Assessing the Potential Impact of Emerging Technologies on Universities

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最先端テクノロジーが大学に及ぼしうる影響に関する評価

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要　　約

　学術機関が、属する学生や教授陣、ひいては機関が存在する社会にとって意義ある存在であり続けるには、経済問題や官僚主義的不活発さという拘束を受けつつも、常に変化する時代に対応していく必要がある。そうするために大学は変化に対応するだけでなく、事前に様々な対策を講じるための最善策も探求しなければならない。クラウド・コンピューティング、モバイル・コンピューティング、オープン・アクセスなど、最近のテクノロジーの進歩は大学が様々な拘束を受けながらも益々増加し続ける大学関係者からの要求と期待に応える為に、多様な機会を提供するであろう。当論文関係者は、関連学術文献を参考に大学にとって興味深い幾つかの重要な最先端テクノロジーの概要や、大学及び大学の要求に対するそれらテクノロジーの長所と短所、さらにはそれらが近い将来与えうる影響に関する評価を考察する。最先端技術は大学関係者全員の様々なニーズに応えうると期待されるが、これらの技術の賢明な適用と起こりうる影響をあらゆる角度から注意深く検討することは非常に重要である。

キーワード：最先端テクノロジー、クラウド・コンピューティング、モバイル・コンピューティング、
　　　　　　　オープン・アクセス、オープン教育リソース

Key words：　emerging technologies, cloud computing, mobile computing, open access,
　　　　　　　open educational resources

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Introduction

As centers of thought, education, and research, academic institutions have always had a need to adapt to changing times in order to remain relevant to the students, faculty, and greater society that they are intended to serve. Without the capacity to continuously reevaluate and reposition their place at the crossroads between teaching, learning, research, and implementation, universities would quickly lose touch with the very educational, technological, and cultural innovations that they are frequently involved in helping to spur on, and their importance to their various constituents would begin to erode just as quickly. Beyond the constant challenge of remaining relevant to an increasingly diverse and continually changing constituency, universities are also often limited in their ability to respond to change by financial concerns and bureaucratic inertia. Given the conflicting demands of continuously adapting to an ever-changing landscape while remaining within often strict financial and bureaucratic limitations, universities must seek out the most efficient ways to be not only responsive, but proactive to change.

Recent technological advances provide an array of opportunities for universities to enact proactive change while remaining within their considerable restrictions. However, as pointed out by Hendrix (2010), it is critically important that emerging technologies are not adopted simply because they are cutting edge or cost efficient, but because they are ultimately effective in meeting the needs of a university's constituents. Indeed, as more and more of these constituents have grown up accustomed to and relying upon the utilization of technological tools in their personal and academic endeavors, they also increasingly expect universities, particularly their libraries and IT services, to keep pace with their technological needs. Neal (2009) attempted to sum up the growing list of technological expectations by noting that those involved in higher education "want more and better content, more and better access, convenience, new capabilities, ability to manage costs, participation and control, and individual and organizational productivity" (p. 466). Clearly, students, faculty, and the greater academic community have increasingly high technological expectations.

Fortunately, recent developments in a number of emerging technologies such as cloud computing, mobile computing, and the open access movement may offer a range of potential opportunities for universities to address the ever-increasing needs and expectations of their constituents while remaining within their notable restrictions. This paper draws from the relevant scholarly literature to provide an outline of several key emerging technological developments of interest to universities, an overview of their relative advantages and disadvantages in relation to the needs of universities and their constituents, and an assessment of their potential implications for the near future. Although emerging technologies may hold a great deal of promise in meeting the

various needs of the diverse body of university constituents, it is critically important that they are implemented wisely and that their potential impact is carefully considered from all sides.

Cloud Computing

One of the emerging technological trends with undoubtedly the most far-reaching potential to impact universities is cloud computing. While a variety of different descriptions of cloud computing exist in the literature, one of the more straightforward and authoritative definitions was recently proposed by Mell and Grance (2011) for the American National Institute of Standards and Technology (NIST) in which they stated, "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e. g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (p. 2). Put another way, cloud computing allows for a wide range of computing resources to be made easily available over the Internet as needed. With this broad understanding in mind, it's worth noting that in many ways aspects of cloud computing have already been ubiquitous for many years in the forms of web-based e-mail and online bulletin boards to name a few. Indeed, the rapid evolution of these now commonplace tools also provides a way to trace the rapid evolution of cloud computing as both of these web-based communication modes initially imposed strict usage limits on the amount of data that could be uploaded and saved within these early cloud-based applications. Year by year, as the technological capabilities of cloud-based services improved, associated costs fell and at the same time Internet speeds also increased. Today, nearly all of major web-based e-mail services offer unlimited storage space and those posting to online bulletin boards have an array of options for sharing all shapes and sizes of electronic files and formats, all as a result of the continued evolution of cloud computing.

