DESIGNING AN EDUCATIONAL APP TO TEACH CHINESE CHARACTERS FOR HERITAGE LANGUAGE EDUCATION

by

Mu He

An executive position paper submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Education in Educational Leadership

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DEDICATION

This project is dedicated to my son, Ethan He, who will soon be a learner of Chinese as a heritage language.
ACKNOWLEDGMENTS

It is with sincere appreciation that I would like to acknowledge those who have supported me on this adventure to complete my doctoral degree in education. First my parents, who selflessly encourage me to pursue my dream overseas, and my wife, who continually supports me with care and understanding.

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Finally, I would like to express my heartfelt gratitude to my advisor Dr. Fred Hofstetter, for his ongoing advice, encouragement, and patience, as well as being a tremendous mentor for me. He has been a beacon of light during this intense doctoral process. I am genuinely thankful for being blessed with his support.
# TABLE OF CONTENTS

LIST OF TABLES ........................................................................................................ viii
LIST OF FIGURES ....................................................................................................... ix
ABSTRACT ................................................................................................................... x

Chapter

1 INTRODUCTION ........................................................................................................... 1

Chinese as a Heritage Language Education .................................................................. 2
Teaching and Learning Chinese Characters ................................................................... 6
Educational App Design and Evaluation ......................................................................... 8
Problem Statement and Key Questions .......................................................................... 13

2 METHODS AND FINDINGS .................................................................................... 15

Participants ................................................................................................................. 16
Data Collection .......................................................................................................... 17

App Review ................................................................................................................. 17
Focus Group Interviews .............................................................................................. 20

Data Analysis .............................................................................................................. 21

App Review ................................................................................................................. 21
Focus Group Interviews .............................................................................................. 21

Findings ....................................................................................................................... 24

Key Question 1: What are the challenges and opportunities of using the educational apps to support CHL education? ................................................................. 24
Key Question 2: What are the advantages and limitations of the existing educational apps for teaching and learning Chinese characters? ................................. 25
Key Questions 3: What are the key features of an effective educational app for teaching and learning Chinese characters in CHL education? .......................... 32

Prototyping ................................................................................................................ 34
3 DISCUSSION AND RECOMMENDATIONS ........................................57

Recommendations ........................................................................59

Recommendations for the mobile app designers and developers .......59
Recommendations for the teachers .................................................62
Recommendations for the administrators at the Chinese community
schools ....................................................................................63
Recommendations for the researchers and scholars .......................64

Limitations ..................................................................................64
Considerations ............................................................................65
Conclusion ....................................................................................66

REFERENCES ...............................................................................67

Appendices

A FOCUS GROUP INTERVIEW INSTRUMENT .................................74
B CONSENT FORM .....................................................................79
C INSTITUTIONAL REVIEW BOARD (IRB) APPROVALS ..............83
D EXISTING APP REVIEW RUBRICS ........................................84
LIST OF TABLES

Table 1. Participants Demographics ................................................................. 16
Table 2. Source of the Key Rubric Questions....................................................... 18
Table 3. App List .................................................................................................. 19
Table 4. Codes that Developed from the Literature Review................................. 22
Table 5. Final Coding Scheme from First Focus Group Interviews ....................... 23
Table 6. Summary of the Features in the App Prototype...................................... 33
Table 7. Summary of the Design Decision Sources in the App Prototype .......... 35
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>A grid for determining the pedigree of an app.</td>
<td>10</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Lee &amp; Kim’s criteria model for app evaluation.</td>
<td>11</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Evaluating Google Earth with Lee and Chernier’s app evaluation rubric.</td>
<td>12</td>
</tr>
<tr>
<td>Figure 4</td>
<td>App review results of rubric question 10.</td>
<td>26</td>
</tr>
<tr>
<td>Figure 5</td>
<td>App review results of rubric question 11.</td>
<td>27</td>
</tr>
<tr>
<td>Figure 6</td>
<td>App review results of rubric question 12.</td>
<td>28</td>
</tr>
<tr>
<td>Figure 7</td>
<td>App review results of rubric question 15.</td>
<td>29</td>
</tr>
<tr>
<td>Figure 8</td>
<td>App review results of rubric question 17.</td>
<td>30</td>
</tr>
<tr>
<td>Figure 9</td>
<td>App review results of rubric question 18.</td>
<td>31</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Tabs UI in the app.</td>
<td>36</td>
</tr>
<tr>
<td>Figure 11</td>
<td>Clean and organized lesson view.</td>
<td>37</td>
</tr>
<tr>
<td>Figure 12</td>
<td>Informative single character view with trace and stroke mode.</td>
<td>39</td>
</tr>
<tr>
<td>Figure 13</td>
<td>Customizable learning contents.</td>
<td>42</td>
</tr>
<tr>
<td>Figure 14</td>
<td>Leaderboard with three ranking systems.</td>
<td>43</td>
</tr>
<tr>
<td>Figure 15</td>
<td>Promoting events related to heritage culture.</td>
<td>45</td>
</tr>
<tr>
<td>Figure 16</td>
<td>Fun culture facts and trivia &amp; popular Chinese local drama.</td>
<td>46</td>
</tr>
<tr>
<td>Figure 17</td>
<td>Engaging articles and news with four practice modes.</td>
<td>46</td>
</tr>
<tr>
<td>Figure 18</td>
<td>Screenshot of “Me” tab-view.</td>
<td>47</td>
</tr>
<tr>
<td>Figure 19</td>
<td>Screenshots of the features on the top row of “Me” tab.</td>
<td>48</td>
</tr>
</tbody>
</table>
Figure 20. Screenshots of the features on the second row of “Me” tab. ...................49
Figure 21. Users may change the app appearance in “Settings” ..........................50
Figure 22. Screenshots of the features on the third row of “Me” tab ................50
Figure 23. Demonstration of management features in a class ..............................51
Figure 24. Using “Analytics” tool to view the class participations by date, activity and student. .................................................................52
Figure 25. Process of creating activity in a lesson ..............................................53
Figure 26. Using “Word List” tool to select or customize the characters in a lesson .........................................................................................54
Figure 27. “Achievements”, “Analytics”, and “Preview” tools in the “Lesson” view .................................................................................................55
Figure 28. Cross-platform compatibility ...............................................................56
ABSTRACT

The growth and wide use of the mobile app not only brought significant changes in our social and economic life but also provided promising opportunities in the field of education. The importance of the educational app has been recognized, as is seen by the efforts of educators and app developers in exploring its potential in the field of teaching and learning practices. The mobile app is currently finding its way into Chinese classrooms, where teachers of Chinese use apps to enhance student engagement and learning outcomes. Although the use of these various mobile apps for the teaching and learning Chinese has become a common practice, most of them concentrate on teaching Chinese as a foreign language with few designed for learning Chinese as a heritage language. Moreover, based on the results of a review of existing mobile apps, most of the apps target language learners for self-study or independent learning, but few of them are designed from the language teacher’s perspective to support instruction in the classroom. It is also noteworthy that many educational apps for learning the Chinese language are created by software engineers and without the expertise of subject matter experts and instructional designers, and thus the pedagogical knowledge, instructional content, and usability of these applications is not guaranteed in the educational settings.

To support heritage language teachers and maximize the opportunities for student learning, this project aims to understand and explore effective design and development of a mobile app for teaching Chinese as a heritage language. By focusing on teaching Chinese characters or Hanzi, which is a highly laborious, demanding and
exceedingly tedious process in learning Chinese, this project attempts to create a high fidelity interactive app prototype from scratch. As a visual presentation of the project outcomes, the design and development process of this prototype is modeled around literature from relevant fields, the analysis of existing apps, and the feedback gained from focus group interviews.

The findings of this project, including the storyboard built upon the functional analysis, the data gathered from the analytics, and user feedback and suggestions collected, could potentially inspire and motivate software engineers in developing future mobile apps for Chinese as a heritage language. Teachers may also find this project helpful for applying similar mobile apps to support instruction and engage students. Last but not least, this project is intended to make contributions to the scarce studies on the use of mobile apps for Chinese in heritage language learning.
Chapter 1
INTRODUCTION

The development of mobile technology and devices has been revamped since the debut of the iPhone and iOS in 2007, especially when Apple launched the App Store in July 2008, which allowed third parties to develop and distribute the app via its platform. Few imagined it would spawn a multibillion-dollar business in less than five years (Shuler, Levine, & Ree, 2012). Up to 2015, there were 1.5 million apps available in the Apple App Store, and more than 100 billion apps were downloaded in total (STATISTA, 2016).

The growth and broad adoption of the mobile app generate not only significant impacts on the economy and society (Hirsh-Pasek et al., 2015) but they also create promising opportunities in education. The potential of the mobile app has been recognized and driving many educators and developers to explore it in teaching and learning practice. As of August 2011, educators had their choice of more than 40,000 educational apps in the App Store. In less than four years, the number of the educational apps has doubled to over 80,000 (Apple Inc., 2016). Regarding integrating mobile apps for language learning, a lot of research has highlighted their enormous potential, based on the theoretical principles and evidence from the field of mobile assisted language learning (Burston, 2014; Godwin-Jones, 2011; Golonka et al., 2012; Kim & Kwon, 2012; Kim, 2013; Lafford, 2011; Lys, 2013; Shinagawa, 2012; Sweeney & Moore, 2012; Yang & Xie, 2013).
To build a solid theoretical basis for this project, in the following sections, the primary investigator will examine the literature related to three critical components of this project, namely, (1) Chinese as a heritage language (CHL), (2) pedagogy in teaching and learning Chinese characters, and (3) educational app design and evaluations.

**Chinese as a Heritage Language Education**

The notion of “heritage language (HL)” has existed under various names such as “home language”, “ancestral language”, “ethnic language”, “immigrant language”, “minority language” or “community language” (He & Xiao, 2008; Duff & Li, 2008). The term “heritage language” was first used in educational contexts in the early 1970s (Hornberger & Wang, 2008) and has gained currency among those concerned about the maintenance, revitalization, and education of non-English languages in the United States since the 1990s (Valdes, 2001). According to Fishman (2001), heritage language in North America has been broadly defined as any ancestral language. Hornberger and Wang (2008) extended the Fishman’s HL range and defined the historical relationships between HL learners and society with three categories in the U.S., including indigenous languages, colonial languages, and immigrant languages.

There is a widely-held view that HL is a precious resource, both for the individual and for society (Krashen, Tse, & McQuillan, 1998; Peyton, Ranard, & McGinnis, 2001; Wong Fillmore, 1991). Many studies on HL learners have demonstrated that minority language students who preserve their own culture, literacy, and ethnic identity, in addition to enjoying pride in their heritage and close relations within their family and community social networks, “will benefit from higher social mobility and personal empowerment, and will more likely succeed in mainstream
school and society” (Duff & Li, 2008, p. 14). Additionally, HL development can also lead to academic and economic benefits (He & Xiao, 2008). Therefore, given the advantages and potentials of knowing more than one language and given the increasingly rising political and cultural consciousness to maintain heritage languages and cultural identity, many immigrant parents are now actively engaging their children in HL learning (Peyton, Ranard, & McGinnis, 2001).

Due to the early exposure to the HL and the heritage related identity, HL learners are reported to possess higher level listening and speaking proficiency than non-heritage learners (Kim, 2005). They are believed to have native like pronunciation, extensive vocabulary and sociolinguistic rules for everyday informal communication (Campbell & Rosenthal, 2000). Moreover, due to the different background and various amounts of HL exposure, HL learners show more significant variability in their HL ability and proficiency than non-heritage learners who start learning the target language from an absolute beginning (Kondo-Brown, 2005). However, previous studies also found that HL learners are not always at an advantage. For example, despite their higher level of listening or speaking proficiency than non-heritage learners, no clear advantage was found in their reading and writing skills (Xiao, 2006).

