Skills and Knowledge Needed to Serve as Mobile Technology Consultants for Information Organizations

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Libraries often lack the in-house information technology (IT) expertise required to (1) implement mobile applications and related technologies (MAT); (2) attain maximum return on investment including patron satisfaction for using MAT; and (3) reduce reliance on expensive IT consultants. Based on secondary analysis of the experiences and advice offered by librarians and IT professionals engaged in implementing MAT in libraries, we identify four *core* and six *supplementary* competencies needed to help libraries better serve their patrons using MAT. LIS graduate programs could equip students with the skills and knowledge needed to build 10 competencies so that they could serve as mobile technology consultants (MTCs) for libraries. Core competencies are mobile application development, human-computer interaction, computer networking, and planning and management of mobile technologies; and the supplementary competencies are: project management, change management, negotiation, data management, policy management, and grant writing.

Keywords: mobile technology, mobile applications, information technology in libraries, mobile technology consultants, LIS education, IT consultants, IT management for libraries, IT in information organizations

Problem Statement

In today's digital environment mobile devices are becoming central to information gathering and communication, so libraries must be prepared to make their services available to their users when and where the user is located (Krishnan, 2011). The "millennial" generation in particular consists of digital natives who have views and expectations that align with quick, convenient information access from handheld, internet-ready devices (Bomhold, 2014). These expectations extend to their use of library services. Students surveyed about academic library use have shown interest in using their mobile device to use research databases, search the library catalog, and access reference and circulation services (Seeholzer & Salem, 2010). Keeping up with these interests and expectations helps libraries establish their rele-

vancy and demonstrate how they are central to communities' information needs.

Information organizations recognize the rising popularity of mobile applications and related technologies (MAT) and their importance to communities, resulting in many libraries increasingly investing their limited resources in MAT (Back & Bailey, 2010). However, libraries often lack the in-house information technology (IT) expertise required to (1) make the best choices in selecting, purchasing, designing, developing, deploying, or maintaining MAT; (2) attain maximum return on investment including patron satisfaction for using MAT in libraries; and (3) reduce reliance on expensive IT consultants who typically work for businesses with fundamentally different missions, information needs, and resources than those of libraries (Potnis, Cortez, & Allard, 2015; Walsh, 2012).

This challenge indicates that information organizations like libraries need affordable mobile technology consultants (MTCs) who can help them select, purchase, design, develop, deploy, and maintain MAT effectively and efficiently. The growing demand for MTCs in information organizations provides a unique opportunity for library and information science (LIS) schools to introduce MTC-related concentrations or specializations in their master's level curricula to equip their graduate students with 21st century skills to respond to the global technological landscape (Potnis & Regenstreif-Harms, 2016). Building an MTC-related concentration requires an answer to the question: What are the skills and knowledge needed to serve as MTCs for information organizations like libraries?

This study addresses the research question by utilizing a content analysis of academic and professional literature. Based on the results of this analysis, we propose four core and six supplementary competencies that MTCs must have to meet the growing mobile technology-related needs of libraries. We propose that LIS graduate programs could develop these 10 competencies by training their students in specific business and technology areas utilizing interdisciplinary graduate coursework. We also discuss the implications of this study, especially for broadening participation in the library profession and helping libraries manage their resources efficiently and effectively when investing in MAT to better serve their patrons.

Our Approach to Address the Problem

This paper adopts a practice-driven approach: we relied on the stories, experiences, and advice offered by practitioners to identify the specific skills and knowledge needed to build a mobile workforce for 21st century libraries. We began this study with Walsh's (2012) handbook on using mobile technology to deliver library services, which guides libraries to use mobile technologies for delivering services to diverse patron populations. We conducted searches using a number of key phrases including but not limited to "mobile technolog*," "mobile applications for libraries," and "mobile websites for libraries" for retrieving relevant professional and academic literature. We applied a snowball sampling technique to collect over 75 items including scholarly research articles, handbooks, ALA library technology reports, and books hosted on the EBSCO and Information Science Source databases. As part of our passive information retrieval strategy, we considered the articles suggested by Emerald Insight and Elsevier Science Direct, two of the most widely used journal hosting sites.

The relevancy of publications to our research was established utilizing the following criteria: (1) accuracy of facts (e.g., one of the authors, who holds advanced degrees in computer science and information science, double checked the technical facts in all of the publications cited in this paper); (2) time period of publications (i.e. artifacts published mostly after 2004);

(3) credibility of authors (e.g., all of the publications considered for this paper are authored by academic or public librarians or IT professionals engaged in developing MAT across the world); and (4) content (e.g., we focused on problems, solutions, advice, and tips for developing MAT). A number of research articles published by *IT and Libraries* and *Library Hi Tech*, two top-tier journals covering the development of MAT for libraries, built the foundation of this research.

