RESEARCH ARTICLE

Use of audio podcast in K-12 and higher education: a review of research topics and methodologies

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Abstract This article reviews past empirical studies on the use of audio podcast (hereby referred to as podcast) in K-12 and higher education settings. Using the constant comparative method, this review is organized into three major research areas or topics: (a) participants' podcast usage profile, (b) effects of podcast on learners' outcomes, and (b) institutional aspects. Findings suggest that the most common use of podcasting is limited to either instructors distributing podcast recordings of lectures or supplementary materials for students to review subject material at their own time and place. A majority of the previous studies were descriptive, and were conducted in higher education and traditional course settings. Students generally enjoy using podcast, and tend to listen to the podcasts at home using desktop computers, rather than on the move (e.g., commuting to school) with a mobile device. Probably the main benefit of podcasting is that it allows students to listen to specific material that they missed or did not understand multiple times. The availability of podcast does not appear to encourage students to skip classes. We also discuss limitations of previous empirical studies, and provide some directions for future research related to the use of podcast in education settings.

Keywords Podcast · K12 · Higher education · Review of research

Introduction

In recent years, the use of podcasts has increased in a number of fields such as tourism, entertainment, library research, and education (Lakhal et al. 2007). Podcast content can include audio, video, and image materials (Rossell-Aguilar 2007). The scope of this article, however, is limited to audio podcast (hereby simply referred to as podcast) since currently it is the most common content used in education contexts (Rossell-Aguilar 2007). Podcast content and frequency can be diverse, from hourly 3-min newscasts, through daily 20-min

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commentaries, to weekly one-hour in-depth discussions (Bell et al. 2007). Some of the characteristics of podcasting include:

1. It uses file-based downloads as opposed to streaming. The latter refers to playing the media as it downloads, whereas podcast files are downloaded in their entirety before they are played (McLoughlin and Lee 2007).
2. Podcasts can be syndicated and used with the Really Simple Syndication (RSS) and Atom technology that allow their contents to be automatically downloaded or pushed to the user (Dixon and Greeson 2006; Maag 2006). Although subscribing to a feed such as RSS is the most convenient way to receive podcast, many podcasts can also be downloaded manually from the Internet if the user chooses to (Copley 2007; Van Orden 2005).
3. The podcast content is consumed on the user's personal computers or portable devices. Examples of portable devices include dedicated MP3 players such as iPods, mobile phones, and personal digital assistants (PDAs) that have MP3 playback capabilities (McLoughlin and Lee 2007).

Podcasting is a relatively recent phenomenon with the first RSS audio feeds appearing in July 2003 (Doyle 2005) and by mid-2005, there were approximately 10,000 different podcasts available on a wide range of topics (Bell et al. 2007). In 2005, the *New Oxford American Dictionary* selected "podcasting" as the word of the year, and it appeared in the dictionary in 2006 (Bell et al. 2007; Lane 2006). According to the Pew Internet and American Life Project (2005), more than 22 million Americans own MP3 players and more than 6 million have downloaded podcasts to enjoy at their leisure.

The case for podcasting in education

Advocates of podcasting believe that it can offer unique educational benefits to learners. One of the earliest reports describing the potential of podcasting in education was by Clark and Walsh (2004). They highlighted that "listening is instinctual, [but] reading and writing are not" (p. 5)—that linguistic psychologists have found that unlike reading and writing, children do not learn how to understand the spoken word, but are hard-wired with the skill (Chan and Lee 2005). Similarly, Durbridge (1984) stressed the advantages of audio for learning. In his opinion, the spoken word can influence a learner's cognition (adding clarity and meaning) and motivation (by conveying directly a sense of the person creating those words).

Another unique advantage of podcast is the time-shifting ability that it affords to the listeners (Muppala and Kong 2007). Listeners are no longer constrained by time and space with regard to their learning activity (Clark and Walsh 2004). Auditory learning is the most portable form of learning, and can be used anytime and anywhere (Muppala and Kong 2007). Lee and Chan (2007b), for example, maintained that short, "bite-sized" (p. 206) audio clips can not only fill dead-time moments amidst other day-to-day activities, but also coincide with these activities for pervasive learning that is interwoven into the learners' lifestyles. This allows for learning that takes place regardless of time and geographical locations (Clark et al. 2007).

It is, of course, possible that the aforementioned educational benefits can also be attributed to the use of other audio technologies such as internet audio streaming, audio cassette tapes, and compact discs (CDs). Although this may be true, there is a certain advantage of podcasting over these audio technologies. Probably the main advantage of podcasting is the simplicity, convenience, and time savings that it offers to learners. First, podcasting greatly simplifies the process of obtaining relevant materials. Learners do not have to manually plough through different various sites for relevant content, or continually

monitor these sites for updates because as new podcasts become available on subscribed feeds, the files the user refers to are automatically downloaded with no intervention on the user's part (Lee and Chan 2007b). Moreover, by having a computer continuously online so that bandwidth-intensive content can be dripped in and made available when ready, the click-and-wait situation typically found in the streaming delivery method can be eliminated, even over slower (e.g., dial-up) Internet connections (Lee and Chan 2007a).

Second, although it is possible to use audio cassette or CDs to convey the spoken words, the ubiquitous nature of the World Wide Web makes it more convenient and easy for students (particularly online students) to access the podcast files in mp3 format, rather than having to ship or mail students the cassette tapes or CDs. For example, in a survey of 199 students, researchers at UC Davis found that 96% of students preferred files in mp3 format versus 2% for audio cassettes (Kleinschmidt and Harrington 2006).

However, it should also be noted that podcasting is not without its detractors. Critics of podcast voice their concerns about the increase in teacher or instructor workload for those who create the podcasts (Blaisdell 2006; Menzies 2005). Another frequently cited criticism of podcasting relates to the issue of absenteeism (Bongey et al. 2006). Blaisdell (2006) noted that if the lecture is going to be available for podcast downloading, why then should students bother coming to class? Similarly, when referring to podcasting, an article in *The Chronicle of Higher Education* states that "…many professors remain wary of the technology…that it will lead to empty classrooms or a crutch for late-sleeping students" (Read 2005, p. A39).

Purpose and significance of this review

The purpose of this article is to review the use of audio podcast in K-12 and higher education settings. The current review follows the guidelines set by Creswell (1994), which stated that the goal of a review is to summarize the accumulated state of knowledge concerning the topic of interest and to highlight important issues that research has left unresolved. This is accomplished by summarizing the predominant research areas or topics, discussing the weaknesses or limitations of current research, and highlighting several directions for future research related to use of audio podcast in education.

This review is significant in three fundamental ways. First, this review helps educators to better understand how learners use this new technology of podcast. Educators could use this information as a basis for a better integration of podcast in teaching and learning that maximizes opportunities for learner success. Second, this review provides a summary and critique of the research methods used thus far in the study of podcast in K-12 and higher education and their limitations. Such knowledge can raise the awareness of the need for a more robust research design in future studies of podcast. Third, this review identifies unanswered questions in the literature and proposes future research directions that could help advance the knowledge base of podcast use in education settings.

