignment descriptions, course contents and announcements, while faculty was more interested in discussion features and real-time chat. Females in general also showed more interest in communication features than did males. Overall, students showed a higher level of appreciation for mobile features than did faculty (Antonenko et al. 2013). These results somewhat contrast those of an earlier study (Koole et al. 2010), where students, on the one hand, reported flexible access to the LMS as being important, but on the other hand rated mobile access low. Usability indicators show that the mobile interface was more difficult to navigate and enter data into compared to the computer interface, indicating that mobile usability was not well developed at this time. This is likely to have negatively affected student perceptions about using mobile access.

5 Obstacles or problems with applications of BYOD to blur time and place

In general, authors are more prone to discuss advantages and positive results, but some have highlighted challenges or problems with applications of BYOD.

The more common themes that could be distinguished are presented under the following headlines.

5.1 Podcasting not as mobile as expected

The assumption that podcasts are suitable for opportunistic learning – that one can learn efficiently or conveniently with a podcast while doing other things – sees little to no support in these studies. One likely reason for this is the cognitive load that active listening demand (Brown 2011; Morris 2010). Students prefer quiet locations, with easy access to their notes and relevant literature, usually listening via a stationary computer (e.g. Kazlauskas and Robinson 2012; Pearce and Scutter 2010; Popova et al. 2014). This is an argument against podcasts as an application for the blurring of the place of use. This is somewhat contradicted by Rosell-Aguilar (2015) in a study on iTunes U users, where a majority preferred to listen via mobile devices. This study, however, did not specifically target higher education but rather sampled iTunes U users regardless of their purposes for using the service. This likely affected the outcome.

5.2 Device challenges

The mobility of small devices comes with certain trade-offs. The portable sizes lead to small screens that can be difficult to navigate and read (Boyinbode et al. 2013; Zawacki-Richter et al. 2009). Keyboards, whether physical or virtual, are small and are not as convenient for text production as are full sized keyboards, and apps do not always work as well as anticipated (Gikas and Grant 2013). Such restrictions put boundaries on learners' use of mobile devices, as:

> although mobile devices and MOOCs do allow anytime and anywhere access, the fact that mobile devices have limitations to content interpretation and content creation, the ubiquity of mobile learning and the immediacy of learner interactions is affected by the limitations of the current mobile technology. (de Waard et al. 2012, p. 43)

Studies later in the review period did not mention device usability as frequently, likely due to devices becoming easier to use with every new device generation (larger and sharper screens, faster, etc.), thus indicating that this problem will become less pronounced over time. A student's familiarity with a device is another factor that can compensate such device usability issues (Boyinbode et al. 2013). Smartphones will likely not – within a foreseeable future – become as well suited for text production as computers with full sized keyboards, but the difference in usability does seem to decrease over time.

5.3 Costs

A prerequisite for BYOD activities is that students have mobile devices and that they can afford to use them for the intended purposes. Many reports on

student device ownership show smartphone adoption rates well above 90% (e.g. Allagui 2014; Bradley and Holley 2011; Brett 2011; Cassidy et al. 2014; Meyer et al. 2015), but this is not universal. Bogdanović et al. (2014) reported that less than 50% of their sample owned smartphones, which became a barrier for the delivery of mobile activities. Even with ubiquitous mobile phone ownership, the costs of mobile services such as SMS can be an issue that inhibits interaction for students, especially for students without contracts (Brett 2011; McClean et al. 2010; Ng'ambi and Lombe 2012). Internet access can also be a cost-related issue where students do not have free data plans, or where such plans are not available, particularly when large files needs to be downloaded, such as podcasts or videos (Bogdanović et al. 2014; de Waard et al. 2012; Ng'ambi and Lombe 2012). These observations are reported from Europe as well as Africa.

5.4 Digital native misconception – unexpected lack of ability

Mark Prensky's theory of digital natives and digital immigrants suggests that teachers, as digital immigrants, need to adapt to digital natives expectations for them to learn to their full extent (Prensky 2001). This, for instance, involves utilizing students' mobile devices and creating non-text representations of learning material. Some studies, however, reported on students having technical difficulties due to faculty's overrating students' abilities and not providing enough support (Morris 2010; Vogt et al. 2010). It is also problematic to assume the opposite about older students "who may in fact be keen to take advantage of learning and teaching innovation" (Chester et al. 2011, p. 244). Benefits of the blurring of time and place boundaries, such as taking advantage of time snippets on the go for learning, are not self-evident to students to the extent that faculty sometimes assumes.

5.5 Improper blurring of public and private

The use of social media that are open to the general public can be problematic. As educational institutions cannot control public social media tools such as Twitter, abusive or inappropriate student behaviour can become problematic. When students use their private Twitter accounts for coursework, communication of a private nature might interfere with class communication, although this can be partly overcome by the proper use of hashtags (Lowe and Laffey 2011). The opposite situation also needs consideration, where the public sphere invades private life. Some students express a desire to distinguish their private lives from their public or professional lives, leading to difficulties incorporating the use of social networking sites such as Facebook for school related work. As one student expressed:

> While on […] our Facebook group, we have lecturers as 'friends.' I am uncomfortable with their presence because Facebook is my private life. Just as I would not have a drink with my supervisor, I don't want them to know about my private life. (Rambe 2013, p. 324)

Complexities of identity management exist in public spaces and cannot be ignored. Such problems can hinder faculty from implementing social media solutions for the blurring of boundaries of time and space (Lowe and Laffey 2011; Rambe 2012, 2013).