We had two coders use conceptual level analysis to code the stories, experiences, and advice offered by librarians and IT professionals engaged in developing MAT for libraries over the last 10 years. During the qualitative analysis of the literature, we developed a codebook with over 1,100 codes with inter-coder reliability of 85 percent. The analysis reveals the specific skills and knowledge required to build 10 competencies for selecting, purchasing, designing, developing, deploying, and maintaining MAT in libraries.

Proposed Solution

LIS graduate programs can equip their students with the skills and knowledge necessary to build the competencies we identified in this study. For instance, we identified four mutually exclusive core competencies and six mutually exclusive supplementary competencies LIS students will need to have to serve as MTCs for libraries. The core competencies, which are mainly related to IT, include mobile application development with a focus on web programming, human-computer interaction (HCI), computer networking, and planning and management of mobile technologies. The supplementary competencies: project management (including communication management), change management, data curation and management, policy management, and grant writing, would help LIS students serve as mobile workforce for libraries in the future.

Core Competencies

C1. Mobile Application Development

Web programming is at the heart of deploying MAT in libraries (Potnis, Regenstreif-Harms, & Cortez, Under Review). Hence, LIS students should be well-trained in client-side and the server-side programming which enables developers to build MAT with a number of value-added features for library patrons. Web programming for mobile applications can be accomplished: (1) using a cluster of markup languages like HTML, XML, etc., (2) using a combination of client-side and server-side scripting such as JavaScript Object Notation, etc., and (3) without any combination of client-side or server-side scripting. It is necessary to teach LIS students these three web programming approaches for developing mobile applications that are capable of running on multiple mobile devices irrespective of screen size, operating system, or other characteristic.

The appropriate web programming approach is usually dictated by the specifications of mobile sites and mobile applications. For instance, a cluster of markup languages is used to design and develop sites with a complete separation of content and presentation (Iglesias & Meesangnill, 2011), cascaded style sheets (CSS) for better user experiences (Elder, 2012), and shortened links facilitating ease of input for users on small or virtual keyboards (Walsh, 2012). Scripting is best suited when designing and developing mash-ups for mobile applications and developing mobile applications using client-server architecture, accessible on mobile devices (Back & Bailey, 2010)—for instance, Cold Fusion, a server-side programming language, can handle the interaction from mobile devices through web browsers, which are invoked through Simple Object Access Protocols connections; this feature allows MAT users to access search engines on library websites via smartphones (Hoivik, 2013). If widgetization alone is

needed to facilitate the integration of mobile sites (i.e. developing a widget library for mobile-based web information systems), no scripting is required.

C2. Human-Computer Interaction (HCI)

The behavioral, cognitive, motivational, and affective aspects of HCI can help students design (1) responsive web sites for libraries to enhance user experience (Kim, 2013), (2) user interfaces meeting the expectations and needs of potential users (e.g., a menu with the following items: library catalog, patron accounts, ask a librarian, contact information, listing of hours, etc.) (Connolly, Cosgrave, & Krkoska, 2011), and (3) meaningful mobile websites based on user needs, and documenting and maintaining mobile websites (DeMars, 2012).

Usability engineering plays a key role in (a1) designing concise interfaces with limited links, descriptive icons, home, and parent-link icons (West, Hafner, & Faust, 2006), (2) creating user-friendly sites (e.g., the DOK Library Concept Center in Delft, Netherlands, offers a welcome text message to first-time visitors) (Houghton, 2012), (3) effectively transitioning from traditional websites to mobile optimized sites with responsive designs (Rempel & Bridges, 2012), and (4) presenting a clean, easy to navigate mobile version of search results (Williams & Peters, 2012).

Finally, the knowledge and skills related to information visualization would help LIS students serving as MTCs for libraries to automatically maintain reliable and stable fundamental information required by indoor localization systems like locating books in libraries or geo-tagging of books in large libraries (Hahn, Twidale, Gutierrez, & Farivar, 2011). Since information visualization techniques facilitate interactive visual representations of abstract data to reinforce human cognition, the application of information visualization could help patrons process information easily when surfing mobile sites redesigned from

existing sites (Becker, Bonadie-Joseph, & Cain, 2013; Rempel & Bridges, 2012).

