
This paper presents a case study of the development, launch, and assessment of a mobile application incorporating iBeacon technology at the Charlotte Mecklenburg Library. The iBeacon protocol, along with other “beacon” technologies, has enjoyed success within the retail sector as a platform for proximity marketing, and is drawing interest from libraries as a means of providing digital enhancements to visitor experiences within physical library spaces. The application launched at the Charlotte Mecklenburg Library was assessed positively by library users in comparison to an earlier mobile application that duplicated features of the Library’s website, although users expressed dissatisfaction with the push-messaging features present within the application. A set of best practices for incorporating beacons and other location-specific technologies in mobile applications is included for use by technologists and administrators in libraries and other cultural heritage institutions.

Headings:

Mobile communication systems -- Library applications.
Public services (Libraries) -- Technological innovations.
Cell phone advertising.
BEACON TECHNOLOGY IN PUBLIC LIBRARY MOBILE APPLICATIONS: 
A CASE STUDY OF A PROJECT AT THE CHARLOTTE MECKLENBURG 
LIBRARY

by

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1. Introduction

As smartphones have increasingly become preferred modes of digital information access for many users, libraries, museums, and other cultural heritage institutions have recognized the need to both provide effective access to their digital services on mobile platforms and the opportunities that mobile technologies present for enhancing visitor experiences. A 2015 study released by the Pew Research Center indicated that over two-thirds of Americans currently own and use smartphones, with a full 13% of this population categorized as “smartphone-dependent”; these users have no forms of reliable Internet access beyond their mobile devices (Horrigan and Dugan, 2015, p. 2). While overall percentages of smartphone ownership increase with higher levels of income, “smartphone-dependent” populations tend to be predominately low-income, making effective mobile content delivery a significant concern for public libraries serving diverse communities (p. 2). This paper will explore the context, development, and outcomes of a mobile application project at the Charlotte Mecklenburg Library in “uptown” Charlotte, North Carolina during the 2015-2016 fiscal year.

1.1. Institutional Context

The Charlotte Mecklenburg Library is a large metropolitan library system serving a diverse community of over one million residents both within the city of Charlotte and within surrounding communities in greater Mecklenburg County. In 2015, the Library’s eighteen branches were visited approximately 3.2 million times, with 271,000 residents
using their libraries cards at least twice within the previous twenty-four months (Charlotte Mecklenburg Library, n.d.). Digital services are a current priority within the Library’s Strategic Plan (Charlotte Mecklenburg Library, 2012), and in October 2015 a redesigned, mobile-responsive Library website was launched at CMLibrary.org to both address the evolving needs of users and reflect the Library’s updated brand.

With the launch of the new mobile-responsive website, the existing Charlotte Mecklenburg Library mobile app became functionally redundant. Introduced in 2012, this application was a vended white-label solution from Boopsie, a mobile application development firm working exclusively within the library services market. Prior to the 2015 redesign of CMLibrary.org, the Boopsie app was a valuable tool for mobile users, effectively facilitating common tasks that were otherwise challenging in a mobile environment due to the fixed-width design of the previous website. Anticipating the upcoming expiration of the Library’s contract with Boopsie in March 2016, Library leadership identified an opportunity to develop a truly customized mobile application that would enhance visitor experiences within the library branches rather than merely duplicating the functionality of the new mobile-responsive website. In April 2015, the Library received a $100,000 Library Services and Technology Act (LSTA) Grant from the State Library of North Carolina to fund the development of a mobile app that would incorporate iBeacon technology to improve access to the library’s collections and resources through location-based tools and notifications.

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Beacon technology, first introduced by Apple in 2013 with its proprietary iBeacon protocol, allows mobile applications to receive data transmitted by nearby “beacons” via
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1.2. Beacon Technology in Mobile Apps

Beacon technology, first introduced by Apple in 2013 with its proprietary iBeacon protocol, allows mobile applications to receive data transmitted by nearby “beacons” via Bluetooth Low-Energy (BLE) signals, facilitating location-based “push-messaging”
The beacons themselves, which are not manufactured by Apple but rather produced by a variety of third-party companies, are typically small pieces of hardware that can be positioned within a physical space to send information directly to a user’s mobile phone depending on their position within the area.

Although the technical specifications of beacons may vary depending on the specific manufacturer, the overall functionality remains relatively consistent; a beacon is configured to transmit a single message at a determined interval, which can be shown to a mobile visitor as they enter, leave, or fulfill some other set pattern of movement (e.g. remaining in a given location for a certain amount of time) within its range of transmission. Unlike Near-Field Communication (NFC) technology, with which iBeacon is often compared, iBeacon transmissions are simple one-way communications, and do not require or support complex, encrypted data-sharing between two separate devices. Since the introduction of the iBeacon protocol with iOS 7, competing standards have been released by companies like Google, which launched its Eddystone beacon protocol in 2015 (Friedman, 2015).

Beacon technology has gained significant traction within the retail sector as a form of direct, location-based mobile marketing; retailers may configure beacons to transmit discount codes, alert visitors to sales or events, or advertise products and services. Beyond the retail sector, interest in beacon technology has been growing within the GLAM (“galleries, libraries, archives, and museums”) community due to the possibilities it presents for enhancing visitor experiences through location-based mobile interactions. Within this context, beacon technology can be framed as a type of
augmented reality tool, creating place-specific digital experiences for mobile users that add value to the physical experience of the library or museum.