5.6 Device as a distraction

The blurring of boundaries between formal and informal learning contexts is presented as a positive effect of mobile learning practices. However, students may become distracted by non-learning material when the device is supposed to be used for learning (Abu-Al-Aish et al. 2013), and the "alternation of informal conversations with academic engagements constitutes distractions that may jeopardise the smooth flow of the scholarly interactions" (Rambe 2012, p. 60). The distractive qualities of mobile devices were not directly examined in the articles in this review. However, from this review, it appears to be more of a faculty preconception than an observed problem. Students acknowledged the risk, but reports being able to separate private and educational use, and "students perceived the effectiveness of Facebook for communication more positively than the instructors" (Gikas and Grant 2013, p. 20).

6 Conclusions

This paper has reviewed journal articles published in the years of 2009 through 2015 that discussed applications of BYOD in higher education to blur the boundaries of time and place. Due to the large variation in publications per year, and the large variation between the publication year and the year of data collection, trend analysis becomes uncertain. A complication is that many articles lack information about the time of data collection. From the 53% of the articles that has a stated year of data collection, it is evident that the year of publication and the year of data collection can vary a lot. In some cases, data were collected the same year as the article was published, but in some cases, data were collected as much as six years prior to publication. The rapid technological development in the field of mobile devices can substantially change the conditions for research in just a few years time. This is a discrepancy worth taking into consideration when examining research in a field where conditions change rapidly due to technological development.

It seems likely that the trend is an increasing number of articles being published, as indicated by the regression analysis, but it cannot be determined with certainty due to the large yearly variation. What is clear, however, is that the number of different digital media and applications that are being discussed increases year over year. Earlier applications remain of interest while newer applications are being added to the researchers' palette. Podcasting, blogging, LMS and text messaging and instant messaging were examined during all of the reviewed years. Articles on social networking such as Facebook and Twitter started to appear in 2010, wikis in 2011, and AR saw one mention in 2013 but did not take off until 2015, together with 3-D. Research on social networking

has increased, as is evident in Table 3, and so has the number of articles discussing constructivist- and sociocultural perspectives on learning over time (Table 4). It is very likely that these trends are related, i.e. that constructivist and socio-cultural perspectives on learning are better met by social networking technologies. Applications of direct instruction decrease, but are still prevalent. A possible part of the explanation for these shifts could be that newer tablets and smartphones afford social networking and diverse forms of communication better than what older mobile devices such as feature phones can, thus allowing more varied instructional models.

A closely related trend is that research becomes less about specific devices and more about which learning opportunities can be unfolded with ubiquitous access. Some earlier studies dealt with the development of platform-specific solutions to enable mobile access. In later studies, mobile access is more or less taken for granted, brands and types of devices are of lesser interest, and the focus of study has shifted more towards what can be done to support learning. Device usability has improved over time. Many observed problems in studies from the earlier part of the examined period are lacking from later studies, e.g. the experiment with a mobile access add-on for Moodle by Koole et al. (2010) compared with Shin and Kang (2015). This is likely due in part to larger and better quality displays, improved user interfaces in web services and apps, and better quality data connections. When device usability improves, the research focus seems to shift away from device limitations, towards activities and learning opportunities.

Experiments with virtual reality (VR) and AR are showing up in the last year being examined. This, together with the popularity of the AR game Pokémon Go (Niantic, Inc. 2016) in mid-2016, a good chance exists that various applications of AR for learning purposes will see increased interest from researchers in the near future.

Little to no support for Prensky's digital native theory exists in these studies. Rather, there are other factors besides age that is of relevance for determining whether the implementation of mobile learning will be successful. Also, assuming that younger students are digital natives are more likely to *cause* problems than to *help*, such as failing to provide adequate support due to false expectations.

There is a motive for further research on learning outcomes that employs experimental design, as there is a lack of rigorous research on the effects of applications of BYOD in higher education. Another area that should benefit from experimental research designs is the assumed distractive nature of mobile devices. This review reveals mixed results, where faculty perceptions indicate a potential problem, but where student perceptions are that the assumed distractions are manageable. Indications also exist that the instructional designs of the learning activities are important for the outcome.

Compliance with ethical standards

Conflict of interest The author declares that he has no conflict of interest.