Nowadays, web-based e-mail and online bulletin boards are hardly the cutting edge of what cloud computing can offer. In fact, Mell and Grance (2011) further clarify the NIST definition mentioned above by expounding on the essential characteristics of cloud computing and outlining the service and deployment models that cloud computing may embody. Of particular importance to a better understanding of the current and potential reach of cloud computing are the three service models it can take on: Infrastructure as a Service, Platform as a Service, and Software as a Service (Mell & Grance, 2011), since these services are most likely to continue to be the part of the cloud most visible to users.

Infrastructure as a Service (IaaS) essentially offers remote access to server-based resources such as storage space or processing power for the consumer to utilize to their own ends (Mell & Grance, 2011). Platform as a Service (PaaS), on the other hand, provides users access to predetermined computing infrastructure for the purposes of developing and maintaining their own web-based applications (Mell & Grance, 2011). The most striking impact of both IaaS and PaaS is that they

provide consumers who may not have either the means or long-term need to purchase their own cutting-edge servers with the opportunity to use them as much or as little as desired and only pay for services used. While the most advanced computing resources were once only available to the largest companies, universities, research labs, and other such groups with the sizable financial clout required to purchase and maintain the expensive physical infrastructure, with IaaS and PaaS as relatively low-cost, scalable alternative means of allowing access, a much wider and more diverse range of users now have the chance to make use of this degree of specialized technology for their own purposes. This opens the doors of access more evenly across society and around the world, which will undoubtedly lead to groundbreaking innovation in many fields that would simply not be possible without such cloud-based resources. Within the commercial sector alone, it is easy to see how these services allow smaller companies or brand-new startups the option of incrementally apportioning access to the computing resources necessary to bring their original visions to life. In relation to experimentation and research too, such affordable, apportioned access also allows for much wider participation. Clearly, access to advanced computing resources that once may have been prohibitively expensive is now within reach for a great many more interested players.

Software as a Service (SaaS) is the third cloud computing service model outlined by Mell and Grance (2011) in their extended definition of cloud computing, and is likely to be the one most familiar to people since nearly all of the most commonly used web-based applications fall under this service model. From the web-based e-mail and online bulletin boards mentioned previously to the ever-increasing list of Web 2.0 applications, so labeled because of their ability to promote interaction and more dynamic, engaged participation as their use increases (Cunningham & Wilkins, 2009), to proprietary software licensed on a subscription basis and used completely online ("Software as a service," 2012), cloud-based SaaS applications are already used by most people actively engaged on the Internet. In fact, blogs, wikis, online discussion forums, social networking and bookmarking sites, and online office suite tools like Google Docs all represent widely-used SaaS applications that allow users to instantly add or edit text-based information or other multimedia entirely within the online environment using only their web browser interface, typically for free. These cloud-based tools allow users the opportunity not only to run such a variety of applications across a wide range of devices and operating systems, including traditional computers and a growing list of mobile devices, but to do so without having to install or update the software itself or manually manage saving any of the work since it is all done in the cloud. While software and storage once tended to tie users down to the specific computers on which they were installed and saved, with SaaS, both the applications and the content created can be accessed and manipulated without concern of physical location. This frees up users to be able to use these applications and access their saved work seamlessly from one computer to another or even from one electronic device to another, an aspect that is growing more important as mobile devices become more widely used and both portability and interoperability are increasingly required of electronic

content of all kinds.

Relevance to Universities

While cloud computing as well as the related Web 2.0 and SaaS applications it has engendered have generated a great deal of commentary regarding the general advantages and disadvantages they may provide, their potential relevance toward meeting the specific needs of the academic community must also be evaluated. Although cloud computing, Web 2.0, and SaaS are relatively recent technological developments, they have already garnered a great deal of attention from scholars and practitioners who have already begun implementing and critiquing their potential benefits and drawbacks, particularly in regards to their application in library and information technology (IT) environments.

