UTILIZING MOBILE TECHNOLOGY IN GIS EDUCATION:

A CASE STUDY OF USING IPAD AND iBOOKS IN FIELDWORK AND LOCATION BASED EXERCISES

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Utilizing Mobile Technology in GIS Education: A Case Study of Using iPad and
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ABSTRACT OF THE THESIS

Utilizing Mobile Technology in GIS Education:
A Case Study of Using iPad and iBooks in Fieldwork and Location Based Exercises
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The advancement of mobile computing technology has provided diverse way for education. Combination of mobile devices and GIS tools has become a trend in many geospatial technology applications (i.e., Google Maps application on smartphones). This research aims to develop an iBook prototype (a GIS textbook) for GIS education on Apple iPads and to evaluate the effectiveness of adopting the GIS iBook in classes and fieldwork exercises. We conducted the evaluation tests in two GIS courses (GEOG104 and GEOG381) in Fall 2014 at San Diego State University. There are two main research questions in this study: (1) How to assess and evaluate the effectiveness of location-based learning exercises (from iBook) and fieldwork exercises for first-time GIS students? (2) What were major technical challenges and opportunities to utilize mobile device and mobile technology in GIS education?

The procedures of developing and evaluating the prototype of the GIS iBook include creating two new chapters (chapter three: Wander the World through Remote Sensing Data and chapter four: Internet and Mobile GIS), interviewing five educators from high schools and community colleges, and improving the contents of the GIS iBook after the interview. There were 31 students who tested the GIS iBook and did a fieldwork exercise with iPads. The 31 students were required to finish five questionnaires after the exercise to express their user experiences and thoughts about the GIS iBook.

Based on the result of questionnaires, most students preferred to take GIS classes with the free GIS iBook and thought fieldwork exercise can help their learning. The students also performed better in knowledge oriented survey after reading the GIS iBook. This research also adopts the SWOT analysis method to evaluate the prototype of the GIS iBook. The result of the SWOT analysis indicates that utilizing mobile device in GIS education does have a great potential value in enhancing student’s understanding. The strengths of utilizing mobile device in GIS education include portability, easy update contents and abundant free development resources, while the weaknesses include distracting multimedia widgets, lack of Internet access, and security issues. The opportunities of SWOT analysis include financial plan for iPads and lack of competitors, while the threats include higher price and incompatibility of iBooks on other tablet computers. The major limitations and key challenges are limited survey time, small sample size, and technical difficulties of developing the GIS iBook.
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CHAPTER 1

INTRODUCTION

The extensive utilization of geographic information systems (GIS) and geospatial technology has made a significant impact on many academic disciplines, professional trainings, and education communities (Cheng et al. 2007; Kong et al. 2007; Zerger and Smith 2003). Courses utilizing GIS technology at high schools, colleges, and universities are more popular than before (Kawabata et al. 2010). As GIS becomes more important for academic learning and teaching, how to provide an effective and accessible material for GIS education is a major challenge for GIS educators. Armstrong and Bennet (2005) indicates that fieldwork plays an essential role in GIS education because it not only lets students know how to collect raw data by themselves but also can provide an opportunity to teach geospatial skills and technological theories (e.g. how Global Positioning System (GPS) and wireless network operate). On the other hand, indoor and software-operation courses sometimes limit what student can learn because of lack of interaction with real-world phenomena (Armstrong and Bennet 2005). Adding fieldwork in GIS education will be valuable for students and GIS career preparedness.

This research aims to develop a GIS iBook prototype for an introductory GIS course and utilize iPads in fieldwork and location-based learning exercises. This research adopts iPad as the development platform because of its comprehensive content development environment (free iBook Author software with more widgets and tools available for iBook format comparing to Andriod O.S.). iPads also possess more user-friendly functions including searching information from wireless networks and cellular networks, and displaying both maps and data during the outdoor survey. In the past, some researchers adopted personal digital assistant (PDA) as a platform to develop customized educational program (Hsu and Chen 2010). However, the small screen size and limited memory of PDA made users hard to display data clearly and cannot operate key functions effectively for fieldwork (Tsou 2004). By implementing the GIS iBook on an iPad as a teaching instrument, students can follow interactive guidance in the GIS iBook to perform outdoor learning.
exercises using built-in GPS and digital camera on iPads. iPads enable a richer learning environment for students to record spatial data, searching web information, and process images and GPS data from multiple resources.

1.1 RESEARCH QUESTIONS

Although GIS has been widely promoted in education, it has been limited to software operation. Lack of data collecting and hands-on experience become challenges in improving GIS education. Students can hardly know techniques of collecting data and observe real-world phenomenon without fieldwork exercise (Armstrong and Bennet 2005). By utilizing iPads in fieldwork, students can record their locations and search information outside classrooms via wireless network. In addition, the GIS iBook in iPads can be updated immediately once a new version is published, while the GIS desktop cost for software renewal.

The combination of iPad in fieldwork has not been studied deeply and widely. This research promotes fieldwork education in GIScience and provides other researchers with an innovative idea in developing teaching material. In terms of theoretical impact, this research 1) can be as a pioneering research to provide researchers who specialize in GIS education with an innovative idea and 2) can promote combination of fieldwork exercise and GIS education. From practical perspective, I expect this research 1) can be a multifunctional tool for fieldwork and 2) can provide free teaching materials for basic GIS education.

The purposes of this research are developing and assessing a GIS iBook prototype for GIS education and location-based learning exercises (fieldwork). The prototype of the GIS iBook had been partly developed by another researcher, Cynthia S. Poloma, on 2013. As an extended study, this research focuses on evaluating and implementing the GIS iBook in fieldwork and location-based learning exercises. To ensure that the GIS iBook can satisfy educators’ demands and help students to do fieldwork, this research collected comments from educators and students through in-person interviews and questionnaire surveys. Methods adopted in this research are in-person interview, pre-assessment and post-assessment through questionnaires on SurveyMonkey.com, and SWOT analysis. This study addresses the following three questions:
1. **How to assess and evaluate the effectiveness of location-based learning exercises (from iBook) and fieldwork exercises for first-time GIS students?**

This research continues to develop a GIS iBook prototype by adding two more chapters and an exercise. The final version of the GIS iBook was tested in two courses, GEOG 104 and GEOG 381 in fall 2014, at the department of geography, San Diego State University. Students in the classes were asked to complete two questionnaires, pre-assessment and post-assessment, on SurveyMonkey.com before and after using iPads in the fieldwork exercise. The questionnaires include questions related to GIS knowledge, reviews of the GIS iBook, and experience of the fieldwork exercise. This research evaluates the GIS iBook with SWOT analysis based on the results of questionnaires and students’ feedbacks.

2. **What are the learning outcomes when the GIS iBook is adopted as a textbook in GIS classes?**

In order to assess whether the GIS iBook could help students in learning new knowledge of GIS technology, this research design a knowledge oriented questionnaire, which students answered twice during the survey (before and after reviewing the GIS iBook). By analyzing students’ scores before and after students read the GIS iBook with dependent samples t-test (paired-samples t-test) through hypothesis testing, this research can compare whether there is a significant difference in learning outcomes of before and after adopting the GIS iBook as a textbook in GIS classes.

3. **What were the major technical challenges and opportunities associated with using mobile device and mobile technology in GIS education?**

To develop and implement the GIS iBook in classes, specific software (iBook author, keynote, Microsoft PowerPoint, etc.) and iPads are necessary. By reviewing the whole developing procedure and results of implementing the GIS iBook, this research discusses technical challenges and human factors that influenced the whole research. The technical challenges refer to software and hardware limitations. The human factors refer to feasibility of implementing iBooks and iPads in classes. Finally, this research analyzes potential threats and opportunities by reviewing challenges encountered during the development and survey.
CHAPTER 2

BACKGROUND AND LITERATURE REVIEW

This research aims to assess the potential value of using mobile devices with GPS capability in GIS education and engages students to grow their GIS knowledge. The research utilizes an iPads as a research instrument and develops a GIS iBook for basic GIS education as a case study. The portability of iPads and location-based map service enable students to apply what they learn in classes in fieldwork. Students can interact with real world phenomena directly and access to information they need by using iPads. To provide an appropriate and complete material, further discussions of GIS implementation was necessary. This literature review addresses issues in three areas: 1) GIS in education, 2) multimedia GIS, 3) and mobile GIS (Fig. 2.1). The first section introduces the role of GIS in current education especially its influence on multi-disciplinary education. The second section illustrates utilizations of multimedia technologies in GIS such as three-dimensional video (3D), on-line interactive map service, location-based service, etc. The last section introduced basic concepts and past studies of mobile GIS.

Figure 2.1 Three main concepts of this research.
2.1 GIS in Education

Many research studies have emphasized the importance of utilizing GIS in geographic and multidisciplinary education in universities and secondary education (Bednarz 2004; Kawabata 2010; Oyana 2012). GIS has been utilized in city planning, environmental monitoring, business decision making, etc. since it is integrated with multiple functions from save, retrieve, analyze data to represent spatial information (Cheng and Yu 2007; Kong et al. 2007; Zerger and Smith 2003). Functions of visualizing and symbolizing spatial data based on their attribute values make GIS become an efficient instrument to enhance students’ understandings of spatial pattern. Students from different disciplines can understand species distribution, human activity pattern, condition of agricultural growth, etc. by analyzing temporal data under GIS software (Fisher and Toepfer 1998; Fischer et al. 2001; Knowles 2005). Kawabata et al. (2010) examined 163 GIS multidiscipline education programs provided by US universities during 2007-2008. They found that students could understand relationships between the environment and their own provinces easier by integrating GIS with other disciplines. The paper also pointed out an increasing tendency in cooperation of geography and other disciplines. GIS is no longer an independent subject but can be integrated with courses of various disciplines. The concept of Kawabata et al. urges multidisciplinary learning in GIS and motivates this research to develop educational materials for students who are not familiar but are interested in GIS.

The importance of applying GIS in secondary education also has been emphasized in the past few years (Baker 2005; Kerski et al. 2013; Wechsler and Pittstr 2004). Liu et al. (2010) investigated whether applying GIS in problem-based learning (PBL) could result in higher learning outcomes. They separated students into two groups: control and experimental group. The experimental group was taught PBL with GIS; and the control group was taught PBL without using GIS. Their result showed that the experimental group had better feedback and cognition. Benefits brought by GIS in education explain its significance in other disciplines. However, most GIS educational materials were designed for professional person in specific fields like geography or urban planning. Therefore, this research expects to provide resources for students who are new to GIS.
2.2 MULTIMEDIA GIS

2.2.1 Integration of multimedia technologies and GIS

The integration of multimedia and GIS brings new developments in map services. Multimedia technologies combine various types of data like sound, video, and 3D images in a context. Multimedia technologies have utilized different platforms such as computer, mobile phone and on-line services (Raper 1999). Multimedia in GIS can leave users with deeper impressions and better understandings. Online discourse maps, Google Earth, 3D landscape simulation video, etc. are examples of integrating GIS and multimedia. Web-based interactive map can provide users with real-time spatial data and spatial analysis tools without installing software (Zerger 2002; Hu 2002; Huang 2011). As the Internet supports more mapping functions than before, web-based interactive map conveying information or providing services becomes in multiple ways. Duran et al. (2004) developed a website to provide functions of saving, analyzing and displaying data. The website emphasized the techniques of 3D GIS and virtual reality model which can present real world landforms vividly. The 3D GIS constructed landforms based on terrain's surface elevation. The techniques of the virtual reality model enabled researchers to visualize and simulate realistic urban pattern. By combining multimedia in GIS, people can gain more accurate and abundant information.