1.3. Project Significance

Although location-based direct-to-consumer mobile marketing has been an established and growing use case for beacon technology within the retail sector, and to some extent within museums and academic libraries, there is virtually no literature on the use and effectiveness of beacons in public library contexts. The relative newness of the availability and applicability of this technology is a likely a significant contributing factor to the dearth of well-documented beacon-related projects within these institutions. As public libraries are increasingly facing the need to improve digital services for smartphone users, a practical case study of the Charlotte Mecklenburg Library’s project will be an important resource for peer institutions developing strategies for mobile content delivery. While literature on mobile apps deployed in academic library settings can certainly provide some useful insight for library staff in non-academic settings, the significant differences in the demographics and information-seeking needs of these institutions’ user communities create a demand for literature focused specifically on beacon-enhanced mobile apps within public libraries.
2. Literature Review

2.1. Mobile websites and applications in libraries

With the rising adoption of smartphones among the general public, including a significant percentage of the population that relies exclusively on mobile devices for access to the internet, libraries have recognized both the necessity of optimizing digital resources for mobile access, and the unique possibilities for innovative modes of interaction with library resources and services that are presented by mobile technologies. However, while the importance of providing effective digital services on mobile devices has been well-established, there are a variety of different strategies that libraries have employed to address the needs of these users, which many vary significantly depending on the size, user demographics, and financial resources of the particular institution. In general, mobile initiatives within library can be classified within two groups: mobile websites, which may offer responsive design and improved interaction with a library’s existing website, and mobile applications, which may either directly replicate the functions of the library’s website, or incorporate enhancements such as social sharing or location-based services.

La Counte (2013) notes the importance of developing mobile tools that will be usable by patrons with a variety of different mobile devices; this is more easily and affordably accomplished with mobile-responsive websites or with device-agnostic services such as “Text a Librarian” services, which can harness mobile devices as platforms for reference services without demanding customization for specific mobile
operating systems (pp. 7-9). Matthew Reidsma (2013) of the Grand Valley State University Libraries similarly notes the necessity of reaching the broadest group of mobile users as is feasible, and reports particular success with providing mobile websites that preserve all aspects of the functionality of the full website. While many “mobile first” design solutions attempt to identify and present only the key functions often performed by mobile users, Reidsma suggests that this is an ineffective strategy for libraries, and particularly for those which support diverse populations with widely varying information-seeking needs (pp. 88-91).

Although the creation of mobile responsive websites may be addressed as a component of a general website redesign process (as was the case with the Charlotte Mecklenburg Library’s redesigned website), custom mobile applications often require technical skillsets that may not be typically represented among possessed by library staff or third-party web development firms. As a result, libraries seeking to introduce branded mobile applications as a part of their digital strategy often purchase vended, white-label “platform as a service” solutions such as Boopsie that can be quickly tailored to interface with a library’s existing catalog and account management infrastructure (Johnstone, 2011, pp. 18-21). Although a benefit of this approach is the ease and speed of implementing the mobile application, these “one-size-fits-all” solutions may present usability challenges if library staff does not effectively customize the app for use within their specific organizations (Miller et al., 2013). At the Charlotte Mecklenburg Library the Boopsie application first launched as a platform for mobile access to the library’s collections failed to achieve widespread user adoption despite a dedicated marketing campaign advertising its availability.
Those libraries that have successfully developed websites with “in-house” teams are primarily academic research libraries; few custom, staff-developed mobile applications within public libraries have been documented within the literature, but those that do exist often present unique approaches to access and discovery of library collections. At the Orange County Library System (OCLS) in Orlando, Florida, staff developers launched the “Shake It” mobile app that presented a virtual slot machine interface, activated by shaking the device, to suggest books to users based on account preferences and demographics (Shivers, 2013, pp. 65-68). In most instances, however, public library systems like the Charlotte Mecklenburg Library often lack the appropriate staff to manage the technical aspects of major mobile web development projects, and turn to third-party development firms for implementation.

2.2. Location-based technologies in libraries

While the iBeacon protocol was selected by the Charlotte Mecklenburg Library to provide location-based functionality within their mobile application, literature exploring the applications of other place-oriented mobile technologies within libraries is also useful to consider. Prior to the release of iBeacon in 2013, Jim Hahn, undergraduate librarian at the University of Illinois Urbana-Champaign’s Undergraduate Library, produced a comprehensive overview of the possibilities and challenges of providing effective location-based recommendation services to on-site library users (Hahn, 2011). Noting the particular advantages of mobile recommendation services that could better connect users within the physical library to similar, relevant digital resources, Hahn stressed improved information-seeking experience that “collocated” physical and digital collections could provide (p. 658). Hahn previously managed the development of a GPS-based mobile
wayfinding prototype at the UI-UC Undergraduate Library that directed students to the physical location of books within the Library based on their call numbers. While students found the wayfinding concept to be useful, the inconsistent performance of GPS while indoors presented some challenges for usability. Other technologies like iBeacon or WiFi-assisted locational positioning are likely a more reliable option for navigational applications within library buildings, and successful beacon-based wayfinding tools have already been introduced outside of library contexts (Hahn et al., 2010, p. 109).

Location-based mobile technologies have additionally been used within libraries to gamify library tasks and instruction. SCVNGR, a game-based geolocation mobile application, has been successfully used at Oregon State University and at Boise State University to orient students to library services with customized scavenger hunts that include both physical and virtual elements (Vecchione and Mellinger, 2012). Nothing about the success of gamified instruction with place-specific digital information in these contexts suggests that similar techniques could not be employed either with beacon technology or in public library contexts; similar initiatives could be especially useful in libraries with a dedicated focus on children’s services, such as the Charlotte Mecklenburg Library’s ImaginOn branch.

2.3. Beacon technology in libraries

In keeping with the early usage of beacons as proximity marketing tools within the retail sector, libraries adopting beacon technology frequently focus on its use in library mobile marketing and outreach functions. Academic libraries have been particularly productive contexts for work in this area, with beacons employed primarily to transmit marketing messages to student populations that may be unfamiliar with the
range of resources and services provided by their institutions’ libraries. Unfortunately, due to the relatively recent development of beacon technology, much of the published literature does not yet include robust, data-driven assessment of the effectiveness of beacon implementations in these settings; these projects merit discussion nonetheless.