The related literature reveals several advantages that cloud computing can offer universities. One of the most obvious and immediate benefits cloud computing offers is in fostering improved access to and availability of information and services (Johnson, Levine, & Smith, 2009; Johnson, Levine, Smith, & Stone, 2010; Sultan, 2010; Yan, 2010), which also goes a long way toward meeting users' increasingly high expectations (Neal, 2009). As noted prominently by Johnson et al. (2010) in *The Horizon Report 2010 Edition*, "People expect to be able to work, learn, and study whenever and wherever they want to." (p. 4). Since cloud computing allows for information and services to be stored and run solely through thin-client, browser-based applications that function independently from the particular system they may be running on, access to the Internet is increasingly becoming all that is required to make gain access to university and academic library content as well as users' own e-mail and documents saved in the cloud. Furthermore, if cloud-based Web 2.0 and SaaS tools are made available to users within a university's system, these applications can also be accessed remotely over the Internet without the need to install and manage proprietary software licenses on each individual device.

While ubiquitous online access to university and academic library content and services is one of the primary appeals of cloud computing for users, there are also numerous related economic incentives for the institutions themselves (Johnson et al., 2009; Sultan, 2010; Yan, 2010). One of the most cited benefits in this regard is the scalability that cloud computing brings about, which often allows for a much more efficient use of limited resources (Johnson et al., 2009; Peters, 2010; Sultan, 2010). Rather than a particular institution purchasing all of the required hardware and software required to host data and services on its own servers, which may be rarely (if ever) used at maximum efficiency, cloud computing allows universities to adjust their usage amounts as needed and pay for only the amount of computing power and storage space that they actually use (Johnson et al., 2009; Peters, 2010; Sultan, 2010). Beyond reducing the costs associated directly with hosting data and services, universities can also shift the economic and logistical burdens of maintaining and overseeing the equipment and services to the external providers (Fox, 2009; Hastings, 2009;

Sultan, 2010; Yan, 2010). This could serve to reduce the burden on a university's IT staff, and, as put forward by Hastings (2009), allow a university to focus its time and energy on "the bigger picture and the more mission-focused projects that it might be working on" (p. 10). Furthermore, because of the ability to easily migrate cloud computing data and services, data can be safely backed up in more than one physical and most maintenance or upgrading tasks can be performed without disrupting service (Duhon, 2007; Yan, 2010). Levack (2009) points out another key benefit by noting that cloud-based services are also upgraded more frequently since they are not reliant on institutions' large-scale hardware, software, or licensing investments to keep pace while, at the same time, cloud-based storage, Web 2.0, and SaaS companies may have a perpetual incentive to keep their customers satisfied with their services or risk losing them to competitors.

Cloud computing has been found to provide several academic benefits as well. First, as noted in *The Horizon Report 2010 Edition*, it can provide users with access to a variety of "free or low-cost alternatives to expensive, proprietary productivity tools" (Johnson et al., 2009, p. 12), which students, faculty, and staff can utilize to advance their educational activities. Additionally, many free or low-cost Web 2.0 and SaaS tools have been found to foster improved communication and collaboration, increasingly important aspects of academic culture (Johnson et al., 2009; McDonald, 2008). Another important academic benefit afforded by cloud computing is that universities can gain access to advanced computing and processing capabilities remotely which can allow for more flexibility in undertaking large-scale research experiments or other new technological projects that might have previously been thought of as too demanding of the limited resources available (Johnson et al., 2009; Peters, 2010; Sultan, 2010; Yan, 2010).

Although the benefits that cloud computing may offer academic institutions are considerable, it is not without its drawbacks. One of the most serious areas of concern relates to the potential security and privacy risks that cloud computing may expose universities and their constituents to (Fox, 2009; Sultan, 2010; Yan, 2010). As universities are often ethically and legally responsible to ensure their constituents' personal information is secure and private, they must carefully consider what kind of information can and should be stored and made accessible through services provided by outside companies (Fox, 2009). Furthermore, the terms of service agreed upon between universities and any cloud computing, Web 2.0, or SaaS providers must cautiously address the issue of the universities' and their constituents' rights to retain ownership of the data and information they create and store in the cloud (Hastings, 2009). Another related concern is the question of the legal jurisdiction of data and information stored within a cloud with international reach (Sultan, 2010; Yan, 2010). Also, academic institutions may have more rigorous accessibility requirements than many cloud-based services may provide (Kelly, Bevan, Akerman, Alcock, & Fraser, 2009).