2.2.2 On-line multimedia GIS in education

Online multimedia GIS educational materials have been developed for GIS or Geography education recently. Comparing to traditional desktop GIS software, online multimedia GIS tools are more accessible for teachers and students. In the United States, only limited computer labs are equipped with desktop GIS software in universities and less than 2% of high schools are equipped GIS desktop. Moreover, half of the schools use the software less than two lessons during whole semester (Kerski 2007; Baker et al. 2009). Except the problems of inadequate instruments, teachers and students need to spend much time on being familiar with operation of desktop GIS (Baker 2005; Chen 2006; Oyana 2012). To enable students understand basic concepts of GIS and validate educators to teach GIS efficiently, researchers have suggested different approaches to learn and teach GIS (Baker 2005; Oyana 2012).
Baker (2005) promoted utilizing Internet-based map instead of desktop GIS in high school GIS courses. He mentioned that online map can satisfy instructors’ demands for teaching knowledge and basic skills of GIS. Chen (2006) collected high school educational materials and GIS layers to build online map by utilizing ArcMIS services. Both Baker’s and Chen’s research provided examples of learning GIS with online multi-media devices. Although their studies revealed new learning ways for GIS education, students could hardly know the procedure of processing data and lack for hands-on experience (Tsou and Yanow 2010). The process of collecting data not only played an important role in GIS but also could be a great opportunity to teach geospatial skills and technological theories (Armstrong and Bennet 2005; Favier and Schee 2009). Therefore, how to provide portable fieldwork learning material is a critical issue in this research.

### 2.3 MOBILE GIS

#### 2.3.1 Mobile GIS in location based service

Mobile GIS is a technology that enables people to access functions of GIS through mobile platforms like personal digital assistant (PDA), smart phone, tablet PC, etc. (Tsou 2004; Hsu and Chen 2010; Kim et al. 2004). Location based services provide users information or applications within specific area via wireless network (Koeppel 2000). The portability of mobile GIS benefits different types of location-based services including fieldwork and navigation (Sadoun and Al-Bayari 2007; Jiang and Yao 2006). For geographers, mobile GIS especially facilitate data sharing, saving, editing during fieldwork. Tsou (2004) utilized Internet map service (IMS), a Pocket PC and GPS to collect spatial data through wireless network. He first established a wireless local network so he could collect data nearby the wireless router. The customized mobile GIS software (ESRI ArcPad 6.0) in the Pocket PC enabled Tsou to collect and upload local data to the map server synchronously and provided him spatial data (e.g., roads, terrain elevation, points of interests, etc.) from a GIS workstation. Compared with Tsou’s research, this research utilizes iPads instead of a Pocket PC to provide more functions during fieldwork. Students can do multiple tasks such as recording location, observing real-world phenomenon, and collecting sample in fieldwork with only an iPads. Tsou’s research established a fundamental framework and concepts for this research (Tsou 2004).
2.3.2 Mobile GIS in fieldwork education

Armstrong and Bennet (2005) advocated that fieldwork can let students learn the procedure of producing data and related knowledge. For example, students can acquire skills of presenting data correctly and knowledge of supporting techniques (e.g., GPS). To demonstrate the effectiveness of integrating fieldwork and GIS learning, Favier and Schee (2009) held a project-based learning experiment and asked high school students to observe and collect spatial data of some areas. The result showed that students get better understanding about spatial pattern and relationship between human activities. Other researchers also emphasized how fieldwork leaves students deep impression of geographic phenomena (Carlson 2007). From classroom to observed field, students could know each procedure of processing and analyze data with GIS software.

This research takes iPads as research instruments because of its portability and multiple functions. Tsou (2010) proposed that combination of wire-less network and mobile devices can connect geographic knowledge to students’ daily lives. Location-based service (LBS) provided relevant geographical information when students were getting close to specific places with their mobile computing devices. Furthermore, students could get information without returning to libraries or classes. Based on these concepts, Hsu and Chen (2010) developed a mobile learning module for high school fieldwork. The module integrated web-based map services, mobile GIS, GPS and educational materials on a personal digital assistant (PDA). However, the limited RAM and small screen of the PDA could hardly satisfy demands from developers and users (Armstrong and Bennett 2005). iPads, on the other hand, possesses wide screen and large memory that can conquer the limitations of past devices. This research examines deficiencies of past mobile computing devices and takes advantages of current technologies to provide a better material for fieldwork and GIS education.
CHAPTER 3

METHODOLOGY

The development and implementation of the GIS iBook in this research is established based on the ADDIE Model – a systematic instructional design model constructed with five phases: analysis, design, development, implementation, and evaluation (Table 3.1) (Branch 2009). The analysis phase defines development objectives, identifying backgrounds and learning problems of learners, and knowing learning environment. The design phase defines learning goals, assessing available instruments, and designing the framework and user interface of the prototype. The development phase relates to the development of the prototype based on the considerations in previous two phases. The implementation phase includes trainings for educators and students to utilize the teaching material and collecting their feedbacks. The evaluation phase refers to analysis of results and feedbacks, assessing learners’ performances, and assessing learners’ outcomes. The evaluation phase is related to each of the other four phases. By evaluating feedbacks in each phase, the teaching material was revised repeatedly. Phases in the ADDIE Model connect and interact with each other through a cycle (Fig. 3.1).

Table 3.1 ADDIE Model (Branch 2009, p.3).

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>Identify students’ characters, content to be learned, learning goals and objectives, etc.</td>
</tr>
<tr>
<td>Design</td>
<td>Decide structure of learning material (e.g., number of chapters, sections, and fieldwork exercises).</td>
</tr>
<tr>
<td>Development</td>
<td>Develop content of learning material and resource to be used.</td>
</tr>
<tr>
<td>Implementation</td>
<td>Learners utilize developed material and complete courses as design. Learners assess the material by following the designed assessment.</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Analyze the overall results including learners’ assessments</td>
</tr>
</tbody>
</table>
and learners’ performances. Evaluate the effectiveness of developed material and revise it if required.

In this research, the first three phases (analysis, design and implementation) in ADDIE Model related to research objectives, materials for the GIS iBook, content decision, outline design, and user interface design (UID) of the GIS iBook. The content, outline, and user interface of the GIS iBook were discussed and examined by collaborators and previous developer, Cynthia S. Paloma. The other two phases, implementation and evaluation, were covered by applying the GIS iBook in GIS classes and analyzing data of survey questionnaire in this research. In general, the procedures of this research could be organized as (Fig. 3.2):

1. Developing the prototype of GIS iBook.
2. Collecting responses and revise details.
3. Testing and assessing the GIS iBook in classes.
4. Analyzing the results with SWOT analysis.
3.1 PROTOTYPE OF THE GIS iBOOK

The first procedure was continuing to develop the prototype of the GIS iBook. There were two sub-steps in this procedure: developing prototype of the collaborative GIS iBook and being evaluated by other collaborators. The first sub-step introduced tools that used for developing the GIS iBook – software and hardware devices, and content of the GIS iBook.
The second sub-step discussed factors that were considered when collaborators reviewed the GIS iBook.

### 3.1.1 Content of the GIS iBook

This research continues to develop an educational material that combines multimedia GIS and a portable device: iPad. The first and second chapters in the GIS iBook were developed by another master student, Cynthia S. Paloma, on 2013. The first two chapters are related to basic introduction of GIS and application of GIS respectively. This research takes over the development work and keep creating and editing new chapters for the GIS iBook. The number of chapters included in the GIS iBook was extended from two to four chapters. The framework of the GIS iBook follows the developed two chapters to ensure the consistency between developed and new chapters – each chapter has a catalog cover and contained three to five sections (Fig. 3.3). Each section is constructed with multimedia widgets: Dynamic Image, Youtube Video, Image Gallery, etc. and textual contents (Figure 3.4). Software and hardware that were used to develop the GIS iBook are listed in Table 3.2.

**Table 3.2 Software and hardware that will be used to develop the GIS iBook.**

<table>
<thead>
<tr>
<th>Software Name</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>iBooks Author (Mac OS)</td>
<td>Used to edit the content of the GIS iBook. (e.g., embed plug-ins, image galleries, textual content, etc.)</td>
</tr>
<tr>
<td>Keynote (MacOS)</td>
<td>Used to produce interactive images and add them to iBook Author.</td>
</tr>
<tr>
<td>iBooks App (iOS)</td>
<td>Used to show and test the final prototype of the GIS iBook on an iPad.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hardware Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPad 4 or newer</td>
<td>Used to show and test the prototype by using iBooks app.</td>
</tr>
<tr>
<td>PC (Windows 7)</td>
<td>Used to installed Windows-based software that will be used in development work</td>
</tr>
</tbody>
</table>
MacBook Pro Used to installed Macintosh-based software that will be used in development work

Figure 3.3 Cover of each chapter in the GIS iBook.

Figure 3.4 Movie and Dynamic image widgets.
The research utilizes an iPad as a research instrument and developed an iBook for GIS education. Compared with other e-readers and tablet computers (e.g., Kindle Fire, Galaxy Tab, Surface Pro, etc.), iBooks on iPads could be created and edited with free software called iBook Author by Apple. The free iBook Author enabled this research to author and to write an educational material with less expenditure. iBook Author provides functions such as document editor, inserting tables and charts, and publishing iBooks. In addition to creating and editing an iBook, iBook Author enables editors to embed build-in widgets: Image Gallery, Interactive Images, Keynote Presentations, videos, etc (Fig. 3.5). Editors can also create their customized plug-in widgets with HTML code. This research not only utilizes built-in widgets in the iBook Author but also downloads and embeds widgets provided by Bookry.com – a website that provides a widget library for developing iBooks (Fig. 3.6). Table 3.3 lists widgets that are embedded in the two new chapters. (See the results and analysis in 4.1)
Figure 3.6 Widget library provided by Bookry.com (https://bookry.com/dashboard/).

Table 3.3 Multimedia widgets in the GIS iBook.