Method

Searching and selection procedures

The search for relevant literature was completed in three stages. First, we examined accessible articles that we found in computerized bibliographic databases using the keyword search *podcast*. One essential criterion for the selection of the articles is that they

must report studies that are original and empirical. Theoretical conceptualizations were not included in this review, although they were used as background reference material.

We used the following databases: (a) *Education Research Complete*, (b) *ERIC*, and (c) *PsycARTICLES*. As of end April 2008, our database searches revealed 85 hits. In the second stage, we searched the *EdITLib Digital Library for Information Technology and Education* that includes paper proceedings from four international conferences: (a) *International Conference on Mathematics/Science Education and Technology*, (b) *Society for Information Technology and Teacher Education International Conference*, (c) *World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education*, and (d) *World Conference on Educational Multimedia, Hypermedia and Telecommunications*. These yielded an additional 49 articles. Finally, we used the "snowball" method by searching for articles that are cited in some of the articles that we had read.

Altogether, we had a total of 153 articles. Of these 153 articles, 123 were discarded. These articles were discarded because they were opinion papers, non-empirical descriptions of program implementations, literature reviews, or non K-12 and higher education related. Articles that reported solely non-audio podcast study (e.g., video podcast or vodcast as more commonly known) were also excluded in this review. However, if an article described a study that made use of audio podcasts, along with some vodcasts, we reviewed it, and highlighted to the reader that a mixture of podcast types was used. The Appendix (Table 2) lists the remaining articles ($n = 30$) which we included in our review of research. These articles are summarized—giving brief details of the authors, year of publication, research aim, research method, data collection method, and context.

Data analysis

The basic unit of analysis was each individual empirical article. We used the constant comparative method or grounded approach by Lincoln and Guba (1985). This method is similar to the iterative pattern coding approach (Miles and Huberman 1994). Using the constant-comparative method, the coding scheme was not predetermined prior to our analysis but emerged inductively from the data. Specifically, the constant-comparative method involves the following steps: examining each individual article, forming various categories, comparing categories, and achieving category saturation. For instance, we began by selecting the first article, reading it, and noting its content to form a tentative *research topic* category. This first article represented the first entry in the first tentative category of research topic. We then selected the next article, read it, and again noted its content to determine whether its content was similar to the first article. If so, we put the second content into the first category and proceeded to the third article. If not, the second content represented the first entry in a new second tentative category of research topic. As we read each unit, we compared it to the existing categories until each category was saturated—meaning new articles began to confirm the existing categories rather than creating new ones. At the conclusion of our constant-comparative approach, we ultimately chose three major topics or themes to define our review of previous research on podcast (see following section).

Podcast research topics

This section presents current findings related to three main topics of podcast research (participants' podcast usage profile, effects of podcast on learners' outcomes, and

Table 1 List of major podcast research topics

Topics	Sub-topics
Podcast usage profile	Current practices in podcasting
	Learners' podcast listening preference
	What do students use to listen to podcasts?
	Where do students listen to podcasts?
	How long do students prefer the podcasts to be?
	Barriers of using podcast
Effects of podcast on learners' outcomes	Cognitive outcomes
	Affective outcomes
Institutional aspects	Impact of podcast on learner attendance in class/lecture
	Costs of producing podcast

institutional aspects), along with the support of exemplar cases. The list of topics and their relevant sub-topics identified are shown in Table 1.

Podcast usage profile

Podcast usage profile is a topic that encompasses the following three sub-topics: (a) current practices in podcasting, (b) learners' podcast listening preference, and (c) barriers of using podcasts.

Current practices in podcasting

A taxonomy has emerged from the review (see Fig. 1). This taxonomy, adapted from Rossell-Aguilar (2007), should not be seen as exhaustive but a way to classify the current uses or practices of podcast in K-12 and higher education settings.

From Fig. 1, it can be seen that podcasting can be divided into two main groups: creating own materials, and using available existing podcast resources. The former can be classified into two main groups: podcasts developed by teachers, and podcasts developed by students (Rossell-Aguilar 2007). Available existing podcast resources typically consist

Fig. 1 Taxonomy of current practices of podcast in K-12 and higher education (adapted from Rossell-Aguilar 2007)
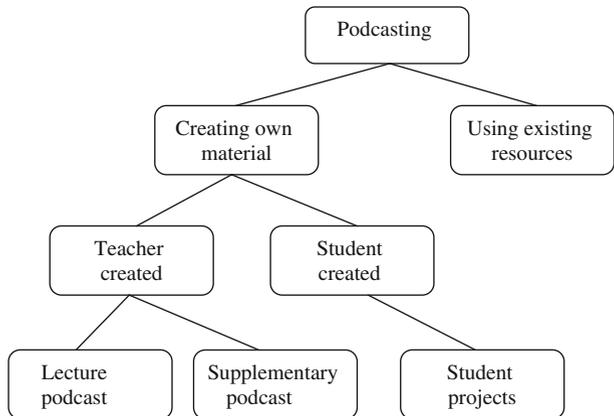
of podcasts found in web pages of mass media organizations (e.g., CNN, BBC), academic institutions (e.g., Stanford University), or hobby sites (e.g., surfing, baseball) (Anzai 2007).

Teacher-created podcasts can be divided into two main types: lecture podcasts, and podcasts of supplementary learning materials. Lecture podcasts refer to audio recordings of lectures, such as a 45-min lecture on marine science (Copley 2007). Supplementary podcasts refer to audio recordings that aid student learning and provide support in relation to the core learning materials (Lee and Chan 2007b). Examples of supplementary podcasts typically include assignment tips, hints and post-assignment feedback from the lecturer (Edirisingha 2007; Lee and Chan 2007b), shortened version of the day's lecture (Baker et al. 2007), and audio recordings of the lecturer reviewing learning outcomes and adding clarification (Evans 2007). Student-created podcasts, on the other hand, typically included student projects involving the use of podcast such as that described in the study by Plankis and Weatherly (2008). Participants in the study were Grade 12 students. Students created a podcast to share with future students a description of their classroom aquatic science projects, as well as how they could have improved their results.

Although the taxonomy provides a useful way to classify the current practices of podcast, it stops short of illustrating how podcasting may be integrated into the school curriculum. Therefore, in order to describe the relationship of the podcasts being employed with the curriculum or with what is going on in the class, we adapted O'Bryan and Hegelheimer's (2007) model of integration scenarios or strategies. O'Bryan and Hegelheimer (2007) originally proposed three schematic integration scenarios or strategies (a, b, and c), as illustrated in Fig. 2.