Recently, at the J. Murrey Atkins Library of the University of North Carolina at Charlotte, Bess et al. (2015) employed beacons to enhance existing library outreach strategies using proximity marketing techniques adopted from the retail sector. Operating within a grant-funded project environment similar to that at the Charlotte Mecklenburg Library, Atkins Library developed a mobile application with iBeacon functionality targeted towards the student population at UNC-Charlotte. Understanding the both the importance of thoughtful design when working with emerging technologies in new contexts and the danger of creating negative user experiences with direct messaging that is perceived as irrelevant or too frequent, usability testing was conducted at the Atkins Library throughout the development of the application (Bess et al., 2015, pp. 294, 297). Although the project has yet to generate sufficient data to assess measurable improvements in the effectiveness of library outreach, the “49er Alerts” app, initially deployed with beacons transmitting outreach messages in four distinct public service categories (“news and events, computer availability, library brochures, and group study room availability”), was well-received by the student community (pp. 296-297).

Many libraries have chosen to purchase beacon-enhanced library mobile app solutions from companies such as CapiraConnect or BluuBeam rather than dedicate financial resources and staff to the development of truly custom mobile applications. These vended solutions, as used at the Borough of Manhattan Community College
(BMCC) and the Orlando Public Library, appear to be a more popular choice than in-house or custom contracted development for public libraries due to their relative ease of implementation and speed of deployment (Eng, 2015). At BMCC, a CapiraConnect mobile app, which delivered location-based notifications to improve awareness of certain library resources and services, was introduced to replace an earlier mobile app that was never widely-adopted by the target student population; Eng notes that both poor promotion and the design of the app itself were key factors in the application’s failure to effectively meet user needs, citing the fact that the “installation required an active and continued effort from the students” as a barrier to adoption within a population with low levels of existing awareness of library services (p. 13). The “push-messaging” functionality of beacons may be especially effective for users who are largely unfamiliar with their library’s resources (p. 13).
3. Methods

The majority of this paper will be a narrative case study based upon the mobile app project completed by the Charlotte Mecklenburg Library during the 2015-2016 fiscal year. Within the case study, I will discuss in detail the context, goals, and development process of the project, along with the decision-making processes of the Library’s Digital Strategy Team. Many details will be drawn from internal documentation generated over the course of the project’s lifecycle. Additionally, data generated from user satisfaction surveys and focus groups administered in Spring 2016 by the Charlotte Mecklenburg Library will be analyzed to assess the effectiveness of the first phase of the mobile app project in meeting current user needs. This data analysis, in conjunction with the narrative case study, will be further expanded upon in the discussion session, which will include a preliminary set of best practices for beacon technologies within public library contexts. Finally, I will discuss the results of the survey within the broader context of augmented and virtual reality possibilities within libraries, museums, and associated cultural heritage institutions.
4. Results

4.1. Early phases

In 2013, the Charlotte Mecklenburg Library developed and issued a Strategic Plan intended to guide the Library’s initiatives and goals over the three-year period from 2013-2017. Included in the Strategic Plan was a stated priority to improve the quality and accessibility of the Library’s digital services; in service of this objective, a Digital Strategy Workgroup was convened in November 2013 to establish specific priorities for different aspects of the Library’s digital strategy, including digitization, user experience, and infrastructure. One of the outcomes of the Digital Strategy Workgroup’s planning was the decision to hire an experienced Digital Strategy Manager to oversee the Library’s digital initiatives, including the development of a new mobile app to replace the existing Boopsie application.

The Digital Strategy Manager was hired in January 2015, and in July 2015 the Charlotte Mecklenburg Library received a Library Services and Technology Act (LSTA) grant from the State Library of North Carolina for the development of the new mobile application. The grant proposal, which noted the necessity of better meeting the needs of the increasing number of Library users who access digital information primarily via smartphone, outlined two general anticipated outcomes of the project: that the new mobile app “improve users’ ability to discover information” and “improve users’ ability to obtain information resources” while incorporating iBeacon technology to enhance
patron experiences within Library spaces. Additionally, four specific functions were
established as priorities for the application:

1. The application should include a digital library card that would be triggered by a
   user’s proximity to the circulation desk, and which could functionally replace the
   current existing physical library cards for users who chose to use the new mobile
   application.

2. The application should connect to individual user accounts and facilitate some
   level of personalization.

3. The application should include push-messaging capabilities to improve awareness
   of library services and programming.

4. The final product should facilitate the collection of basic data regarding user visits
   to physical library branches.

The grant further specified that the project funds would support both the development of
the new mobile app, and the purchase and installation of beacons at the Main Library
branch and at ImaginOn, the Library’s children’s branch. The State Library granted the
Charlotte Mecklenburg Library $100,000 for the project, which CML would supplement
with another $15,500 in matching funds from its Foundation.