Appendix

Table 5 Summary of articles included in the review, including year of publication, year(s) of data collection, first author affiliation country, respondent type, and stated purpose

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
Abdous, M.; Camarena, M. M.; Facer, B. R.	MALL Technology: Use of Academic Podcasting in the Foreign Language Classroom	2009	2007	USA	Students	Examine the differential effectiveness of various instructional uses of podcasting in student language acquisition.
Abu-Al-Aish, A.; Love, S.; Hunaiti, Z.; Al-masaeed, S.	Toward a sustainable deployment of m-learning in higher education	2013	2013	UK	Faculty & Students	Create a model that can be used as a road map for both pre- and post-deployment stages of m-learning.
Al-Emran, M.; Shaalan, K.	Attitudes Towards the Use of Mobile Learning: A Case Study from the Gulf Region	2015	2014	Oman	Faculty & Students	To investigate students and faculty members' attitudes towards the use of M-learning in higher educational institutions within two countries in the Gulf Region (Oman & UAE).
Alden, J.	Accommodating Mobile Learning in College Programs	2013	2012	USA	Students	Examine what strategy an institution of higher learning with limited resources should use in adapting the capabilities of mobile devices to benefit its academic programs.
Alfarani, L. A.	Influences on the Adoption of Mobile Learning in Saudi Women Teachers in Higher Education	2015	N/A	Saudi Arabia	Faculty	This study extends the Unified Theory of Acceptance and Use of Technology in order to explore the addition of two new factors—resistance to change (RC), and perceived social culture (SC). Moreover, gender, age, and experience are hypothesized to be moderators of the effects of the four constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions), as well as the two additional

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
						constructs on current use and intention to use.
Allagui, B.	Writing through WhatsApp: an evaluation of students writing performance	2014	2013	United Arab Emirates	Students	Examine how well students can write in a non-traditional classroom setting using WhatsApp.
Almaiah, M. A.; Jalil, M. A.	Investigating Students' Perceptions on Mobile Learning Services	2014	N/A	Malaysia	Students	To explore the students' perceptions of the application of m-learning services in higher education environments.
Almutairy, S. M.; Davies, T.; Dimitriadi, Y.	The Readiness of Applying m-learning among Saudi Arabian Students at Higher Education	2015	2013	UK	Students	To investigate the extent to which Saudi students understand and are familiar with mobile learning. It investigates students' use of handheld devices and considers the daily activities for which they could be used while also evaluating m-learning in Saudi Arabia.
Alrasheedi, M.; Capretz, L. F.; Raza, A.	Management's Perspective on Critical Success Factors Affecting Mobile Learning in Higher Education Institutions—An Empirical Study	2015	N/A	Canada	Manage-ment	To present the assessment of the critical success factors of m-Learning from the perspective of university management.
Althunibat, A.	Determining the factors influencing students' intention to use m-learning in Jordan higher education	2015	N/A	Jordan	Students	To explore the factors that affect the acceptance of m-learning experience by the university students. The paper examines the existing researches conducted in this regard. The paper includes the state of higher education in the institutes, the research model, research methodology, results and findings, together with concluding the final argument in support of the m-learning environment.
Antonenko, P. D.; Derakhshan, N.; Mendez, J. P.	Pedagogy 2 go: student and faculty perspectives on the features of mobile learning management systems	2013	N/A	USA	Faculty & Students	This study employed two surveys to explore the perceptions of university students and faculty regarding their patterns of use and usefulness

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
						of mobile learning management system (LMS) features.
Bogdanović, Z.; Barać, D.; Jovanić, B.; Popović, S.; Radenković, B.	Evaluation of mobile assessment in a learning management system	2014	2010	Serbia	Students	Investigate student habits, motivations and technical possibilities in order to incorporate mobile learning activities in e-learning habits
Boyinbode, O. K.; Ng'ambi, D.	An Interactive Mobile Lecturing Tool for Empowering Distance Learners	2013	2011–2012	South Africa	Students	To propose a mobile lecturing tool that enables users to comment on lecture vodcasts using mobile devices, and aggregated comments become an educational resource. The paper reports on the architecture of the MOBILect, its framework for student-vodcast interaction, and evaluation results.
Boyinbode, O.; Ng'ambi, D.; Bagula, A.	An Interactive Mobile Lecturing Model: Enhancing Student Engagement with Face-To-Face Sessions	2013	2011–2012	South Africa	Students	To describe the architecture, implementation and evaluation of MOBILect; an interactive mobile lecturing tool, which seeks to enhance students' engagement with face-to-face (f2f) sessions in higher education institutions (HEIs).
Bradley, C.; Holley, D.	Empirical Research into Students' Mobile Phones and their Use for Learning:	2011	2009–2010	UK	Students	Find out about higher education students' mobile phone ownership, and the ways in which they are using their mobiles for learning.
Brett, P.	Students' Experiences and Engagement with SMS for Learning in Higher Education	2011	N/A	UK	Students	Examines students' experiences and engagement with SMS for two different learning activities, as well as for administrative communications, across a large cohort and in many different disciplines.
Brown, L.	Podcasting and vodcasting to BSc Geography students	2011	2007–2009	UK	Students	1) evaluate the methods used by students to access and listen to podcasts or view