Figure 2a shows how podcasting in the first strategy merely duplicates the class or lecture sessions. Lecture podcasts were mainly utilized in this integration strategy. Typically, in this strategy, students had already attended the day's face-to-face lecture in person—the podcasts served mainly as a safety net or backup for students to have in case they wish to review the materials covered in the face-to-face lectures. In the second integration strategy, the podcasts adds relevant information to what was covered in class or lecture and thereby provides more information, as indicated by the two-directional arrow connecting the class and podcast, and the plus sign (O'Bryan and Hegelheimer 2007) (see Fig. 2b). Podcasts used in the second integration scenario therefore were primarily supplementary in nature. The third integration strategy (Fig. 2c) builds on the second one, with the difference being the podcast in the third strategy provides relevant new material for subsequent classes or lectures, thus also serving a preparatory function (O'Bryan and Hegelheimer 2007). For example, the podcasts used in


Fig. 2 Schematic integration scenarios of podcast (the first three—**a**, **b**, and **c** are extracted from O'Bryan and Hegelheimer (2007)
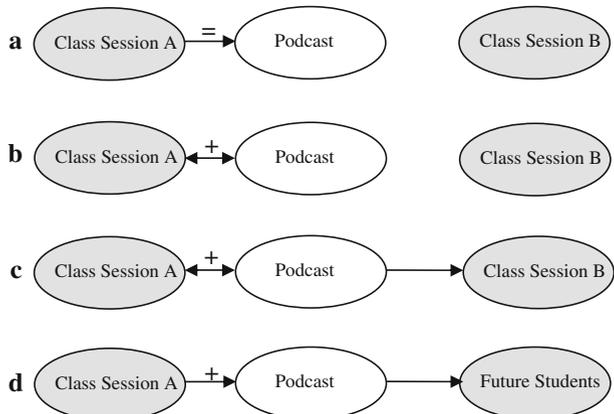
Bell et al. (2007) reviewed the lecture material from the past week, as well as discussed upcoming topics that would be covered in the subsequent class. Similarly, the podcasts employed in O'Bryan and Hegelheimer (2007) acted as a bridge between classes by building on concepts discussed in the current class and helping students prepare for the next class by introducing some pertinent new material that will be referenced in the next class. Our review contributed to the knowledge base by revealing a fourth integration scenario. In the fourth scenario (Fig. 2d), the podcast represents work accomplished by the students in a particular course, and this work serves as materials for use by future stakeholders, as illustrated by the students in Plankis and Weatherly's (2008) study. Unlike the first strategy, the podcast created in "d" did not duplicate what was covered in class.

On the whole, the past research reviewed on podcast had been carried out in six different disciplines of study: engineering and sciences (e.g., electrical engineering and biology), computing and information technology (e.g., computer science), language (e.g., English as a foreign language), business and law (e.g., marketing), education, and other. The "other" category is reserved for any disciplines that were not defined or clearly explicated by the authors of the study. For example, Tohill (2008) reported a study that collected data from a survey of more than 100 participants from various disciplines who expressed their opinions of using podcast in the classroom. The exact disciplines were not indicated. Results suggested that podcast had been most frequently used in the engineering and science (33.3%), as well as computing and information technology disciplines (33.3%). This was followed by business and law (13.3%), language (10%), others (6.7%), and education (3.3%) (see Fig. 3). Surprisingly, the use of podcast is relatively low in the language discipline since one might expect that the use of audio as an instructional medium would be self-evident in cases such as learning a foreign language (Barron 2004). We speculate that educators and students of science and technology might have more familiarity with Internet technologies such as podcast than would their counterparts in other majors.

We also summarized the various settings, such as K-12, higher education, traditional courses, and distance courses, in which past research on podcast had been conducted. We defined traditional courses as face-to-face courses, or face-to-face courses with an online
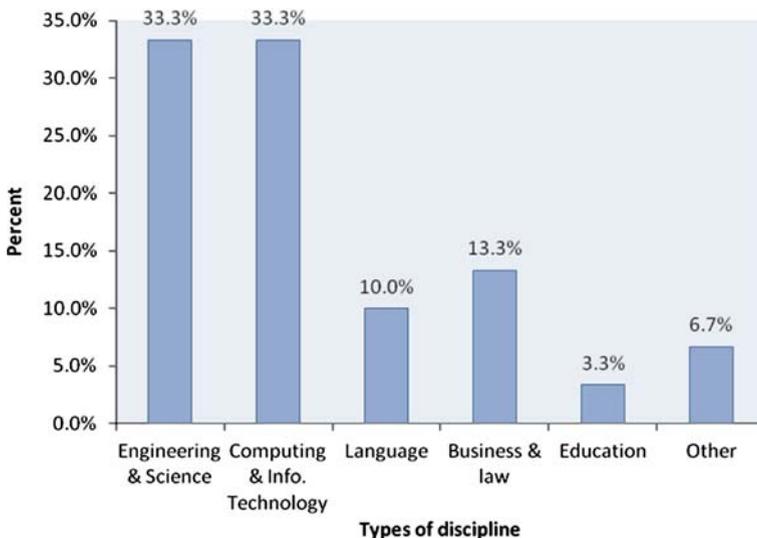
Fig. 3 Types of disciplines of study in which podcast had been used

component added (blended or hybrid). We defined distance education courses as courses taught totally online. On the whole, a majority of previous studies on podcast were carried out in higher education settings (93.3%). One study was conducted in a K-12 setting while one was carried out in both higher education and K-12. In addition, results suggested that past podcast research had been more frequently carried out in traditional course settings (80%) than distance courses (20%).

A further examination of the previous studies yielded the following observations about the use of podcasts. First, in both traditional, as well as distance education courses, the most common use of podcasting was primarily restricted to instructors distributing podcast recordings of lectures (i.e., integration scenario, Fig. 2a) or supplementary materials for students to listen (integration scenario, Fig. 2b). Additionally, in traditional courses, we found integration scenarios (Fig. 2c, d) of podcast implementation. These, however, were currently not evident in the distance courses. Second, hitherto in our review, we found that the second integration scenario was the most commonly used strategy of podcast implementation in higher education, followed by the first integration scenario. The study in K-12 setting (Plankis and Weatherly 2008) utilized podcast illustrated by the fourth integration scenario in which students created podcasts for use by future students taking the course. We are presently limited in our attempt to make further comparison between the use of podcasts in K-12 and higher education because of the current lack of research attention on K-12 contexts.

Learners' podcast listening preference

Before the impact on any learning experience can be studied, data are usually needed on the learners' use (Rossell-Aguilar 2007) or preferred use of podcast. Research in this section addressed the following questions: (a) what do students use to listen to podcasts? (b) where do students listen to the podcasts? and (c) how long do students prefer the podcasts to be? The answers to these questions can help inform design. For example, knowing whether learners prefer to listen to only 5 min or less of audio materials as opposed to 30 min would have an impact on the actual design of the podcast duration.