The Mobile App Team of the Digital Strategy Workgroup was then officially
convened in August 2015, and included the Library’s Digital Strategy Manager; the
Associate Director of Access and Organization Initiatives; a consultant from Seismic, a
local technology consulting firm; an IT Analyst from Charlotte Mecklenburg County
assigned to the Library’s Web Services department; and a graduate assistant from the
University of North Carolina at Chapel Hill.
As the grant required that the project be both completed and evaluated within twelve calendar months, it was essential for the Library to quickly develop a refined vision for the mobile application, including a comprehensive list of requirements; it would also be necessary to contract with a mobile application development firm who could work within the specifications of the grant, and within a relatively short development timeframe. With a proposed launch date of March 2016, a general project schedule was set:

<table>
<thead>
<tr>
<th>Month</th>
<th>Task</th>
</tr>
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<tbody>
<tr>
<td>August-September</td>
<td>Define project requirements and priorities for developers</td>
</tr>
<tr>
<td>October</td>
<td>Interview and select developer</td>
</tr>
<tr>
<td>November-February</td>
<td>Application development and installation of beacons at Library branches</td>
</tr>
<tr>
<td>March</td>
<td>Application launch</td>
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### 4.2. Planning and development

The LSTA grant proposal submitted by the Charlotte Mecklenburg Library included an outline of basic functions that were intended to be included in the new mobile application. In preparation for identifying an appropriate organization to contract for the development of the app, the team generated a more comprehensive set of project requirements, with the understanding that it was possible that some features would need to be deferred to a subsequent phase of the project if the selected firm was unable to
include them within the established budget or within the short timeframe. In addition to the general goals outlined in the initial project proposal, specific beacon-supported tools were established as priorities for inclusion in the mobile application, including a location-based “Ask a Librarian” tool in which users could alert nearby reference staff to a need for assistance, and a mapping tool that could guide users to book locations or service points within the library.

In October 2015, the Mobile App Team solicited proposals from multiple local mobile development firms, eventually selecting Skookum, a Charlotte and Denver-based company with an excellent track record in rapid development for complex mobile application projects. Unfortunately, during the selection process, it became evident that the scope of requirements would need to be significantly reduced to be completed within both the project budget and timeline. Although many firms expressed interest in the possibilities for user-initiated beacon functionality such as the location-based “Ask a Librarian” tool, incorporating these features promised to be expensive and time-consuming. As a result, it was necessary to split the existing list of requirements into those that could reasonably be accomplished within the four-month development window, and those that would become priorities for the next project phase, which was slated to be funded by the County for the 2016-2017 fiscal year.

Although the Mobile App Team believed that the user-initiated “Ask a Librarian” and library mapping tools were ideal uses of beacon technology for the Charlotte Mecklenburg Library, it was important to first fulfill the explicit requirements of the grant; the digital library card and push-messaging features were therefore retained as requirements for Skookum, with all other beacon-enhanced user tools postponed for later
project phases. As both the digital library card and access to digital resources as advertised by the proximity marketing beacons relied upon user account access, the initial phase of the mobile application would also include full user account management capabilities (including renewals and fine payment), as well as integration with BiblioCommons, the Library’s catalog search and discovery interface.

The push-messaging aspect of the mobile application was primarily intended to increase awareness of the Library’s digital collections and resources based on a user’s physical location within the building. Reference staff in each different Library department were asked to track daily in-person referrals to digital library resources to inform the positioning of beacons and the content of their notifications. Although beacons could be repositioned and reconfigured with relative ease, the initial locations and messages would correspond with those digital resources to which library staff frequently directed visitors who requested information-seeking assistance.

As the purchase of beacons was a relatively minor expense in comparison to overall development costs, it was decided to include an additional branch in the pilot program. To better assess the application’s effectiveness across demographic groups, Plaza Midwood, a branch serving the northeast Charlotte neighborhood of the same name, was selected due to its diversity of age, ethnic, and economic groups. Although the Plaza Midwood branch would have fewer beacons installed for the initial pilot, a more comprehensive installation was slated for the planned second phase of the mobile app project.

For the visual style of the mobile application, Skookum faced the challenge of creating a user interface that both reflected the Charlotte Mecklenburg Library’s visual
brand (including its established color scheme, typography, and textual style guidelines) and that would be appropriate for three Library branches serving very different audiences. Although the Plaza Midwood branch serves a broad variety of users, ImaginOn specifically caters to families with children under the age of eighteen, while the Main Library’s user base is predominately adults over the age of eighteen. The application, therefore, had to be effective in a children’s library setting without being too identifiably juvenile to resonate with adult users.

With the need to balance these different user demographics in mind, the team decided on a visual style that incorporated several illustrated explanatory screens; the task-oriented areas of the application were primarily text-based and used a minimalist visual design with black, sans-serif text on a white background and. The icons and illustrations, which used the Library’s official brand colors, included imagery that would be appropriate for the children’s branch (such as a magic wand, a telescope, and a bookshelf), while avoiding visuals such as dolls or teddy bears that would immediately be identifiable as specifically intended for a family audience (Figure 1).

Figure 1 Explanatory screens incorporating the Charlotte Mecklenburg Library’s official brand colors (Luke, 2016).
4.3. Implementation and Evaluation

To evaluate user response to the new mobile application, the Mobile App Team planned to collect data in accordance with the specifications of the grant, including conducting customer satisfaction surveys to measure user perceptions of the application at multiple stages during and after the launch of the app, and running Library branch-specific focus groups to assess user experiences with the application at each location. In consultation with the Marketing & Communications department at the Charlotte Mecklenburg Library, the Digital Strategy team developed a launch schedule for the new application that would begin with a “soft launch” of the application during which the first user survey assessing the new app would be administered, followed by a publicized wide release coinciding with the end of the Boopsie contract.

Survey and focus group participants were recruited via email blast directed to a list of Library patrons maintained by the Library’s Marketing & Communications department; this list included the specific Library branch with which each user was affiliated, which allowed the team to direct the recruitment message to only those users who had indicated that Main, ImaginOn, or Plaza Midwood were their preferred locations. The email invited users to register their interest in participating in the mobile app user surveys and in the focus groups, and participants were then selected randomly from those who responded affirmatively.