<table>
<thead>
<tr>
<th>widget name</th>
<th>Source</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before and Comparison</td>
<td>Bookry.com</td>
<td>This widget shows two images. One displays a scene before it experienced changes, and the other displays the same scene after it experienced changes. This widget is suitable for showing places that have transitions after periods of time.</td>
</tr>
<tr>
<td>Dynamic Image</td>
<td>iBook Author</td>
<td>The Dynamic Image widget shows images in an interactive way. By sliding and tapping images in the widget, the images will be zoomed in and display pop-ups dynamically. The pop-ups include further information of the zoom-in part. This widget is useful for showing images that contain many detailed elements in them.</td>
</tr>
</tbody>
</table>
### Word Search Puzzle

<table>
<thead>
<tr>
<th>Bookry.com</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Word Search Puzzle is a widget that contains several letters of words hidden inside a grid box. This widget is helpful for leaving readers a deep impression of key words of each chapter.</td>
</tr>
</tbody>
</table>

### Youtube Video

<table>
<thead>
<tr>
<th>Bookry.com</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Youtube Video widget is similar to a video player. Different from embedding a video file from one’s computer, the Youtube Video widget can play a video which is put on Youtube website through a hyperlink. This widget can make the size of an iBook file as small as possible.</td>
</tr>
</tbody>
</table>

### Image Gallery

<table>
<thead>
<tr>
<th>iBook Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Image Gallery widget displays a list of images and images’ descriptions. Readers can change the displayed image by sliding the widget with their fingers. Each image has its own description at the bottom of the widget. This widget saves lots of space in an iBook if there are many images that need to be displayed.</td>
</tr>
</tbody>
</table>

### 3.1.2 Collaborators’ reviews

To ensure that the framework of following chapters consisted with previous ones, the GIS iBook was examined by ex-developer, Cynthia S. Paloma. Other collaborators including Dr. Ming-Hsiang Tsou and Dr. Wing Cheung, a professor of geography and GIS at Palomar College, reviewed the content of each chapter to make sure the quality of the GIS iBook. The collaborators examined the ways of displaying information and consider whether the content was accordance with raw educational material such as textbooks or lecture notes. For example, the contents of chapter three and four are designed based on lecture notes from GEOG 104 and GEOG 381 in fall 2014.
3.2 INTERVIEWS OF EDUCATORS

Because the GIS iBook is designed as a teaching material and is tested in classes, this research needs to know educators’ demands and their comments for the GIS iBook. The developed GIS iBook was reviewed by not only collaborators but also educators who may use it as a teaching material in the future. This research interviewed 5 high educators from high school and community college during a GIS workshop organized by GeoTech Center in Summer 2014 at San Diego State University. To realize interviewees’ experiences and comments for the GIS iBook, the following questions were asked during the interview:

1. **Have you ever utilized any non-paper material to teach GIS? If yes, what are those materials?**

   Sub-question:
   - a. *What is the difference between the GIS iBook and material you used in the past?*
   - b. *Could you describe the advantages and disadvantages of past materials and the GIS iBook?*

2. **As an educator, what features do you think that should be contained in the GIS iBook?**

   Sub-question:
   - a. *If you can, how would you improve the current version of the GIS iBook?*
   - b. *Are there any features in this GIS iBook you think are useful or distracting for student’s learning?*

By interviewing the educators in person, the educators could not only answer the questions above but also provides innovative ideas and their teaching experiences for this research. The GIS iBook was revised and renewed based on educators’ comments before the implementation test in GEOG 104 and GEO 381 in Fall 2014 at San Diego State University. Feedbacks that gained from this interview are listed and evaluated in 4.2.

3.3 SURVEY IN GEOG104 AND GEOG 381

3.3.1 Pre-assessment and post-assessment

The experimental procedure of this research adopts one-group pre-assessment-post-assessment (Creswell 2013). To know students’ backgrounds and how familiar are they with GIS related knowledge, a pre-assessment and a post-assessment were requested before and
after applying the GIS iBook in classes. Students finished questionnaires on an online survey service called Survey Monkey. This research adopts Likert scale questionnaire in survey collection because of its understandability and universality. (Laerhoven et al. 2004). Students could spend more time on thinking questions instead of understanding how to answer the questions.

Questions in the pre-assessment ask about students’ backgrounds like level of education, reading habits or preferences, and understanding of GIS. Questions in the post-assessment ask about students’ experiences of using the GIS iBook, reviews of multimedia in the GIS iBook, whether the GIS iBook could help learning basic GIS knowledge or not, and understanding of GIS. The pre-assessment and post-assessment questionnaires are hosted on Survey Monkey website. Students finished all questionnaires online within 10 minutes in the test.

3.3.2 Test of the GIS iBook

The prototype of the GIS iBook was used as a teaching material in parts of course of GEOG 104 and GEOG 381 in Fall 2014 at the department of geography, San Diego State University. Students first reviewed new chapters in the GIS iBook within 20 minutes and then utilized iPads to do a fieldwork exercise within another 20 minutes. By following audiences provided in the GIS iBook, students recorded spatial data, using online mapping services during fieldwork and uploaded collected information to online maps supported by ESRI by using iPads. For instance, one of the exercises requested students to record places they spent money and amounts of expenditures to know the spatial pattern of their consuming behaviors. Finally, students were asked to finish post-assessment questionnaire after doing the exercises. Utilizing iPads in fieldwork exercise not only helped students to get information they need from the Internet but also enabled them to edit and display collected data during a fieldwork. The whole test, including answering the questionnaires, took about 50 minutes to finish. (See the results and analysis in 4.3)
3.4 Evaluation Methods

3.4.1 Dependent samples t-test

Dependent samples t-test, also called paired-samples t-test, is used for determining whether there is a significant difference between two related groups based on the same variables under different conditions. This research tested the GIS iBook with one sample group of students from GEOG 104 and GEOG 381 at San Diego State University at 2014 and asked the students to take a knowledge oriented questionnaire twice (before and after reviewing the GIS iBook). There were five questions in the questionnaire, and each question was selected from the content of the GIS iBook. The results of before and after reviewing the GIS iBook are taken as two related groups and questions in the questionnaire are unchanged variables. The procedures of doing dependent sample t-test including defining null and alternative hypotheses, stating alpha, calculating degrees of freedom, calculating test statistic. The null and alternative hypotheses are as follows:

\[ H_0: \mu_{\text{before}} = \mu_{\text{after}} \] (There is no significant difference between pre-test and post-test.)

\[ H_A: \mu_{\text{before}} \neq \mu_{\text{after}} \] (There is a significant difference between pre-test and post-test.)

If the result of t-test accepted the null hypothesis, reading the GIS iBook did not make a significant impact on students’ learning outcomes. On the other hand, if the result rejected the null hypothesis, reading the GIS iBook did make a significant impact on students’ learning outcomes. (See the result of dependent samples t-test in 4.4)

3.4.2 SWOT analysis

After testing the GIS iBook in classes, this research analyzes comments from educators and questionnaires’ results from students with SWOT analysis. To further improve the prototype of the GIS iBook, strengths and weakness of the GIS iBook are considered. SWOT analysis, also called strategic planning, is used to evaluate one product from four different aspects: strengths, weaknesses, opportunities, and threats (Lee et al. 2000). Strengths and weaknesses consider the advantages and disadvantages of the GIS iBook while opportunities and threats are related to potential competitors or market (Table 3.4). This research adopts SWOT analysis because it can be used to evaluate a subject internally and externally (Hill and Westbrook 1997). Strengths and weaknesses are internal assessments, while opportunities and threats are external assessments. The internal assessments helped this
research to examine factors that influence the effectiveness of the GIS iBook. For example, whether the interactive images, movies, lab exercises, etc. in the content are helpful for students’ learning or not. On the other hand, aspects of opportunities and threats help this research to consider how to promote the GIS iBook and what obstacles that may encounter in the future development. Figure 3.4 are questions that are considered for SWOT analysis. By considering each question with collected data, this research discusses how iPads and iBooks influenced GIS education and potential values of using these materials in GIS education from four different aspects. (See the discussions of SWOT analysis in 5.1)

Table 3.4 General guidelines for SWOT Analysis.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distinctive competence?</td>
<td>Lack of competence?</td>
</tr>
<tr>
<td>Well-organized strategy?</td>
<td>Unclear strategy?</td>
</tr>
<tr>
<td>Abundant resource?</td>
<td>Weak-structure content?</td>
</tr>
<tr>
<td>Location advantage?</td>
<td>Lack of record?</td>
</tr>
<tr>
<td>Economic advantages?</td>
<td>Economic disadvantages?</td>
</tr>
<tr>
<td>Product innovative abilities?</td>
<td>Lack of innovation?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional customers?</td>
<td>New competitors?</td>
</tr>
<tr>
<td>New Market?</td>
<td>Technical difficulties?</td>
</tr>
<tr>
<td>Expand course to make more needs?</td>
<td>Unfavorable for external factors?</td>
</tr>
<tr>
<td>Faster student growth?</td>
<td>(e.g. government policy)</td>
</tr>
<tr>
<td></td>
<td>Slower student growth?</td>
</tr>
<tr>
<td></td>
<td>Competitive pressure?</td>
</tr>
</tbody>
</table>
CHAPTER 4

RESULT

4.1 DEVELOPMENT OF THE PROTOTYPE OF THE GIS iBOOK

4.1.1 Content

For this research, the author added two new chapters to the developed prototype of the GIS iBook. The two chapters are chapter three: “Wander the World through Remote Sensing Data” and chapter four: “Internet and Mobile GIS”. Chapter three is related to remote sensing technology. Contents of chapter three range from the basic concepts to the introductions of different types of remote sensing platforms and sensors. Chapter four is related to Internet and mobile GIS. Contents of chapter four include the history of GIS, the evolution of platforms for GIS, and application of Internet and mobile GIS. Both these two chapters were developed by following the structure of previous developed chapters (chapter 1 and chapter 2) – each chapter has one catalog cover and multiple sections.

Chapter three has three sub-sections that explain backgrounds of remote sensing, satellite imagery data, and application of remote sensing respectively. The first sub-section introduces broad and narrow background of remote sensing technology – from the definition of remote sensing to the introduction of electromagnetic spectrum and operation of satellite sensors. The first sub-section gives readers a brief concept and basic theories of remote sensing, features of different types of satellite, and differences between active and passive sensors. The second sub-section explains different formats of remote sensing data provided by aerial and satellite sensors. Types of various remote sensing data include film based and video, microwave radiometer (MWR), hyper-spectral imagery, RADAR, and LiDAR data. This section also explains the 4 major types of resolution (spatial, temporal, spectral, and radiometric resolution) in remote sensing and how the 4 resolutions influence satellites’ operations and their data product. Readers can further understand satellite imagery and factors that influence the scale of imagery data from second sub-section. The third sub-section introduces current applications of remote sensing data in daily life and academic
research. The application of remote sensing data include identifying land use/land cover changes, detecting vegetation distributions, building terrain module, and so on. This sub-section contains a “Before and After Comparison” widget to provide students a practical example of utilizing remote sensing data on land use/land cover identification (Fig. 4.1). All of chapter three can teach students, who are new to remote sensing, a simple but complete knowledge of remote sensing technology.

Figure 4.1 Before and After Comparison widget. Students can slide the blue bar (the one the blue arrow points at) to see the differences between two scenes. (A screen capture from the GIS iBook chapter three).

Chapter four, Internet and Mobile GIS, has four sub-sections that explain development history of GIS, Internet GIS, Mobile GIS, and future development of GIS respectively. The first sub-section introduces a brief background of the development of GIS—the history of software development and transition of platforms from 20th century to today. This sub-section also explains differences between the traditional GIS systems and today’s distributed GIS systems. Readers can have a preliminary understanding of the history of GIS systems. The second and third sub-section were designed to give readers a general idea of
Internet and Mobile GIS. The second sub-section contains the definition and key concepts of Internet GIS. This sub-section explains the operation of Internet GIS services and how Internet GIS enables the real-time web maps. The Dynamic Image widget in this sub-section helps students to know the procedures of requesting GIS data from servers via the Internet (Fig. 4.2). The third sub-section introduces the basic concept of mobile GIS and how mobile GIS benefits people’s lives and business circles. The structure of this sub-section is similar to the second sub-section – explains the operation of mobile GIS and practical examples. The last sub-section in chapter four discusses the current trend of utilizing Internet and mobile GIS and the future development of this technology. The main idea of this sub-section is Digital Earth – a virtual representation of Earth with a database that provides natural and cultural information (Consensus definition adopted at 2nd interagency workshop, 1999 Sept. 23). People can gain information from a web map and interact with the map. All of chapter four enables students to understand the trend of GIS development and enlighten students with the application of new technology in web mapping.