C3. Computer Networking

Libraries expect mobile technology consultants to identify and address technology infrastructure-related issues (e.g., connectivity, security, speed, signal strength, etc.) faced by patrons using mobile applications and related technologies in libraries. LIS students should be equipped to provide solutions like the ones listed below for service delivery issues experienced by libraries: cutting down on unnecessary data transmissions (Spitzer, 2012), leveraging existing Wi-Fi access points and supplementing wireless infrastructure with additional wireless beacons (RFID tags and RFID readers) for collections-based wayfinding, and designing and managing a multi-tiered infrastructure solution of Wi-Fi fingerprinting in an autonomous mobile system (Hahn *et al.*, 2011). In addition, LIS graduates serving as MTCs should be able to deploy MAT capable of exploiting advancements in technology such as faster mobile data networks while still able to run on low performing mobile networks typically observed in libraries in rural, remote areas with weak signal strength. Hence, LIS programs need to provide hands-on networking training to their students interested in working as MTCs for libraries.

To host mobile applications on appropriate Internet servers that meet desired safety and security standards, currently, libraries need networking experts with training in (1) cryptography (e.g., use of a client server environment where multiple clients and servers are involved for launching mobile apps across campus, etc.) (Wilson & McCarthy, 2010), and (2) networking administration and management (Elder, 2012; Thomas, 2011).

The ability to assess a wide range of commercial-off-the-shelf (COTS) products like open source web browser engines (e.g., WebKit), which render web pages on smartphones and allow users to view

high quality graphics on 3G data networks with faster output, is a desirable skill for installing mobile networks for libraries (Wilson & McCarthy, 2010). The techniques for optimizing the use of network bandwidth for running client-side processing of classes using a widget library (e.g., HTML written by adapter), which allows patrons to use their mobile devices as thin clients, should also be taught to LIS students interested in working as MTCs for libraries. The term "thin clients" refers to a computer with low or no memory and low processing capabilities; typically, mobile devices that cannot access Internet fall into this category.

C4. Planning and Management for Implementing MAT

Cutting-edge mobile technologies do not necessarily benefit libraries and create advantages for library patrons at all times (Potnis, Regenstreif-Harms, & Cortez, Under Review). It becomes necessary for libraries to strategically plan and manage their investment in MAT. To be able to plan and manage effective deployment of MAT in libraries, it is essential for MTCs to be aware of new developments and trends in the market (Elder, 2012). For instance, developers should be aware of (1) print resources on relevant technologies such as Apache, ASP, JavaScript, PHP and Python, etc., (2) online resources such as detectmobilebrowser.com and W3C mobileOK Checker to test catalogs, design functionality, and accessibility on mobile devices, and (3) various online communities of developers who could provide peer-support when needed (Houghton, 2012). Advancements in mobile devices, platforms, operating systems, digital rights management terms and conditions, and emerging standards for content formats also shape the overall planning and management of MAT (Pendell & Bowman, 2012).

Libraries expect MTCs to help them make strategic choices. One of the most critical strategic choices libraries make in this context is whether to use a mobile app or a mobile site (i.e. a web portal running on mobile devices) when offering services to patrons. Typically, mobile apps are more challenging to build than mobile sites, since they require separate and specific programming for each operating system (Houghton, 2012). Mobile apps require the most effort and memory on the part of the user and the user's device. However, potential profitability, better mobile device functionality, and greater exposure through app stores can make mobile apps a lucrative option compared to mobile sites (Hanson, 2011). Another critical choice is whether to buy a commercial-off-the-shelf mobile application or build a customized mobile application. MTCs should have the necessary skills and knowledge to evaluate COTS mobile applications in terms of customer support and service, maintenance, the ability to meet patron needs, and needs of the library when making this choice (Huwe, 2013). Sometimes libraries purchase COTS products and customize them, benefiting from both options. For instance, some libraries first purchase packaged mobile frameworks to create simple, static mobile sites and subsequently develop dynamic library apps specific to library services (Iglesias & Meesangnill, 2011). LIS graduates with expertise in the strategic planning and management of mobile technologies could help libraries evaluate, invest in, and manage MAT smartly in the future.

Supplementary Competencies

Our analysis shows that project management, change management, data management, policy management, and grant writing are the six supplementary competencies that would help LIS students serve as MTCs for libraries.

S1. Project Management

The management of scope, time, cost,

Table 1. Applying Project Management Principles for
Implementing MAT in Libraries.