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
						vodcasts; 2) consider the extent to which students took opportunities to listen to podcasts whilst on the move as opposed to sat at a study desk in university or at home, and; 3) discuss some of the perceived benefits of podcast and vodcast resources among those studying Geography.
Cassidy, E.D.; Colmenares, A.; Jones, G.; Manolovitz, T.; Shen, L.; Vieira, S.	Higher Education and Emerging Technologies: Shifting Trends in Student Usage	2014	2013	USA	Students	Investigate student usage of communication and educational technologies, determine preferred technologies for library services.
Cavus, N.; Ibrahim, D.	m-Learning: An experiment in using SMS to support learning new English language words	2009	2007	Turkey	Students	Find out the potential of using mobile phones in teaching new technical English language words to 1st-year undergraduate students to support their normal English language lectures.
Chang, Y.; Chen, S.; Yu, K.; Chu, Y.; Chien, Y.	Effects of cloud-based m-learning on student creative performance in engineering design	2015	N/A	Taiwan	Students	To explore the effects of cloud-based m--learning on students' creative processes and products in engineering design.
Chester, A.; Buntine, A.; Hammond, K.; Atkinson, L.	Podcasting in Education: Student Attitudes, Behaviour and Self-Efficacy	2011	N/A	Australia	Students	To describe the characteristics of podcast users, compare uptake across courses, examine preferred modes of use and satisfaction, assess the impact of podcasts on lecture attendance, and evaluate reasons for use and non-use.
Cochrane, T.; Sissons, H.; Mulrennan, D.; Pamatatau, R.	Journalism 2.0: Exploring the Impact of Mobile and Social Media on Journalism Education	2013	2006–2008	New Zealand	Faculty & Students	Explore the impact of social media upon journalism education from two perspectives: both from the pedagogical changes Web 2.0 and mobile devices enable, and within the context of the changes in journalism that social media use are driving.

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
de Waard, I.; Koutropoulos, A.; Hogue, R.J.; Abajian, S.C.; Keskin, N.Ö.; Rodriguez, C.O.; Gallagher, M.S.	Merging MOOC and mLearning for Increased Learner Interactions:	2012	2011	Belgium	Students	Explore the similarities between MOOCs and mLearning and to investigate if these emerging educational innovations have a potential to be merged into a learning environment that optimizes learner dialogue fitting informal, contextual and life- long learning.
Dow, C.; Huang, L.	Context-aware and LBS learning systems using ubiquitous teaching assistant (u-TA): A case study for service-learning courses	2011	2010–2011	Taiwan	Students	To design a mobile system for learning.
Economides, A.A.; Grousopoulou, A.	Mobiles in education: students' usage, preferences and desires	2010	2007–2008	Greece	Students	To investigate the students' use, preferences and desires regarding mobile devices in education.
El-Hussein, M.O.M.; Cronje, J.C.	Defining Mobile Learning in the Higher Education Landscape	2010	N/A	South Africa	N/A	Reflect on and understand the position of mobile learning in higher education. It also hopes to develop a succinct definition applicable in the context of university and college education.
Ernst, H.; Harrison, J.; Colthorpe, K.	Mobile learning materials as a 'prompt' for participation in physiology practical classes	2012	2008–2010	Australia	Students	To present evidence that 90-s video vignettes designed for delivery by way of mobile communication devices contribute to 'engaged learning' as measured by higher student participation and attainment in physiology practical classes.
Ernst, H.; Harrison, J.; Griffin, D.	Anywhere, anytime, with any device: scenario-based mobile learning in biomedical sciences	2013	2011–2012	Australia	Students	- To mobilise student demand for mobile learning, as evidenced by Andrews et al. (2009) and Andrews (2010), and the leveraging of diverse, but student-owned, technology for academic benefit using the

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
						project's design of uncomplicated, easy to navigate web-based interfaces that ensures normalised access across handsets by working within the mobile browser environment; - Recognise the near ubiquity of internet-enabled handheld devices using multiple operating platforms and systems (Johnson et al. 2012) and create active, high-impact, decision-based learning opportunities; - Facilitate deep learning through consolidated understanding and application of learning in physiology, anatomy and pharmacology.
Ernst, H.; McGahan, W.T.; Harrison, J.	Questionable Benefit of Visual and Peer Mediated Learning on Overall Learning Outcomes of a First-Year Physiology Course:	2015	2012–2013	Australia	Students	To determine the level of increased learning that took place around chosen topics, as a result of using creative visual literacy to explain the disease in focus; and to assess the effects of the peer mediated, receptive visual component of the task, by examining learning and retention of the entire course content for the semester long health sciences course.
Fouh, E.; Breakiron, D.A.; Hamouda, S.; Farghally, M.F.; Shaffer, C.A.	Exploring students learning behavior with an interactive etextbook in computer science courses	2014	2013–2014	USA	Students	Examine student behavior using interactive electronic textbook.
Gikas, J.; Grant, M.M.	Mobile computing devices in higher education: Student perspectives on learning with cellphones, smartphones & social media	2013	N/A	USA	Faculty & Students	Explore teaching and learning when mobile computing devices, such as cellphones and smartphones, were implemented in higher education.