Figure 4.2 The Framework of Internet GIS (A screen capture from the GIS iBook chapter four).
4.1.2 GIS iBook website

After developing the GIS iBook, how to make the GIS iBook become an easy accessible resource for students and educators is a key question. There are two ways to publish the GIS iBook on the Internet. One is publishing the GIS iBook to iBooks Store, and the other is sharing the GIS iBook via a hyperlink that links to the iBooks file. This research adopts the later method since the GIS iBook is a prototype but not a final version. The contents of the GIS iBook still need to be tested and revised.

To make the GIS iBook be easy to access and introduce people the background of this research, this research built a website called “GIS Textbook for iBook on iPads” (http://mappingideas.sdsu.edu/ibook/index.html) to introduce the objectives, developers, and available resources of the GIS iBook. The website contains 6 different webpages: Home, Participants, About Book, Download, Contact Us, and References pages (Fig. 4.3). The Home page clarifies the idea of the GIS iBook; the participants page lists developers and collaborators in the GIS iBook development project; the About Book page lists the GIS iBook’s outlines and available materials for developing an iBook; the Download page provides a hyperlink for downloading the latest version of the GIS iBook and instruction of downloading the GIS iBook file on an iPad; and the Contact Us and References pages list participants’ emails and reference documents respectively. Students and educators can not only link to the website to download the latest GIS iBook but also get resources for developing their own iBook.
4.2 FEEDBACKS FROM EDUCATORS

Five geography or GIS educators from high schools or community colleges reviewed the GIS iBook and were interviewed with questions related to GIS education and their teaching experience during a workshop held by GeoTech Center in Summer 2014 at San Diego State University. The interview was no longer than 20 minutes due to the limited time of the workshop. Each educator got an iPads and reviewed the GIS iBook. The researcher asked the following questions to gather feedbacks and ideas from the educators and improved the contents of the GIS iBook before the test in GEOG 104 and GEOG 381.

1. *Have you ever utilized any non-paper material to teach GIS? If yes, what are those materials?*

For question one, all of the educators expressed that they utilized web based maps such as ArcGIS Online and Google Earth as parts of their teaching materials except paper based textbooks. The educators pointed out that web mapping resources not only attract students’ attentions but also give students better understandings about applications of GIS.
Sub-questions:

a. What is the difference between the GIS iBook and material you used in the past?

b. Could you describe the advantages and disadvantages of past materials and the GIS iBook?

For sub-questions of question one, some of the educators indicated that the portability of the iPad and the easy-update content are the main advantages of the GIS iBook. On the other hand, disadvantages mentioned by the educators include lack of accessible network for students, distracting Youtube Video widget, and security issues of using iPad in classes (i.e., students may damage or lose iPads).

2. As an educator, what features do you think that should be contained in the GIS iBook?

For question two, all of the educators implied that embedding more Quiz widgets can help students review what they learned in their classes efficiently and can enhance students’ impressions.

Sub-questions:

a. If you can, how would you improve the current version of the GIS iBook?

b. Are there any features in this GIS iBook you think are useful or distracting for student’s learning?

For sub-questions of question two, educators expressed that they would like to remove the embedded hyperlinks in the GIS iBook because clicking the hyperlinks will break down iBooks application but launch a web browser. The launch of a web browser will disrupt student’s readings, and students may even start to surf the Internet. The educators also mentioned that they would like to see social media widgets or some online collaboration tools in the future GIS iBook.

Comments and ideas provided by educators help this research to develop a better and more appropriate educational resource for students and educators. However, due to some technical limitations such as unavailable widgets and lack of accessible Internet, this research can only improve parts of the content of the GIS iBook based on the educators’ feedbacks. For future development work and improvement, see 5.2.2.
4.3 SURVEY IN GEOG104 AND GEOG 381

This research collects 31 questionnaires finished by students who were taking GIS courses, GEOG104 and GEOG 381, at San Diego State University during Fall 2015. Figure 4.4 shows percentages of different student groups in this survey. Over 60% of students were taking their first GIS course and less than 10% of students finished over three GIS courses.

![Pie Chart: Numbers of different groups of testers]

4.3.1 Reviews of the GIS iBook

The most influential factor in reviewing the GIS iBook are students’ reviews of multimedia widgets because the widgets enable interactive learning materials, which are different from traditional textbooks. Overall, the result of 31 questionnaires indicates that all students thought multimedia widgets were helpful in GIS learning, while some students thought it might be distracting (Fig. 4.5). Distracting factors might refer to the links linking to other videos or advertisements in the Youtube widget. Students might also be distracting if they focus on the multimedia widgets, while ignore the texture content. This research also surveyed reviews of different widgets in the GIS iBook (Fig. 4.6 and Fig. 4.7). The multimedia widgets in the GIS iBook include Before and After Comparison, Dynamic images, Word Search Puzzle, movies, etc. Students ranked each widget from 1 to 5 point. Higher point implies that the widget was more interesting or more helpful for the students, while lower point implies that the widget was less interesting or less helpful for the students.
Figure 4.5 Reviews of multimedia widgets in the GIS iBook.

Figure 4.6 Comparison of different multimedia widgets (level of interesting).

Figure 4.7 Comparison of different multimedia widgets (level of helpful in GIS learning).
Figure 4.6 shows that Youtube Video and Dynamic Image are the most interesting widgets for students. Based on students’ feedbacks, the embedded Youtube videos can help students to review each chapter efficiently without instructors. Students can also watch the videos repeatedly until they understand the content of each chapter. In terms of the Dynamic Image, which is different from traditional static pictures in textbooks, the embedded images are displayed like animated images and can show sequential changes (e.g. terrain changes and land use land cover changes). On the other hand, the least interesting widgets were Word Search Puzzle and Single Image. The Word Search Puzzle is a widget that consists of the letters of key words in each chapter. Students can have deep impressions by finding words hidden in the puzzle. However, students mentioned that the Word Search Puzzle could not provide further information related to professional knowledge since it only display words. Students could remember key words in a chapter but did not know the meaning of those key words through the Word Search Puzzle. In terms of Single Image, this widget did not catch much attention from students since it is similar to static images in traditional textbook.

Figure 4.7 shows that Dynamic Image and Image Gallery were the most helpful widgets for students in learning GIS. Although Youtube Video got a higher score in interesting part, it got a a lower score in this question compared to Dynamic Image, Image Gallery, and Single Image. This may be because students did not have sufficient time to finish watching each video in the GIS iBook, and they therefore could not understand videos’ contents thoroughly. However, since differences between these four widgets (Youtube Video, Dynamic Image, Image Gallery, and Single Image) are inapparent and the score of Youtube Video widget is above 4 point, the Youtube Video will still be one of the most important widgets in the future development. In terms of the Image Gallery, this widget can save more space for texture content display a list of images. Students can slide images using their fingers to browse images and descriptions in the this widget, which eases assimilation of new knowledge and leaves students deep impression. Word Search Puzzle, which is also the least interesting widget for students in previous question, was thought to be the least helpful widget for student in this question. Similar to the reason in previous question, students could not get further information, such as explanation of a key word, from this widget. The Word Search Puzzle wideget will be removed from the GIS iBook based on the results in Figure 4.6 and 4.7.
This research also surveyed whether students can learn new knowledge from the GIS iBook within limited time (approximately 20 minutes). Students were required to finish an online questionnaire, which includes five questions related to the content of GIS iBook, before and after reading the GIS iBook. The five questions were selected from texture content, Dynamic Image widget, and Quiz widget (Fig. 4.8). The first three questions are about remote sensing in chapter 3, and the last two questions are about Internet and Mobile GIS in chapter 4. Appendix contains further information of each question in this survey.

![Figure 4.8 Percentage of students who answer questions correctly before and after reading the GIS iBook.](image)

Figure 4.8 illustrates that more students answer correctly after reading the GIS iBook for each question, specially for question 2 and 4. Before reading the GIS iBook, 50% of students answer question 2 correctly, while only about 10% of students answer question 4 correctly. After reading the GIS iBook, correct percentage of both question 2 and 4 increased by over 20%. The common ground between question 2 and 4 is that both they were selected from Quiz widget in chapter three and four. In the GIS iBook, each Quiz widget contains 3 questions, which are key concepts of each chapter. By answering questions in the Quiz widgets, students can learn new knowledge from incorrect answer. The Quiz widget can enhance students’ impression, and therefore students could remember the correct answer after reading the GIS iBook.
4.3.2 Reviews of utilizing iPads in fieldwork exercise

Based on the result of 31 questionnaires, all the students thought fieldwork could enhance their understanding of GIS learning, and over 90% of them inclined to take more fieldwork exercises in their GIS classes. However, some problems of using iPads in fieldwork were also revealed in this survey. Figure 4.9 shows problems that might be encountered during the fieldwork exercise using iPads. Students ticked all the problems they had during fieldwork in this question. With 20 votes in this question, needing two hands to operate iPads was the most difficult problem for students to use iPads in fieldwork. The size of an iPad is too big to be operated with only one hand, and therefore students could hardly bring other tools with them in fieldwork. Hard to take note with two hands was another difficulty for students using iPads in fieldwork. Although there is a notepad application on iPad, students could only take note with one hand, which is very slow and incontinent. Others such as fragile iPads and screen reflection were also problems of utilizing iPads in fieldwork in this survey.

![Figure 4.9 Problems of utilizing iPads in fieldwork.](image)

### 4.4 DEPENDENT SAMPLES T-TEST

There are total 31 students took the knowledge oriented questionnaires before and after reviewing the GIS iBook. All of the students answered all of the questions (five questions) in the questionnaire. Table 4.1 shows the number of correct answers in pre-test and post-test of each student. Formula of calculating t value is as follow:
\[ t = \frac{\bar{X}_D}{S_D/\sqrt{n}} \]

\( \bar{X}_D \) is the mean of differences between the two groups of numbers (pre-test and post-test); \( S_D \) is the standard deviation; and \( n \) is the sample size. Table 4.2 lists the value of \( \bar{X}_D, S_D \), standard deviation, degree of freedom, critical t score, and the final t value. The final t value is 4.93, which is larger than the critical t score (2.04). Therefore, this research rejects the null hypothesis: \( H_0: \mu_{\text{before}} = \mu_{\text{after}} \) (There is no significant difference between pre-test and post-test.) but accepts the alternative hypothesis: \( H_A: \mu_{\text{before}} \neq \mu_{\text{after}} \) (There is a significant difference between pre-test and post-test.). With 95% of confidence, students had better learning outcomes after reviewing the GIS iBook (Fig. 4.10).

**Table 4.1 Result of knowledge oriented questionnaire.**

<table>
<thead>
<tr>
<th>Students</th>
<th>Before</th>
<th>After</th>
<th>Students</th>
<th>Before</th>
<th>After</th>
</tr>
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<tbody>
<tr>
<td>1</td>
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<td>1</td>
<td>Mean</td>
<td>2.58</td>
<td>3.58</td>
</tr>
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</table>

**Table 4.2 Result of dependent samples t-test.**

<table>
<thead>
<tr>
<th>Mean of differences (( \bar{X}_D ))</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of freedom</td>
<td>31-1=30</td>
</tr>
<tr>
<td>Critical t score</td>
<td>2.04 and -2.04 (p=0.05)</td>
</tr>
</tbody>
</table>
### 4.5 Technical Challenges

Technical challenges that encountered during development included 1) nonsupport of animated GIF images and 2) hyperlinks that force iBooks application to close.