#	Principle	Key Activities
1	Scope management	• Plan a project for implementing MAT in library (i.e. document how the project scope will be defined, verified, controlled, and how the work will be broken down in a structured way; gather information from each vendor that supplies content to the library; etc.) • Make data-driven choice (e.g., consider reader preferences and their lack of knowledge about the library and mobile technology when selecting such technology) • Define a project goal (e.g. create a stable and user-centered mobile service platform for wayfinding in library) meeting user needs • Subdivide project into smaller, more manageable components • Develop a business process management plan for a project • Prioritize tasks (e.g., identify and prioritize functional areas like reference service, collection development, checkout, providing a streamlined OPAC, etc. for developing mobile apps) • Identify mission-critical features of the project • Control changes to the project scope
2	Time management	• Select appropriate software development methodology (e.g., structured methodology like waterfall or parallel, rapid application prototyping like phased, prototyping, or throwaway prototyping, or agile methodology like extreme programing) since it affects duration of any project implementing MAT in libraries • Save time by redesigning existing websites capable of operating on mobile devices instead of developing mobile applications from scratch • Identify specific schedule activity and documenting dependencies in schedule activity • Estimate the type, quantities of resources, and work periods required for each activity in implementing MAT • Control changes to the schedule
3	Cost management	• Calculate return on investment (ROI) before investing in MAT and make data-driven decisions using ROI • Consider the overall cost of purchasing, maintaining, and training staff and patrons for using newly introduced MAT in library • Perform cost-benefit analysis by comparing various mobile devices and services • Establish cost baseline by developing an approximation of the costs of the resources needed to complete project activity • Manage scarce financial resources • Control cost by monitoring cost variances and controlling cost changes
4	Quality management	• Identify quality standards relevant to the project and decide how to satisfy them (e.g., establish key performing indicators for library's mobile site, ongoing evaluation of user needs, and incorporating the needs with the current library mobile site) • Apply the planned systematic quality activity to ensure that the project staff processes necessary to meet set requirements • Monitor project results to make sure they comply with relevant quality standards and identify ways to eliminate cases of unsatisfactory performance

Table 1 (continued). Applying Project Management Principles for Implementing MAT in Libraries.

#	Principle	Key Activities
5	Human resource management	• Identify and document roles, responsibilities, and reporting relationships of team members involved in implementing MAT • Obtain human resources (e.g., recruit people with experience using HTML 5 and CSS) and periodically track team member performance, provide feedback, resolve conflicts, and coordinate changes
6	Communications management	• Make sure that MTCs are able to work with different stakeholder groups (e.g., students, librarians, professors from different departments, staff members, etc.) • Determine information and communications needs of project stakeholders • Make necessary information available to project stakeholders in a timely manner • Manage communications to satisfy the requirements of and resolve issues with project stakeholders
7	Risk management	• Decide how to approach, plan, and execute risk management activity • Determine which risks might affect the project and document their characteristics • Prioritize risks for subsequent analysis and assessment, combining the probability of occurrence and impact • Develop alternatives and corresponding actions to enhance opportunities and to reduce threats to project objectives • Track identified risks, monitor current risks, identify new risks, execute a risk response plan, and evaluate its effectiveness throughout the project life cycle

quality, human resources, and communications collectively represent project management (PMBOK, 2003). LIS students should have the experience and expertise necessary to manage projects aiming to deploy MAT in libraries (Thomas, 2011). The following table illustrates specific activities involved in managing the seven dimensions of the projects implementing MAT in libraries.

S2. Change Management

Institutionalization of MAT is critical to ensure their ongoing usage in libraries. For instance, if library staff and patrons are not on board, a newly developed mobile application will not be used as expected by the library, wasting its investment in MAT. Joe Murphy (2010) identifies the significance of user training in managing the change from traditional to mobile search,

and advises librarians to explore the mobile literacy skills of their patrons and educate them on how to use the new system. In support, Peters (2011) advises: "To be useful in the mobile era, library reference services need to overcome the reference desk mentality and the schedule fetish (p. 88)." He adds: "The mobility of documents is a wonderful thing, but this mobility does not intrinsically alter how humans interact with individual documents or individual kernels of information (p. 91)." LIS schools should equip their students with the management and psychological techniques critical for recognizing, preparing, and adopting the changes associated with implementing MAT in libraries.