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
Hashim, K.F.; Tan, F.B.; Rashid, A.	Adult learners' intention to adopt mobile learning: A motivational perspective	2015	N/A	Malaysia	Students	To employ the uses and gratification theory to provide a better understanding of what motivates m-learning adoption in adult learners.
Hayati, A.; Jalilifar, A.; Mashhadi, A.	Using Short Message Service (SMS) to teach English idioms to EFL students	2013	N/A	Iran	Students	Gauge the efficacy of three modes of instruction of English idioms, ie, Short Message Service (SMS)-based learning, contextual learning and self-study learning.
Hong, J.-C.; Hwang, M.-Y.; Chang, H.-W.; Tai, K.-H.; Kuo, Y.-C.; Tsai, Y.-H.	Internet cognitive failure and fatigue relevant to learners' self-regulation and learning progress in English vocabulary with a calibration scheme	2015	2013	Taiwan	Students	To determine the factors of learning effectiveness in English vocabulary learning when using a calibration scheme, this study developed a freshman English mobile device application (for iPhone 4) for students with low levels of English proficiency to practise vocabulary in the beginning of their Freshman English course.
Huang, R.-T.; Jang, S.-J.; Machtmes, K.; Deggs, D.	Investigating the roles of perceived playfulness, resistance to change and self-management of learning in mobile English learning outcome	2012	2010	Taiwan	Students	Investigate the roles of mobile technology playfulness, users' resistance to change and self-management of learning in mobile English learning outcomes.
Huang, Y.-M.; Jeng, Y.-L.; Huang, T.-C.	An Educational Mobile Blogging System for Supporting Collaborative Learning	2009	N/A	Taiwan	Students	To investigate the learning effects of the mobile blogging system in a collaborative learning model as well as to explore the learning behavior of mobile blogger.
Ilic, P.	The Effects of Mobile Collaborative Activities in a Second Language Course:	2015	2011–2015	Japan	Students	The purpose was to gain a deeper understanding of the processes and outcomes of the completion of collaborative learning activities through smartphones by Japanese university students in order to answer the research question: "Does the use of

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
						smartphones for homework affect the relationship between Japanese university students, their mobile phones, and their homework?"
Ishtaiwa, F.F.; Khaled, A.; Dukmak, S.	Faculty Members' Perceptions of the Integration, Affordances, and Challenges of Mobile Learning	2015	2014–2015	United Arab Emirates	Faculty	To qualitatively explore faculty members' integration of m-learning strategies in their teaching as well as their perceived affordances and challenges with m-learning.
Jaradat, M.-I. R. M.	Understanding the acceptance of mobile university services: an empirical analysis	2010	N/A	Jordan	Students	Explore the utilisation of mobile phone services in the educational environment and investigate students' expectations and attitudes towards mobile university services in Jordan.
Jordine, T.; Liang, Y.; Ihler, E.	A Mobile Device Based Serious Gaming Approach for Teaching and Learning Java Programming	2015	2013	Germany	Students	To create a mobile device based serious gaming approach along with a serious game for enhancing mobile teaching and learning for Java programming.
Kazlauskas, A.; Robinson, K.	Podcasts are not for everyone	2012	N/A	Australia	Students	To plan, implement and evaluate student usage of lecture podcasts with the aim to improve both the podcasts' and students' abilities to benefit from them.
Ke, F.; Hsu, Y.-C.	Mobile augmented-reality artifact creation as a component of mobile computer-supported collaborative learning	2015	N/A	USA	Students	To examine the effectiveness of smartphone-based collaborative learning activities, comprising augmented reality (AR) artifact creation and VoiceThread-based discussion, in reinforcing the technological pedagogical content knowledge (TPACK) of teacher education students or pre-service teachers.

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
Koole, M.; McQuilkin, J.L.; Ally, M.	Mobile Learning in Distance Education: Utility or Futility	2010	N/A	Canada	Students	To report the results of an innovative study exploring the usability, learning, and social interaction of mobile access to online course materials at a Canadian distance education university.
Kranz, M.; Möller, A.; Diewald, S.; Roalter, L.; Beege, B.; Meyer, B. E.; Hendrich, A.	Mobile and contextual learning: a case study on mobile didactics in teaching and education	2013	N/A	Germany	Faculty & Students	To provide an up-to-date overview of the demand on mobile services in higher education and learning environments grounded on two large-scale studies. We investigated the current use and the demand of online campus services among students and academic staff at a university of technology. In a follow-up study, we focused on the demand of mobile learning applications. We identified requirements for a didactics application in higher education as an example for ubiquitous mobile learning support. We introduce the MobiDics application, describe its didactic foundation and its implementation.
Li, S.c.; Pow, J.w.c.; Cheung, W.c.	A delineation of the cognitive processes manifested in a social annotation environment	2015	2012–2013	Hong Kong	Students	To examine how students' learning trajectories progress in an online social annotation environment, and how their cognitive processes and levels of interaction correlate with their learning outcomes.
Liu, Ming-Chi; Huang, Yueh-Min	Collaborative experience sharing with the support of M-Learning 2.0: a fundamental framework, a case study and research issues	2015	N/A	Taiwan	Students	Students should be taught system-thinking skills in order for them to gain an overall understanding of complex environmental issues. The purpose of this paper is to solve this issue by integrating social media into