Three versions of the customer satisfaction survey were developed. The first, a “pre-launch” survey, was intended to generate data on user opinion of the existing Boopsie mobile application that could then be directly compared to customer satisfaction data for the new mobile application; most of the questions posed on each version of the survey were identical to facilitate comparisons. The second, a “post-launch” survey, was
developed to collect data at multiple points after the launch of the application to reveal changes in user opinion or usage habits over time; this was judged to be particularly necessary for an application incorporating proximity-triggered notifications, as there was some concern that users would eventually opt out of notifications if they failed to provide new information upon subsequent visits to a library branch. The final version of the survey, administered at the end of the pilot, added several open-ended questions regarding the overall experience of the pilot program, ideas for extending the mobile application’s functionality in future development phases, and intentions for future use of the new digital library card.

Each version of the survey was designed to be completed in under five minutes in order to minimize the number of participants who abandoned the form. The first seven questions consisted of five-point Likert scales, for which users were shown a pair of descriptive traits (e.g. “confusing” vs. “intuitive”) at either end of the scale, and asked to register their opinion. Following the rating scale section, the two post-launch surveys included between two to six additional multiple choice and free-response questions; these were not used for comparison between surveys, but were intended to gauge additional aspects of user opinion. These questions touched on topics including user motivations for using the library, likelihood of recommending the application to other users, and possibilities for additional features to be incorporated in future phases of the mobile application project.

Focus groups, meanwhile, were scheduled to be conducted concurrently with the customer satisfaction surveys, and were intended to capture qualitative data about user experiences with the mobile application. Participants were selected at random from the
initial recruitment pool, with a goal of eight to ten participating Library patrons for each branch-specific focus group. Each focus group session was an hour long, and consisted of a pre-determined set of six open-ended questions:

- What part of the app is the most helpful for you?
- What about the app do you find confusing?
- What parts of the app do you use most frequently?
- Where and when do you use the app?
- Have the notifications been helpful? Are you still receiving them? Why or why not?
- Are there tasks that you prefer to do on the app vs. in the physical library branch (and vice versa)?

Additionally, while the grant proposal specified that download and usage data would be compared to the data from the Library’s earlier Boopsie mobile app, it is too soon post-launch to make a useful comparison; the Digital Strategy Workgroup intends to make an assessment based on this data at both six months and twelve months past the date of release. The more limited availability of the new mobile app is an additional complicating factor; while the Boopsie app was available on both Android and Apple devices, the Skookum-developed application is available solely for iOS during the initial launch. A worthwhile comparison of usage data will therefore need to distinguish between Android and Apple users of the Boopsie application.

4.4. Focus group response

The focus groups provided incomplete, but useful data. One focus group meeting, of Plaza Midwood branch patrons, was unable to be held due to last-minute participant cancellations, and turnout was lower than anticipated at each of the other focus group
sessions. Regardless, the data generated by the focus groups suggested some polarity in opinion, with overall satisfaction split between users who indicated a strong dislike for the new mobile application, and those who registered a strong approval of the app. Focus group discussions revealed that many of the patrons who had used the previous Boopsie application regularly, and who registered a strong dissatisfaction with the new application, were primarily concerned by the loss of several features that had been available in the defunct application. Although these features were now available through the mobile responsive website, these users were accustomed to completing tasks within the Boopsie app and were unaware that these functions had shifted to website-only access.

The lack of features formerly included in the Boopsie application was a common sentiment in all focus group meetings when participants were asked to detail aspects of the application that they found confusing. Users additionally noted that the interface for accessing electronic resources such as e-books and digital audio through the library was jarring. Currently, selecting a resource currently takes the user out of the mobile application and into the mobile web browser to access the service, and participants noted a strong preference for completing all tasks within the application itself. This has been a common finding in general mobile application usability studies; Google’s UX documentation for mobile designers explicitly cautions against disrupting user “geography” by forcing links to open unexpectedly in external mobile browsers and was an expected result (Griffiths, 2015). In-application access of digital resources was an initial goal of the Library’s project, but was found to be impossible to implement within the budget and short timeline afforded by the grant. Based on this specific feedback, the
Digital Strategy Workgroup hopes to minimize redirection to mobile web browsers in the second phase of the mobile application project.

Within the focus groups, users in each session indicated that the mobile library card feature was both helpful and frequently used; one participant noted her surprise that the beacon technology triggered the display of the card automatically on her upon her arrival at the circulation desk (“it was just like Star Trek!”). Users additionally indicated frequent use of the book renewal and book hold features, both of which were described as far more helpful and user-friendly than the access to these tasks provided within the earlier Boopsie application.

Although the intention of the mobile application project was to develop a tool that would be particularly useful within the physical library space, most participants were found to use the app primarily at home or in third locations (e.g. at work, waiting to pick up children at school, etc.). As a result, some participants were entirely unaware of the beacon notifications that could be triggered while moving throughout the library; many of these users nonetheless found the application to be useful for search, account management, and access to digital resources. This suggests that the Library’s mobile application would continue to be useful without the beacon-enhanced capabilities.

Users who frequently visited the library branches with their mobile phones reported varying levels of satisfaction with the beacon notifications. Among those who indicated a dislike of the notifications, a sense of being “annoyed”, “pestered” or “marketed to” was often cited. Previous work on customer perceptions of unsolicited push messaging in the retail sector has shown that users tend to perceive unexpected direct-to-consumer notifications, particularly those that are not personalized for
individual groups of users, as significantly less useful (Sá et al., 2015). We can see that that holds true in libraries spaces as well. Meanwhile, users who appreciated the notifications noted that they were alerted to collections (such as the digital video collection available through the mobile application) of which they were not previously aware.

User demographics appeared to influence perception of the beacon notifications. The ImaginOn user group, primarily parents with young children, described their overall experience with the notifications far more positively than those at the Main branch. It is possible that some of the difference in user satisfaction with the Charlotte Mecklenburg Library mobile application at the ImaginOn branch versus the Main Library branch could be attributed to the varying nature of the typical user goals for visiting these institutions; while ImaginOn presents an environment that actively encourages play and exploration, Main Library users may tend to have more rigidly defined information-seeking goals and task-based motivations for visiting.