Chinese is one of the most commonly used languages in the world, spoken by almost one fifth of the world’s population. With the recent influx of immigrants from Chinese speaking regions, in the U.S., Chinese (including Mandarin and Cantonese) is the second most common foreign language spoken by those living on U.S. soil, following Spanish (U.S. Census Bureau, 2012). Driven by the recent rise of China as an active global economic entity with the fastest growth rate, within Chinese
communities there emerged great needs to maintain the Chinese language and culture among the younger generations. Therefore, Chinese as a heritage language (CHL) learning is fast expanding in community language schools, mainstream schools, and universities (Xiao, Tao, & Soh, 2011). From 2002 to 2005, the total enrollments in Chinese community schools reached 160,000, which was four to five times the Chinese enrolment in K-12 schools in 2002 (McGinnis, 2005). Chinese programs in K-12 schools have increased 200% from 2004 to 2008 (College Board Internal Study, 2008). At the university level, based on the 2006 survey of foreign language enrollments in U.S. institutions of higher education conducted by the Modern Language Association (MLA), students learning Chinese increased 51% since the last MLA survey in 2002 (Furman, Goldberg, & Lusin, 2007).

To define Chinese as a heritage language is not an easy task. The term “Chinese” is not a monolithic entity, but a collective term for many dialects used by Chinese people or people with Chinese origin. He (2008, p. 3) pointed out that “Linguistically, in the context of mainland China, there are seven groups of dialects under the name of Chinese, including Wu, Xiang, Gan, Min, Cantonese, Hakka, and Mandarin, many of which are mutually incomprehensible”. Even the term “Mandarin” is not monolithic. In mainland China, the pronunciation and grammar of Mandarin are originated from the dialect of Beijing and its surrounding areas. However, the Mandarin used in mainland China, Taiwan, and Singapore varies regarding lexis, phonetics, writing systems and discourse norms (He, 2008, p. 3).

With the economic growth of mainland China, Mandarin spoken in the mainland context is gaining increasing importance, and many learners with different dialect backgrounds are learning Mandarin as the heritage language. Realizing the
complexity of learning Chinese as a heritage, He (2008, p. 3) claimed that “to learn Chinese as a heritage language appears not merely to inherit one’s heritage language” but also to “transform the heritage language.”

CHL learners in the U.S. are diversified. Most of CHL learners come to or are born in America. The immigrants from mainland China, Hong Kong, and Taiwan use Mandarin simplified, Cantonese, Mandarin traditional, and other dialects as their home language. Some American families adopt Chinese children. Parents would like their adopted children to have certain Chinese culture understandings which would help them to keep close friendships with other Chinese children, so the CHL learners have a number of the students from adopted families. The other CHL learners are from a mixed family, which means one of two parents of CHL learners has no Chinese language background.

In the U.S., the opportunities of speaking Chinese are seldom outside home. Therefore, CHL learners are mainly learning Chinese from three backgrounds. The first setting is their home language background. Chinese is often spoken at home and considered as their “mother tongue” or “home language.” The second context is their interaction background in society. English is the communication tool in the school and other outside communication environments. The interaction in the family is back to the “native language”, which is Chinese. This intertwining language situation makes a bilingual environment for CHL learners. The third context is the community heritage background. Comanaru and Noels (2009) found that CHL learners felt more strongly that Chinese community was a central part of their self-concept. Compared with the non-CHL learners, the CHL learners reported a higher frequency of contact with the community as well as more use of the heritage language outside of the classroom.
Concerning speaking/listening skills and grammatical knowledge, CHL learners have been reported to be at a higher level than their non-heritage counterparts. Xiao (2006) found that CHL learners performed significantly better than non-CHL learners in the oral, listening and grammatical tasks (Ming & Tao, 2008). However, concerning their reading and writing abilities, current findings show no significant difference exists between the CHL learners and non-CHL learners. While Xiao (2006) demonstrated that CHL learners were advantageous over non-CHL learners in a series of oral, listening and grammatical tasks, no such advantage was found in the vocabulary/character writing tasks as well as reading comprehension tests. Additionally, Ke (1998) found no significant difference in Chinese character recognition/production for CHL and non-CHL learners.

Regarding the motivational orientations of CHL learners and non-CHL learners, Hendryx (2008) claimed that CHL learners were primarily motivated by integrative motivations, and that they lacked instrumental motivation compared to the non-CHL counterparts. Lu and Li (2008), however, found that CHL learners did not differ from their non-CHL counterparts in the integrative orientation, but were more significantly motivated by instrumental orientations.

**Teaching and Learning Chinese Characters**

The review of the literature on Chinese language learning unveils three challenges of studying Chinese characters. The first challenge is helping students to develop the structural awareness of characters. In general, Chinese characters are made out of eight single strokes and their variations. Therefore, the understanding of the character’s internal structure significantly affects recognition as well as the reading of the characters (Tan et al., 2005). The second challenge is memorizing proper stroke
order for writing Chinese characters. The execution of the correct stroke sequence has traditionally been suggested as the key to accurate production and recognition of Chinese characters (Flores d’Arcais, 1994). However, it is common for students make errors in stroke sequencing, even after being repeatedly taught stroke order rules (Law, Ki, Chung, Ko, & Lam, 1998). The last challenge is related to pronunciation (So & Siegel, 1997). Unlike languages with alphabets, such as English, use letters to spell words, Chinese characters often do not indicate pronunciation. What makes it more confused is that a substantial portion of Chinese characters corresponds to multiple pronunciations (Lu, Meng, & Tam, 2014). As a result, an extra mental effort has to be made to connect the pronunciation of each character with its written form (Wang & Leland, 2011).

The traditional approach to teach Chinese characters is rote learning, which has a heavy emphasis on copying and repeating. To ensure that students memorize the order of strokes in the characters correctly by heart, teachers often ask them to practice writing every character several times until its recall is automatic. As a result, it is common to find students writing a single character one hundred times on their workbooks (Ministry of Education, People’s Republic of China, 2001). The primary method for assessing student learning in this traditional approach is dictation, which requires students to write Chinese characters upon hearing the words. If students make errors, they usually have to write the characters correctly multiple times as a homework. In the light of practices as mentioned earlier, most learners find the traditional approach of learning Chinese characters is laborious, demanding and tedious (Tse, Marton, Ki, & Loh, 2007).
In an effort to improve the learning process and make it more appealing to learners, over the years, various teachers and scholars have developed a range of new pedagogies to teaching Chinese characters. Teachers in the Hebei province of China adopted a strategy which emphasizes instruction on structure and form of characters. This approach helps learners to remember the character by understanding its internal components. In Anhui and Hunan province, the students are encouraged to associate characters and their forms using creative thinking (Li, 1989). Guessing games are common practice in this approach (Dai, 1998). The pedagogy widely used in Tianjin focuses on speech and text association. By listening to the speech and tracing characters synchronously, students integrate the sound and meaning of words with the form of the character (Gu & Tian, 1999). Liaoning province adopts the strategy of teaching character clusters with similar or the same radicals (Zhang et al., 1995), and characters possessing the same rhyme (Jiang, 1997). This pedagogy enables students to memorize a large number of words within a short amount of time. Although no single approach has been identified as the best method for teaching Chinese characters, each strategy has its merits and strengths and appeals to different teachers.

**Educational App Design and Evaluation**

Based on the data from decades of research in the science of learning, Hirsh-Pasek et al. (2015) illustrated four psychological principles, “pillars,” that can serve as a guide to design and evaluate educational apps. They claimed that “humans learn best when they actively involved, engaged with learning materials and undistracted by peripheral elements, have meaningful experiences that relate to their lives and socially interact with others in high quality ways around new material, within a context that provides a clear learning goal” (Hirsh-Pasek et al., 2015, p. 7). Regarding the app
design, Hirsh-Pasek et al. provided the following suggestions. First, the users should be actively involved and mentally stimulated when they interact with the user interface, content, and information in the app. Second, contingent interactions (such as touch or press screen), extrinsic motivation and feedback (such as respond to activities with prompt and meaningful feedback), and intrinsic motivation (such as open-ended sandbox apps, Minecraft, that provide user driven and intrinsically motivating experiences) are three primary design strategies to foster sustained user engagement. Third, to apply meaningful learning to apps, high quantity and quality of connections between the app experience and the user’s real-life experience should be established. Fourth, apps should provide social interaction, such as video teleconferencing, multiple user collaboration through typing, drawing, or interacting with virtual objects (e.g., Drawing Together!), and voice recognition and a virtual assistant powered by A.I. (e.g., Siri). Last, the app should employ scaffolded pedagogical structure to guide user experience toward a learning goal, such as implement adaptive learning systems that enable personalized learning experience.

By combining the four pillars from the science of learning and educational context, Hirsh-Pasek et al. proposed a straightforward framework to evaluate the educational value, “pedigree,” of an app (Hirsh-Pasek et al., 2015, p. 25), as seen in Figure 1. In this grid system, the app with high learning goals and high summation of the pillars is a true, evidence-based educational app, which is likely to result in deep learning. If an app is low on learning goals but high in the summation of the pillar scores, it will be categorized as entertainment app. This kind of app may be fun to play and might lead to some ancillary learning, but it is mostly non-educational in flavor. For those apps that are high in learning goals but low in the summation of the pillar
scores, they are likely just translating existing materials onto the mobile device without support from the science of learning, which are unlikely to promote deep learning. Finally, apps in the lower left quadrant will not likely result in learning.

Figure 1  A grid for determining the pedigree of an app.

The “pedigree” model is a robust research-oriented educational app evaluation framework. However, due to the massive focus on the science of learning, the educational value of some apps such as Dropbox, Google Docs, and iMovie, which do not directly carry educational content but have been well adopted in many educational activities, can be overlooked and incorrectly categorized. Another shortcoming of this framework is not allowing reviewers to get a precise analysis of an educational app, but a general category.

Lee & Kim (2015) proposed another research-based criteria model for evaluating educational apps. Different than other technology-centered and intuitive-
driven evaluation framework, this rubric is designed to focus on instruction, technology, and statistical validity. As illustrated in Figure 2, it contains four interdependent factors (teaching & learning, screen design, technology, economy & ethics) and thirty-three evaluation criteria, which require the reviewers to evaluate the app in a systematic approach. Besides a tool to assess the effectiveness and efficiency of the educational apps, the criteria in this rubric also can serve as technical requirements to guide the app design process.

*Figure 2*  Lee & Kim’s criteria model for app evaluation.
Upon review of two rubrics from Walker (2010) and Buckler (2012), Lee and Cherner (2015) developed a comprehensive evaluation rubric to quantify the value of educational apps. The rubric contains three domains (instruction, design, and engagement) and twenty-four dimensions. For each dimension, it includes a leading question and five indicators which describe an app’s functionality or design as responses to the leading question. Lee and Cherner (2015) demonstrated how to use this rubric through evaluating the Google Earth mobile app, and the results were displayed in Figure 3.

<table>
<thead>
<tr>
<th>Domain A: Instruction</th>
<th>Domain B: Design</th>
<th>Domain C: Engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1. Rigor: 2</td>
<td>B1. Ability to Save Progress: 1</td>
<td>C1. Learner Control: N/A</td>
</tr>
<tr>
<td>A5. Feedback to Teacher: N/A</td>
<td>B5. Navigation: 4</td>
<td>C5. Interest: 5</td>
</tr>
<tr>
<td></td>
<td>B9. Cultural Sensitivity: 4</td>
<td></td>
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**Figure 3** Evaluating Google Earth with Lee and Cherner’s app evaluation rubric.

Although Lee and Cherner’s rubric was designed to be comprehensive and inclusive, they did not genuinely resolve the problems that they have criticized. First of all, they believe the 5-point Likert scale is superior to the 4-point Likert scale in the research design, which is still controversial. Regarding odd or even point scale, an odd number of points allows people to select a middle option while an even number forces
the respondent to take sides. Therefore, there is no preferred or better choice (Taylor-Powell, 2008). Second, given the large number of existing apps, to evaluate all varieties of educational apps with a single rubric is “not possible” (Lee & Cherner, 2015, p. 37), which makes this rubric also “limited” and “not comprehensive”. Third, with 24 dimensions and 120 indicators in the rubric, subjective element, bias, and misunderstandings would be inherent in the evaluation process. The evaluation results can be inconsistent and different from one another, which conflicts with the purpose of scoring each dimension. Despite the shortcomings in this rubric, the attempt to build a rubric with direct research support is genuine and indisputable.