Thirteen studies covered the first two questions either singularly or as one of the questions being investigated (Anzai 2007; Brittain et al. 2006; Clark et al. 2007; Copley 2007; Edirisingha et al. 2007; Evans 2007; Gribbins 2007; Lane 2006; Lee and Chan 2007b; Malan 2007; Muppala and Kong 2007; Tynan and Colbran 2006). All these studies employed the descriptive research method. Descriptive research is typically naturalistic and depicts conditions as they exist in a particular setting (Ross and Morrison 1997). Such research is mainly concerned with *what is* type of questions that describe events focusing on a particular issue or phenomenon (Knupfer and McLellan 1996). Data collection methods used by these studies typically included student questionnaires, student interviews, and teacher interviews.

For example, regarding the first question on "what students use to listen to the podcasts?", Copley (2007) used a student questionnaire to examine marine science undergraduate and graduate students' use of podcasts. The survey consisted of several sections, one of which examined students' download of podcasts and the equipment they used to them. Results revealed that most of the respondents (94% of 84 students) who downloaded the podcasts played them mostly on a personal computer. Lane's study (2006) explored students' use of podcasting in large lecture courses and found that of the 41 students, 81% used a desktop computer rather than a portable player to listen to their podcasts. Overall, with various majors such as English as a Foreign Language, health

sciences, marketing, marine science, linguistics and communication, business and management, and law represented in the 13 studies that examined the first two questions, the majority of studies suggested that students both in the traditional and distance education settings tend to listen to the podcasts at home using desktop computers, rather than on the move (e.g., commuting to school) with a mobile device.

Other researchers (e.g., Anzai 2007; Chan and Lee 2005; Muppala and Kong 2007) were interested in examining the third question: "how long do students prefer the podcasts to be?" These studies also employed the descriptive research methodology. So far, studies yielded mixed results. For example, Anzai (2007) found that most students indicated that the length of the podcast they preferred to listen to was about 5 min. Chan and Lee (2005) employed student questionnaires and focus groups in their study to explore students' preference for the optimal length of podcasts. When asked how many minutes they would be willing to the supplementary podcasts, a majority of the students (45% of 26) indicated that they preferred between 9 and 10 min, 29% preferred between 3 and 5 min, and 25% between 6 and 8 min. Results from the Muppala and Kong (2007) study found most students downloaded and listened to about 5–20 min of the podcasts.

Barriers of using podcasts

Seven studies, utilizing the descriptive research methods, examined the barriers of using podcasts. The key barriers could be parsimoniously categorized as either student-encountered or instructor-encountered.

Student-encountered barriers include: unfamiliarity with podcasts, technical problems in accessing and downloading podcasts, and not seeing the relevance for their learning (Bell et al. 2007; Edirisingha et al. 2007; Lane 2006; Ogawa and Nickles 2006; Tynan and Colbran 2006). Instructor-encountered barriers include: unfamiliarity with podcasts, not seeing the relevance of podcasts for their subject areas, and lack of time to prepare the podcasts (Bull et al. 2007; Tohill 2008).

Discussion

Our review in this section of podcast usage profile increases our understanding of the research method employed, and the different facets related to podcast usage such as the types of podcasts employed, podcast integration strategies, podcast listening preference, and the barriers to using podcasts. In this section, we discuss some of the findings, as well as highlight some unanswered issues.

First, all of the previous research studies examining participants' podcast usage profile were descriptive in research design, and employed small numbers of participants to generalize findings to a larger population. One possible reason for the wide use of descriptive research methods is that the use of podcast in K-12 and higher education is a relatively new field of study, in which important variables and processes have yet to be fully developed and understood. Hence, other research methods such as experimental research that involve questions about cause and effect might be regarded as premature. The use of descriptive research can provide information that can help isolate the variables that will eventually be used to measure cause and effect, and at the least can help furnish background information that will aid logical interpretations of research questions within the context of a specific situation (Knupfer and McLellan 1996).

Second, interestingly, the prediction that podcasting could result in pervasive mobile learning that truly takes place anywhere, as argued by advocates, did not bear fruit. The

current findings suggest that students both in the traditional and distance courses tend to listen to the podcasts mostly on a desktop computer at home or at their halls of residence rather than on the move on a mobile device. In addition, most students said that they listened to podcasts while not engaged with any other activities. These findings suggest that impressions or beliefs, rather than empirical evidence, are often used as the basis for arguing that podcasting allow students to multitask and promote a high level of lifestyle integration (Lee and Chan 2007b).

We conducted an additional literature search to uncover the possible reasons for the tendency of students in podcasting studies to avoid multitasking. Our search yielded three possibilities. The first possible explanation is that students' perceptions of listening to academic or educational material are different from listening to music (Edirisingha 2007). Students, for example, pointed out that the mode of listening to educational or academic material requires one to sit down and work on the material as opposed to multi-task with it. Music, on the other hand, is something one plays in the background while being engaged in other work. Second, students may not wish their study to infringe on their personal (e.g., social, leisure) and professional (work) time, and hence purposefully choose to demarcate boundaries to keep these aspects of their lives separate (Lee and Chan 2007b). The third possibility is that students may find it difficult to absorb and process information from multiple concurrent sources (Lee and Chan 2007b). Cognitive load theory informs us that a split attention effect occurs when a student attempts to attend to multiple information sources concurrently, causing him or her to divide attention between tasks (Lee and Chan 2007b). According to Sweller (1999), few, if any, humans are capable of dealing effectively with many of the cognitive tasks demanding split attention due to our limited working memory. For example, Hembrooke and Gay (2003) found that students who multitasked using their laptops while listening to lectures performed more poorly on recall and recognition questions for the lecture content when compared with those who did not multitask. Although Hembrooke and Gay did not actually examine the use of podcast, there is little reason to think that students who use podcast would find it easier to multitask.

Third, the studies reviewed produced mixed findings with regard to students' preference of a podcast length. Taking the combined results of the three empirical studies conducted in traditional course settings would yield a range of 5 to 20 min. Other scholars, however, disagree (Chan and Lee 2005; Walsh 2004). Walsh (2004), for example, advocates designing podcast length in adherence to the metaphor of a song. He explains (para. 6):

There's a reason most songs are *less than four minutes* [italics added]. If you haven't gotten to the hook by then, you're not going to make it in the next nine. People go to the bar during the drum solo. They do the same in their minds when you don't tell it quick and tell it straight in your learning delivery, whatever the mechanism.

However, if, as students in Edirisingha's (2007) study suggested, listening to academic podcast was different from listening to music, then Walsh's notion appears to be incorrect. We believe the question of how long a podcast should be is a complex one that involves the interplay of many factors, including the content of the subject matter that is being podcasted, the perceived usefulness of the podcasts in the eyes of the students, and whether listening to the podcasts is a mandatory requirement. For example, research on wiki[1] showed that students generally persevered and were more significantly inclined to use wiki when such use was mandated and backed up by an incentive scheme (Mindel and Verma

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[1] A wiki is an expandable collection of interlinked web pages, a hypertext system for storing and modifying information—a database where each page is easily editable by any user (Leuf and Cunningham 2001).