4.5. Customer satisfaction surveys

The data from the customer service surveys is below. Only those questions that appear across all three surveys are evaluated comparatively, although the various free-response questions included in different iterations of the survey are later considered briefly as well. Data from the pre-launch survey and from the first survey are compared to the final data separately, to assess both the difference in user opinion between the two different mobile applications (Boopsie and the newly-launch app), and any difference in opinion that may be recorded from the beginning to the end of the pilot project period. As the surveys were completed with different numbers of participants and exhibited
inconsistence variance, significance was evaluated using an unpaired two-tailed t-test with Welch’s algorithm. Results are considered to be significant at p < .05.

**Question 1: Is the mobile app complex (1) or simple (5)?**

<table>
<thead>
<tr>
<th>Survey</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>Average</th>
<th>St. Dev.</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-launch</td>
<td>6</td>
<td>8</td>
<td>12</td>
<td>10</td>
<td>6</td>
<td>3.05</td>
<td>1.27</td>
<td>42</td>
</tr>
<tr>
<td>Survey 1</td>
<td>0</td>
<td>4</td>
<td>10</td>
<td>21</td>
<td>21</td>
<td>4.05</td>
<td>.92</td>
<td>56</td>
</tr>
<tr>
<td>Survey 2</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>18</td>
<td>22</td>
<td>4.33</td>
<td>.80</td>
<td>45</td>
</tr>
</tbody>
</table>

Comparing the pre-launch responses to the final survey responses (Survey 2), we have a statistically significant difference (p < .0001) in user evaluation of the simplicity of the Boopsie application versus the Library’s new mobile application. Although simplicity is not necessarily universally more positive than complexity, the new mobile application was intended to reduce the vast number of complicated features available in the earlier Boopsie application to provide a more streamlined app experience. Although there appears to be some increase in average perception of the application’s simplicity between the two surveys distributed during the pilot project that might indicate users found the application to be simpler over time, the result is not statistically significant (p = .1057).

**Question 2: Is the mobile app bland (1) or interesting (5)?**

<table>
<thead>
<tr>
<th>Survey</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>Average</th>
<th>St. Dev.</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-launch</td>
<td>10</td>
<td>14</td>
<td>14</td>
<td>4</td>
<td>0</td>
<td>2.29</td>
<td>.94</td>
<td>42</td>
</tr>
<tr>
<td>Survey 1</td>
<td>3</td>
<td>6</td>
<td>15</td>
<td>20</td>
<td>12</td>
<td>3.57</td>
<td>1.11</td>
<td>56</td>
</tr>
<tr>
<td>Survey 2</td>
<td>0</td>
<td>1</td>
<td>15</td>
<td>19</td>
<td>10</td>
<td>3.84</td>
<td>.80</td>
<td>45</td>
</tr>
</tbody>
</table>
Here, we again see an extremely statistically significant difference (p > .0001) in user perception of the extent to which the two different mobile applications could be considered interesting. With an average response rate of 3.84, users found the new application to be far more interesting than the Boopsie application. As seen in the previous question, although there was an increase in the average rating between the first iteration of the survey to the next, the result is not statistically significant (p = .1539).

**Question 3: Is the mobile app unhelpful (1) or helpful (5)?**

<table>
<thead>
<tr>
<th>Survey</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>Average</th>
<th>St. Dev.</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-launch</td>
<td>8</td>
<td>4</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>3.33</td>
<td>1.48</td>
<td>42</td>
</tr>
<tr>
<td>Survey 1</td>
<td>1</td>
<td>4</td>
<td>13</td>
<td>19</td>
<td>19</td>
<td>3.91</td>
<td>1.01</td>
<td>56</td>
</tr>
<tr>
<td>Survey 2</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>17</td>
<td>21</td>
<td>4.29</td>
<td>.79</td>
<td>45</td>
</tr>
</tbody>
</table>

Here, we have a statistically significant difference in perceptions of helpfulness between the Boopsie application and the Library’s new mobile application (p = .0004).

Additionally, the improvement in helpfulness ratings seen between the results from the first survey and the second survey is indeed statistically significant (p = .0374), showing an increase in user perception of helpfulness that could potentially be attributed to a greater number of interactions with the mobile application.
**Question 4:** Is the mobile app boring (1) or engaging (5)?

<table>
<thead>
<tr>
<th>Survey</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>Average</th>
<th>St. Dev.</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-launch</td>
<td>6</td>
<td>8</td>
<td>20</td>
<td>5</td>
<td>3</td>
<td>2.79</td>
<td>1.07</td>
<td>42</td>
</tr>
<tr>
<td>Survey 1</td>
<td>3</td>
<td>6</td>
<td>17</td>
<td>22</td>
<td>8</td>
<td>3.46</td>
<td>1.04</td>
<td>56</td>
</tr>
<tr>
<td>Survey 2</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>26</td>
<td>7</td>
<td>3.89</td>
<td>.65</td>
<td>45</td>
</tr>
</tbody>
</table>

The data here again shows a statistically significant difference (p < .0001) between the level of engagement users indicate with the Boopsie application versus the new mobile application, which was specifically intended to provide an engaging experience separate from that of the mobile-responsive website. The improvement seen between the first and second survey is also statistically significant (p = .0141), showing that users found the application to be more engaging over time. Once again, it is possible that the extended period of time during which users had the opportunity to use the mobile application allowed users to discover features that they found to be engaging.