Types of raw teaching materials ranged from Powerpoint slides and html file to paper-based textbooks. Animated images in Powerpoint slides and html files can enhance students understanding and leave them a deep impression of knowledge. However, iBooks does not support embedding images in Graphics Interchange Format (GIF) extension, which has been extensively used to save animated images. To display animated images from the Powerpoint slides or html files in the GIS iBook, this research utilized Keynote for Mac to create slides to imitate dynamic changes in the original GIF images. In a Keynote file, subtle differences are shown in each slide, and therefore can be presented like an animated image when playing the slides. Although Keynote slides are not able to display continuous actions as smooth as original GIF images, it does achieve the same effect in conveying information in a dynamic way.

The other technical challenge was the hyperlinks embedded in the GIS iBook. The embedded hyperlinks force iPads to launch a web browser but close the iBooks application. Readers need to jump back to the home screen and re-launch iBooks application to get back...
to the GIS iBook. To prevent launching a web browser, this research replaced hyperlinks in the GIS iBook with a widget called “Browser” provided by Bookry.com. The widget is created with HTML code and can display web page in a frame in the GIS iBook. Readers can directly browse the embedded web page without launching a web browser, and the iBook application can therefore keep running.
CHAPTER 5

DISCUSSION

5.1 SWOT ANALYSIS

From the development of the GIS iBook to the survey of implementing the GIS iBook in classes, SWOT Analysis provides a structure for reviewing the utilization iBooks on iPads in GIS education from four different aspects: strengths, weaknesses, opportunities, and threats. This research discusses each aspect by considering educators’ opinions, collaborators’ suggestions, development experience, results of the questionnaires, and students’ feedbacks. For identifying the strengths aspect, this research takes positive feedbacks from educators and students into account, and assesses the results of knowledge oriented questionnaires from the survey of implementing the GIS iBook in classes. For identifying the weaknesses aspect, this research takes negative feedbacks from students and educators into account, and considers problems met during the development of the GIS iBook. For identifying the opportunities aspect, this research compares the GIS iBook with other multimedia resources for GIS education by considering their target users, feasibilities, and future plans. For identifying the threats aspect, this research considers technical challenges met during the development and problems students mentioned during their fieldwork exercise.

Table 5.1 Strengths and weaknesses (internal factors) of utilizing iBooks on iPads in GIS education.

<table>
<thead>
<tr>
<th>Strengths (Internal Factors)</th>
<th>Weaknesses (Internal Factors)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Multimedia widgets can attract students’ attentions and enhance students’ understandings.</td>
<td>• Some multimedia widgets in the GIS iBook can only work in places with wireless networks.</td>
</tr>
<tr>
<td>• The GIS iBook can be renewed and updated frequently and can be easily accessed.</td>
<td>• Hyperlinks in the GIS iBook force iBooks application to close.</td>
</tr>
<tr>
<td>• Educators and students can create</td>
<td>• Some students need to spend extra time to learn how to operate and...</td>
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</table>
- iPads support multiple useful functions either in classes or in fieldwork.
- The combination of textbook and fieldwork exercise on a mobile device is an innovative idea in GIS education.
- iPad has many convenient and user-friendly designs: portability, large screen, easy and intuitive user interface, numerous synchronization tools.

The size and fragility of the iPad cause inconveniences during fieldwork.
Some applications on iPads and multimedia widgets in the GIS iBook may distract students’ attentions.

Table 5.2 Opportunities and threats (external factors) of utilizing iBooks on iPads in GIS education.

<table>
<thead>
<tr>
<th>Opportunities (External Factors)</th>
<th>Threats (External Factors)</th>
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<tr>
<td>The popularization of using mobile device familiarizes students with the operation of iPads.</td>
<td>Compared with other tablet computers, Apple iPad costs more money.</td>
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<tr>
<td>There is no other teaching material for GIS education that adopts iPads as devices.</td>
<td>Other teaching materials may be easier to access than the GIS iBook (e.g., web maps) since iBooks can only be launched on iPads or computers with OS X Mavericks or newer.</td>
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<tr>
<td>As technology advances, GIS becomes more important than the past.</td>
<td>Future policy change in free widgets and iBook Author may hinder the development of the GIS iBook.</td>
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<tr>
<td>With new version of Mac OS X (OS X Mavericks or newer), students can read iBooks without an iPad.</td>
<td>Technology changes so rapidly and</td>
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<tr>
<td>New release widgets can enrich the</td>
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content of the GIS iBook (i.e. embedding ArcGIS Online web maps in iBooks).

- Apple provides several plans for education: education financing plan and volume purchase program.

### 5.1.1 Strengths

1. **Multimedia widgets in the GIS iBook could attracted students’ attentions and enhance students’ understandings.** Based on the results of questionnaires collected from class GEOG104 and GEOG 381, nearly all of the multimedia widgets in the GIS iBook interested over half of the students in the survey. For the question “Please rate how interesting you feel for different multimedia widgets in the GIS iBook on a scale from 1 (very boring) to 5 (very interesting)”, over 50% of the students rated 4 (somewhat interesting) or 5 (extremely interesting) for each multimedia widget except Word Search Puzzle. For another question “Do you find multimedia elements (widgets) helpful or distracting?”, 54% of students expressed helpful, and the other 46% of students expressed helpful but somewhat distracting. In addition, the Quiz widget in the GIS iBook did improve students’ academic performances based on the survey results (Fig. 4.8). Overall, the multimedia widgets in the GIS iBook provide more diverse ways to convey knowledge and make GIS education more interesting and understandable.

2. **The GIS iBook can be renewed frequently and be easily accessed.** Compared with traditional paper based textbooks, which needs to be reprinted if there are adjustments, the GIS iBook can be easily revised and added new contents without printing a new edition. By using free iBook Author application, the GIS iBook can be edited and republished to the GIS iBook website or iTunes once there are errors or modifications in it. Educators and students only need to download the latest GIS iBook using their computers or iPads via the Internet.

3. **Educators and students can create their own iBooks for free.** The advantages of adopting iBook as a teaching material instead of other electronic books are free
development environment and abundant available resources (developed widgets). Unlike other paid applications (e.g., Evernote, PagePlus, Scrivener, etc.) for creating electronic books, iBook Author can be downloaded from iTunes for free. In the interview of asking feedbacks from educators, one of the high school teachers mentioned that she would like to create her own iBook for her classes and would ask her students to create one as their class projects. She mentioned that by creating an iBook by students themselves, students can be inspired by the processes of collecting data and have opportunities of improving their teamwork skills. The free resources for creating an iBook facilitate more various teaching methods and materials.

4. **iPads support multiple useful functions either in classes or in fieldwork.** For classes, students can take notes, searching information, and recording class lectures using built-in audio recorder with iPads. Students can even only have to bring iPads with them to school if all of textbooks that they need are available in PDF, HTML, DOC(X) or other electronic book formats (e.g., iBook, Kindle eBook, EPUB, MOBI, etc.). For fieldwork exercise, iPads provide functions such as Camera, GPS, Notes, and Maps. iPads also support many applications (ArcGIS, Collector for ArcGIS, sketch board, and measuring tool kit) which are useful as tools for fieldwork. Furthermore, instant messenger applications on iPads enable communication and data exchange immediately in fieldwork (i.e., team members can send photos or videos to each other).

5. **The combination of textbook and fieldwork exercise on a mobile device is an innovative idea in GIS education.** There have been various teaching materials for GIS education – from GIS textbooks, ArcGIS Desktop, to web-based GIS. However, those teaching materials lack consideration of fieldwork education. The GIS iBook on iPads contains not only knowledge of GIS but also fieldwork exercises in some chapters. By following the guidance in the fieldwork exercises, students can make flexible use of knowledge they learn and have deeper impressions.

6. **iPad has many convenient and user-friendly designs: portability, easy and intuitive user interface, and numerous synchronization tools.** One of the main ideas in Apple’s design is to provide users an intuitive user interface, which implies that users can spend less time learning how to use their products and get used to the
operating system easily. For example, although there were 6 students who never used iPads before the survey of utilizing iBooks on iPads in GIS education, every student finished the fieldwork exercise within 20 minutes, and only one student took over 15 minutes to finished the exercise. In addition to the intuitive design, users can synchronize data in their iPads and computers with iTunes. Users can move or update their data to iPads or computers via synchronization.

5.1.2 Weaknesses

1. **Some multimedia widgets in the GIS iBook can only work in places with wireless networks.** Multimedia widgets such as Youtube Video widget and Browser widget can only show embedded contents with connection to a wireless network. The two widgets call data stored in servers via the Internet using HTML and JavaScript. In the interview of educators, one high school teacher mentioned that her students cannot access to the Wi-Fi networks in the campus. The Wi-Fi network only allows staffs and faculty to access. Some other high school teachers mentioned that a few specific websites (e.g., Facebook and Youtube) are not allowed to access via their schools’ Wi-Fi networks. The environmental limitations mentioned above may be obstacles of using the GIS iBook in some campuses.

2. **Hyperlinks in the GIS iBook force iBooks application to close.** As mentioned in 4.3 (technical challenges), clicking hyperlinks embedded in the GIS iBook will force iPads to launch web browser applications (e.g., Safari, Mozilla Firefox, Chrome, etc.) but close iBooks application. Readers need to re-launch the iBooks application to resume their readings. One of the methods to solve shutdown of the iBooks application is replacing all hyperlinks in the GIS iBook with Browser widgets. By using Browser widget, developers can embed windows (or frames) to show contents of websites in their iBooks directly. However, replacing all the hyperlinks in the GIS iBook with Browser widgets will consume too much space and make user interface become more crowded.

3. **Some students need to spend extra time to learn how to operate and interact with the GIS iBook.** Based on comments from the students in GEOG 104 and GEOG 381, some students indicated that they need more time than others in the classes to
Some students did not finish reading one chapter since they were not familiar with tablet computers. Although the GIS iBook contains a list of video demonstrations in the preface chapter to teach students usages of the GIS iBook, students still had problems when they were navigating between chapters and interacting with widgets. On the other hand, traditional paper based textbooks will not cause problems that mentioned above.

4. **The size and fragility of the iPad cause inconveniences during fieldwork.** As illustrated in Figure 4.9, using iPads in fieldwork has some deficiencies, i.e., the size of the iPad is too big to be operated by one hand. The big size and fragility of the iPad disenable students in fieldwork to take notes and to measure objects easily. One of the approaches to solve the issue of size and fragility is replacing the iPad with iPad mini. The iPad mini can be handled by one hand and is more portable than an iPad.

5. **Some applications on iPads and multimedia widgets in the GIS iBook may distract students’ attentions.** Based on the feedbacks from educators, distracting applications in iPads are the most frequent concerns of using iPads in education. Students may play with built-in camera and browse unrelated website with Safari (a web browser application) when they are using iPads. In addition, some educators also indicated that multimedia widgets in the GIS iBook can be distracting for students. For example, the Youtube Video widget may show some advertisements (videos or hyperlinks) before videos.

### 5.1.3 Opportunities

1. **The popularization of using mobile device familiarizes students with the operation of iPads.** As technology advances rapidly, the percentage of American who have smartphones increased from 35% in 2011 to 60% in 2014 (Mobile Technology Fact Sheet 2013). The percentage of American Adult who have tablet computers increased from 10% in 2011 to over 40% in 2014. The increased percentage of people who have mobile devices not only implies the popularization of mobile device but also means that more and more people become familiar with the operation of mobile devices. With this trend, students will spend less time learning the operation of iPads and iBooks and focus on reading the content of the GIS iBook.
2. **There is no other teaching material for GIS education that adopts a mobile device as its platform.** Similar to the concept “The combination of textbook and fieldwork exercise on a mobile device is an innovative idea in GIS education” mentioned in the 5.1.1, the GIS iBook is an innovative idea in GIS education.