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
						conventional mobile learning, using a system called M-Learning 2.0.
Lowe, Ben; Laffey, Des	Is Twitter for the Birds?: Using Twitter to Enhance Student Learning in a Marketing Course	2011	N/A	UK	Students	Ascertain the degree to which Twitter has positive learning outcomes in a marketing course.
Lowenthal, Jeffrey N.	Using Mobile Learning: Determinates Impacting Behavioral Intention	2010	N/A	USA	Students	The purpose of this article is twofold: first, to explore the issue of readiness of the potential learners—that is, explore the determinates of a successful m-learning intervention; and second, to examine if age or gender has any mediating impact of behavioral intention.
Malone, Judi L.	Engaging Psychology Students at a Distance: Reflections on Australian and Canadian Experiences	2012	2010	Canada	Students	Compare the different e-learning models used to instruct Theories of Counselling and Psychotherapy, and Ethics and Current Issues in Psychology.
May, D.; Ossenberg, P.	Organizing, performing and presenting scientific work in engineering education with the help of mobile devices	2015	2014–2015	Germany	Students	Within this project two working packages are focusing on mobile learning and on a research workshop for students (Fig. 1). Combining these two views was a first step into design process for the presented course. This paper will explain the underlying research concepts as well a preliminary considerations, the course design itself, the students' feedback and planned improvements for the future.
McClean, S.; Hagan, P.; Morgan, J.	Text Messaging for Student Communication and Voting	2010	2009	Ireland	Students	To report upon the implementation of a two-way SMS texting service within an introductory chemistry module delivered to students taking biology, biomedical science,

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
						human nutrition, food and nutrition, dietetics, pharmacy and pharmacology degrees in the School of Biomedical Sciences at the University of Ulster.
McKinney, D.; Dyck, J. L.; Luber, E. S.	iTunes University and the Classroom: Can Podcasts Replace Professors?	2009	N/A	USA	Students	To evaluate [podcasts as an] alternative to getting notes from a friend in the class for a lecture session the student missed.
Menkhoff, T.; Chay, Y. W.; Bengtsson, M. L.; Woodard, C. J.; Gan, B.	Incorporating microblogging ("tweeting") in higher education: Lessons learnt in a knowledge management course	2015	2010–2012	Singapore		To share tweeting experiences made during a course on Knowledge Management taught at the Singapore Management University (SMU) in Singapore by addressing the following research questions: 1. How can social media such as twitter enrich blended learning in order to engage Gen Y students in institutions of higher learning? 2. How can twitter be effectively integrated into course designs? 3. Besides the opportunities which twitter offers for both instructors and students, what are the key challenges when it comes to implementing respective initiatives in the classroom?
Merhi, M. I.	Factors influencing higher education students to adopt podcast: An empirical study	2015	N/A	USA	Students	To investigate the technological, individual, and social aspects that influence the adoption of podcast use in education using the Technology Acceptance Model and Diffusion of Innovation Theory as base models.
Meyer, Amanda J.; Stomski, Norman J.; Innes, Stanley I.; Armson, Anthony J.	VARK learning preferences and mobile anatomy software application use in pre-clinical chiropractic students	2015	N/A	Australia	Students	(1) identify the preferred learning styles of pre-clinical chiropractic students at Murdoch University; (2) examine the pattern of

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
						ownership and use of mobile anatomy apps in the pre-clinical chiropractic cohort; and (3) examine the relationship between preferred learning styles and mobile anatomy app use.
Milošević, I.; Živković, Dr.; Manasijević, D.; Nikolić, D.	The effects of the intended behavior of students in the use of M-learning	2015	2014	Serbia	Students	To present the results of research in the application of new technologies in higher education with particular emphasis on M-learning as a modern innovative approach.
Mohammadi, H.	Social and individual antecedents of m-learning adoption in Iran	2015	2014	Iran	Students	To explore the effects of perceived ease of use, perceived usefulness, subjective norm, perceived image, personal innovativeness, individual mobility, absorptive capacity, and self-efficacy on user intention and satisfaction, alongside the mediating effect of usability towards use of m-learning in Iran.
Morris, Neil P.	Podcasts and Mobile Assessment Enhance Student Learning Experience and Academic Performance	2010	N/A	UK	Students	To combine podcasts of lectures with mobile assessments (completed via SMS on mobile telephones) to assess the effect on examination performance.
Muñoz-Cristóbal, Juan A.; Prieto, Luis P.; Asensio-Pérez, Juan I.; Martínez-Monés, Alejandra; Jorrín-Abellán, Iván M.; Dimitriadis, Yannis	Coming Down to Earth: Helping Teachers Use 3D Virtual Worlds in Across-Spaces Learning Situations	2015	2012–2014	Spain	Faculty & Students	To propose the architecture and prototype of a system capable of supporting teachers in creating, with a number of existing authoring tools, and deploying their own across-spaces learning situations in a variety of technological ecosystems comprising multiple learning spaces. These ecosystems may be composed of different mainstream virtual learning engines (VLEs) and Web 2.0 tools (web learning space), multiple mobile augmented