**Problem Statement and Key Questions**

The literature indicates that character reading and writing are the significant challenges for CHL learners. To improve student learning performance in these tasks, CHL educators and professionals have integrated mobile technologies into their teaching and learning practices (Lu, Meng, & Tam, 2014; Rosell-Aguilar & Qian, 2015). However, with over one million educational apps available in the App Store, teachers need support in identifying quality apps to use, or they risk wasting their time with inferior apps (Lee & Cherner, 2015). Notably, many educational apps for teaching and learning Chinese characters are created by software engineers without proper consultations with subject matter experts, and thus the usability of these apps does not always meet expectations (Rosell-Aguilar & Qian, 2015). Furthermore, when a search for existing apps for CHL education was conducted, only one app was identified. To support heritage language teachers and maximize the opportunities for student learning, the purpose of this project is to explore the effective design of a mobile app for teaching and learning Chinese characters in the context of CHL.
education. Additionally, since studies on the use of mobile apps for Chinese language learning are scarce (Rosell-Aguilar & Qian, 2015), the research and studies dedicated to CHL education are even fewer. This project would also be expected to raise awareness for CHL education, to enrich the research of CHL teaching and learning practices and to inspire and motivate software engineers in developing future mobile apps for CHL. This EPP focused on these questions to lead the project:

- What are the challenges and opportunities of using the educational apps to support CHL education?
- What are the advantages and limitations of the existing educational apps for teaching and learning Chinese characters?
- What are the key features of an effective educational app for teaching and learning Chinese characters in CHL education?
Chapter 2

METHODS AND FINDINGS

The purpose of this project is to explore the effective design of a mobile app for teaching and learning Chinese characters in the context of CHL education. In order to have a deep analysis of the key questions and findings, the case study has been selected as the research method for this project. As the main type of qualitative research in social research, the case study is broadly applied to the study of social and human sciences (Yin, 1994). It is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident (Yin, 1984). Moreover, the case study is appropriate for investigating phenomena when a large variety of factors and relationships are included; no basic laws exist to determine which factors and relationships are important; and when the factors and relationships can be directly observed. Gerring (2004) states that case studies are probably an ideal path to understanding rather than a method with hard and fast rules. As for this project, researching all the CHL teachers is not realistic. Therefore, the case study would be one of the most efficient and effective methods to uncover answers to the key questions.
Participants

Participants in the project represented a convenience sample. Six experienced CHL teachers from local Chinese language schools in Delaware and Pennsylvania were invited on a voluntary basis. A consent to participate form was developed and approved by the University of Delaware’s Institutional Review Board (IRB) for Human Subjects Research. The form provided information about participation in two focus group interviews as well as interview procedures and protocols. All of the participants completed and returned the consent forms. Table 1 provides further demographic information regarding the participants. Participants were given pseudonyms to guarantee confidentiality during the course of the project.

Table 1 Participants Demographics

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Grade Level</th>
<th>Character System</th>
<th>Years of CHL Experience</th>
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<tbody>
<tr>
<td>Mr. Ethan</td>
<td>5-9</td>
<td>Traditional</td>
<td>5</td>
</tr>
<tr>
<td>Ms. Tracy</td>
<td>8-9</td>
<td>Traditional</td>
<td>3</td>
</tr>
<tr>
<td>Ms. May</td>
<td>9-12</td>
<td>Simplified</td>
<td>10</td>
</tr>
<tr>
<td>Ms. Yue</td>
<td>5</td>
<td>Simplified</td>
<td>3</td>
</tr>
<tr>
<td>Ms. Wendy</td>
<td>6-12</td>
<td>Simplified</td>
<td>4</td>
</tr>
<tr>
<td>Ms. Janice</td>
<td>3</td>
<td>Traditional</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: Grade level stands for the student’s grade level in the Chinese community school system, not the typical public-school system.
Data Collection

This project involved both quantitative and qualitative research methods. Following a review of the literature specific to CHL education in the U.S. as well as educational app design and evaluation, the primary investigator evaluated 28 existing educational apps for teaching and learning the Chinese characters. Subsequently, the investigator conducted focus group interviews with all participating CHL teachers.

App Review

After carefully reviewing the literature, the primary investigator, disappointingly, could not identify any evaluation rubric or framework for the educational apps of teaching and learning Chinese characters. To facilitate the task of reviewing existing apps, by borrowing the ideas and criteria from current educational app evaluation rubrics, the findings from the literature review, and the outcomes from focus group discussion, the primary investigator created a customized rubric to evaluate the apps of teaching and learning characters for CHL education. This rubric has three components: educational app dimension, which focuses on assessing the general educational value of the app; language learning dimension, which evaluates the app from various language learning perspectives; and CHL dimension, which examines the elements related to CHL learning practices. Appendix D shows the complete rubric that guided the existing apps review, and Table 2 shows the source of the key questions in this rubric (excluding the questions for collecting basic app information).
Table 2  Source of the Key Rubric Questions

<table>
<thead>
<tr>
<th>#</th>
<th>Rubric Question</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>This app can be used for following learning model.</td>
<td>Findings from the literature review</td>
</tr>
<tr>
<td>2</td>
<td>The app can be used for the following teaching and learning practices.</td>
<td>Findings from the literature review, and the outcomes from focus group discussion</td>
</tr>
<tr>
<td>3</td>
<td>Evidence of learning.</td>
<td>“Pedigree” Grid System</td>
</tr>
<tr>
<td>4</td>
<td>In terms of the user experience of this app, to what extent do you agree or disagree with each of the following statements.</td>
<td>Lee and Kim’s criteria model and Lee and Cherners comprehensive evaluation rubric</td>
</tr>
<tr>
<td>5</td>
<td>To what extent do you agree or disagree with each of the following statements.</td>
<td>Lee and Kim’s criteria model, Lee and Cherners comprehensive evaluation rubric, and the outcomes from focus group discussion</td>
</tr>
<tr>
<td>14</td>
<td>What is your reflection on each of the following statements?</td>
<td>Findings from the literature review and the outcomes from focus group discussion</td>
</tr>
<tr>
<td>15</td>
<td>This app is aligned with the following standards for learning languages.</td>
<td>The outcomes from focus group discussion</td>
</tr>
<tr>
<td>16</td>
<td>This app is focusing on the following language skills.</td>
<td>Findings from the literature review</td>
</tr>
<tr>
<td>17</td>
<td>The app adopts the following pedagogy for teaching and learning Chinese characters.</td>
<td>Findings from the literature review</td>
</tr>
<tr>
<td>18</td>
<td>This app is dedicated to teaching and learning CHL.</td>
<td>Findings from the literature review, and the outcomes from focus group discussion</td>
</tr>
<tr>
<td>19</td>
<td>This app supports the following character system.</td>
<td>Findings from the literature review</td>
</tr>
<tr>
<td>20</td>
<td>According to Chinese proficiency test standards, this app is suitable for [ the following options].</td>
<td>Findings from the literature review, and the outcomes from focus group discussion</td>
</tr>
</tbody>
</table>

Based on the App Store rating and ranking, recommendations from the CHL teachers, and web search, a total of 28 Chinese language learning apps were selected for review. All of them were downloaded and installed on the investigator’s iOS devices. The basic information about the apps is summarized in Table 3.
Table 3  
App List

<table>
<thead>
<tr>
<th>#</th>
<th>Name</th>
<th>Reason for Choosing this App</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Du Chinese</td>
<td>Recommended by CHL teacher</td>
</tr>
<tr>
<td>2</td>
<td>2 Kids</td>
<td>Recommended by CHL teacher</td>
</tr>
<tr>
<td>3</td>
<td>3000 Chinese Character</td>
<td>Mobile version of a popular Chinese dictionary</td>
</tr>
<tr>
<td>4</td>
<td>AnkiMobile Flashcards</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>5</td>
<td>Art of Chinese Characters</td>
<td>Recommended by CHL teacher</td>
</tr>
<tr>
<td>6</td>
<td>Chairman’s Bao</td>
<td>Highly rated in App Store and featured on the web</td>
</tr>
<tr>
<td>7</td>
<td>Characteroo</td>
<td>Recommended by CHL teacher</td>
</tr>
<tr>
<td>8</td>
<td>Chinagram</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>9</td>
<td>ChineseSkill</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>10</td>
<td>FluentU</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>11</td>
<td>Fun with Chinese Characters</td>
<td>Featured on the web</td>
</tr>
<tr>
<td>12</td>
<td>HSK Hero</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>13</td>
<td>iLearn Chinese Characters</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>14</td>
<td>Learn Chinese by MindSnacks</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>15</td>
<td>Learn Chinese characters</td>
<td>Recommended by CHL teacher</td>
</tr>
<tr>
<td>16</td>
<td>MagiChinese</td>
<td>Recommended by CHL teacher</td>
</tr>
<tr>
<td>17</td>
<td>Mango Languages</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>18</td>
<td>Memrise</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>19</td>
<td>Pleco Chinese Dictionary</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>20</td>
<td>Read Chinese, Learn Mandarin</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>21</td>
<td>Routledge Chinese Character Trainer</td>
<td>Featured on the web</td>
</tr>
<tr>
<td>22</td>
<td>Skritter Chinese</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>23</td>
<td>Smart Learn Chinese characters</td>
<td>Recommended by CHL teacher</td>
</tr>
<tr>
<td>24</td>
<td>Standard Mandarin</td>
<td>Recommended by CHL teacher</td>
</tr>
<tr>
<td>25</td>
<td>Learn Chinese Vocabulary with PinyinTutor.com</td>
<td>Highly rated in App Store</td>
</tr>
<tr>
<td>26</td>
<td>WeChat</td>
<td>WeChat is one of the most popular communication apps in China. It was chosen for studying how to design social and chat features.</td>
</tr>
<tr>
<td>27</td>
<td>Four-Five Reading</td>
<td>Recommended by CHL teacher</td>
</tr>
<tr>
<td>28</td>
<td>Wu-Kong Character HD</td>
<td>Featured on the web</td>
</tr>
</tbody>
</table>
To verify the reliability of this customized rubric, the primary investigator recruited a CHL teacher as a rater to conduct the assessment of inter-rater reliability (IRR). For all 32 measurable items on the rubric, after training with the rater, the obtained percent agreement between two raters is 75%. However, it is important to clarify that this rubric is designed to help the primary investigator understand and identify the pros and cons of the current apps for teaching and learning Chinese characters in a systematic way. It is not guaranteed to be a valid and reliable framework for evaluating educational apps.

Moreover, the evaluation rubric was transformed into an online survey by utilizing Qualtrics, a web-based survey software available at the University. Following the online survey, evaluation data was accurately collected and securely stored on the server.

Focus Group Interviews

Two focus group interviews with CHL teachers were scheduled and conducted in this project. The first focus group interview instrument contains four leading questions, which concentrate on recognizing the challenges and opportunities in CHL education, collecting data about utilizing existing mobile apps for teaching and learning Chinese characters, and exploring the key features and expectations for the app prototype.

Subsequently, the second focus group interview was conducted to examine if the original design concepts from the first focus group interview were fully implemented. Given the hands-on experience with the app prototype, this discussion was guided by five leading questions in the instrument and was intended to explore how to further refine the prototype.
During the interviews, the primary investigator utilized the protocol in Appendix A to guide the questioning. All recordings and transcripts were stored and secured in accordance with IRB procedures.

Data Analysis

App Review

App evaluation data were downloaded from Qualtrics and imported into Excel for data cleaning. Subsequently, the data were imported into Tableau for analysis and data visualization. Descriptive statistics were conducted to summarize and categorize all data.