S3. Negotiation

MTCs are also required to identify vendors (e.g., Altarama, LibraryH3lp, SMS

Gateway, Text a librarian) and negotiate contracts with them for offering estimates of services offered by MAT (Nowlan, 2013). MTCs are expected to protect the interest of libraries when negotiating IT contracts with external stakeholders including but not limited to government agencies, digital content providers, private sector IT partners (e.g., mobile technology platform vendors like Boopsie), cloud technology providers, etc. (Hoivik, 2013). Sample negotiation techniques for LIS students include focusing on interest rather than position in any argument, knowing the context, making the first offer for anchoring effect and not countering too low, ranking priorities, knowing the financial limits (e.g. target price, walk-away price, etc.), emphasizing potential, and sharing information by keeping all options on the table, etc. (Klein, Faratin, Sayama, & Bar-Yam, 2003).

LIS graduate programs should expose their students to real-world scenarios involving negotiation to acquire hands-on experience. Sometimes MTCs are required to build consensus among stakeholders (Keating, 2010). MTCs could help libraries gauge change in user needs. For instance, in academic libraries, it is important for libraries to embrace changing student behavior by providing services optimized for mobile devices (Paterson & Low 2011).

S4. Data Management

MTCs are expected to be well versed in (1) cleaning data to be used by MAT, (2) integrating COTS MAT with existing library services, and (3) managing interoperability of multiple mobile platforms and operating systems when sharing data over MAT (Connolly *et al.*, 2011).

LIS programs should train their students for the curation of local media content, and the creation and sharing of data in multiple formats on multiple platforms of mobile devices (Yelton, 2012). Integrating a backend database of metadata with frontend mobile technologies is critical for offering a better user experience (Hahn *et al.*, 2011). The ability to convert formats (e.g., WMA files into MP3 files, etc.), and integrate mobile devices with existing reference services (e.g., Altarama communicating with Eudora, an email reference system; AIM hack service; etc.) are a few examples of interoperability between multiple platforms (Houghton, 2012; Stahr, 2011) in libraries.

S5. Policy Management

Development and continuous assessment of library policies for the usage of MAT by library employees and patrons, and the management of privacy concerns and the complexities of digital rights management are the key areas of policy management LIS schools need to train their students for. Typically, mobile technology policies for libraries guide (1) user etiquette (Lever & Katz 2007); (2) text reference and email reference service, including issues related to privacy, acceptable use, etc. (Stahr, 2011); and (3) access to audio book collections, notifications, and device lending programs (Yelton, 2012).

LIS programs should also equip students to craft data-driven, feedback-based policies for mobile environments in libraries where students are trained to revisit, rethink, and revise policies to ensure that the library's vision and mission statement is continually updated and aligned with the ways mobile users access information (McEwen & Scheaffer 2012).

S6. Grant Writing for Seeking Funds

To implement MAT, libraries need funds. The ability to seek funding for developing MAT-related services is one of the supplementary competencies LIS graduates need to have to help libraries enhance patron experience through MAT. LIS programs could require students to take graduate courses on research methods (e.g., conducting literature review, quali-

tative and quantitative data collection and analysis, etc.) since it is an integral aspect of writing research grants. This would equip them to seek funds for developing the contemporary user experience of digital libraries through a technological development and usability evaluation framework (Paterson & Low 2011; Stahr, 2011).

Conclusion

Our analysis of the stories, experiences, and advice offered by librarians and IT professionals engaged in developing MAT for libraries over the last 10 years shows that LIS graduate programs need to train their students with interdisciplinary coursework in information science, business, and technology to equip their students with the 10 competencies to serve as MTCs for libraries. LIS graduate programs could collaborate with computer science, information technology, and business programs at their institutions to train their students using multiple perspectives for implementing MAT in information organizations like libraries. The interdisciplinary coursework could create more lucrative non-traditional career choices, in the form of mobile technology consulting, for LIS graduates.

As of September 2015, none of the ALA-accredited LIS graduate programs in the US offers a combination of graduate coursework with the interdisciplinary skills and knowledge required to select, purchase, design, develop, deploy, and maintain MAT in libraries. Thus this paper identifies a critical gap in the existing curricula of LIS graduate programs in North America and illustrates specific ways to bridge the gap.

This 21st century mobile workforce could help libraries make smart choices to efficiently manage their resources and better serve their patrons using MAT, leading to better community engagement. If newly trained LIS graduates come into the library to train other staff and to work more effectively as IT/library professionals,

then it will be less likely that the library will have to hire outside IT consultants or outsource the management of MAT. In an era of economic strains, this project could help libraries better manage their scarce financial resources.

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