**Question 5:** Is the mobile app outdated (1) or cutting edge (5)?

<table>
<thead>
<tr>
<th>Survey</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>Average</th>
<th>St. Dev.</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-launch</td>
<td>13</td>
<td>16</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>2.20</td>
<td>1.22</td>
<td>42</td>
</tr>
<tr>
<td>Survey 1</td>
<td>2</td>
<td>6</td>
<td>16</td>
<td>22</td>
<td>10</td>
<td>3.57</td>
<td>1.02</td>
<td>56</td>
</tr>
<tr>
<td>Survey 2</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>24</td>
<td>3</td>
<td>3.53</td>
<td>0.50</td>
<td>45</td>
</tr>
</tbody>
</table>

Here, while we see an extremely statistically significant difference between the Boopsie application and the Library’s new mobile application (p < .0001) which shows that users perceive the new application to be more innovative, we actually see a decline in the
average perception between the first round of the survey and the second. While the result is not statistically significant (p = .8079), it was expected that user perception of the application’s novelty would decline after initial use.

**Question 6:** Is the mobile app dull (1) or stimulating (5)?

<table>
<thead>
<tr>
<th>Survey</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>Average</th>
<th>St. Dev.</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-launch</td>
<td>10</td>
<td>6</td>
<td>18</td>
<td>4</td>
<td>4</td>
<td>2.67</td>
<td>1.22</td>
<td>42</td>
</tr>
<tr>
<td>Survey 1</td>
<td>3</td>
<td>7</td>
<td>22</td>
<td>18</td>
<td>6</td>
<td>3.30</td>
<td>1.01</td>
<td>56</td>
</tr>
<tr>
<td>Survey 2</td>
<td>0</td>
<td>1</td>
<td>16</td>
<td>23</td>
<td>5</td>
<td>3.71</td>
<td>0.69</td>
<td>45</td>
</tr>
</tbody>
</table>

Users found the new mobile application to be more stimulating than the Boopsie application; the result was extremely statistically significant, with a p-value of less than .0001. The difference between the results from the first and the second iterations of the survey are statistically significant as well (p = .0184), showing a measurable increase in the extent to which users find the new mobile application stimulating.

**Question 7:** Is the mobile app confusing (1) or intuitive (5)?

<table>
<thead>
<tr>
<th>Survey</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>Average</th>
<th>St. Dev.</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-launch</td>
<td>10</td>
<td>6</td>
<td>6</td>
<td>14</td>
<td>6</td>
<td>3.00</td>
<td>1.43</td>
<td>42</td>
</tr>
<tr>
<td>Survey 1</td>
<td>1</td>
<td>8</td>
<td>9</td>
<td>25</td>
<td>13</td>
<td>3.73</td>
<td>1.04</td>
<td>56</td>
</tr>
<tr>
<td>Survey 2</td>
<td>1</td>
<td>2</td>
<td>10</td>
<td>19</td>
<td>13</td>
<td>3.91</td>
<td>0.95</td>
<td>45</td>
</tr>
</tbody>
</table>

Users found the new mobile application to be more intuitive than the Boopsie application (the result was extremely statistically significant with a p-value of .0009). The increase in
user perception of the application’s intuitiveness between versions of the survey was not statistically significant (p = .3681), and no conclusions can be drawn from the slight improvement in opinion.

Overall, the customer satisfaction surveys conducted by the Library indicated a generally positive user perception of the new mobile application, with meaningful change in opinion over the course of the pilot program for several aspects of the project that were assessed. A measurable improvement from the Boopsie application was found for each of the questions. Additionally, survey questions which allowed for open-ended responses generated particularly useful feedback for the Digital Strategy Workgroup. These questions were not carried over between different version of the survey, and are therefore not useful for comparison between either Boopsie and the new application, or between the first and second iterations of the post-launch survey.

In the first post-launch survey, users were asked to indicate changes or additional features that they would suggest for the mobile application, and were provided a text box to enter a free-form response. Responses largely echoed the frustrations revealed in the focus group, with users indicating a desire for access to digital resources like e-books directly within the application rather than within a mobile browser window. Another frequent request was for social or personalized recommendations for books or digital resources, which was explored as a possibility in early phases of the mobile application project. Unfortunately, due to the difficulty of adequately developing appropriate recommendation algorithms while maintaining high standards of privacy for patron data, the Digital Strategy Workgroup did not find the inclusion of highly personalized or social recommendations to be a realistic possibility for this particular project.
Responses from this question were separated into distinct categories (with features that would be impossible to implement discarded), and presented as options for a similar question on the final survey (“Which of the following would be the top three (3) you would like to see in a future version of the app?”). Presented with options, users indicated a preference for increased functionality of the search and hold features:

![Chart showing responses]

This portion of the survey also provided valuable data regarding the beacon “push” notifications. When asked to provide free-form feedback regarding the notifications, few of the responses were positive. Unlike the participants in the ImaginOn focus group, survey users considered the push notifications to be “random,” “not relevant,” and “not useful.” Interestingly, a large number of users reported never receiving a notification, either due to opting out of notifications from the application, or due to technical issues with wireless reception in the branches. This data was invaluable for assembling the best practices detailed in the discussion section.
5. Discussion

Although no two institutional contexts are completely alike, and it is essential for organizations to thoughtfully evaluate the appropriateness of incorporating beacon technology into their mobile application projects, the Charlotte Mecklenburg Library’s mobile app is a useful model to evaluate for typical challenges that other organizations may encounter. After an analysis of the background, development, and reception of the Library’s mobile application, the following best practices have been developed to assist libraries and other cultural heritage organizations as they begin planning and executing mobile projects:

1. Effectively communicate and advertise the introduction of new technology.

When introducing any new digital service, it is crucial to adequately inform the user base about the both the purpose of new digital projects and their relationship to other digital services of the organization; this is especially true for mobile applications that have location-based functionality which may not be immediately evident to users exploring the application outside the context of the beacon-equipped space. For the Charlotte Mecklenburg Library, some users were initially confused about the role of the new mobile application as it related to the old mobile application. While the new application was not intended to replicate all of the features of the Boopsie app, as this functionality was now offered by the redesigned, responsive website, it became clear that this distinction was not effectively communicated. As a result, some users felt that the new mobile app was an incomplete and inferior replacement, with several frequently-
used tools missing from the new app (although these tools were now available via the website itself). A better marketing and communications strategy for the Library’s new website and for the mobile application could have clarified the roles of each separate digital platform.