Focus Group Interviews

Focus group interviews were audio recorded. To code the data, the primary investigator played back the recorded interviews, transcribing them by pulling out key phrases that either reflected the literature or provide new insight. Referring to Bogdan and Biklin’s (1998) common types of coding categories and Berkowitz’s (1997) suggestions in qualitative data coding, coding scheme and categories are classified and applied to the data analysis. Following the initial review of literature pertaining to Chinese character study and educational app design, the primary investigator generated a list of initial codes presented in Table 4. Note that the category codes only reflect the general category to which these initial codes belong.
Table 4  Codes that Developed from the Literature Review

<table>
<thead>
<tr>
<th>Initial Code</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bite-size learning</td>
<td>Teaching and learning</td>
</tr>
<tr>
<td>Progressive learning</td>
<td></td>
</tr>
<tr>
<td>Integrating writing, listening, reading and vocabulary building</td>
<td></td>
</tr>
<tr>
<td>Student-centered learning</td>
<td></td>
</tr>
<tr>
<td>Self-paced learning</td>
<td></td>
</tr>
<tr>
<td>Active, engaged, meaningful and socially interactive learning</td>
<td></td>
</tr>
<tr>
<td>Trackable learning progress</td>
<td></td>
</tr>
<tr>
<td>Ease of use</td>
<td>User interface and user experience</td>
</tr>
<tr>
<td>Multimedia integration</td>
<td></td>
</tr>
<tr>
<td>Cultural sensitivity</td>
<td></td>
</tr>
<tr>
<td>Instant and positive feedback</td>
<td></td>
</tr>
<tr>
<td>Gaming feature</td>
<td>Student engagement</td>
</tr>
<tr>
<td>Badges and achievements</td>
<td></td>
</tr>
<tr>
<td>Competition</td>
<td></td>
</tr>
<tr>
<td>Collaboration</td>
<td></td>
</tr>
<tr>
<td>Learning community</td>
<td></td>
</tr>
<tr>
<td>Cross-platform</td>
<td>Accessibility</td>
</tr>
<tr>
<td>Color blind</td>
<td></td>
</tr>
<tr>
<td>Low cost or free</td>
<td>Economy and ethics</td>
</tr>
<tr>
<td>Advertisement free</td>
<td></td>
</tr>
<tr>
<td>Personal information protection</td>
<td></td>
</tr>
</tbody>
</table>
Initial codes were used to guide the coding of the focus group interviews. When transcribing the interviews, the primary investigator counted the number of instances that a code emerged in the interviews. Codes occurring with minimal instances were dropped or collapsed. Codes that emerged from the discussions were added to the list of codes generated from the literature and app review. After dropping and adding codes based on the feedback from the focus group interviews, a final coding scheme was created as presented in Table 5.

Table 5 Final Coding Scheme from First Focus Group Interviews

<table>
<thead>
<tr>
<th>Code</th>
<th>Number of Instances in the Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to use</td>
<td>3</td>
</tr>
<tr>
<td>Class/learning management</td>
<td>4</td>
</tr>
<tr>
<td>Drill practice</td>
<td>8</td>
</tr>
<tr>
<td>Learning community</td>
<td>3</td>
</tr>
<tr>
<td>Learning analytics</td>
<td>8</td>
</tr>
<tr>
<td>Customizable learning content</td>
<td>4</td>
</tr>
<tr>
<td>Engagement and gamification</td>
<td>9</td>
</tr>
<tr>
<td>Instant and positive feedback</td>
<td>3</td>
</tr>
<tr>
<td>Self-paced learning</td>
<td>4</td>
</tr>
<tr>
<td>Accessibility</td>
<td>5</td>
</tr>
</tbody>
</table>
Findings

Based on the existing app review and the outcomes from the focus group discussions, the following sections will present the findings from the key questions.

Key Question 1: What are the challenges and opportunities of using the educational apps to support CHL education?

Regarding language learning, mobile educational apps offer not only pure multimedia and interactivity of content but also portability, personalization, access to location-specific features, touch sensitivity, cameras and various motion sensors. As Lu, Meng, and Tam (2014) described in their research, a character writing practice app can detect stroke order and formation, and then generate instant feedback based on finger gestures so that learners can correct their mistakes without a teacher’s supervision.

Pedagogically, self-paced learning, game-based learning, differentiated instruction, and various pedagogies can be implemented in the mobile app to personalize the learning experience and to enhance learning performance. Behaviorally, many studies have proved that the combination of social interaction and gaming will improve learning engagement, particularly among younger users (Burke, 2014). Economically, the affordability and accessibility of mobile devices are no longer a barrier. For instance, many schools have established one-to-one mobile device programs where each student is equipped with a mobile device to assist learning.

Along with these promising opportunities, there are challenges for teachers to integrate educational apps into their instructions. Nearly all interview participants agreed that without proper classroom management, using apps in the classroom would become a “disaster.” Students are easily distracted, which is leading to decreased
instruction time. Moreover, two CHL teachers mentioned that the functions they need were scattered in different apps. During the class time, they have to ask students to switch from one app to another, which is inefficient and inconvenient. Furthermore, one participant shared a concern regarding insufficient support for the usability of existing apps, saying, “I was thinking to use mobiles apps [in my classroom]. But my workload is too heavy to spend extra time in learning how to use those apps”.

Key Question 2: What are the advantages and limitations of the existing educational apps for teaching and learning Chinese characters?

From the literature review, criticisms of the design of current language learning apps include too many translations, lack of sound or pictures, poor navigation and user interface design and little use of the unique properties of mobile devices such as the motion sensor, location detector, and connectivity with other users (Godwin-Jones, 2011; Sweeney & Moore, 2012; Burston, 2014). Burston found that language learning activities on mobile apps have mostly replicated what had been done before with other technologies and were limited to basic flashcards, multiple choice, blank filling, drag and drop, and vocabulary and grammar drills and games. In their review of language learning mobile apps, Kim & Kwon (2012) highlighted that most apps focus on cognitive processes and receptive language skills rather than socio-cognitive activities, with little collaborative learning.
The following results of the app evaluation echoed the findings from the literature. As illustrated in Figure 4, the results of rubric question 10, *this app can be used for the following teaching and learning practices*, indicate that only 5.77% of the reviewed apps provide features other than the dictionary, flashcards, quizzes, and delivering learning contents. Most of the apps are merely translating the learning practices and activities to the mobile environment.

![Figure 4](image)

**Figure 4** App review results of rubric question 10.
Rubric question 11 is intended to review the apps with the pedigree model. Each app was rated on a scale of 1 to 3 (standards for low, mid, and high) for five items in the model. For instance, if an app scores 3 in “Engagement in the Learning Process,” it means users are very unlikely to feel bored when learning with that app. The overall evaluation results, as presented in Figure 5, illustrated that the majority of the apps could keep users engaged during the learning process. However, a lack of social interaction and coherent learning goals are the primary weaknesses among the reviewed apps.

![Figure 5](image)

*Figure 5  App review results of rubric question 11.*
Regarding the user experience, easy to use, straightforward navigation, user ability to control learning progress, organized information, and free of the cosmetic bug are the advantages shared by the reviewed apps. The problems emerging from the results of rubric question 12, as presented in Figure 6, are not allowing users to customize learning contents, and there are limited documentation and tutorials for user support.

<table>
<thead>
<tr>
<th>#</th>
<th>Field</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overall this is a great app.</td>
<td>14.29%</td>
<td>53.57%</td>
<td>25.00%</td>
<td>7.14%</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>The user interface of this app is attractive.</td>
<td>17.86%</td>
<td>39.29%</td>
<td>25.00%</td>
<td>17.86%</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>This app is easy to use.</td>
<td>7.41%</td>
<td>85.19%</td>
<td>7.41%</td>
<td>0.00%</td>
<td>27</td>
</tr>
<tr>
<td>4</td>
<td>The navigation of this app is easy.</td>
<td>3.57%</td>
<td>78.57%</td>
<td>17.86%</td>
<td>0.00%</td>
<td>28</td>
</tr>
<tr>
<td>5</td>
<td>Organization of information is clear.</td>
<td>3.57%</td>
<td>78.57%</td>
<td>17.86%</td>
<td>0.00%</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>Use of multimedia is excellent.</td>
<td>33.33%</td>
<td>28.63%</td>
<td>25.93%</td>
<td>11.11%</td>
<td>27</td>
</tr>
<tr>
<td>7</td>
<td>This app allows user to control learning progress</td>
<td>7.41%</td>
<td>14.81%</td>
<td>26.88%</td>
<td>3.70%</td>
<td>27</td>
</tr>
<tr>
<td>8</td>
<td>This app allows user to customize learning contents</td>
<td>3.70%</td>
<td>11.11%</td>
<td>62.99%</td>
<td>22.22%</td>
<td>27</td>
</tr>
<tr>
<td>9</td>
<td>This app is cosmetic bug free.</td>
<td>7.14%</td>
<td>82.14%</td>
<td>7.14%</td>
<td>3.57%</td>
<td>28</td>
</tr>
<tr>
<td>10</td>
<td>The tutorial in this app is helpful</td>
<td>14.29%</td>
<td>17.86%</td>
<td>28.57%</td>
<td>39.29%</td>
<td>28</td>
</tr>
</tbody>
</table>

Figure 6  App review results of rubric question 12.
Rubric question 15 measures the app with the standards for language learning. Participants in the focus group interviews mentioned that they closely followed *The World-readiness Standards for Learning Languages* to design instructional materials and activities, and to measure student language skills and competency. The standards have five goal areas and the eleven standards, which influences language learning from elementary, through secondary, to postsecondary levels (American Council on the Teaching of Foreign Languages, 2017). As illustrated in Figure 7, the results of app evaluation with these standards demonstrated interpretive communication (learners understand, interpret, and analyze what is heard, read, or viewed on a variety of topics) is well addressed among the existing apps. On the other hand, the dominance of “interpretive communication” also indicates that most apps are offering a relatively closed and monotonous learning experience. Interpersonal communication, social interaction, and collaboration need to be emphasized in the app design.

<table>
<thead>
<tr>
<th>#</th>
<th>Field</th>
<th>Choice Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interpersonal communication</td>
<td>0.49% 5</td>
</tr>
<tr>
<td>2</td>
<td>Interpretive communication</td>
<td>0.94% 27</td>
</tr>
<tr>
<td>3</td>
<td>Presentational communication</td>
<td>0.00% 0</td>
</tr>
<tr>
<td>4</td>
<td>Relating cultural practices to perspectives</td>
<td>0.37% 6</td>
</tr>
<tr>
<td>5</td>
<td>Relating cultural products to perspectives</td>
<td>0.00% 0</td>
</tr>
<tr>
<td>6</td>
<td>Making connections</td>
<td>0.00% 0</td>
</tr>
<tr>
<td>7</td>
<td>Acquiring information and diverse perspectives</td>
<td>0.00% 0</td>
</tr>
<tr>
<td>8</td>
<td>Language competencies</td>
<td>0.00% 0</td>
</tr>
<tr>
<td>9</td>
<td>Cultivation comparison</td>
<td>0.00% 0</td>
</tr>
<tr>
<td>10</td>
<td>School and global communities</td>
<td>1.03% 3</td>
</tr>
<tr>
<td>11</td>
<td>Lifelong learning</td>
<td>7.55% 4</td>
</tr>
<tr>
<td>12</td>
<td>Others</td>
<td>1.03% 3</td>
</tr>
</tbody>
</table>

*Figure 7*  App review results of rubric question 15.
Rubric question 17 examines the pedagogy for teaching and learning Chinese characters in the app. The results of this question, as illustrated in Figure 8, show most of the apps in the review adopt the traditional character teaching and learning methods which heavily focus on pronunciation, meaning and character structure.