3. **As technology advances, GIS becomes more important than the past.** GIS is no longer restricted to run on standalone computers. The advance of web application and Internet GIS has made GIS be utilized in more diverse ways. GIS can be media that connects different communities to each other and transfer information based on spatial locations (Sui and Goodchild 2011). The popularization of web mapping application such as Google Maps enables more people to utilize GIS functions intentionally or unintentionally than in the past. People can utilize web mapping service to provide volunteered geographic information (Goodchild 2007) or build their own online maps without knowing how to use GIS. To ensure good data quality and establish standards for web mapping applications, educating public and training students in related fields are important.

4. **With new version of OS X (OS X Mavericks or newer), students can read iBooks without an iPad.** Before OS X Mavericks (OS X 10.9) was released by Apple, readers can only read iBooks on iPads or iPad minis. Although readers can read iBooks in PDF format, multimedia widgets and videos are not supported by PDF reader software. After Apple released OS X Mavericks, readers can read iBooks on their MacBook or iMac using iBooks for Mac application.

5. **New release widgets can enrich the content of the GIS iBook (i.e., embedding ArcGIS Online web maps in iBooks).** Except built-in widgets in iBook Author and widgets provided by Bookry.com, there have been more and more widgets available on the Internet. For instance, ESRI has released a new widget for developers to embed ArcGIS Online web maps or Story Maps in their iBooks. Story Maps are web applications that combine interactive maps and multimedia content such as videos together. By interacting with Story Maps in the GIS iBook, students can learn knowledge in a geospatial way and learn how to design their own Story Maps. Other new widget resources such as split whiteboard, Wikipedia browser, piano, etc. provided by BookWidgets.com can also be new widgets in the future development.
6. **Apple provides several plans for education: education financing plan and volume purchase program.** To support students to afford their educational resources, Apple cooperates with Citizens Bank to provide student a special loan plan. Apple also gives discounts for volume purchase of iPads to encourage educators to take iPads as teaching devices. These financing plans may not only help Apple to increase its market share in education domain but also raise the percentage of people who have iPads.

### 5.1.4 Threats

1. **Compared with other tablet computers, Apple iPad costs more money.** According to the prices shown on official websites of different latest tablet computers, Apple iPad is more expensive than other brands (Table 5.3). Although Apple provides students special loan plan for buying their products, students or their parents need to have good credits for applying the loan. The higher price of the iPad may become an influential factor that makes people to select other bands of tablet computers.

2. **Other teaching materials may be easier to access than the GIS iBook (e.g., online web mapping applications) since iBooks can only be launched on iPads or computers with OS X Mavericks or newer.** The advances of technology coupled with the popularization of GIS diversify teaching materials for GIS education. Those teaching materials include paper based textbooks, PowerPoint slides, CD-ROM, and online web mapping applications. Although the GIS iBook possess several features that other teaching materials do not have, it is less accessible than the other teaching materials. Unlike online web mapping applications, which can be access using web browsers on any devices, GIS iBook can only be read on iPads or computers with OS X Mavericks or newer. The limitation of iBooks may be a potential threat for the GIS iBook in competition with other teaching materials.

3. **Future policy change in free widgets and iBook Author may hinder the development of the GIS iBook.** At present, multimedia widgets of Bookry.com and iBook Author are free resources. On the other hand, there are also many paid resources on the Internet (e.g., BookWidgets.com). The GIS iBook is a free teaching material for GIS education at the present time since it is developed with free resources. However, if Bookry.com or Apple changed their policies and started to charge for downloading multimedia widgets or iBook Author, the GIS iBook might no longer be a free resource. The paid GIS iBook would be a less preferred choice than other free teaching materials.
4. **Technology changes rapidly and therefore it is hard to forecast problems of compatibility between old and new version of iPads.** One of the most influential threats caused by external changes is the advances of technology. Technology enables the development of iBooks and Wi-Fi environment but at the same time advances too fast to be caught up with. For instance, iPad 1 is too old to be updated to a newer iOS and cannot be installed a newer version of iBooks application. Therefore, some features such as multi-touch interaction and multimedia widgets might not be supported on iPad 1. The potential issue of compatibility between old and new devices and applications is an important consideration for developing the GIS iBook in the long run.

<table>
<thead>
<tr>
<th>Brand</th>
<th>Size (diagonal)</th>
<th>Capacity</th>
<th>Price (official)</th>
</tr>
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<tbody>
<tr>
<td>Apple iPad Air 2</td>
<td>9.7”</td>
<td>16GB</td>
<td>From $499</td>
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<tr>
<td>Kindle Fire HDX 8.9</td>
<td>8.9”</td>
<td>16GB</td>
<td>From $349</td>
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<tr>
<td>Samsung Galaxy Tab</td>
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<td>From $399</td>
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<tr>
<td>Google Nexus</td>
<td>8.9”</td>
<td>16GB</td>
<td>From $399</td>
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**5.2 CONCLUSION**

Based on the result of the SWOT analysis and implementation survey, this research demonstrates that utilizing iBooks on iPads has a great value in helping educators’ instructions and students’ learning of GIS. For educators, replacing paper based textbooks with iBooks can make teaching materials be more flexible and diverse. Educators can develop and customize their own iBooks for their classes using free resources on the Internet and can utilize classroom applications such as interactive white board, class organizer, classroom management, etc. with iPads to increase interactions with students. Educators can also design a lesson plan for students to develop their own iBooks as team work projects. For students, the GIS iBook provides new learners a free learning resource, which combines basic introductions of GIS related technologies and fieldwork programs together. The multimedia widgets in the GIS iBook also impressed students and gave them better understandings of GIS technologies based on the result of knowledge oriented questionnaire. In addition, the portability and multifunctional characteristics of iPads enable students to take class and to do fieldwork conveniently. Both GIS iBook and iPads can be helpful tools in teaching and learning GIS.
However, based on the result of SWOT analysis and implementation survey, utilizing iBooks on iPads in GIS education still leaves much room for improvement. In terms of internal factors, items such as Youtube Video widget and Browser widget in the GIS iBook can only work at places with Internet access. As mentioned by the educators during the interview, the requirement of Internet access has been one of the main obstacles to implement the GIS iBook on iPads in education. Although replacing Youtube Video widget and Browser widget with embedded videos and HTML file can solve this kind of issue, the size of the GIS iBook file would be extremely large and hard to be downloaded from the GIS iBook website. In addition, taking static HTML file instead of Browser widget would decrease the interaction between students and the GIS iBook. Striking a balance between the facility requirements and the functionality of the GIS iBook needs to be pondered profoundly. Other considerations of the GIS iBook on iPads include the size and fragility of the device. In terms of the external factors, price of the iPad, policy changes, and compatibility issues are also need to be considered to prevent future difficulties.

After considering and evaluating the advantages, disadvantages, benefits, survey feedbacks, limitations and potential issues of this research, the two research questions can be answered as follows.

**Question 1: How to assess and evaluate the effectiveness of location-based learning exercises (from iBook) and fieldwork exercises for first-time GIS students?**

To evaluate whether the GIS iBook and the fieldwork exercise can enhance students’ understanding or not, this research implemented a survey to ask students in two GIS courses to review the GIS iBook, doing fieldwork exercise using iPads and answering online questionnaires for feedbacks. Questions in the questionnaires refer to student’s background of GIS knowledge, comments about the GIS iBook and fieldwork exercise, and improvements of the survey. As shown in Figure 4.4, there are 21 students who were taking their first GIS course. To assess whether the GIS iBook and fieldwork exercise were effective for these new GIS students or not, this research evaluates the questionnaires of these 21 students. In respect of reviewing the GIS iBook, all of the new GIS learners thought the multimedia widgets in the GIS iBook are helpful, and some of them thought the multimedia widgets may sometimes be distracting (Fig. 5.1). In addition, most of the new learners expressed that they are willing to use the free GIS iBook as teaching materials in
their classes (Fig. 5.2). In respect of doing the fieldwork, all of the new GIS learners thought doing fieldwork exercise can help them to learn more GIS knowledge, and 19 of them would like to take more fieldwork exercise in the future. In respect of knowledge oriented questions, each question in the knowledge oriented questionnaire get higher correct rate after students read the GIS iBook (Fig 5.3). Although the sample size and survey time were very limited, the result of the questionnaires expresses that GIS iBook and fieldwork exercise do interest and help first-time GIS students.

**Figure 5.1** Multimedia widgets in the GIS iBook for first-time GIS students.

**Figure 5.2** How free GIS iBook influence students’ choices for first-time GIS students.
Figure 5.3 Number of students who answer the knowledge oriented questions correctly.

**Question 2: What are the learning outcomes of adopting the GIS iBook as a textbook in GIS classes?**

As mentioned in 4.4, the final t value is larger than the critical t score (2.04) and locates at the right side of the distribution (Fig. 4.10). Therefore, this research rejects the null hypothesis: $H_0: \mu_{\text{before}} = \mu_{\text{after}}$ (There is no significant difference between pre-test and post-test.) but accepts the alternative hypothesis: $H_A: \mu_{\text{before}} \neq \mu_{\text{after}}$ (There is a significant difference between pre-test and post-test.). The result indicates that the students had better learning outcomes by adopting the GIS iBook as a textbook in GIS classes.

**Question 3: What were major technical challenges and opportunities to utilize mobile device and mobile technology in GIS education?**

During the development of the GIS iBook and the test of using GIS iBook on iPads, the main technical challenges are shutdown of the iBooks application due to the embedded hyperlinks, slow loading web pages of Browser widget, nonsupport of animated images in iBooks and the lack of stable Internet access environment. As mentioned in 4.3, the shutdown of iBooks application due to the hyperlinks in the GIS iBook has been pointed out by both educators and students. The automatic launch of web browsers to open the hyperlinks has caused inconvenience for users and has interrupted their readings. Although this kind of problem can be solved by embedding Browser widget, Browser widget takes longer time to load a web page and even breaks down the iBooks application when it is loading an interactive web map. Nonsupport of animated images in iBooks is also a technical
challenge encountered during the development. To replace the animated images in the original PowerPoint slides with Keynote slides, this research created several Keynote files and embedded the files in the GIS iBook as Dynamic Image widget. The Dynamic Images widgets were displayed like animated images and can be used to show a series of changes in the images. Except the shutdown of iBooks application and the nonsupport of animated images that encountered during the development, another big challenge that encountered during the fieldwork exercise part of the survey is the availability of stable Internet access environment. Some students responded that their iPads could not show correct locations when they were at basements. However, it is hard to improve the low signal because there are many factors that influence the quality of wireless network (e.g., long distance, construction, device interferences, etc.). Using iPads in fieldwork may be restricted to places with stable WiFi signal.

Based on the result of SWOT analysis, utilizing iBooks on iPads in GIS education has several opportunities to increase its value in education. In terms of long-term trend of technology development, the advanced technology and increased utilization of GIS technology enables the popularization of mobile device and promotes GIS education. In terms of comparison between iBooks and other electronic books, there have been abundant free resources for developing iBooks, and this kind of resources is still increasing on the Internet. The new released widgets enrich the content of the GIS iBook and make the GIS iBooks be more engaging and helpful for learning GIS. In terms of marketing strategy, Apple provides various financial plans for students, educators and educational facilities. Students can afford iPads through special loan plan and have more opportunities to access to iPads in their schools. In addition, as wireless network become more general than in the past, mobile devices enable more convenient learning environment either in classrooms or fieldwork. With the opportunities above, the possibility of using mobile device and mobile technology in GIS education may highly increase in the future.