Other areas of concern with cloud computing for universities frequently mentioned in the literature are related to questions of reliability, portability, and control. With cloud-based storage and applications, there is always the possibility of temporary or even permanent loss of data if the

Internet, an Internet connection, or third-party service provider fails (Fox, 2009; Sultan, 2010; Yan, 2010). Another related worry expressed in the literature is that universities may be locked into a long-term reliance on a particular cloud-based service vendor, thereby potentially serving to discourage universities from seeking out other options and leaving them vulnerable if the service provider decides to alter or discontinue their services or goes out of business (Sultan, 2010). One final related aspect that has been raised as a concern in the literature is the lack of university control available with many cloud-based services. By their very nature, most cloud-based applications currently rely on underlying software stringently controlled by their providers, which may not allow many options for local customization or more onsite development (Fox, 2009). Such a lack of customization options may indeed work against with universities' efforts to meet the specific needs of their own constituents.

Implications for the Future

Although there are clearly many disadvantages to consider as a number of unanswered questions, most universities have already begun integrating some degree of cloud computing services into their technological repertoire. While the risks and drawbacks may be considerable, as Kelly et al. (2009) poignantly conclude, there are also "risks, potentially greater risks, in failing to engage with a rapidly changing environment" (p. 324). As a result, the primary implication for universities will be of wider and more robust use and reliance on cloud computing services in the near future. As long as the major concerns outlined are adequately addressed, it is not difficult to foresee a much more wide scale and permeating utilization of cloud-based services throughout universities.

While a detailed assessment of the particular ways universities may come to make use of cloud computing in the future is beyond the scope of this paper, some examples taken from the literature about the possible implications for academic libraries and IT services may serve to better illustrate the potential impact. For one, several authors foresee computing hardware shifting dramatically to the use of predominantly thin clients systems capable of accessing applications, data, and information entirely from the cloud via subscription-based services (Fox, 2009; Pace, 2009). As more and more academic content and services are made available from the cloud, users will increasingly be able to access and use this material via universities' websites which will act as ever more important portals capable of some degree of personalization (Sodt & Summey, 2009; Yong-Mi & Abbas, 2010). Likewise, many authors predict an expansion of the Library 2.0 concept in which a variety of Web 2.0 applications have been applied to the library environment along with the central Web 2.0 premise of fostering openness, interaction, and improvement through wider use (Stephens & Collins, 2007). Web 2.0 applications also have the potential, as Sodt & Summey (2009) note, "to transform reference services and create better collaborative work spaces and Intranets for staff" (p. 107). Beyond staff collaboration, Hendrix (2010) points out that "libraries

and librarians are expected to partner with many types of institutions, organizations, and individual users to provide both traditional and cutting-edge services and flexible, usable physical and online environments" (p. 15).

As a result of the changes that a heightened reliance on cloud computing will bring about, it is clear that an expansion of the technological and managerial skills will be required of those charged with implementing these services within universities (Peters, 2010). In particular, academic librarians and other IT professionals will have an increased responsibility for overseeing and managing the secure deployment of cloud-based services throughout the university system and will be much more engaged with ensuring smooth Web 2.0 and SaaS integration into the library's growing portfolio of technology-driven services, outreach, and instructional activities. As a result, it is incumbent upon universities to support continued training, education, and faculty/staff development as well as to seek out and cultivate faculty and staff that have positive attitudes toward embracing these new technologies (Aharony, 2009). As many administrators, faculty, and staff may be resistant to the changes that cloud computing will likely bring about, Kelly et al. (2009) argue that continued informed advocacy of the many benefits it can afford will be critical.

Mobile Computing

Another area of emerging technologies that is expected to have an increasingly large impact on universities is mobile computing. Recently and rapidly evolving from the rudimentary mobile phone used only to place person-to-person calls and the early personal digital assistant (PDA) used simply to retain and recall addresses and appointments, mobile computing now encompasses an increasingly sophisticated and versatile array of portable Internet-accessible devices such as smart phones, palmtop computers, tablet computers, netbooks, laptops, e-book readers, and media players. Coupled with the advances in cloud computing outlined in the previously (on which many of its own strengths rely), a number of scholars such as Hendrix (2010) believe that mobile computing is already beginning to have "a profound effect on the way users find, access, and process information" (p. 7).