2006; Moshirnia 2007). Additional research is needed to explore this possible interpretation in podcast use.

Fourth, we found one surprising issue in that although subscribing to a feed is the most convenient way to receive a podcast, not all students preferred to do so. An illustrative example can be found in Lee and Chan's (2007b) study. Specifically, they reported that despite students being in clear agreement with the statement "Subscribing to the feed using an aggregator or podcatcher to allow automatic downloading of the podcasts makes it easier for me to obtain them", 61.1% of students (11 of 18) indicated that they favored manual download of the files via a web browser. Unfortunately, the actual reason for this was not explored by the researchers. We speculate that some students chose to manually download the podcasts because it gave them control over which podcast episodes to download as compared to the subscription mode. Additional research could be conducted to investigate this issue.

Fifth, four main barriers associated with the use of podcasts were uncovered in the review. These barriers, which were mainly associated with podcast use in traditional course settings, could be classified as either first- or second-order barriers (Ertmer 1999). First-order barriers, which are obstacles external to the participant, include lack of time to prepare podcasts, and technical problems in accessing and downloading podcasts. Second-order barriers, which are obstacles intrinsic to the participant, include unfamiliarity with podcasts, and not seeing the relevance for their learning. To determine if there are any differences between the barriers related to podcast usage and the use of other computing devices, we examined Hew and Brush's (2007) work that summarized the findings of research on desktop computers, laptops, and handheld computers. We found that much of what had been written about the first- and second-order barriers related to podcasting were similar to those of other computing devices. Consequently, the strategies to overcome such podcast usage barriers may be extrapolated from strategies found effective in overcoming barriers of using other computing devices.

However, there is one limitation that is unique to podcast usage: inability of podcasts to relay visual information. We feel that this issue, however, may not be a fair criticism of audio podcasting because the original intended use of such podcast is to convey audio, not visual, information. One strategy seems to hold particular promise in such a case: vodcast, rather than audio podcasts may be used to convey *both* visual and audio information.

There are several limitations concerning previous research studies. First, several studies had incomplete description of methodology and context such as failing to clarify what the design or style of podcasts that were used look like (e.g., no indication of the duration of the podcasts or the types of podcasts used), or failing to report the research duration, and number of participants. We recommend that future research should provide a rich, thick description of the methodology and context so that findings can be adequately interpreted.

Second, we found that a majority of the studies tend to place greater emphasis on the features of the tools and procedures, rather than on the theoretical rationale or justification for using them. As with any novel technological tool, educators need to evaluate the reasoning behind the use of podcast (Maag 2006). The use of theoretical foundations will not only provide a rationale for using podcasts, but also help inform the pedagogy of using them. We therefore recommend that researchers invoke appropriate theoretical foundations to inform future research. Some of these might involve multiple intelligences theory (Gardner 1993), second language acquisition theory (O'Bryan and Hegelheimer 2007), mental representation theory (Paivio 1986), and multimedia learning theory (Mayer 2001).

Third, the most common use of podcasting at present is predominantly limited to instructors distributing lecture or supplementary podcasts for students to listen to. This

tendency is possibly due to the relative ease of generating such content (Copley 2007). Such a practice may be considered an extension of the now-common practice of providing electronic versions of slides either as PowerPoint files or pdf handouts (Copley 2007). Although there is much to be gained by listening to instructors' podcasts, it is an even more valuable experience for students to create their own podcasts (Jonassen et al. 2008). However, studies that employ the use of student-created podcasts are hitherto lacking.

Effects of podcast on learning and affective outcomes

The effects of podcast on learning and affective outcomes were also explored in previous research studies.

Learning outcomes

One question that people who use podcasts for teaching and learning want to answer is whether podcasts can help improve students' learning. There are two major approaches to answering this research question. The first approach analyzes the effects through participants' self-reports. Data sources in this approach typically include students' retrospective self-perception data via questionnaires or interviews. The second approach explores the effects through the use of experimental, quasi-experimental, or ex-post facto designs. Data sources in this approach typically include examination scores, test scores, or quiz results.

In our review of the research, we found eight studies that utilized the first approach to examining the effects of podcast on student learning (Anzai 2007; Bongey et al. 2006; Clark et al. 2007; Evans 2007; Lane 2006; Lee and Chan 2007a; Maag 2006; Tynan and Colbran 2006). These studies did not employ any control group in their designs. Results from the student self-report studies in both traditional and distance courses, on the whole, appeared to suggest that the use of podcast could enhance student learning. For example, Anzai (2007) surveyed Japanese students regarding their experience in using supplementary podcast in an English as a foreign language course. The study found that most students felt that utilizing podcasts could enhance their learning of English. Another study (Bongey et al. 2006) surveyed 246 biology college students regarding their use of lecture podcasts. The study showed similar results to those in Anzai (2007). Students perceived that podcasts to be useful in helping them increase their understanding of material covered in lectures. In another study, Clark et al. (2007) surveyed 30 postgraduate marketing students on their experience of using podcasts. Results indicated that 96% of the students felt they had gained learning benefits from using the podcasts. Another study (Lane 2006) explored 42 health sciences students' experience of using lecture podcasts. Of the 41 students, 70% indicated that podcasts supported their learning and were helpful when preparing for examinations. Students in these studies typically pointed out that the use of podcast enabled them to listen to specific information or material they had missed or did not understand multiple times.

Instead of relying on student self-report data, other researchers used students' examination, test or quiz scores (Abt and Barry 2007; Baker et al. 2007; Lakhal et al. 2007). For example, Abt and Barry (2007) utilized an experimental research design to examine the effect of students using podcasts in a first year undergraduate exercise physiology module. Fifty students were randomly assigned to either a podcast group or a control group. The podcast group listened to six podcasts over six weeks, while the control group was given exact transcript of the podcasts in printed form. The podcasts produced for the study were recorded in a 'radio' style format incorporating a question-and-answer discussion between two

instructors of the course. After six weeks, both groups were examined using a 32-question multiple-choice test. The control group improved their test performance by 43%, whereas the podcast group improved by 46%. The difference between the groups was a mean effect size of 0.19 (trivial). This suggested that the use of podcasts might not result in a worthwhile improvement in student achievement over-and-above the use of written material.

Baker et al. (2007) were interested in knowing whether the inclusion of podcasts as a supplementary tool in a blended university course had an effect on student learning outcomes based on course grade. Each podcast was an abbreviated lecture of that particular day's 50-min regular class lecture. The researchers utilized an ex-post facto research design. Quizzes were administered to students in the previous semester when podcasting was not available (control group). The same quizzes were given to the students in the following semester when podcasting was available. Results of t-tests suggested that the mean score of both quizzes was not affected by the availability of podcasting.