Another benefit of a robust communications initiative is that it is likely to generate interest in and reduce concerns about beacon technology among those who may be unfamiliar with its mechanics. Without a proactive strategy to market the application and communicate the role that beacons play within the product, users may become confused by the location-based notifications or develop concerns about perceived privacy issues. While iBeacon does not collect and track identifiable user information, privacy-conscious users may be concerned about opportunities for identity theft and location-tracking posed by beacon technology; a clear, explanatory communications campaign that addresses these issues is a worthwhile investment of time for organizations implementing similar programs.

Understanding the population being served by an organization and by a mobile application is crucial to an application’s success. While gathering data on the local community and on the demographic clusters that may exist within it is an important foundational step, with beacon-enhanced applications it is additionally important to assess the information needs and access patterns of users who both visit the library and who own smartphones. With this information, beacon notifications can be tailored to effectively meet the needs of the specific user community.

At the Charlotte Mecklenburg Library, beacon notifications were developed to increase awareness of digital resources and collections related to the user’s location in the
physical library branch; unfortunately, many users visiting the library with the mobile app installed were often already “power users” with higher levels of familiarity with the Library’s electronic resources. The configured beacon notifications were therefore unhelpful for a significant proportion of Library visitors using the new mobile application. Hybrid digital-physical “collocation” itself may be a promising direction for use of beacon and other location-specific technologies for mobile users as in Hahn’s (2015) work at the University of Illinois’ Undergraduate Library, but would perhaps be better implemented via user-initiated action rather than via push messaging. With users initiating a collocation link, would be less likely that users well-versed with digital resources will be inundated with irrelevant notifications.

Not all “push” features were received poorly; the virtual library card that was automatically triggered by proximity to the circulation desk was highly successful, and perceived as both convenient and unobtrusive. It is possible that the task-oriented nature of this particular beacon was a factor in its success, as it simply provided a way to complete a transaction without the physical library card.

2. **Prioritize user-friendly beacon configurations.**

   In beacon-enhanced mobile application projects that do incorporate push-messaging, it is essential for beacons to be appropriately configured to maximize their usefulness to visitors and decrease the frequency of pushing irrelevant or redundant notifications. While many configuration options have the potential to influence the success of push messaging, the trigger range settings and the between-notification settings are particularly important for ensuring that messages arrive in appropriate places and in appropriate times. If the trigger range is too large, users may receive notifications that are out-of-context given their current location within the library space. Similarly, if the time
between notifications is set to too low an interval, users may be messaged with redundant information if they cross into the trigger range multiple times within a visit. When push messages are too frequent or redundant, users will likely either opt out of receiving the notifications, or will simply ignore the messages when they come in.

3. **Empower users to control their participation in iBeacon messaging.**

   Perhaps the most basic, and most crucial guideline for launching beacon-enhanced mobile applications is that users must be given full and easily-accessible control over their participation in proximity messaging. Notifications must be an optional component of any application on a user’s personal mobile device--although it is understood, and may similarly be stated to the user, that the functionality of the app will be reduced without enabling the beacon-enhanced components. Furthermore, a user’s reception of beacon notifications should be “opt-in” rather than “opt-out”; the Charlotte Mecklenburg Library’s mobile application serves a prompt to mobile users upon their first launch of the application, which asks them to allow the Library to direct notifications to their phone via iBeacon. Users can easily opt out of the beacon messages, and can access and edit their beacon preferences within the account settings area.

4. **Emphasize user-initiated actions.**

   While some level of marketing-oriented push-messaging may indeed be useful to visitors within library contexts as long as the notifications are well-suited to the needs of a specific user community, user-initiated tools are more likely to facilitate good user experiences within the physical library space. Libraries planning to incorporate beacons or other location-based technologies into a new mobile application will be well-served by emphasizing thoughtful user-initiated functions within the project.
With these best practices in mind, it is important to emphasize that merely adhering to these guidelines will not ensure the success of a project; contracting the development of a truly custom mobile application (or developing such an application “in-house”) is a significant undertaking that can quickly be derailed by challenges related to project funding, staffing, or infrastructure. The budget and limited timeline outlined by the LSTA grant was a major roadblock for the project at the Charlotte Mecklenburg Library, as it necessitated the elimination of several valuable beacon-supported tools.

Many, if not most, libraries are likely to find it preferable to purchase a third-party vended solution with some customization options rather than to comprehensively manage the development of a new application. In either development context, it is imperative to thoughtfully evaluate the need for beacon technology (or other location-based tools) within the mobile application. While libraries, museum, and archives are promising sites for exploring the possibilities that emerging technologies present for enhancing the visitor experience, projects are ultimately unlikely to be successful without a genuinely compelling reason for incorporating location-based tools.

Beacon technology is one small component of a much greater movement towards immersive experiences in GLAM institutions that harness digital technologies to enhance visitor experiences within libraries, museums, and historical sites. While the best practices detailed above may specifically address the use of beacons in libraries, many of the concepts will likely be useful even as the specific technologies evolve. Although the beacon technology incorporated within the Charlotte Mecklenburg Library’s mobile application failed to consistently create engaging user experiences, significant potential remains for innovations in the field.
6. Bibliography