Relevance to Universities

With the rapid development and dramatic improvement in the capabilities offered by mobile computing devices has also come a surge in their popularity and, concomitantly, in the attempts to better understand how they may be most effectively utilized in different environments. Of particular interest are the ways in which mobile computing stands to influence universities and the content provided through their academic libraries. While the growing popularity and improving functionalities afforded by mobile computing makes its more wide scale use for academic purposes seem almost inevitable, the specific advantages and disadvantages already outlined in the related literature are important starting points for considering its potential impact.

Mobile computing has been found to offer several advantages when employed in the university context. One of the most immediate benefits that universities can capitalize on is reflected in the very name of these devices: mobility. Johnson et al. (2010) succinctly outlined many of these benefits in *The Horizon Report 2010 Edition*:

> The portability of mobile devices and their ability to connect to the Internet almost anywhere makes them ideal as a store of reference materials and learning experiences, as well as general-use tools for fieldwork, where they can be used to record observations via voice, text, or multimedia, and access reference sources in real time. (p. 10)

Another strength of mobile computing that can be readily capitalized on in the academic environment is the widespread acceptance and adoption that it already enjoys. According to a recent study by the EDUCAUSE Center for Applied Research (ECAR), 87% of the American undergraduate students surveyed indicated that they owned a laptop and 55% stated that they owned a smartphone (Dahlstrom, de Boor, Grunwald, & Vockley, 2011). Similar data on recent Japanese undergraduate students seems to indicate comparable levels of computer access and even higher rates of ownership of Internet-capable mobile phones (Elwood & MacLean, 2009; Gromik, 2009; Lockley, 2011). Furthermore, Lippincott (2008) found evidence to support the notion that undergraduate students today are also increasingly more inclined to use mobile devices for educational purposes because they are "less likely to dismiss the usefulness of information on small screens" (p. 1). This view is increasingly supported by evidence such as that of Dahlstrom et al. (2011) who found that 37% of the American undergraduates surveyed remarked that they had used smartphones in academic activities. This has important ramifications on the potential usefulness of mobile computing in education since providing exposure to course materials and collaboration opportunities via mobile devices has shown positive results in increasing the time students spent accessing and discussing them (Johnson et al., 2010).

While the trend toward supporting more mobile computing functions in academic contexts seems somewhat inevitable given the growing list of benefits, several limitations must be addressed. First, as more and more mobile computing devices increasingly rely on the underlying services provided through cloud computing, all of the many unanswered questions with that technology affect mobile computing as well. Beyond these numerous concerns, mobile computing presents additional potential security, privacy, and legal risks because wireless technology remains notoriously poorly secured (Parsons & Oja, 2006). Handheld mobile devices also present several unique challenges as they are typified by slower connection and data transfer speeds, smaller screens with limited display capabilities, less powerful processing and memory resources, and often limited browsing functionality (West, Hafner, & Faust, 2006). Although all of these limitations are being continuously improved, they remain important aspects for universities to consider when implementing any mobile computing initiatives.

Implications for the Future

As universities' constituents are increasingly likely to own and rely on mobile computing devices for more of their computing activity, academic institutions will have to move quickly if they truly seek to accommodate these devices in all of their technological endeavors. As a result, one of the primary implications as we go forward is the need for universities to develop and maintain a campus-wide approach to mobile computing to ensure that access is widely available, reliable, and secure, services are smoothly and intuitively integrated across divisions, and both connections and services are maintained and upgraded as often as possible. Lippincott (2008) also points out that physical spaces on campus will also have to be rethought with mobile computing in mind. As one of the main campus centers of information and technology, the academic library can serve as an important mediator between the various sectors of the university and should be intimately involved in the development and refinement of the overall university approach to mobile computing (Lippincott, 2008; Lippincott, 2010).

Academic libraries themselves must also be responsive to the unique demands created by the upswing in mobile computing. As put forward by Lippincott (2010), "Librarians should think creatively about the development of services for users of mobile devices, especially taking into account user needs and preferences and the relationship of services to the academic program of their institution" (p. 10). While a few university libraries such as the North Carolina State University Library in the U.S. have already begun tailoring new services to mobile devices by providing mobile catalog access, two-way text and instant messaging (IM) communication and reference options, and podcasts, there is an ever-growing need for all institutions to further expand, refine, and better optimize the mobile computing services offered (Hendrix, 2010). Some see the creation of digital collections designed specifically to suit mobile computing devices as one of the next steps in this effort (Hendrix, 2010). Undoubtedly, more and more content will have to be made available in formats compatible with mobile computing devices, as is already underway at many academic institutions around the world. As Hendrix (2010) put it, this will allow the library of the future to "remain both a portal and a destination for information seekers" (p. 9). Beyond expanding the types of mobile services and content available, there will also be an increasing need for academic libraries to better inform and educate their constituencies about the new mobile options available, perhaps by promoting them on popular Web 2. 0, mobile-friendly social networking and microblogging sites like Facebook and Twitter (Lippincott, 2010). As with cloud computing, if universities and academic libraries are to foster an environment receptive to mobile computing, new technological skills will be needed by the faculty and staff implementing and overseeing these services.