In a quasi-experimental study with 192 undergraduate students in a management information systems course, Lakhal et al. (2007) compared the final marks of students who listened to lecture podcasts with those who did not. Although results suggested that listening to podcasts had a positive effect on student *satisfaction*, listening to podcasts had no effect on students' performance.

Affective outcomes

In addition to learning outcomes in the cognitive domain, researchers were also interested in outcomes in the affective domain, such as students' or faculty members' attitudes, and satisfaction of podcasting. Researchers typically used descriptive research methods to report students' or faculty's affective outcomes (Bull et al. 2007; Gribbins 2007; Nathan and Chan 2007; O'bryan and Hegelheimer 2007; Ogawa and Nickles 2006; Plankis and Weatherly 2008). Generally, the results of these studies suggested that students in traditional and distance courses were positive towards using podcast, and their willingness to assimilate this new technology into their learning. Some of the reasons for the positive perceptions included the opportunity for students to learn at their own time, and to listen to specific material that they miss or do not understand multiple times. Instructors were also generally satisfied with podcasting. They felt that when learning is available through podcasts, students will have more opportunities to interact with the curriculum. Hence, they may learn more.

Discussion

Although studies have documented that students generally felt that the use of podcast could enhance their learning, there was no significant difference in students' actual performance between those who used podcast versus those who did not. This latter finding should, however, be viewed with some caution given the limitations of previous studies in this section. For example, in a study by Baker et al. (2007), the researchers highlighted that the sample size was too small (only 4 participants who used podcast, compared with 17 who did not) for much validity to be attributed to the result. Similarly, Lakhal et al. (2007) pointed out that the number of students who listened to the podcasts was much lower than those who did not (42 versus 150). Moreover, most of the students did not choose to write the final examination which gave a higher performance for those who did.

However, despite the cautionary note, we believe that it may not be too farfetched to suggest that students learn equally well regardless of whether they use podcasts or not.

Evidence from past media comparison suggests that this is so (Clark 1994; Russell 1999). Given that many of the past media comparison research studies show that students learn equally well regardless of the types of media used, there is little reason to think that students who use podcast would learn better than their counterparts who do not.

Our review found three other limitations concerning previous empirical studies. First, research in this section limited its focus primarily on higher education settings (17 studies) with very little attention on K-12 contexts (only one study). This aspect limited our attempt to make comparisons about the effects of podcasts across different education settings and participants' age.

Second, studies examining the effects of podcast on students' cognitive domain were limited mainly to disciplines such as engineering, science, and technology, and business and law. More research addressing the use of podcasting in other disciplines is needed. It should be noted that we are not advocating more media comparison studies per se. Historically researchers in instructional technology have voiced concerns about comparing learning outcomes between different media. This is due to the presence of many potential confounding variables which makes the task of pinpointing specific factor or factors that may account for the learning difference difficult, if not impossible (Clark 1983; Tallent-Runnels et al. 2006). Instead, since different media possess different attributes and capabilities (Kozma 1994), future research might focus on examining where and how to best use podcast as an instructional medium. As noted by Barron (2004), the selection of audio as an instructional medium is self-evident in some cases such as learning a foreign language, or studying music. Hitherto, research on the use of podcasting in these subjects is scarce.

Third, more than three-quarters of the studies (78%) were limited in their duration, ranging from less than three weekends to one semester (3 of the 18 studies did not indicate the study duration). Studies that are short-term may be more prone to suffer from a novelty effect. Novelty effects with newer media is a confounding variable due to the tendency of participants to pay increased attention to technology that is new to them (Clark 1983). Such a possibility, has indeed, been surfaced by Malan (2007) who found that sheer novelty explained some students' enthusiasm for the podcasts.

Fourth, so far in our review of studies, only one (Abt and Barry 2007) reported effect sizes in the findings. The APA Task Force stressed that researchers should provide some effect-size estimate such as Cohen's d when reporting a p value since reporting and interpreting effect sizes is essential to good research (Wilkinson and APA Task Forceon Statistical Inference 1999). Kotrlik and Williams (2003) argued that reporting effect size allows a researcher to judge the magnitude of the differences present between groups, thus increasing the capability of the researcher to judge the practical significance of the results derived.

Fifth, the study by Lakhal et al. (2007) used a quasi-experimental approach. However, no pretest was conducted to determine whether the two groups were indeed similar with regard to their prior knowledge or ability of a certain subject or skills. Ross and Morrison (2004) stressed that an important component of the quasi-experiment study is the use of pretesting or analysis of prior achievement in order to establish group equivalence.

Institutional aspect

The final group of studies was devoted to examining the institutional aspect of podcasting which includes the impact of podcast on learners' attendance, and the costs of producing podcasts.

Learners' attendance

Four studies examined this particular aspect. All four studies were carried out in traditional course settings. Brittain et al. (2006) reported a descriptive study involving first-year dental students at the University of Michigan. By analyzing questionnaire data from 70 students, the study found that a small percentage (9.1%) used lecture podcasts as a replacement for attending class.

Copley (2007) also explored the effects of lecture podcasts on students' lecture attendance. Copley analyzed questionnaire data from 84 students from two-first-year undergraduate and two-fourth-year undergraduate or masters-level marine science courses. The study found that 12% of survey respondents indicated that having access to podcast records would increase their likelihood of skipping lectures. The majority (57%) stated that podcasting would not reduce their attendance, while some (31%) indicated that any effect would depend on the lecture course. Students were invited to give their reasons for still attending lectures and the 25 responses received can be categorized as follows: need for routine or structured learning (20%); opportunities for interaction or questions at the lecture (40%); 'live' is simply better than pre-recorded (40%).

In another descriptive study, Lane (2006) examined the effects of podcasting on health sciences students' lecture attendance. The study collected and analyzed questionnaire data from 41 participants. Results overall suggested that lecture podcasts did not appear to have a negative impact on student attendance. For example, a majority of students (77%) indicated that the availability of podcasts had no impact on their attendance, 13% reported that the podcasts made them more likely to attend class, and 10% indicated that they would skip class on account of the podcasts.

Muppala and Kong (2007) also conducted a descriptive study that examined the effects of podcasts on lecture attendance. The researchers collected and analyzed data from students in a Hong Kong university. The actual number of students was not reported. Results of a student questionnaire suggested that the availability of lecture podcast did not seem to promote absenteeism. The students seemed to value the in-class interaction and classroom dynamics a lot more and saw it as a valuable component of their learning experience.

Cost of producing podcasts

Two studies investigated this particular aspect by describing and analyzing the staff time, types of technology, and storage size that are required to record, process, and post the podcast files. Muppala and Kong (2007) described the use of a MP3 player (Samsung YEpp YP-T6) to record the audio during lecture. The audio was recorded in wav format and was converted to mp3 format. The typical mp3 file size was about 15 MB for one hour of audio. Anecdotal evidence suggested that the quality of the audio was quite clear and acceptable to the students. The audio files were then made available online. Post-processing of the recorded audio and making it online took about 15 min.