<table>
<thead>
<tr>
<th>#</th>
<th>Field</th>
<th>Choice Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>phonetic systems</td>
<td>26.57% 22</td>
</tr>
<tr>
<td>2</td>
<td>explicit instruction on the structure and form of characters</td>
<td>10.87% 14</td>
</tr>
<tr>
<td>3</td>
<td>emphasizing the meaning of the characters</td>
<td>25.30% 21</td>
</tr>
<tr>
<td>4</td>
<td>emphasizing the association between character, form and meaning</td>
<td>13.25% 11</td>
</tr>
<tr>
<td>5</td>
<td>emphasizing speech and text association</td>
<td>10.84% 9</td>
</tr>
<tr>
<td>6</td>
<td>emphasizing the use of character clusters</td>
<td>0.00% 0</td>
</tr>
<tr>
<td>7</td>
<td>teaching characters possessing the same rhyme</td>
<td>0.00% 0</td>
</tr>
<tr>
<td>8</td>
<td>teaching text that contains character clusters</td>
<td>1.20% 1</td>
</tr>
<tr>
<td>9</td>
<td>integrative language instruction</td>
<td>2.47% 2</td>
</tr>
</tbody>
</table>

Figure 8 App review results of rubric question 17.
Rubric question 18 is intended to determine if the app is designed for CHL. However, none of the apps in this review are designed for teaching and learning CHL, as seen in Figure 9. Although some of them are used in the CHL study, contents and activities in these apps might not meet the instructional requirements and expectations for heritage learners. Additional evaluations, reviews, and adjustments are required for teachers to adopt them in the curriculum, which can be very time-consuming and often lead to frustration.

Figure 9  App review results of rubric question 18.
Key Questions 3: What are the key features of an effective educational app for teaching and learning Chinese characters in CHL education?

The six participants involved in this project shared their experience and insights with using educational apps for teaching Chinese characters. All of them agreed that “the [mobile] technology can extend the learning beyond the classroom.” Therefore, participants would like to integrate self-paced learning into the app. Mr. Ethan further commented that the app should be able to “track student’s performance and activities” and provide a dashboard for monitoring learning progress.

In addition to self-paced learning, Ms. Tracy indicated that “game-based learning is essential” for motivating and encouraging students to practice writing characters. The rest of the participants all agreed with this statement and proposed to add gaming feature to the app. For instance, Ms. Wendy suggested that “games in the app would make the repetition exercises more entertaining and engaging to the students.” Regarding the design of the game, participants stressed that the feedback in the game should always be quick and positive. When practicing with the app, students should be immediately notified when they make a mistake, and informative and encouraging feedback should be provided to help them moving forward. Moreover, Ms. Yue pointed out that the gamification features, such as badge and leaderboard, should also be included to make the drill practices “more fun to play”.

Moreover, participants believe CHL students would benefit from an immersive cultural environment, and they would like to build a learning community within the app. The social features would “promote student collaboration and communication,” which will improve their learning performance.

Regarding the user interface, participants suggested that users should have the autonomy to choose color scheme and layout. The print in the app must be “large
enough for the students to see.” Besides, Ms. Yue stressed that the app must be accessible to people with disabilities, based on her experience in teaching a student who is color blind. Furthermore, she suggested the contents of the app should also be cross-platform for better accessibility. Additionally, participants in the focus group interview also requested to integrate user management features into the app because their Chinese community schools “normally do not provide learning management systems, such as Canvas or Sakai.”

In all, according to the focus group discussions, all the key features requested by the participants are summarized in Table 6.

Table 6  Summary of the Features in the App Prototype

<table>
<thead>
<tr>
<th>Features of the app</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility</td>
<td>Compliance with the laws and regulations</td>
</tr>
<tr>
<td>Culture immersion</td>
<td>Promoting culture awareness</td>
</tr>
<tr>
<td>Cross-platform</td>
<td>Reaching more users and increasing flexibility</td>
</tr>
<tr>
<td>Customizable character list</td>
<td>Enabling self-paced learning and differentiate instruction</td>
</tr>
<tr>
<td>Customizable user interface</td>
<td>Providing better user experience</td>
</tr>
<tr>
<td>Dashboard for both teacher and student</td>
<td>Improving students learning efficiency and effectiveness, and providing actionable insights to teachers</td>
</tr>
<tr>
<td>Easy to navigate</td>
<td>Enhancing user experience</td>
</tr>
<tr>
<td>Engaging drill practices and repetition activities</td>
<td>Improving learning performance</td>
</tr>
<tr>
<td>Games &amp; gamification system</td>
<td>Enhancing learning engagement and interests</td>
</tr>
<tr>
<td>Informative character instruction</td>
<td>Helping students to remember characters</td>
</tr>
<tr>
<td>Instant and positive feedback</td>
<td>Avoiding student frustration and improving learning performance</td>
</tr>
<tr>
<td>Learning community</td>
<td>Enhancing learning engagement</td>
</tr>
<tr>
<td>Student/class management</td>
<td>Making learning performance and progress trackable</td>
</tr>
</tbody>
</table>
Prototyping

Prototyping is a vital phase of mobile app development. It is when conceptual goals and practical reality come into balance. With detailed feedback from the prototype, it grounds the developers in reality and helps them to make essential design choices regarding priorities, ergonomics, shape, functions, and production (Cao, 2015). Moreover, prototyping can reduce the build time and cost by 50% and reduce rework and bug fixes post-launch by 25%. Additionally, an interactive prototype requires little description, which can reduce the requests for clarification by the development team by 80% (Fluid UI, 2016).

Given the scope of this project, instead of developing an actual app, the primary investigator created a high-fidelity prototype to illustrate all the design concepts and features from the findings. The most native way to create a credible prototype is to use a storyboard based Xcode template to build a basic app and populate it with appropriate placeholder content. With a short turnaround time, the primary investigator decided to adopt a professional prototype design app, Flinto, for this project, because of its user-friendly interface and powerful features.

The following sections will demonstrate how the findings from the key questions, literature, app review and focus group discussions are translated into the design decisions. Table 7 summarizes the design decision sources in the app prototype.
<table>
<thead>
<tr>
<th>#</th>
<th>Design Decision</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tab-bar UI</td>
<td>Apple’s <em>Human Interface Guidelines</em></td>
</tr>
<tr>
<td>2</td>
<td>Character review with highlighted character radical and informative character instruction</td>
<td>Focus group discussions</td>
</tr>
<tr>
<td>3</td>
<td>Tracing and practicing modes in the character review section</td>
<td>Focus group discussions and app review</td>
</tr>
<tr>
<td>4</td>
<td>Engaging educational games in the challenge section</td>
<td>Focus group discussions, literature review, and app review</td>
</tr>
<tr>
<td>5</td>
<td>Gamification features, such as badge and leaderboard</td>
<td>Focus group discussion, literature review, and app review</td>
</tr>
<tr>
<td>6</td>
<td>Customizable learning content in the practice mode</td>
<td>Focus group discussion</td>
</tr>
<tr>
<td>7</td>
<td>Culture-immersive environment</td>
<td>Literature review and focus group discussions</td>
</tr>
<tr>
<td>8</td>
<td>Learning community</td>
<td>Focus group discussions</td>
</tr>
<tr>
<td>9</td>
<td>Customizable UI</td>
<td>Focus group discussions</td>
</tr>
<tr>
<td>10</td>
<td>Social and chat features</td>
<td>Focus group discussions and app review</td>
</tr>
<tr>
<td>11</td>
<td>Comprehensive app support documentations</td>
<td>App review</td>
</tr>
<tr>
<td>12</td>
<td>Dashboard with learning analytics data for both teacher and student</td>
<td>Focus group discussions and literature review</td>
</tr>
<tr>
<td>13</td>
<td>Light-weighted learning management system</td>
<td>Focus group discussions and app review</td>
</tr>
<tr>
<td>14</td>
<td>Cross-platform compatibility</td>
<td>Focus group discussions</td>
</tr>
<tr>
<td>15</td>
<td>Accessibility</td>
<td>Focus group discussions and literature review</td>
</tr>
</tbody>
</table>
Following the “Human Interface Guidelines” from Apple, the app has adopted a tab-bar to organize information at the app level. As one of the most used components of mobile UI, a tab bar appears at the bottom of an app screen and provides the ability to quickly switch between different views, sections or modes of an app. Nick Babich, the chief editor of UX Planet, demonstrated the benefits of well-designed tabs from three aspects: first, as interface control, tabs are very intuitive and easy to use; second, tabs can improve content organization via logically chunking the content so users can predict what they will find; third, tabs provide visually consistent UI which allows users to access the content quickly and with ease.

As illustrated in Figure 10, the app in this project contains five tabs, from left to right, including Discover, Practice, My Class, Leaderboard, and Me. As the home tab, after logging in, users always start with the My Class tab. This design intends to convey the impression that learning is the top priority and the primary emphasis of this app.

![Figure 10](image)  Tabs UI in the app.
The *My Class* tab view lists all the classes in which a user is enrolled. Users may use the search bar or filter feature to locate the class if they have too many classes. By clicking on the name of the class, users will be led to lesson view, as seen in Figure 11. In general, there are four sections on the lesson view, from top to bottom, including lesson information, rules and rewards, character review, and challenges. These sections are nested in a single view for a clean and compact user interface. However, the problem with this design is that users may swipe up & down or left & right to access stacked elements in this view. For instance, if a lesson has multiple challenges, users see the first challenge by default and need to swipe to the left to check the next challenge. To avoid confusion, the visual cue for the scrollable area, white and grey dots, will be applied in this circumstance.

*Figure 11*  Clean and organized lesson view.
The banner area of the lesson view presents the basic information about the lesson, such as title, instructor name, availability period, and total points. The section titled *Rules & Rewards* illustrates detailed instruction regarding lesson completion requirements, rewards, and rules. The text content in this area is editable by the teacher, except the points for completing a challenge is fixed to 100. This is meant to prevent point “inflation,” and keep the leaderboard fair and competitive. The *Character Review* section provides an opportunity for users to go over all the characters that they need to master before taking the challenges. Upon tapping on the single character, a sub-view, single character view, will pop up, which encompasses comprehensive information about that character. As illustrated in Figure 12, an enlarged character in written form with a highlighted radical is displayed on the top of the screen. Five buttons are arranged horizontally under the character figure. Upon tapping on the button, the following actions happen:

- sound button: play pronunciation in Mandarin;
- stroke button: play animated stroke sequence;
- trace button: trace the character stroke by stroke following the animation;
- practice button: practice writing the character without hints. However, when wrong stroke or wrong stroke sequence is detected, the system will prompt the error alert, and show the hint to the users;
- favorite button: add current character to “My Favorites” on “Me” tab.
Figure 12  Informative single character view with trace and stroke mode.

The rest of the view contains comprehensive information related to the character, including Pinyin, HSK level, radical, components, definition, common words, examples, etymology, historical variant, and homonym.

For drill practice, users can trace and practice character writing repetitively on this page, and their attempts will be recorded and collected in the background for learning analytics. Thanks to the mobile technology, users can write the character with the “best pointing device in the world”, the human finger. This intuitive and natural input method may make the tedious practice more enjoyable and engaging. It is also worthy to mention that the app automatically populates everything on this page. Besides defining a list of characters, it does not require any extra efforts from the teacher. Additionally, characters in this section will be served as the “feed” for the activities in the challenge section.
The challenge section is the most crucial component of the lesson. As the only assessment tool and the primary exercise method, challenges in this app have to be carefully designed to ensure effectiveness and engagement. After carefully reviewing the literature, especially in the field of Chinese language study, game-based learning or teaching with games stands out from the other learning theories and practices. By definition, game-based learning is learning that happens with the help of games, which often refers to learning by playing games. In the article, “Harnessing the Power of Game Dynamics”, Kim (2012, p. 466) states that games can help in learning because people are more motivated, engaged, and achieve more in games than in the real world. Additionally, Salter (2011) claims in the article, “Games in the Classroom: Part 1”, that games allow for the exploration of content from a new point of view, and reinforcement of teamwork and collaboration. Furthermore, the Federation of American Scientists suggested in a report that “research on games in education should be a part of a coherent research program in learning science and technology” (Federation of American Scientists, 2006, p. 7). The outcomes from the focus group discussion and app review also prove the finding from the literature. All the participants agreed that “game-based learning is very essential”, and they highly suggested to incorporate games into the app. Gaming features are quite popular among highly rated apps for teaching and learning Chinese, such as “ChineseSkill”, “Fun Chinese” and “Memrise”.

By employing the powerful mobile technology in iOS 11, including the built-in camera, motion sensors, gesture recognition, touch screen, Siri kit, and machine learning kit, the primary investigator decided to “gamify” the challenge section. Three interactive educational games were designed as a proof of concept to support character
study. Given the nature of this app, the learning goal for all the games is helping users to master the characters in the lessons.