Open Access

One final major sphere of emerging technologies that stands to impact universities is the

move to promote open access scholarly communication and educational resources. As part of an even larger movement to create a more developed and valuable sense of an "open commons", open access can be though of as the content-based counterpart to the perhaps more widely known concept of open source software (Belliston, 2009). As mentioned, two key areas of open access content are of particular interest to academic institutions: open access journals and open educational resources. Although definitions differ, the concept of an open access journal typically refers to an online scholarly publication that allows users to freely read, copy, download and distribute articles in a digital form (Palmer, Dill, & Christie, 2009; Schmidt, Sennyey, & Carstens, 2005). While they may include open access journal articles if they are used for instructive purposes, open educational resources (OER) essentially refer to "digitised materials offered freely and openly for educators, students and self-learners to use and reuse for teaching, learning and research" (Organization for Economic Co-operation and Development, 2007, p. 10).

Relevance to Universities

Open access journals and educational resources are obviously closely connected to academic institutions since it is faculty, students, and staff who are likely to serve as the creators, users, and even publishers of such modes of content. However, the fact that the open content model represents only a minor means by which scholarly communication or educational materials are created, distributed, or used today indicates that there must be compelling reasons why the traditional model of copyrighted content still holds sway. Clearly, open access presents a number of advantages and disadvantages that must be examined in order to fully understand and predict how the continued evolution of this movement may continue to impact universities.

The most appealing aspects of open access are readily apparent when considered from the points of view of those who stand to potentially benefit from them. First and foremost, for nearly all of the academic community, open access to scholarly articles and educational resources translates into cost savings in an era of increasingly tight budget concerns (Palmer et al., 2009). Students save when OER are used instead of expensive copyrighted textbooks and course packs, scholars save on open access journals they would have paid for otherwise, and institutions save by reducing the ever-rising costs associated with scholarly journal subscriptions and license agreements, as well those associated with processing and maintaining physical copies within libraries (Schmidt et al., 2005; Yiotis, 2005). Beyond cost savings, some argue that since much of the research behind scholarly articles and educational resources has been publicly funded, any resulting publications or materials should be made freely available in the public domain (Navin & Starratt, 2007). Additionally, providing academic content through open access modes may not be entirely without reward as making this content available can be seen as a good public relations move and marketing opportunity for universities (Hylén, 2005; Read, 2008).

Open access journals and OER also offer other benefits because they are published

comparitively quickly online. Open access journals, for instance, can save time for scholars either hoping to make their findings known quickly or wanting to access others' findings in a timely manner. Since they do not have to deal with any interference or scheduling concerns of for-profit publishing companies and they are only made available online, open access journals are typically able publish articles in a more timely manner and have the potential to reach a wider audience of readers (Navin & Starratt, 2007; Palmer et al., 2009; Schmidt et al., 2005). As open access content may be freely available for others to modify and create derivative works from, its wide reach also means the potential for a wider pool of possible contributors and collaborators for the improvement of any shared content. Likewise, it means that any individual instructor or student can also modify and customize the content to better suit specific needs and contexts (Belliston, 2009), as well as cut down on the costs in time and money that may be associated with developing new content from scratch (Hylén, 2005). The broad reach afforded by online open access to academic content also presents an altruistic benefit in that these materials can be utilized by scholars and students around the world, particularly by those who may be without access to many educational opportunities or may not be able to afford comparable copyrighted materials (Taylor, 2007). This type of philanthropic activity may also be in line with the institutional missions of many universities and their goal to benefit society at large (Read, 2008).

While open access journals and OER clearly offer many advantages, several problems have been outlined as well. One of the primary concerns raised in the related literature is that there may be more costs involved in creating, managing, and sharing open access content than generally assumed. While some have come to question the long-term sustainability of the open access model, Read (2008) also points out that quality open access content can be expensive and time consuming to initially develop. This view also exposes a related concern for ensuring quality control over the content being made openly available (Belliston, 2009; Hylén, 2005). Clearly, methods such as peer-review and editorial control should always be in place so that open access content is rigorously evaluated according to the highest academic standards (Belliston, 2009; Hylén, 2005).