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
						reality (AR) applications (augmented physical learning space), as well as distinct 3D virtual worlds (3DVW learning space).
Ng'ambi, D.; Lombe, A.	Using Podcasting to Facilitate Student Learning: A Constructivist Perspective	2012	2008–2009	South Africa	Students	To investigate how students enrolled on a blended postgraduate programme in Educational Technology used podcasts for reflective learning.
Pearce, K; Scutter, S.	Podcasting of Health Sciences Lectures: Benefits for Students from a Non-English Speaking Background	2010	2009	Australia	Students	Investigate the ways in which a large group of students from a selection of health science programs utilise podcasts.
Pegrum, M.; Bartle, E.; Longnecker, N.	Can creative podcasting promote deep learning? The use of podcasting for learning content in an undergraduate science unit	2015	2009–2010	Australia	Students	To examine the effect of the podcasting task on examination results. In addition, students' podcasts were coded according to their contextualisation levels to determine any possible link between contextualisation and improved examination performance.
Pimmer, C.; Linxen, S.; Gröhbiel, U.	Facebook as a learning tool? A case study on the appropriation of social network sites from mobile phones in developing countries	2012	2011	Switzerland	Faculty & Students	Shed light on aspects of technology use, such as engagement with SNSs and mobile phones, in the context of health education in developing countries.
Pimmer, C.; Linxen, S.; Gröhbiel, U.; Jha, A. K.; Burg, G.	Mobile learning in resource-constrained environments: A case study of medical education	2013	2011	Switzer-land	Faculty & Students	This study intended to explore the use and impact of educational technology in medical education in resource-constrained environments.
Popova, A.; Kirschner, P. A.; Joiner, R.	Effects of primer podcasts on stimulating learning from lectures: How do students engage?	2014	N/A	Nether-lands	Students	Examine students' perceptions of whether and how primer (audio) podcasts and questions affected their learning from lectures.
Rambe, P.	Social Media-Enhanced Phones for Productive Learning of South African Postgraduate Students:	2012	N/A	South Africa	Students	To investigate the potential of Facebook-enabled mobiles to leverage learning in informal learning environments.

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
						Third Space Theory illuminated understanding of how students draw on potentially contradictory, multiple "funds of knowledge" in their meaning making and discourses.
Rambe, P.	Converged Social Media: Identity Management and Engagement on Facebook Mobile and Blogs	2013	N/A	South Africa	Students	Investigate academic and social implications of converged media on students' lives.
Rambe, P.; Nel, L.	Technological utopia, dystopia and ambivalence: Teaching with social media at a South African university	2015	2013	South Africa	Faculty	To draw on technological ambivalence to unravel the complex, multiple possibilities that accompany pragmatic use of technology including the double-bound relationship between human agency and educational technology. This paper therefore seeks to answer the following questions: 1. What are the general determinist (utopian and dystopian) and ambivalent views of educators about emerging technologies? 2. How do the varying perceptions of a group of Computer Science and Informatics educators at a South African university on the educational value of social media shape and inform their pragmatic instructional uses of these technologies?
Reychav, I.; Dunaway, M.; Kobayashi, M.	Understanding mobile technology-fit behaviors outside the classroom	2015	2012–2014	Israel	Students	To understand the challenges of mobile devices for academic learning outside the classroom.
Reychav, I.; Warkentin, M.; McHaney, R.	Exploring Effects of Media Type and Delivery Technology on Facilitating Critical Thinking Among College Students	2015	2012	Israel	Students	To investigate (a) whether technology approach (e.g., tablet vs. computer) impacts learning strategies adopted by students; and (b) whether media type (e.g., text vs. video)

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
						impacts learning strategies adopted and critical thinking approaches adopted by students.
Rogan, F.; San Miguel, C.	Improving clinical communication of students with English as a second language (ESL) using online technology: A small scale evaluation study	2013	2008–2009	Australia	Students	Describe and evaluate an innovation using podcast and vodcast technology to assist first-year undergraduate ESL nursing students develop their clinical communication skills and practice readiness using online learning resources that blend with classroom activities and facilitate flexible and independent learning.
Rosell-Aguilar, F.	Podcasting as a Mobile Learning Technology:: A Study of iTunes U Learners	2015	2009–2011	UK	Students	To review past and current literature on podcasting as a mobile learning technology and present a number of key ques.- tions about learners'use of podcasts, and then present the data collected from a large study into users of iTunes U resources, discuss them and present conclusions about whether the delivery of media files through such platforms can be considered a mobile technology.
Sadik, A.	Students' Preferences for Types of Video Lectures: Lecture Capture vs. Screencasting Recordings	2015	2013–2015	Oman	Students	To investigate students' preferences for lecture capture and screencasting recordings as a supplement to classroom lectures, regardless of learning outcomes.
Scott, K. M.; Nerminathan, A.; Alexander, S.; Phelps, M.; Harrison, A.	Using mobile devices for learning in clinical settings: A mixed-methods study of medical student, physician and patient perspectives	2015	2012–2013	Australia	Students	To determine use of mobile devices for learning, and beliefs and attitudes about others' use, using a mixed-methods sequential explanatory design, conducted with