The first game is named “Speedy Dash”. By giving the Pinyin of the character, players need to quickly draw the character on the pad with the correct stroke order and form. If the handwriting is accurate, the spaceship will get fuel to move forward. The faster the writing speed, the more fuel it will get. Students need to quickly recognize the Pinyin or the sound of the character, retrieve the stroke sequence from memory, and then quickly write it down. The game ends once all the characters in the lesson have appeared. The pedagogical strategy behind this game is to strengthen the relationship between character form and pronunciation.

The second game is “Hanzi Detective”. Given the definition of a character, players need to find that character from a group of characters which share a similar form but different pronunciations, and then press the microphone icon to say that character. With the speech recognition API, the game can rapidly recognize the speech as input in real time and then compare it with the character sound in Mandarin. No matter right or wrong, positive feedback will be given to the players. The game ends once all the characters in the lesson have appeared. This game focuses on the connections between sound and form of a character and employs the strategy that emphasizes the use of character clusters (Zhang et al., 1995).

The last game is Kung-fu Pin Yin. The design of this game utilizes the machine learning framework (Core ML) in iOS 11, which allows the developer to integrate a variety of machine learning model types into the app. By giving the Pinyin and definition of a character, players need to write down the character on a paper and then use the camera to take a picture of their handwriting. Powered by vision machine
learning features, the app can perform text detection and determine if the handwriting is correct. The game ends once all the characters in the lesson have appeared. The purpose of this game is to reinforce the form, sound, and meaning of a character.

Depending on the instructional goals and objectives, teachers may adjust four completion conditions (character system, time limitation, correction rate, and repetition) to control the rigor of the challenges. For instance, heritage teachers from Taiwan can make traditional Chinese as the default character system.

These games are also available in the “Practice” tab, which allows students to play the games with customized learning contents. Besides the characters given by the instructor, students can choose other character lists shared in the community or create personalized character lists, as demonstrated in Figure 13. Note that the completion conditions for each game default to go through all the characters in the list, and no points will be rewarded upon completion of the game. However, the time and effort that students are spending on the practices will be recorded as experience points. When it accumulates to a certain level, special badges and achievements will be awarded to motivate students.

![Customizable learning contents.](image)

*Figure 13* Customizable learning contents.
Besides game-based learning, gamification, as an effective technique to engage
learners, is also integrated into this app. While related to game-based learning,
gamification and game-based learning are not the same. Kapp (2012, p. 10) defines
gamification in his book, *The Gamification of Learning and Instruction*, saying,
“Gamification is using game-based mechanics, aesthetics and game thinking to engage
people, motivate action, promote learning and solve problems”. The reward structure,
as an integral part of the gamification system in this app, contains points, badges,
achievements, and a leaderboard. Points can be earned by fulfilling the challenges in
the lesson. Badges and achievements can be earned when meeting certain conditions,
such as completing 100 challenges, reviewing 1000 characters, spending 50 hours in
the app, etc. As presented in Figure 14, the leaderboard is a list of the top scores. On
the “Leaderboard” tab, it ranks the users according to the points they have earned.
With this simple invention, users are motivated to play the game again and again to
compete with their friends, classmates, and global app users.

*Figure 14*   Leaderboard with three ranking systems.
The importance of the cultural learning and understanding is seen by most of the parents, teachers and language educators. It is regarded as a bridge that connects CHL learners to their home culture (An, 2011). Regarding CHL education, Kramsch (1993) thinks that cultural awareness and learning can help improve second language proficiency. The results of app review also demonstrate that more and more apps have integrated culture immersion contents and activities, such as “HelloChinese” and “ChineseSkill”. Therefore, to promote the heritage culture awareness and to improve learning performance, the “Discovery” tab is dedicated to cultural immersion content and resources.

The banner on the “Discovery” tab is assigned to promote heritage culture-related events, presentations, activities, and in-depth reports. Due to the visual nature of the banner, contents in this area can quickly grab viewer attention. By analyzing geolocation, learning habits, personal interests and other user data, the content displayed in the banner could be highly personalized. For instance, in Figure 15, a presentation about Boston’s China town history has been placed on a scrollable banner if the user is around the Boston area. The scholarship program sponsored by the Renmin University of China will be displayed if the user has reached an advanced level.
Besides promoting cultural related events and activities, the app is intended to build a virtual culture-immersive environment for users. For example, short articles about fun culture facts and trivia, such as introduction to Go or historical figures, are pushed to the public feed under the “Discovery” tab. A variety of high quality local Chinese cartoons, dramas, movies, and documentaries are available under the “Multimedia” page. Engaging articles and the latest hot news are accessible under the “Immersion” page. It is noteworthy that all the articles come with native audio spoken and four practice modes. All of these efforts are striving to bring the authentic culture environment to the CHL learners. With the increasing cultural awareness and recognition, the tedious and boring language learning process should become more interesting and engaging. Figure 16 demonstrates an introduction to Go in the reading feed and Chinese dramas listed on the “Multimedia” page. Figure 17 presents an
article discussing a social topic. It comes with audio in both Chinese and English, word to word translation and four practice modes.

Figure 16  Fun culture facts and trivia & popular Chinese local drama.

Figure 17  Engaging articles and news with four practice modes.
The last tab in this app is “Me”. Everything related to the user will be gathered in one place. Users may find user id, avatar, level and accumulated usage data on the top of this page. Under the user’s stats, nine buttons are listed in a 3x3 “Tic-Tac-Toe” layout, as seen in Figure 18.

**Figure 18** Screenshot of “Me” tab-view.
On the first row, users can check badge collection in “My Badges”. For unearned badges, users can find clear instruction and their current progress toward getting it. For earned badges, users can view and share their collection at any time. As a communication tool, users can chat with their friends through “My Friends”. Of course, they also can add a new friend with user id and remove a user from the friend list. “My Classes” lists all the lessons across all the classes that users are enrolled. No matter complete or not, users can review any previous lessons at any time. Figure 19 presents the screenshots for the above features.

![Screenshots of the features on the top row of “Me” tab.](image)

*Figure 19* Screenshots of the features on the top row of “Me” tab.
On the second row, “My Calendar” is a tool to view everything related to classes in one place. It displays any lessons, announcements, and events that are added to the calendar. To promote the traditional culture, “Today in History” is also a part of the calendar in this app. As mentioned before, users can add character to the favorites list, and they can manage the list with “My Favorites”. Characters will be grouped by radicals in this view. “My Bookmarks” contains all the articles that are bookmarked on the “Discover” tab. For each item, title, author, and bookmarked date will be listed. Searching, adding, and removing features are always available to users. Figure 20 presents the screenshots for the above features.

![Figure 20](screenshots.png)

*Figure 20* Screenshots of the features on the second row of “Me” tab.
On the last row, “Notifications” contains messages received by the users, such as a chat message from a friend, an announcement for a class, and a notification for getting a badge. “Settings” is the place to manage settings for this app. Figure 21 shows the feature of changing user interface that was requested by the focus group participants. Figure 22 presents the screenshots for the above features.

**Figure 21** Users may change the app appearance in “Settings”.

**Figure 22** Screenshots of the features on the third row of “Me” tab.
To better track student learning progress and to encourage collaboration and group work, focus group participants suggest to integrate some learning management system (LMS) features into the app to enable student management, learning analytics, and group collaboration and competition. Modern full feature LMS is a complicated system, such as Canvas, Blackboard, and Schoology. After reviewing the mobile app for Canvas, the primary investigator identified some core features to fulfill the expectations from the focus group participants. A separate app for teachers was created with a light weighted LMS, which allows the teachers to add/remove students, to create/edit classes and lessons, and to track student learning progress, activities and achievements.

As illustrated in Figure 23, there are four tools available to the teacher for a class. The “Settings” tool is the place to modify class name and availability. The “People” tool allows the teacher to add/remove students. It is worthy to notice that every class will have a unique 4-digit access code and a QR code on the homepage. Students can either scan the QR code or type the access code to join the class quickly.

![Figure 23](image.png) Demonstration of management features in a class.
The “Analytics” tool provides visualized learning analytics data based on student participation by date, activity, and the individual student, as seen in Figure 24. Moreover, students who have lower participation will be highlighted with a red light, which enables teachers to grasp student performance at a quick glance.

Figure 24 Using “Analytics” tool to view the class participations by date, activity and student.
Learning activities can be created and assigned to the students in the “Lesson” tool. Multiple lessons can be created for a class. Similar to the layout of the class page, teachers can adjust the title and availability in the “Settings” tool, manage students in the “People” tool, and design the lesson activities in the “Activities” tool. As illustrated in Figure 25, for each activity, teachers can choose to use simplified Chinese or traditional Chinese. To challenge and to engage students, completion conditions, such as time limit, accuracy, and attempt, can be set based on the instruction goals.

Figure 25  Process of creating activity in a lesson.
In the “Word List” tool, teachers can customize the character list for the activities. It is possible to choose an existing list shared by other CHL teachers or to create an entirely customized word list. Figure 26 demonstrates the process of selecting an existing word list for a lesson.

Figure 26 Using “Word List” tool to select or customize the characters in a lesson.
Additionally, teachers can award badges to students who complete the lesson via the “Achievements” tool. Similar to the analytics tool on the class page, student participation will be tracked and visualized in the “Analytics” tool. At the end of the lesson page, teachers can preview the lesson at any time. Figure 27 presents the screenshots of these features.

![Figure 27](image)

*Figure 27* “Achievements”, “Analytics”, and “Preview” tools in the “Lesson” view.

Last but not the least, besides the functions and features related to teaching and learning, accessibility was mentioned multiple times during the focus group discussions. Given the experience of teaching students who are color blind, a participant suggested that “making sure the app is accessible to every student” is a must. Therefore, it is important to embrace accessibility with every app design and
development decision. In 2012, the Department of Justice made changes to the *Americans With Disabilities Act* requiring all mobile apps to adhere to people with disabilities. Based on the research, the federal government has two different standards for accessibility, namely ADA Section 508, and WCAG 2.0 guidelines. When using web technologies to build an app, ADA requirements need to be followed. However, if the app gets built with native smartphone components, it needs to align with the WCAG (Web Content Accessibility Guidelines). The WCAG 2.0 guidelines are available on the World Wide Web Consortium (W3C) website. Additionally, Apple provides an abundance of resources about accessibility on iOS to help developers deliver a superior mobile experience to every user. Moreover, two participants suggested that the app should also be accessible cross-platforms, “at least the app contents should be accessible from the web”. Figure 28 demonstrates that the app layout should be flexible and adapts to different platforms.

![Figure 28](image_url)  Cross-platform compatibility.
Chapter 3
DISCUSSION AND RECOMMENDATIONS

This Executive Position Paper describes how a Chinese character learning app prototype was designed for heritage students and teachers from scratch. This project set out to explore what features, functions, pedagogies, and content should be included in a mobile app to support Chinese as a heritage language teaching and learning processes. This section offers recommendations to stakeholders in CHL education regarding how to effectively engage heritage learners through the use of educational apps and discusses the major issues identified in the analysis of the qualitative and quantitative data.

After considering all data sources, it was clear that Chinese as a heritage language education deserved more attention. The increasing demands for CHL education are accompanied by the growth of Chinese immigrants. In 2011, the number of Chinese Heritage Language Schools in the U.S. had already reached more than a thousand (Cheng, 2011). However, the number of educational apps dedicated to CHL in the App Store is insufficient (only one). Additionally, although many authors have highlighted the potential of using mobile technology for language learning, the research on the use of mobile apps for Chinese language learning is still scarce (Rosell-Anguilar & Qian, 2015). Studies have shown that educational apps can enhance student engagement, enable differentiated instruction, extend learning beyond the classroom, and reduce teacher workload. The findings of the app review and focus group interviews conducted to supplement this EPP also revealed the heritage
language teachers’ strong interests in using educational apps to improve the CHL teaching and learning experience.