Another area of consternation involves the complex set of copyright issues that open access content brings up. While the general understanding may be that open access implies unrestricted free access, in fact, there are several different gradations in licensing which presents problems when materials are modified and combined with others shared under a different type of license (Belliston, 2009). The situation is even more complex when previously copyrighted material has been used within something destined for open access as it is often a difficult and drawn out affair to clear third-party intellectual rights (Read, 2008). Finally, another challenge that has been identified in the open access realm is the question of how to ensure that longstanding scholarly reward and reputation systems are accurately reflected in the emerging open access publication model (Johnson et al., 2010). If scholars are unable to get the same kinds of rewards in terms of notoriety and career advancement from open access modes as from the more traditional publication routes, other

systems will have to be considered.

Implications for the Future

As the issues surrounding open access journals and OER continue to unfold with their growing development, universities of the future are very likely to be shaped in part by the related changes already underway. Academic libraries, in particular, face an uncertain future in part because of the inability to predict with any certainty if the open access movement will become the predominant model for content distribution in the future, if it will fade from relevance, or if it will continue to exist with alongside the traditional model (Schmidt et al., 2005). As several authors have conjectured, the open access and traditional models are most likely to continue to co-exist at least for the near future, with perhaps a heightened role for open access (Schmidt et al., 2005).

If open access does begin to play a greater role in content distribution, there are several effects likely to be felt by universities and their libraries. Perhaps the starkest scenario was offered by Schmidt et al. (2005) who stated that "libraries could lose their central place in the scholarly research process" because open access resources "do not require patrons to use the library" (p. 410). While this is certainly a possibility, it would only occur if patrons did not have any need to use the academic library. With an increase in open access content, the academic library of the future will have to adapt many of its policies, procedures, and services in order to survive. Indeed, there are many ways in which academic libraries can adapt to a rise in open access content while keeping user needs at the forefront. First, as with the current print-based and electronic content available today, users may often be unaware of the best places to look for information or unable to locate it without assistance. Clearly, academic librarians of the future can continue to serve their patrons by helping to direct them to the resources that best meet their needs via aggregators, indexes, databases, and reference support. Here, too, librarians will likely play a large role in creating and maintaining databases specifically geared around open access content (Schmidt et al., 2005). In addition to indexing these materials, librarians are also likely to be charged with monitoring them for quality assurance, archiving, and ensuring that the library's print-based, electronic, and open source resources are all smoothly integrated (Schmidt et al., 2005). Ultimately, as mentioned above, users must be made aware of the content and services available to meet their needs and learn how best to make use of them.

While the traditional library policies, procedures, and services will have to expand in order to sufficiently address changing user needs in relation to open access content, academic libraries may also be asked to take on other roles. Bailey Jr. (2007) points out that academic libraries may need to become digital publishers of open access works, expand the traditional role of the institutional repository to include hosting open access content and resources, and undertake digitization projects of out-of-copyright materials. As with all of the emerging technologies examined in this paper, academic librarians tasked with implementing them within universities must be prepared to revise

their skill sets accordingly. In regards to open access, librarians must be well informed of copyright issues, open access resources and how to best to search, identify, and index them, and collection development matters (Bailey Jr., 2007). Furthermore, academic librarians of the future who support open access initiatives should demonstrate this support by actively contributing to them themselves and by assisting and collaborating with other faculty who also wish to do so (Belliston, 2009).

Conclusion

Cloud computing, mobile computing, and open access all represent rapidly emerging technologies that have already begun to make a mark on academic institutions around the world. As these technologies continue to evolve at a very high pace, universities and their constituents stand to gain considerably from the many benefits that they increasingly engender. However, several serious concerns remain insufficiently addressed, and entirely new ones are undoubtedly on the horizon. In order for universities to be best positioned to continue to meet the growing technological needs and expectations of their constituents, emerging technologies like those outlined in this paper must be continuously monitored and their potential advantages and disadvantages in academic contexts must be constantly reevaluated. Ultimately, while the technological changes embraced by universities should be shaped by the specific needs and expectations of their constituents, ensuring that their overall impact is positive will be determined by how well academic institutions implement them strategically.

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