Brittain et al. (2006) compared the use of iPod and Apple Powerbook G4 as a lecture audio capture device. Initially, a few students placed iPods with supplementary microphones on their desks in the front row of the lecture halls. Anecdotal evidence suggested that such method produced unsatisfactory audio quality and was highly dependent on instructor position. This method was subsequently modified by directly connecting the iPod to the lecture hall's amplified PA system via a Belkin Universal microphone adapter. Results were again disappointing—the resulting audio was of very poor quality and almost useless due to the inability to accurately monitor audio levels for the iPod along with the

iPod's limited recording frequency (16-bit mono, 8KHz equivalent to analog telephone quality). On the other hand, using a computer to capture audio- an Apple Powerbook G4 in which the analog signal from the classroom's PA system was fed into a computer and captured using Apple's QuickTime Broadcaster resulted in a superior audio quality than the iPods. Also, using a computer for both media capture and processing reduced the time associated with capturing, converting, and posting files. Automating the process of converting and posting files using Apple's AppleScript technology also speeded the process. Staff processing time dropped from about two hours per class hour to 15 min a week (mostly maintenance on processing machines), and files are available on the Web within 5 min of a lecture's conclusion.

Discussion

Overall, the research reviewed suggests that contrary to opinions that using podcasts may encourage students to skip class, students in traditional courses were *not* more likely to miss class due to the availability of lecture podcasts. The primary reason is that students value the opportunity to interact or ask questions during face-to-face lectures which is currently not possible through the use of lecture podcasts.

Probably the main limitation of studies examining the impact of podcast on learners' attendance is that a majority of these studies based their findings primarily on participants' self-reported data such as interviews and questionnaires. Only one study (Bongey et al. 2006) used actual attendance counts in one of the two courses in addition to students' self-reported questionnaire data. A limitation of self-reported data is that participants usually have correct notions about socially desirable answers, and thus tend to provide answers that cause them to look good (Hakkarainen et al. 2001; Hancock and Flowers 2001; Rosenfeld et al. 1996).

The studies reviewed are still limited. For example, Copley (2007) found that as many as 31% of students indicated that their likelihood of skipping lectures would depend on the lecture course being podcasted. However, what exactly these lecture courses are and why such courses would encourage absenteeism are not explored. In addition, we need research on the *cost-effectiveness* of using podcast. Although it is useful for instructors to know the costs such as the staff time, and storage size that are required to record, process, and post the podcast files, such information may not be sufficient to convince institutions at large to utilize podcasts in their courses. Institutions would be interested to know if the time, and money used to produce podcasts could affect certain outcomes, for example whether student enrollment is positively affected by use of podcasts in completely online courses. If more students choose to enroll in online courses that utilize podcasts, it would help justify the money that institutions must spend for producing podcasts.

Conclusion

This article reviewed the use of podcast in K-12 and higher education settings. Overall, we found that the most common use of podcasting is limited to instructors' use of lecture and supplementary podcasts. This review also suggested that most of the studies reviewed were descriptive, and that most podcasts were implemented in higher education and traditional course settings. Students generally enjoy using podcast, and tend to listen to the podcasts at home using desktop computers, rather than on the move with a mobile device. In addition,

the availability of podcast does not appear to encourage students to skip classes. Limitations of current research on podcasting have also been described throughout this article.

Suggestions for future research

In this closing section, we focus on several other unanswered questions or issues in the literature and propose research that could help advance the knowledge base on podcast use in K-12 and higher education settings. Some suggestions for research have already been made earlier in this article; a few additional questions and issues are described here.

First, additional research is needed to determine whether and how the involvement of students in designing and producing their own podcasts may influence their learning. As previously mentioned, a majority of the previous studies focused on instructor- or lecturer-created podcasts with no or very little student involvement. Jonassen et al. (2008) suggested that students should develop podcasts that contain original material or that analyze and deepen the understanding of existing material. Moreover the technical aspects of producing a podcast offer students a unique learning opportunity with decision-making in the forefront as students grapple with issues related to the purpose and content for the podcast.

Second, future research should examine the impact of using podcast on students' learning and affective domains over a longer period of time, perhaps more than one year as this would help mitigate novelty effects. Doing longitudinal studies not only provides researchers the opportunity to examine whether students' and teachers' perceptions of podcasts undergo change, but also help reveal any detrimental effects of using podcasts over a long period of time, which hitherto has not been investigated at all.

Third, future research may also be conducted to address the question of which types or characteristics of courses, if podcasted, would most benefit students. So far, in our review, only one study attempted to examine this issue. Brittain et al. (2006), in a survey study of 70 dental first-year students found that information-dense course content with heavy reliance on visuals may lend itself better to being podcasted. For example, the course indicated by most students that would most benefit them to have podcasts was histology which involves great details and a large number of diagrams. This finding suggested that students could concentrate on what was being said during the lecture instead of trying to be stenographers capturing all the presented information. The audio podcasts allowed students to listen to the lecture repeatedly for specific information they missed during class. Students identified the next course, biochemistry, due to the lecturer's fast speaking rate which made it difficult for students to record all important information in class. Hence, the ability to review the podcast lecture was very important. Additional research is needed to verify Brittain et al.'s (2006) findings, and to determine other characteristics of course that would most benefit students if podcasted.

Fourth, we urge future research to focus on K-12 settings which, hitherto have not been as frequently examined as compared to higher education. In addition, future research should investigate the use of podcast in completely online courses. Most of the previous studies were situated in face-to-face contexts, or blended settings with a mixture of face-to-face and online sessions. In a completely online course, an instructor, for example, must account for the fact that he or she is not in the presence of live students (Dennen 2001), and thus may not be able to build a close rapport with his or her students. The use of podcast may offer certain advantages such as creating a greater sense of rapport and intimacy, realism and motivation (Barron 2004). (Power 1990, para. 2) posited that "spoken words

through heightened intonations or subtle nuances can communicate…emotions and create a sense of intimacy at the same time."

Fifth, future research should examine the interplay between learner characteristics and the use of podcast. The importance of understanding learner characteristics (e.g., cognitive style) is a basic tenet of instructional design (Tallent-Runnels et al. 2006). Hodges et al. (2008) conducted a case study of 17 female undergraduate students in order to identify possible learner characteristics such as self-efficacy, self-regulation, and cognitive style that might affect academic achievement when instruction was delivered via podcast. Results revealed that learner cognitive style was a statistically significant predictor of achievement with podcast instruction, where a positive relationship was found relating higher achievement to higher, more field independent scores. Future research can be conducted involving male students to examine gender differences, if any. In addition, it would be useful to study the type of podcasts used (audio only, audio and video, audio with images) and their relation to cognitive style because it could be that cognitive style is a better predictor of achievement for certain types of podcasts (Hodges et al. 2008).