Sweeney and Moore (2012) stated that the critical success factors in the design of apps for language learning are pedagogy and technology. As a primary outcome of this project, the app prototype designed in this project is based on the analysis of the strengths and weaknesses in the existing apps for Chinese language study and is a collaborative effort incorporating perspectives from six practicing teachers, an instructional designer, and a mobile app designer. Compared to other related educational apps, the design of this prototype took into account many elements that promote the effectiveness of teaching and learning Chinese characters in the context of heritage language education. First, learning games were designed as the strategy to intrinsically motivate students to spend more time on learning. Second, the experience of writing with fingers on a mobile device is more intuitive and close to the handwriting experience. Notably, research shows that the interaction with the tangible mobile user interface also reduces cognitive load for users (Kim & Maher, 2008). Third, the lightweight learning management system enables comprehensive learning analytics and allows teachers to manage students and instructional content with ease. Fourth, immersive learning content and exercises promote heritage cultural awareness and provide extended learning opportunities. Fifth, innovative mobile technology, including machine learning and voice recognition, has made it possible to offer enhanced interactivity and user engagement. Most importantly, ease of use and accessibility, as core design principles, are integrated with all critical stages of the app prototype development.
Recommendations

The findings of this project support the notion that well-designed educational apps can benefit CHL education, particularly in teaching and learning characters. The recommendations in this section are directed to the mobile app designers and developers considering build apps for CHL, the teachers who participated in this project, the researchers and scholars in the field of CHL education, and the administrators at the Chinese community schools.

Recommendations for the mobile app designers and developers

Design for Chinese as a heritage language education. Findings from the literature review and focus group discussion that heritage learners demonstrated high level abilities in listening and speaking, but no such advantage was found in the reading and writing tasks (Xiao, 2006; Ming & Tao, 2008; Ke, 1998). Therefore, the learning content, activities and exercises in the app for CHL students and teachers should be more emphasized on promoting reading and writing skills. For instance, the games in the prototype are designed on purpose only to give Pinyin or definition of a character and to have users write the corresponding character to complete the challenge. Moreover, culture is essential to the success of heritage language learning. It is an integral part of the world-readiness standards for learning languages and is considered as one of the primary motivations to CHL learners. The educational app developer should blend the cultural elements into the app design and strive to provide an immersive learning experience to strengthen learning engagement and effectiveness. Furthermore, it is necessary to involve teachers, instructional designer, learning science experts, and heritage students in the design process. Without proper consultations with subject matter experts, the usability and educational value are
always questionable. Collaborating with the stakeholders in CHL education would not only make the app more valuable and practical to the users but also save the time for future development. Last but not the least, it is recommended that the app designer should adopt a research based educational app evaluation rubric to support app development.

Supporting resources:

- International Society of the Learning Sciences (https://www.isls.org/)
- Confucius Institute (http://english.hanban.org/)

**Embrace the latest technologies.** Criticisms of the current language learning apps are centered on poor user interface and user experience design, little use of the unique properties of mobile devices, simple replications of learning content and activities from other technologies. Regarding the user interface, the prototype in this project followed suggestions from the focus group by providing multiple themes or skins to the users. This user centered design principle has also been applied to other design decisions, such as customize learning contents in the practice mode.

To avoid replicating the learning activities from the other technologies, the primary investigator attempted to tap the potential of mobile technology by incorporating some new features coming with the iOS 11 in the prototype. The educational games are designed to utilize machine learning, voice recognition, and gesture tracking. Thanks to the support from the Apple Developer Center, including well documented instructions, sample codes, and active community, the integration of these features are easy and efficient. Additionally, other promising mobile technology especially augmented reality and virtual reality also could be integrated into the educational practices to provide a more engaging and immersive learning experience.
Supporting resources:

- Apple developer (https://developer.apple.com/)
- SiriKit (https://developer.apple.com/sirikit/)

**Privacy, security and accessibility.** The results of existing app review show very few of them provide protection for user privacy or data security. However, in education, particularly in K-12 education, student data integrity is essential. Since most of the CHL learners are children, when developing the app for them, developers need to ensure data security and comply with various regulations and laws including the Family Educational Rights and Privacy Act, Health Insurance Portability and Accountability Act, the Children’s Online Privacy Protection Act, and the Digital Millennium Copyright Act. In addition, developers also need to be aware of accessibility issues with the app, including the American with Disabilities Act and the Web Content Accessibility Guidelines.

Supporting resources:
- Privacy Pitfalls as Education Apps Spread Haphazardly
- Family educational rights and privacy act (FERPA)
- Children’s online privacy protection rule (COPPA)
- Americans with disability act (ADA) (https://www.ada.gov/)
- Web content accessibility guidelines (WCAG)
  (https://www.w3.org/WAI/intro/wcag)

**Recommendations for the teachers**

**Integrate educational app.** Findings from this project demonstrated that apps are considered as an important and growing medium for providing educational contents to young learners (Shuler, 2012). In the field of language learning, many studies claim that teachers who adopted educational apps to facilitate their teaching practices reported very positive impressions and learning outcomes (Wong, Chin, Tan, & Liu, 2010; Lai & Gu, 2011; Kim, 2013; Yang & Xie, 2013; Lu, Meng, & Tam, 2014; Rosell-Aguilar & Qian, 2015). Hence, CHL teachers should consider using educational apps to raise student engagement, extend learning time beyond the classroom, enable differentiated instruction, and allow students to learn at their own pace.

**App review matters.** Since mid-2013, Apple changed its app store search algorithm to place a higher level of importance on ratings and reviews, rewarding
higher rated apps and penalizing lower rated apps. Rating and reviews, as increasingly essential triggers regarding app discoverability, become core metrics to gauge app success. According to the survey conducted by Apptentive (2015) 70% of people read at least one review before downloading an app, 75% of survey respondents identified reviews as a key driver for downloading an app, and 42% view app store reviews as equally or more trustworthy than personal recommendations. Therefore, besides downloading and using the educational apps in the classroom, CHL teachers should consider more actively rating and reviewing the app in App Store. Comprehensive feedback from teachers would not only drive the app developers to improve their apps but also make the good apps easier to be found by other CHL teachers and students.

Recommendations for the administrators at the Chinese community schools

Provide professional development. Administrators of the Chinese community schools should strongly consider implementing professional development that provides opportunities to integrate the educational apps into teaching and learning practices. Findings indicate that teachers in this project need professional development to learn how to effectively select, evaluate, and use apps. Moreover, with teachers who possess various skills and experience related to mobile technology integration, the administrators of the school should consider taking advantage of these internal resources. For instance, those teachers could offer workshops to share how they integrate the educational apps into the daily teaching and learning activities in their classes. By providing workshops led by pioneering teachers, administrators would give the teachers a chance not only to learn from one another but also to be recognized for their achievements.
Recommendations for researchers and scholars

**Develop educational app evaluation rubrics for CHL education.** With over 80,000 iOS educational apps available in the App Store, teachers need support identifying quality apps to use, or they risk wasting their time with inferior apps. This situation creates a pressing need for an evaluation rubric that examines the quality of educational apps. With such a rubric, teachers would have a tool that supports them in identifying quality apps to use with their students as part of their instruction, and educational app designers would have indicators to consider when developing their apps. Over the past few decades, a few rubrics have been developed for evaluating educational apps. Although some rubrics are research based and aim to develop a reliable and valid evaluation model for assessing and selecting educational apps, none of them is tailored to apps for Chinese language study, let alone for teaching and learning Chinese as a heritage language. Therefore, it is a great opportunity for researchers and scholars in the relevant fields to develop a rubric adapted to Chinese language learning standards, curriculum, pedagogies, content, and practices.

**Limitations**

This project has four noteworthy limitations. The first one is the sample size. There were six teachers interviewed, which may not accurately represent the typical CHL teacher. Second, the project was conducted in one area. Most of the teachers (5/6) who were interviewed were from the State of Delaware. Therefore, findings of this project may not be generalized to other schools in other States due to the influence of issues related to this location. The third limitation is that the teachers participating in the project were mostly teaching lower grade students. Thus, the features and functions requested by these teachers may not be as applicable for higher-grade
teachers. Fourth, this project only relied on teacher perspectives without including opinions from the other stakeholders, such as students and parents. Further limitations involve the issues of reliability and validity. The bias introduced by the subjectivity of the researcher and others involved in the case study might impact the rigor of the research (Hamel, 1993).

**Considerations**

There are also some considerations to remember before implementing some recommendations. First, integration of educational apps depends on access. Inequitable access to mobile devices is a limitation to implementing many of the above-mentioned recommendations. Teachers must consider students who do not have the access to the devices, and those who are not comfortable with using mobile apps. For this reason, teachers should survey students before integrating educational apps into the instruction. Second, integration of educational apps needs to comply with agreements, laws, and regulations. State and federal laws and regulations, such as the Family Educational Rights and Privacy Act (FERPA) and the Americans with Disabilities Act (ADA), must continuously be followed. Apps that collect personal information or apps that have accessibility concerns should be carefully reviewed before using. Third, gaming features in the educational apps could be addictive. According to an American Psychological Association survey of over 3,500 U.S. parents, 48% say that regulating their child’s screen time is a “constant battle,” and 58% say they feel like their child is “attached” to their phone or tablet (American Psychological Association, 2017). Therefore, it is necessary to communicate clearly and frequently with students and parents to avoid these side effects.
Conclusion

Giving the increasing demands of CHL education and the scarcity of CHL apps in the market, the potential of developing educational apps for heritage students and teachers is very promising in both academic and economic aspects. There are a large number of factors involved in designing an effective educational app. By capturing the perceptions of the practicing CHL teachers, the results from this project reported that the app prototype created in this project led to very positive impressions. Sufficient evidence in the data suggests that the design principles and design decisions involved in the prototype development are useful and valuable to the CHL education.

Regarding the future work, the app prototype in this project needs to be transformed into a real iOS app. Although the participants in this project highly rated the prototype, evidence of actual value in educational practices is needed. This could involve further research with CHL students and teachers using control groups, pre- & post- learning activity tests, and the actual app. Additionally, more information is required to understand how educational apps would help with CHL education beyond character study.
REFERENCES


Li, W.M. (1989). *Qite Lianxiang Shizifa de Tansuo yu Shijian* [The investigation and implementation of creative thinking learning Chinese characters]. Beijing People's Education Publisher.


Appendix A

FIRST FOCUS GROUP INTERVIEW INSTRUMENT

First, I want to thank you for taking the time to participate in this discussion. You all have been invited to join this group given your involvement in teaching Chinese as a heritage language (CHL). This focus group interview is expected to last about 90 minutes.

To support heritage language teachers and maximize the opportunities for student learning, this study aims to understand and explore effective design and development of a mobile app for teaching CHL. By focusing on teaching Chinese characters or Hanzi - a highly laborious, demanding, and exceedingly tedious (Tse et al., 2007, p.375) process in learning Chinese - this research attempts to create a high-fidelity, interactive app prototype from scratch. As a visual presentation of the research outcomes, the design and development process of this prototype will be modeled around literature from relevant fields, the analysis of existing apps, and the feedback gained from focus group interviews.

The findings of this study, including the storyboard built upon the functional analysis, the data gathered from the analytics, and user feedback and suggestions collected, could potentially inspire and motivate software engineers in developing mobile apps for CHL. Teachers may also find this paper helpful for adopting similar mobile apps to support instruction and engage students. Last but not least, this research is intended to make contributions to the scarce studies (Rosell-Aguilar and Qian, 2015, p.21) on the use of mobile apps for CHL.
For this discussion, I would like you to think about your teaching experiences with your students. I am interested in hearing from all of you, in your words, about the challenges and successes in this process. There are no wrong answers, only differing perspectives that are valued equally. Please feel free to share your opinions even if you disagree with one another. By that token, both positive and negative comments and reflections about your teaching are welcome.

In order to capture all the details of the discussion for data analysis, this focus group interview will be recorded but your confidentiality will be guaranteed. Your names will be replaced with pseudo names in my executive position paper (EPP). Let us start this session with a brief self-introduction by going around the table.