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
						medical students, physicians, patients and carers in a paediatric and an adult hospital
Sevillano-García, M. L.; Vázquez-Cano, E.	The Impact of Digital Mobile Devices in Higher Education	2015	N/A	Spain	Students	To examine the acceptance, incidence, and use of digital mobile devices (tablets and smartphones) among university students in the European Higher Education Area (EHEA).
Shin, W. S.; Kang, M.	The Use of a Mobile Learning Management System at an Online University and Its Effect on Learning Satisfaction and Achievement	2015	2013	South Korea	Students	To investigate online students' acceptance of mobile learning and its influence on learning achievement using an information system success and extended technology acceptance model (TAM).
Soon, L.	E-Learning and M-Learning: Challenges and Barriers in Distance Education Group Assignment Collaboration	2011	N/A	Australia	Students	Explore the relationship between e-learning and m-learning by investigating distance education students' use of a learning management system, "Interact," for virtual team work.
Strickland, K.; Gray, C.; Hill, G.	The use of podcasts to enhance research-teaching linkages in undergraduate nursing students	2012	2010	UK	Students	To report the outcomes of an evaluation of the introduction of podcasts in an undergraduate research module in the School of Nursing, Midwifery and Social Care at Edinburgh Napier University.
Taylor, L.; McGrath-Champ, S.; Clarkeburn, H.	Supporting student self-study: The educational design of podcasts in a collaborative learning context	2012	2007–2009	Australia	Students	This study addresses two aspects of team-based learning in an aim to better support and facilitate student learning and engagement: (1) supporting students during their pre-class preparation by providing metadata on the often-difficult required readings, and (2) offering students communication from the teacher, or 'expert'

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
Walls, S. M.; Kucsera, J. V.; Walker, J. D.; Acee, T.W.; McVaugh, N. K.; Robinson, D. H.	Podcasting in education: Are students as ready and eager as we think they are?	2010	2007	USA	Students	Examine students' readiness and attitudes towards repetitive and supplemental podcasting. A secondary interest is to contribute to the research debate of whether repetitive podcasting can affect student attendance.
Wang, M.; Chen, Y.; Khan, M. J.	Mobile Cloud Learning for Higher Education: A Case Study of Moodle in the Cloud	2014	N/A	USA	Faculty & Students	To explore how cloud computing changes traditional mobile learning. A case study of the usage of Moodle in the cloud via mobile learning in Khalifa University was conducted.
Wang, M.; Shen, R.; Novak, D.; Pan, X.	The impact of mobile learning on students' learning behaviours and performance: Report from a large blended classroom	2009	2007–2008	USA	Students	To gauge learner response to the benefits and challenges of the Shanghai mLearning system towards a goal of shaping further developments.
Wilson, M.; Bolliger, D. U.	Mobile Learning: Endless Possibilities for Allied Health Educators	2013	2010–2012	USA	N/A	To expand ideas on what mobile learning is, the possibilities that it holds to influence education both inside and outside the classroom, and how allied health educators may be able to incorporate mobile learning into their curricula.
Vogt, M.; Schaffner, B.; Ribar, A.; Chavez, R.	The impact of podcasting on the learning and satisfaction of undergraduate nursing students	2010	2007–2009	USA	Students	Examine the impact of podcasting on nursing student learning and satisfaction.
Vuojärvi, Hanna; Eriksson, Miikka; Ruokamo, Heli	Designing Pedagogical Models for Tourism Education: Focus on Work-Based Mobile Learning	2012	2010–2011	Finland	Students	Develop a pedagogical model that exploits mobile technologies and electronic learning environments and that is applied especially to develop decentralised tourism education in tourist destinations with extremely mobile tourism students.

Table 5 (continued)

Author(s)	Title	Publ. Year	Year of Data	1st Author Country	Respondent Type	Purpose
Yau, J. Y.-K.; Joy, M.	A Mobile Context-Aware Framework for Managing Learning Schedules: Data Analysis from an Interview Study	2009	N/A	UK	Students	Describe the design of a theoretical framework to support those students who wish to carry out their learning at different locations with variable amounts of time available to them. Our goal is to recommend (the most) appropriate activities to them, given the particular circumstances, in an attempt to maximize their learning productivity.
Yau, J. Y.-K.; Joy, M.	An adaptive context-aware mobile learning framework based on the usability perspective	2010	N/A	UK	Students	Determine whether a diary approach can be used as a successful way of retrieving: 1 the user's learning contexts; 2 which learning materials would be appropriate for which circumstances.
Yen, J.-C.; Lee, C.-Y.	Exploring problem solving patterns and their impact on learning achievement in a blended learning environment	2011	2008–2009	Taiwan	Students	Explore problem solving patterns and their impact on learning achievement in a blended learning environment.
Yin, K. Y.; Fitzgerald, R.	Pocket learning: a new mobile learning approach for distance learners	2015	2014	Malaysia	Students	To explore mobile learning methods that could promote distance learners' interest and engagement. A subsequent investigation of the facilitators and distance learners' views was conducted following the use of the mobile app.
Young, P.; Moore, E.; Griffiths, G.; Raine, R.; Stewart, R.; Cownie, M.; Frutos-Perez, M.	Help is just a text away: The use of short message service texting to provide an additional means of support for health care students during practice placements	2010	2007–2008	UK	Students	Evaluate SMS as a means to make students feel lessa abandoned while on placement.
Zawacki-Richter, O.; Brown, T.; Delport, R.	Mobile Learning: From Single Project Status into the Mainstream?	2009	2006–2007	Germany	Faculty	To explore mobile learning as a new field of pedagogical activity.

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