### 5.2.1 Limitations of This Research

Utilizing iBooks on iPads is effective in fieldwork and GIS education based on the result of the survey in GEOG 104 and GEOG 381. However, the result does not mean that utilizing iBooks and iPads in GIS education is absolutely suitable for every GIS learner since
there were various challenges and limitations. First, the researcher may not explain the survey processes clearly in GEOG 104 and GEOG 381 and might not interpret feedbacks from students and educators completely due to language and cultural barriers. The unclear explanation of survey might confuse students of reading the GIS iBook and cause inaccuracies in survey’s results; and the incomplete interpretations of subjects’ feedbacks may lead to neglects in SWOT analysis. Second, the limited time for doing survey in GEOG 104 and GEOG 381 might lead to inaccuracies in the result. This research only tested the GIS iBooks and fieldwork exercise using iPads with 50 minutes in both two classes respectively, and the test was only held once since schedules of the two classes were extremely tight. Students only had 20 minutes to review the GIS iBook and had to finish the fieldwork exercise and questionnaires within 20 and 10 minutes. Students might pay less attention to the contents of the GIS iBook in order to finish reviewing the two new chapters in the given time. The short 10 minutes for answering the survey questionnaires might also influence students’ answers and cause inaccuracies. The potential issues above might lead to biases, and therefore the results may not reflect students’ opinions thoroughly. Lastly, the testing subjects were not randomly picked up but were chosen from two GIS courses. Although the GIS iBook is designed for new learners and over half of the test subjects were taking their first GIS course, nearly all the students know GIS before the test. The result of this research may not representative enough to conclude that the GIS iBook is suitable for every learner.

5.2.2 Future Work

To improve the contents of the GIS iBook and the implementation survey in GIS courses based on the result of SWOT analysis and survey questionnaires, future work includes modifying multimedia widgets in the GIS iBook, developing new chapters with educators, and implementing the GIS iBook on iPads in a longer time based on a random sampling from a larger group.

Modifying multimedia widgets in the GIS iBook includes removing less interesting and less helpful widgets based on the survey result. For instance, Figure 4.6 and Figure 4.7 indicate that Word Search Puzzle widget is the least interesting and least helpful widget for learning GIS. Therefore, Word Search Puzzle will be replaced with other multimedia widgets, and the content of the GIS iBook will be reviewed again after the modification. Modifying
multimedia widgets in the GIS iBook also includes adding new widgets that can enhance students’ understandings to the GIS iBook. For instance, the new released web mapping widget by ESRI enables developers to embed Story Maps and ArcGIS Online Maps directly in iBooks instead of launching a web browser to open the web based maps. Students can also create their own Story Maps and display their maps using a maps gallery widget by ESRI. Embedding new widgets not only increases the interaction between students and the GIS iBook but also provides more opportunities for students to improve their skills of designing maps.

Developing new chapters with educators and implementing the GIS iBook in a longer time based on a random sampling from a larger group can fit the GIS iBook for more educators and students. By collaborating with educators to edit new chapters, educators can be familiar with not only the contents of the GIS iBook but also skills of developing their own iBooks. Educators can also contribute their teaching experiences and ideas to make the GIS iBook be more useful and meet their needs. By implementing the GIS iBook in a longer time based on a random sampling from a larger group can decrease the inaccuracies and biases in the result of this research. The long implementation enables students to have enough time to focus on the content and interact with the multimedia widgets thoroughly. Randomly choosing testers can make the result of the implementation be more reliable and representative because every tester is given equal opportunity to be chosen; and selecting testers from a larger population can help this research to improve the GIS iBook based on more diverse feedbacks.
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APPENDIX A

SURVEY QUESTIONNAIRES
SURVEY QUESTIONNAIRES FOR GEOG104 AND GEOG381

Utilization of GIS iBook on iPads (Pre-Assessment)

*What is your unique ID?

*How familiar are you with geographic information system (GIS)? (Choose ONE answer)
   1. I have never heard about GIS.
   2. I know GIS but have never take a GIS class.
   3. I am taking my first GIS class now.
   4. I have completed 2 GIS classes before.
   5. I have completed 3 or more GIS classes before.

*What kind of GIS have you used before?
   1. Desktop GIS software (e.g. ArcMap, IDRISI GIS, QGIS, etc.)
   2. Internet GIS (ArcGIS online, ArcGIS Explorer, etc.)
   3. Both
   4. None of the above

* How often do you use an Apple iPad (Choose ONE answer)?
   1. I have never used an iPad before today.
   2. I have occasionally used an iPad.
   3. I sometimes use an iPad. (One or more times a month, but not every week.)
   4. I regularly use an iPad. (One or more times a week, but not every day.)
   5. I frequently use an iPad. (One or more times a day.)

*Have you read books in digital format (for example, PDF or web based) before? (Choose ONE answer)
   1. Yes
   2. No

*Have you read books using iBooks on iPads before? (Choose ONE answer)
1. Yes
2. No

*Please rank your preference for reading books from 1 (most preferred) to 7 (least preferred). Select the value from the drop down menu to rank your preference. (Rank 1 to 7)

1. I prefer to read books on a laptop computer.
2. I prefer to read printed books.
3. I prefer to read books on a full size tablet computer. (Example: iPad)
4. I prefer to read books on a desktop computer.
5. I prefer to read books on a small size tablet computer. (Example: iPad mini)
6. I prefer to read books on a smartphone.
7. I prefer to read books on a dedicated ereader device. (Example: Kindle)

*Have you locate your position by using devices listed below?

1. Yes, by using a smartphone.
2. Yes, by using a tablet PC.
3. Yes, by using a GPS.
4. Yes, by using a PDA
5. Yes, but none of the above.
6. No, I never use a device to locate my position.

*Have you used any mobile devices (smart phone, tablet PCs) in fieldwork?

1. Yes, I used mobile device(s) in fieldwork.
2. No, I never use a mobile device in fieldwork.
3. I do not have experience of fieldwork.

**Utilization of GIS iBook on iPads (Post-Assessment)**

*What is your unique ID?*

*What parts of the GIS iBook did you read?*

1. Preface
2. Chapter 1, Section 1: The Magic of Spatial Relationships
3. Chapter 1, Section 2: The Magic is at your Fingertips
4. Chapter 1, Section 3: Building the GIScience Castle
5. Chapter 1, Section 4: A brief history of GIS
6. Chapter 1, Section 5: Why is GIScience Important?
7. Chapter 1, Exercise: Follow the Money
8. Chapter 2, Section 1: Geospatial Technologies and Emergency
9. Chapter 3, Section 1: The magic of collecting data remotely
10. Chapter 3, Section 2: Diving into data
11. Chapter 3, Section 3: The invisible information
12. Chapter 5, Section 1: Media Credits

*Please rate how interesting you feel for different features in the GIS iBook on a scale from 1 (very boring) to 5 (very interesting):
  1. Before and After Comparison
  2. Dynamic Image
  3. Word Search Puzzle
  4. Youtube Video
  5. Imager Gallery
  6. Single Image

*Please rank the most helpful and least helpful feature you think in the GIS iBook from 1 to 6. Select the value from the drop down menu to rank. (Rank 1 to 6)
  1. Before and After Comparison
  2. Dynamic Image
  3. Word Search Puzzle
  4. Youtube Video
  5. Imager Gallery
  6. Single Image

*How long did you spend on watching a video in average? (Choose ONE answer)
  1. Did not watch
  2. For a few seconds
  3. More than a few seconds, but less than 30 seconds
  4. For over 30 seconds, but not to the end
5. From start to finish

*Do you find multimedia elements helpful or distracting? (Choose ONE answer)
  1. Helpful.
  2. Mostly helpful, but sometimes distracting.
  3. Mostly distracting, but sometimes helpful.
  4. Distracting.

*Please RANK your preference for reading textbooks about GIScience from 1 (least preferred method) to 7 (most preferred method).
  1. I prefer to read a book about GIScience on a smartphone.
  2. I prefer to read a book about GIScience on a laptop computer.
  3. I prefer to read a book about GIScience on a desktop computer.
  4. I prefer to read a book about GIScience on a full-size tablet computer. (iPad)
  5. I prefer to read a printed book about GIScience.
  6. I prefer to read a book about GIScience on a smaller size tablet computer. (iPad mini)
  7. I prefer to read a book about GIScience on a dedicated e-reader. (Kindle)

*Assuming access to iPads, how would the use of free interactive multimedia iBooks for GIScience textbooks influence you in selecting GIScience classes? (Choose ONE answer)
  1. Prefer to always take a GIScience class that uses free iBooks instead of printed textbooks.
  2. Prefer to take a GIScience class that uses free iBooks, but not a deciding factor in GIScience class choice.
  3. Doesn't matter whether the GIScience class uses free iBooks or printed textbooks.
  4. Prefer not to take a class that uses free iBooks, but not a deciding factor in GIScience class choice.
  5. Prefer to never take a GIScience class that uses free iBooks instead of printed textbooks.

**Utilization of iPads in fieldwork (Post-Assessment)**

*What is your unique ID?

*Except ArcGIS for mobile device and GPS service, what applications or functions on iPads have you used during the fieldwork?
  1. Internet browser
2. Note
3. iBooks
4. Camera
5. Other:

*Do you think information in the GIS iBook is helpful enough for today’s fieldwork?
   1. Yes
   2. No

*What problems have you met when you were in fieldwork with iPads?
   1. hard to take notes with two hands
   2. distracting
   3. screen reflection
   4. need two hands to operate
   5. fragile
   6. other:

*Assuming you have questions during fieldwork, rank your preference for searching answer from 1 to 4. Select the value from the drop down menu to rank. (Rank 1 to 4)
   1. I prefer to find answer from an iBook.
   2. I prefer to find answer from the Internet.
   3. I prefer to find answer from a printed book.
   4. I prefer to find answer by asking others.

*How long did you take for finishing the fieldwork exercise?
   1. less than 10 minutes
   2. less than 15 minutes
   3. less than 20 minutes
   4. more than 20 minutes

*Do you think fieldwork exercise can help you learn more about GIS knowledge?
   1. Yes
   2. No
*Would you prefer to take more fieldwork exercises in your GIS classes?
   1. Yes
   2. No

**Knowledge Oriented Questionnaires in Pre-assessment and Post-assessment**

*In remote sensing, which is not included in the 4 types of resolution?*
   1. spatial resolution
   2. biophysical resolution
   3. spectral resolution
   4. temporal resolution
   5. radiometric resolution

*In remote sensing, which resolution defines a satellite’s revisit frequency?*
   1. spatial resolution
   2. biophysical resolution
   3. spectral resolution
   4. temporal resolution
   5. radiometric resolution

*NDVI is an index of vegetation’s condition. Areas with healthier and dense vegetation will have _____ NDVI.*
   1. higher
   2. lower
   3. moderate
   4. zero

*Which feature is not included in Three Kinds of Internet GIS?*
   1. data sharing
   2. information sharing
   3. maps sharing
   4. knowledge sharing
* Which feature makes mobile GIS become a powerful tool in location based exercise?