The use of podcast is an emerging trend. We hope this review would be useful to researchers as they continue to study and build knowledge base about the use of podcast in K-12 and higher education settings.

Appendix

Table 2 Summary of podcast empirical studies

Author(s) and year	Research aim	Research method	Data collection method	Context
Abt and Barry (2007)	Report the quantitative effect of students using podcasts	Experiment	Pre-post multiple choice exam	50 first-year undergraduate exercise physiology module in the UK
Anzai (2007)	Explore the use of podcasts in English learning for EFL students	Descriptive research	Student survey	$N = 4$ EFL Japanese students
Baker et al. (2007)	Evaluate the benefits of incorporating podcasting into a university course	Ex-post facto	Student quizzes	$N = 6$ students in an "Aviation science for private pilots" course
Bell et al. (2007)	Report the experiences of using podcasts to supplement two undergraduate courses	Descriptive research	Student questionnaire	About 150 and 250 undergraduates from computer science courses (COSC122 and COSC110) in New Zealand
Bongey et al. (2006)	Explore the benefits, challenges, and impact of podcasting in higher education	Descriptive research	Observation, attendance counts, server statistics, student survey	246 biology college students in the USA

Table 2 continued

Author(s) and year	Research aim	Research method	Data collection method	Context
Brittain et al. (2006)	Explore use of podcasts and cost of producing them	Descriptive research	Student survey, student focus group, server logs	105 first-year dental students at the University of Michigan. 70 students completed the survey. One focus group of 6 students
Bull et al. (2007)	Address the perceptions of faculty on integrating iPods and podcasting in instruction	Descriptive research	Faculty survey	27 faculty members in the USA
Clark et al. (2007)	Evaluating the impact of podcasts on learning and teaching	Descriptive research	Student survey	$N = 30$ postgraduate marketing students
Chan and Lee (2005)	Examine podcasting to address preconceptions and anxiety on student learning	Descriptive research	Student survey, student focus group	26 first-year undergraduates in an information technology course at Charles Sturt University, Australia
Copley (2007)	Evaluate student use of audio and video podcasts	Descriptive research	Student survey	84 students from two-first-year undergraduate and two-fourth-year undergraduate/masters-level marine science courses
Edirisingha (2007)	Examine the learning opportunities offered by podcasts	Descriptive research	Student survey ($n = 24$), student interview ($n = 6$)	Undergraduates in electrical engineering at the University of Leicester, UK
Edirisingha et al. (2007)	Explore students' access to and use of podcasts, and how podcasts helped students' learning	Descriptive research	Focus group ($n = 2$ with 8 students), student interview ($n = 6$), student survey ($n = 35$)	Undergraduate students (UK) in Linguistics and Communication
Evans (2007)	Evaluate the effectiveness of mobile learning in the form of podcasting for teaching undergraduate students	Descriptive research	Student survey	196 first-level students in Business and Managment in the UK
Frydenberg (2006)	Describe one information technology course use of podcast	Descriptive research	Student survey ($n = 48$)	First year students in an introductory technology course at a business college, USA
Gribbins (2007)	Explore students' attitudes and intention to use podcast	Descriptive research	Student questionnaire	49 graduates in 2 Management Information Systems courses in the USA

Table 2 continued

Author(s) and year	Research aim	Research method	Data collection method	Context
Guertin et al. (2007)	Questioning the student use of and desire for lecture podcasts	Descriptive research	Student survey	65 Penn State (USA) students in introductory-level geoscience and Earth science courses
Hodges et al. (2008)	Investigate possible factors that may affect academic achievement with podcast instruction	Ex-post facto	Online technologies self-efficacy scale, Motivated Strategies for learning questionnaire subscales, demographics survey, cognitive style scale, multiple-choice objective test	17 female communication sciences and disorder students, USA
Lakhal et al. (2007)	Evaluate the effectiveness of an educational environment incorporating podcasts	Quasi-experiment	Student survey, student final mark	192 undergraduate students in a Management Information Systems course, Canada
Lane (2006)	Explore students' perceptions about the benefits and drawbacks of using podcasting in large lecture courses	Descriptive research	Student survey	41 out of 148 students (Health Sciences) at UW, USA responded to the survey
Lee and Chan (2007a)	Explore the potential of using podcasts to reduce anxiety caused by isolation and to promote inclusivity among online students	Descriptive research	Student survey	18 info. Tech undergraduate & postgraduate distance students in Australia and overseas
Lee and Chan (2007b)	Examine the use of podcasts to deliver supplementary listening material to distance learners	Descriptive research	Student survey, student interview	Undergraduate and postgraduate students in a HCI course in Australia
Maag (2006)	Explore nursing students' satisfaction in using podcast	Descriptive research	Student survey	Nursing students in the USA. Three academic semesters (Spring 2005, Fall 2005, Spring 2006) with 34, 33, and 43 students respectively. One class ($n = 26$) also completed the survey in Spring 2006
Malan (2007)	Evaluate the use of podcasting in a computer science course	Descriptive research	Server logs, student survey	$N = 22$ student respondents enrolled at Harvard extension school's computer science course

Table 2 continued

Author(s) and year	Research aim	Research method	Data collection method	Context
Muppala and Kong (2007)	Describe the use of podcasting as a means of delivering course lecturers	Descriptive research	Student survey	Students in a Hong Kong university (non-native English speakers). Students appeared to hail from the dept. of computer science and engineering
Nathan and Chan (2007)	Explore the use of podcasting with undergraduates in a business subject	Descriptive research	Student survey	$N = 21$ undergraduates in business in Australia
O'bryan and Hegelheimer (2007)	Describe an attempt to integrate podcasts into an academic ESL course on listening strategies	Descriptive research	Student survey, student interview, instructor reflective journal	Both graduate and undergraduate students in the USA from various majors (e.g., Agronomy, Economics, Mechanical engineering), and a variety of primarily East-Asian language backgrounds (e.g., Korean, Chinese, Vietnamese)
Ogawa and Nickles (2006)	Explore students' perceptions of podcast lectures	Descriptive research	Student survey, lecturer interview, teaching assistant interview	>500 undergraduates ICS 101 at the University of Hawaii at Manoa. ICS 101 was a course in which students learn the basics of computer usage
Plankis and Weatherly (2008)	Explore the use of podcasting in an environmental education course	Descriptive research	Student survey, teacher interview, student interview, forum postings	$N = 24$ grade 12 students in an aquatic science classroom in the USA
Tohill (2008)	Explore the use of podcasting as a learning tool in second language classrooms	Descriptive research	Survey of various educators from at least 6 school districts in Pennsylvania, New York, Maryland, and Virginia, and at least 3 universities in Pennsylvania	$N = 138$ participants. Types of podcast not indicated
Tynan and Colbran (2006)	Present results of using podcasting in 6 law units	Descriptive research	Student survey, online focus groups	$N = 1244$ tertiary law and business students during semester 1, 2006

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