1. What are your students’ challenges and difficulties in mastering Chinese characters?
2. How can students be assisted to overcome these challenges and difficulties?
3. What is your experience using the existing mobile apps for teaching and learning Chinese characters?
   a. What are your criteria for choosing a mobile app?
   b. What are your favorite mobile apps for teaching and learning characters?
   c. What is the positive/negative experience you have had with using mobile apps?
4. If you were going to design a mobile app to facilitate the teaching and learning of Chinese characters to heritage learners, how would you design it?
a. Do you know what challenges are being addressed by the mobile app to be designed?

b. What features would be applied in this app (e.g., present learning content, game-based learning, self-paced learning, practicing strokes, learning analytics, etc.)?

c. What would be the pedagogy applied in this app (e.g., instruction on the structure and form of characters; instruction on the association between character, form and meaning; teaching characters possessing the same rhyme; teaching text that contains character clusters, etc.)?

d. Have you seen features from another app you would like to incorporate into this app? If so, please specify.

e. Have you seen features from another app you would like to avoid in this app? If so, please specify.

f. How would you envision the user interface of this app (e.g., layout, color scheme, etc.)?

g. How would you use this app (i.e., in class/after class/hybrid)?

As we come to the end of our discussion, we have just a few questions to wrap up. Referring to all things we mentioned, here is the summary of the features that we have agreed to include in this app. Is there anything else you want to add or remove? Is there anything else you would like to add about the issues we have been discussing? Finally, I would like to express my sincerest gratitude for sharing your thoughts and experiences with us here today. Many Thanks!
SECOND FOCUS GROUP INTERVIEW INSTRUMENT

First, I want to thank you for taking the time to participate in this study again, and I expect this focus group interview will last about 60 minutes. For this discussion, I would like you to review the prototype that I developed based on the feedback from our first focus group interview. Here is a summary of our first discussion. Please take a moment to review the prototype and our last meeting notes, and then we will start our discussion.

1. What was your first impression of this prototype?
2. Regarding the features, does this prototype meet your expectations? Why or why not?
   a. Are all the feature requests from the first discussion covered?
   b. Would you tweak/add/remove any features?
3. Regarding the user interface, does this prototype meet your expectations? Why or why not?
   a. Does the prototype use the appropriate color scheme, images, videos, etc.?
   b. Is the user interface consistent (i.e., common action sequences, fonts, units, layouts, etc.)?
   c. Does the user interface provide informative timely feedback for every user action?
4. Regarding the user experience, does this prototype meet your expectations? Why or why not?
   a. Navigation
   b. Ease of use
c. Organization of the information

d. Supporting documents, such as tutorial, help, Q&A, etc.

5. Is there anything else you would like to suggest to improve this prototype?

Finally, I would like to express my sincerest gratitude for sharing your thoughts and experiences with us here today. Your time and devotion are truly appreciated. Many Thanks!
Appendix B

CONSENT FORM

Project Title: Design and Evaluation of Mobile Application for Chinese as a Heritage Language Education

Principal Investigator: Mu He

You are being invited to participate in a research study. This consent form tells you about the study including its purpose, what you will be asked to do if you decide to take part, and the risks and benefits of being in the study. Please read the information below and ask me any questions you may have before you decide whether or not you agree to participate.

Introduction

To promote the practice of integrating mobile apps in Chinese as a heritage language (CHL) education, the purpose of this study is to try and understand how to design and evaluate mobile app for teaching and learning CHL effectively and efficiently. The information learned in the focus groups will be used to understand the decision-making process of CHL teachers choosing and using the mobile app for their instruction. Moreover, the information learned in the focus groups will also be used to build an iOS app, which is intended to help CHL teachers find the right mobile apps for their instruction easily and quickly.
You can choose whether or not to participate in the focus group and stop at any time. Although the focus group will be tape recorded, your responses will remain anonymous, and no names will be mentioned in the report. There are no right or wrong answers to the focus group questions. I want to hear many different viewpoints and would like to hear from everyone. I hope you can be honest even when your responses may not be in agreement with the rest of the group. In respect for each other, I would ask that only one individual speak at a time in the group and that response made by all participants be kept confidential.

**Risks/Benefits to the Participant**

There are no risks associated with participating in this study. Your responses are completely anonymous, and the questions themselves are not personally probing. There are no direct benefits to you for agreeing to be in this study. Please understand that although you may not directly benefit from participation in this study, you have the opportunity to enhance knowledge of design and evaluate mobile apps for CHL education which could potentially impact your teaching practice.

**Cost and Compensation to the Participation**

Your time is the only cost to participate this research, and no compensation will be provided.

**Confidentiality of Records**

The confidentiality of your records will be protected to the extent permitted by law. Your research records may be viewed by the University of Delaware Institutional
Review Board, which is a committee formally designated to approve, monitor, and review biomedical and behavioral research involving humans. Moreover, records relating to this research will be kept for at least three years after the research study has been completed. I will treat your identity with professional standards of confidentiality. Any information you provide will remain strictly confidential and remain in a locked cabinet. Any information obtained through the internet will be kept on a secured network which only I will have access to the information. The qualitative responses will not be identifiable to you personally. Your name will not appear in any published materials which result from this research. However, I cannot promise that information shared with other study participants during the focus groups will be kept confidential.

Withdrawal

Taking part in this research study is entirely voluntary. You do not have to participate in this research. If you choose to take part, you have the right to stop at any time. If you decide not to participate or if you decide to stop taking part in the research at a later date, there will be no penalty or loss of benefits to which you are otherwise entitled. Your decision to stop participation, or not to participate, will not influence current or future relationships with the University of Delaware

Contact Information

If you have any questions about this study, please contact the Principal Investigator, Mu He, at (646) 477-2836 or muh@udel.edu. If you have any questions
or concerns about your rights as a research participant, you may contact the University of Delaware Institutional Review Board at hsrb-research@udel.edu or (302) 831-2137.

**Signature**

Your signature on this form means that: 1) you are at least 18 years old; 2) you have read and understand the information given in this form; 3) you have asked any questions you have about the research and the questions have been answered to your satisfaction; and 4) you accept the terms in the form and volunteer to participate in the study. You will be given a copy of this form to keep.

_________________________  ___________________________  ________
Printed Name of Participant    Signature of Participant    Date

_________________________  ___________________________  ________
Person Obtaining Consent    Person Obtaining Consent    Date

(PRINTED NAME)    (SIGNATURE)
Appendix C

INSTITUTIONAL REVIEW BOARD (IRB) APPROVALS

DATE: July 11, 2017

TO: Mu He, Ed.D
FROM: University of Delaware IRB

STUDY TITLE: [999908-1] Designing a Mobile App for Teaching Chinese as a Heritage Language

SUBMISSION TYPE: New Project

ACTION: APPROVED
APPROVAL DATE: July 11, 2017
EXPIRATION DATE: July 10, 2018
REVIEW TYPE: Expedited Review

REVIEW CATEGORY: Expedited review category # 7

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.
Appendix D

APP REVIEW RUBRIC

General Information

1. App Name
2. App Store URL
3. Publisher
4. App Store Category
5. Last Update (mm/dd/yy)
6. App Store Customer Rating
7. Current Price
8. Besides iOS devices, this app is also working on: (select all that apply)
   • Android OS
   • Web
   • Other ________________________________

Educational App Dimension

9. This app can be used for following learning model: (select all that apply)
   • Traditional classroom instruction
   • Online learning
   • Blended learning
   • Self-paced learning
   • Cooperative learning
   • Problem-based learning
• Project-based learning
• Game-based learning
• Gamification
• Flipping the classroom
• Digital storytelling
• Teaching with data
• Teaching with visualization
• Others ________________________________________________

10. This app can be used for the following teaching & learning practices: (select all that apply)
• Classroom management (e.g. ClassDojo, etc.)
• Classroom response system (e.g. Polleverywhere, etc.)
• Lesson planning (e.g. Lesson Planning, Teacher Plan, etc.)
• Learning management (e.g. Canvas, Edmodo, etc.)
• Self-taught (e.g. ChineseSkill, FluentU, etc)
• Deliver learning materials, content, & resources
• Assessment/Quiz (eg. Quizlet, Kahoot, etc.)
• Study aid (e.g. Xin Hua Dictionary, Flash Card, etc)
• Collaboration (e.g. Google Drive, Dropbox, etc.)
• Communication (e.g. Zoom, Adobe Connect, etc.)
• Others ________________________________________________
11. Evidence of Learning

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Mid</th>
<th>High</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engagement in the Learning Process</td>
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<tr>
<td>Meaningful Learning</td>
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<tr>
<td>Social Interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scaffolded Exploration toward a Learning Goal</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

12. In terms of the user experience of this app, to what extent do you agree or disagree with each of the following statements

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall, this is a great app.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The user interface of this app is attractive.</td>
<td></td>
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<tr>
<td>This app is easy to use.</td>
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<tr>
<td>The navigation of this app is easy.</td>
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<tr>
<td>Organization of information is clear.</td>
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<tr>
<td>Use of multimedia is excellent.</td>
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<tr>
<td>This app allows user to control learning progress.</td>
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<td></td>
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<tr>
<td>This app allows user to customize learning contents.</td>
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<tr>
<td>This app is cosmetic bug free.</td>
<td></td>
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<tr>
<td>The tutorial in this app is helpful</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
13. To what extent do you agree or disagree with each of the following statements

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>The responsiveness of this app is fast.</td>
<td></td>
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<tr>
<td>The performance of this app is stable</td>
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<tr>
<td>This app requires Internet connection all the time.</td>
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<td></td>
</tr>
</tbody>
</table>

14. What is your reflection to each of the following statements?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Maybe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contains Advertisement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contains Morally Biased Contents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contains Violent and Lascivious Contents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contains Copyrighted Materials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offers User Privacy Protection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offers Data Security Protection</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Language Learning App Dimension

15. This app is aligned with following standards for learning languages (select all that apply)

- Interpersonal communication
- Interpretive communication
- Presentational communication
- Relating cultural practices to perspectives
- Relating cultural products to perspectives
- Making connections
- Acquiring information and diverse perspectives
- Language comparisons
- Cultural comparisons
- School and global communities
- Lifelong learning
- Others ________________________________________________

16. This app is focusing on the following language skills: (select all the apply)

- Listening
- Speaking
- Reading
- Writing
- Others ________________________________________________

17. The app adopts the following pedagogy for teaching and learning Chinese characters: (select all the apply)

- phonic systems
• explicit instruction on the structure and form of characters
• emphasizing the meaning of the characters
• emphasizing the association between character, form and meaning
• emphasizing speech and text association
• strategies emphasizing the use of character clusters
• teaching characters possessing the same rhyme
• teaching text that contains character clusters
• integrative language instruction
• Others ________________________________________________

Chinese as a Heritage Language App Dimension

18. This app is dedicated for teaching & learning CHL:
   • Yes
   • No
   • Others ________________________________________________

19. This app support following character system: (select all that apply)
   • Traditional
   • Simplified
   • Others ________________________________________________

20. According to Chinese proficiency test (HSK) standards, this app is suitable for:
   (select all that apply)
   • HSK Level I: Designed for learners who can understand and use some simple Chinese characters and sentences to communicate, and prepares
them for continuing their Chinese studies. In HSK 1 all characters are provided along with Pinyin.

- HSK Level II: Designed for learners who can use Chinese in a simple and direct manner, applying it in a basic fashion to their daily lives. In HSK 2 all characters are provided along with Pinyin.
- HSK Level III: Designed for learners who can use Chinese to serve the demands of their personal lives, studies and work, and are capable of completing most of the communicative tasks they experience during their Chinese tour.
- HSK Level IV: Designed for learners who can discuss a relatively wide range of topics in Chinese and are capable of communicating with Chinese speakers at a high standard.
- HSK Level V: Designed for learners who can read Chinese newspapers and magazines, watch Chinese films and are capable of writing and delivering a lengthy speech in Chinese.
- HSK Level VI: Designed for learners who can easily understand any information communicated in Chinese and are capable of smoothly expressing themselves in written or oral form.

Others

Summary

21. Pros of this app

22. Cons of this app