1. Faster data management than a computer.
2. Synchronization and wireless communication
3. Abundant and high-level functions
4. None of these answers is correct
APPENDIX B

RESULTS OF SURVEY QUESTIONNAIRES
RESULTS OF SURVEY QUESTIONNAIRES

Utilization of GIS iBook on iPads (Pre-Assessment)

*How familiar are you with geographic information system (GIS)? (Choose ONE answer)

- Don't know GIS: 3% (1)
- 1 course: 65% (20)
- 2-3 courses: 26% (8)
- >3 courses: 6% (2)

Total: 31

*What kind of GIS have you used before?

- Internet GIS: 3
- Desktop GIS software: 8
- Both: 19
- None of the above: 1

Total: 31

* How often do you use an Apple iPad (Choose ONE answer)?

- I frequently use an iPad: 6
- I regularly use an iPad: 2
- I sometimes use an iPad: 6
- I have occasionally used an iPad: 11
- I have never used an iPad before today: 6

Total: 31
*Have you read books in digital format (for example, PDF or web based) before? (Choose ONE answer)

Total: 31

- Yes: 26
- No: 5

*Have you read books using iBooks on iPads before? (Choose ONE answer)

Total: 31

- Yes: 14
- No: 17

*Please rank your preference for reading books from 1 (most preferred) to 7 (least preferred). Select the value from the drop down menu to rank your preference. (Rank 1 to 7)

Total: 31

- I prefer to read books on a laptop…: 4.61
- I prefer to read books on a dedicated…: 3.23
- I prefer to read books on a smartphone: 3.58
- I prefer to read books on a smallsize…: 4
- I prefer to read books on a desktop…: 4.19
- I prefer to read books on a fullsize tablet…: 4.03
- I prefer to read printed books. : 4.35
- I prefer to read books on a laptop…: 4.61
*Have you locate your position by using devices listed below?

<table>
<thead>
<tr>
<th>Option</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, but none of the above.</td>
<td>0</td>
</tr>
<tr>
<td>Yes, by using a PDA</td>
<td>1</td>
</tr>
<tr>
<td>Yes, by using a GPS</td>
<td>21</td>
</tr>
<tr>
<td>Yes, by using a tablet PC.</td>
<td>11</td>
</tr>
<tr>
<td>Yes, by using a smart phone.</td>
<td>29</td>
</tr>
<tr>
<td>No, I never use a device to locate my position.</td>
<td>1</td>
</tr>
</tbody>
</table>

Total: 31

*Have you used any mobile devices (smart phone, tablet PCs) in fieldwork?

<table>
<thead>
<tr>
<th>Option</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>I do not have experience of fieldwork.</td>
<td>13</td>
</tr>
<tr>
<td>No, I never use a mobile device in fieldwork.</td>
<td>7</td>
</tr>
<tr>
<td>Yes, I used mobile device(s) in fieldwork.</td>
<td>11</td>
</tr>
</tbody>
</table>

Total: 31

Utilization of GIS iBook on iPads (Post-Assessment)

*What parts of the GIS iBook did you read?

<table>
<thead>
<tr>
<th>Section</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td>1</td>
</tr>
<tr>
<td>Chapter 1, Section 1: The Magic of Spatial Relationships</td>
<td>1</td>
</tr>
<tr>
<td>Chapter 1, Section 2: The Magic is at your Fingertips</td>
<td>1</td>
</tr>
</tbody>
</table>

Chapter 1, Section 3: Building the GIScience Castle 0
Chapter 1, Section 4: A brief history of GIS 1
Chapter 1, Section 5: Why is GIScience Important? 1
Chapter 1, Exercise: Follow the Money 0
Chapter 2, Section 1: Geospatial Technologies and Emergency 1
Chapter 3, Section 1: The magic of collecting data remotely 27
Chapter 3, Section 2: Diving into data 28
Chapter 3, Section 3: The invisible information 28
Chapter 4, Section1: Development History 21
Chapter 4, Section2: Internet GIS 20
Chapter 4, Section3: Mobile GIS 20
Chapter 4, Section4: Future Development 16

*Please rate how interesting you feel for different features in the GIS iBook on a scale from 1 (very boring) to 5 (very interesting):

<table>
<thead>
<tr>
<th>Feature</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before and After Comparison</td>
<td>3.52</td>
</tr>
<tr>
<td>Dynamic Image</td>
<td>3.94</td>
</tr>
<tr>
<td>Word Search Puzzle</td>
<td>4.16</td>
</tr>
<tr>
<td>Youtube Video</td>
<td>3.45</td>
</tr>
<tr>
<td>Image Gallery</td>
<td>4.32</td>
</tr>
<tr>
<td>Single Image</td>
<td>3.68</td>
</tr>
</tbody>
</table>

Total: 31

*Please rank the most helpful and least helpful feature you think in the GIS iBook from 1 to 6. Select the value from the drop down menu to rank. (Rank 1 to 6)
**How long did you spend on watching a video in average? (Choose ONE answer)**

<table>
<thead>
<tr>
<th>Multimedia Element</th>
<th>Average Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before and After Comparison</td>
<td>3.65</td>
</tr>
<tr>
<td>Dynamic Image</td>
<td>3.84</td>
</tr>
<tr>
<td>Word Search Puzzle</td>
<td>2.52</td>
</tr>
<tr>
<td>Youtube Video</td>
<td>4.29</td>
</tr>
<tr>
<td>Image Gallery</td>
<td>4.71</td>
</tr>
<tr>
<td>Single Image</td>
<td>4.42</td>
</tr>
</tbody>
</table>

**Do you find multimedia elements helpful or distracting? (Choose ONE answer)**

<table>
<thead>
<tr>
<th>Helpful Perception</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helpful</td>
<td>17</td>
</tr>
<tr>
<td>Mostly helpful, but sometimes distracting</td>
<td>14</td>
</tr>
<tr>
<td>Distracting</td>
<td>0</td>
</tr>
<tr>
<td>Mostly distracting, but sometimes helpful</td>
<td>0</td>
</tr>
</tbody>
</table>
*Please RANK your preference for reading textbooks about GIScience from 1 (least preferred method) to 7 (most preferred method).

### Total: 31

<table>
<thead>
<tr>
<th>Preference</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>I prefer to read a GIS book on a dedicated ereader. (Kindle)</td>
<td>3.13</td>
</tr>
<tr>
<td>I prefer to read a GIS book on a smaller size tablet computer. (iPad mini)</td>
<td>3.61</td>
</tr>
<tr>
<td>I prefer to read a printed GIS book.</td>
<td>3.87</td>
</tr>
<tr>
<td>I prefer to read a GIS book on a full size tablet computer. (iPad)</td>
<td>3.74</td>
</tr>
<tr>
<td>I prefer to read a GIS book on a desktop computer.</td>
<td>4.58</td>
</tr>
<tr>
<td>I prefer to read a GIS book on a laptop computer.</td>
<td>4.87</td>
</tr>
<tr>
<td>I prefer to read a GIS book on a smartphone.</td>
<td>4.19</td>
</tr>
</tbody>
</table>

*Assuming access to iPads, how would the use of free interactive multimedia iBooks for GIScience textbooks influence you in selecting GIScience classes? (Choose ONE answer)  

### Total: 31

<table>
<thead>
<tr>
<th>Preference</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Prefer to always take a GIS class that uses free iBooks.</td>
<td>13</td>
</tr>
<tr>
<td>Prefer to take a GIS class that uses free iBooks, but not a deciding factor.</td>
<td>10</td>
</tr>
<tr>
<td>Doesn't matter whether the GIS class uses free iBooks or printed textbooks.</td>
<td>6</td>
</tr>
<tr>
<td>Prefer not to take a class that uses free iBooks, but not a deciding factor.</td>
<td>2</td>
</tr>
<tr>
<td>Prefer to never take a GIS class that uses free iBooks.</td>
<td>0</td>
</tr>
</tbody>
</table>
Utilization of iPads in fieldwork (Post-Assessment)

*Except ArcGIS for mobile device and GPS service, what applications or functions on iPads have you used during the fieldwork?

- **Camera**: 24
- **iBooks**: 6
- **Note**: 6
- **Internet browser**: 17

*Do you think information in the GIS iBook is helpful enough for today’s fieldwork?

- **Yes**: 31
- **No**: 0

*What problems have you met when you were in fieldwork with iPads?

- **Fragile**: 7
- **Need two hands to operate**: 20
- **Screen reflection**: 5
- **Distracting**: 1
- **Hard to take note with two hands**: 10
*Assuming you have questions during fieldwork, rank your preference for searching answer from 1 to 4. Select the value from the drop down menu to rank. (Rank 1 to 4)

Total: 31

I prefer to find answer by asking others. 2.4
I prefer to find answer from a printed book. 1.83
I prefer to find answer from the Internet. 3.13
I prefer to find answer from an iBook. 2.63

*How long did you take for finishing the fieldwork exercise?

Total: 31

less than 10 minutes 25
less than 15 minutes 4
less than 20 minutes 1
more than 20 minutes 0

*Do you think fieldwork exercise can help you learn more about GIS knowledge?

Total: 31

Yes 31
No 0

*Would you prefer to take more fieldwork exercises in your GIS classes?
Knowledge Oriented Questionnaires in Pre-assessment and Post-assessment

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3. Abundant and high-level functions
4. None of these answers is correct
ABSTRACT OF THE THESIS

Utilizing Mobile Technology in GIS Education:
A Case Study of Using iPad and iBooks in Fieldwork and Location Based Exercises
by
Yi-ting Chuang
Master of Science
San Diego State University, 2015

The advancement of mobile computing technology has provided diverse way for education. Combination of mobile devices and GIS tools has become a trend in many geospatial technology applications (i.e., Google Maps application on smartphones). This research aims to develop an iBook prototype (a GIS textbook) for GIS education on Apple iPads and to evaluate the effectiveness of adopting the GIS iBook in classes and fieldwork exercises. We conducted the evaluation tests in two GIS courses (GEOG104 and GEOG381) in Fall 2014 at San Diego State University. There are two main research questions in this study: (1) How to assess and evaluate the effectiveness of location-based learning exercises (from iBook) and fieldwork exercises for first-time GIS students? (2) What were major technical challenges and opportunities to utilize mobile device and mobile technology in GIS education?

The procedures of developing and evaluating the prototype of the GIS iBook include creating two new chapters (chapter three: Wander the World through Remote Sensing Data and chapter four: Internet and Mobile GIS), interviewing five educators from high schools and community colleges, and improving the contents of the GIS iBook after the interview. There were 31 students who tested the GIS iBook and did a fieldwork exercise with iPads. The 31 students were required to finish five questionnaires after the exercise to express their user experiences and thoughts about the GIS iBook.

Based on the result of questionnaires, most students preferred to take GIS classes with the free GIS iBook and thought fieldwork exercise can help their learning. The students also performed better in knowledge oriented survey after reading the GIS iBook. This research also adopts the SWOT analysis method to evaluate the prototype of the GIS iBook. The result of the SWOT analysis indicates that utilizing mobile device in GIS education does have a great potential value in enhancing student’s understanding. The strengths of utilizing mobile device in GIS education include portability, easy update contents and abundant free development resources, while the weaknesses include distracting multimedia widgets, lack of Internet access, and security issues. The opportunities of SWOT analysis include financial plan for iPads and lack of competitors, while the threats include higher price and incompatibility of iBooks on other tablet computers. The major limitations and key challenges are limited survey time, small sample size, and technical difficulties of developing the GIS iBook.