

An Evaluation of Mandarin Learning Apps Designed for English Speaking Pre-schoolers

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Touch screen tablets such as iPads are becoming increasingly popular as educational tools to support children's first language learning in pre-schools. Apps can also be used to support early learning of a second language in English speaking countries. However, little work has been done to evaluate these apps. The present research developed criteria for assessing Mandarin learning apps and applied them to evaluate 28 Mandarin apps for English speaking pre-schoolers. The criteria included the domains of interactivity, usability, cultural awareness, collaboration, language and literacy content, and learning outcomes. The application of the criteria showed that half the Mandarin learning apps lacked key educational fea-

tures essential for second language learning. The categories in which the apps scored most highly were interactivity, cultural awareness, usability, and language and literacy content. The apps scored lowest in the categories of collaboration and provision of learning outcomes. The findings suggest that further research is needed to inform best practice, app design, and to provide guidelines that help teachers select quality apps to support second language learning.

Key words: Touch screen tablets, iPads, apps, Chinese, Mandarin, second language learners, pre-schoolers, evaluation

Introduction

From a socio-cultural perspective young children use a range of tools to develop literacy and language skills (Kucirkova, Messer, Sheehy, & Panadero, 2014; Neumann & Neumann, 2014; Schetz & Stremmel, 1994). These include traditional tools (e.g., paper and pencils, paper printed books) and digital tools (e.g., computers, tablets, iPads) (Hisrich & Blanchard, 2009; Neumann, Finger, & Neumann, 2017). The intuitive touch-based interface of tablets, where no mouse is required for operation, has allowed pre-schoolers to gain the skills (e.g., tap, swipe, drag) to successfully navigate through apps and learn with these devices (Crescenzi, Jewitt, & Price, 2014; Fletcher-Watson, 2013; Goodwin & Highfield, 2012). The multimodal features of apps such as sounds, images, text, pictures, animation, and audio narration, can assist early learning by stimulating and engaging children's senses (Crescenzi et al., 2014; Kucirkova et al., 2014; Merchant, 2015; Sandvik, SmørDAL, & Østerud, 2012). For example, pre-school aged children ($N = 60$; aged 2 to 8 years) have been observed to confidently complete counting and matching tasks on iPads, explore apps through trial, error, and repeat strategies and enjoy using apps that contain colourful, engaging, and interactive characters (Michael Cohen Group & USDOE, 2011). These interactive multimodal features of tablets and apps provide young children with valuable opportunities to learn through visual, tactile, kinaesthetic, and auditory experiences (Crescenzi et al., 2014; Neumann & Neumann, 2017).

In recent years, touch screen tablets have been more frequently used in pre-school classrooms to support children's learning across curriculum areas such as literacy, language, and numeracy (Beschoner & Hutchison, 2013; Kucirkova et al., 2014; Marsh, 2016; Priyankara et al., 2013; Verenikina & Kervin, 2011). Research has shown how children in early years

classrooms are using apps to read interactive and engaging e-books (Salmon, 2014). Roskos, Burstein, You, Brueck, and O'Brien (2011) explored children's engagement with tablets and e-books during shared book reading in small groups lead by a pre-school teacher. Children were observed to competently track the words being read, point to words and turn the digital pages to follow the story, evidencing positive benefits for developing early print concepts.

Pre-schoolers also use tablets to create and write personalised stories, construct emails, and share their language and literacy experiences (Beschoner & Hutchison, 2013). Tablets have also been used by educators as a tool to assist learning of letters, words, phonics, and numeracy (Brown & Harmon, 2013; Huang, Clark, & Wedel, 2013; Riconscente, 2013). For example, to foster learning of English letters and sounds, Northrop and Killeen (2013) showed how a range of educational apps (e.g., Pocket Phonics app, iWrite app, Word Connex app, Fry sight words app and Toontastic app) supported pre-schoolers' learning of letter sounds, blends, emergent writing, sight words, comprehension and language skills. Further benefits of tablets and apps in the early years classroom have also been highlighted by several researchers. These include the promotion of children's ownership of learning, provision of opportunities for social interaction, communication, and motivation for learning (Conn, 2012; Flewitt, Messer, & Kucirkova, 2015; Geist, 2014; Lee, 2015).

Based on these positive educational benefits of tablets, language and literacy learning apps have the potential to support young children's learning of a second language. These technologies and resources can help ease the constraints of time and resources that mainstream educational environments often lack for teaching a second language (Cenoz, 2009). Technology can also assist in preparing children for globalisation and connecting with their world (Genesee, 2014) and has the potential to take advantage of young children's natural language learning abilities opening them to new cultural experiences (Genesee, 2004; Griva & Sivropoulou, 2009). However, without rigorous research to determine the benefits and limitations of tablets and apps for early second language learning, educators will most likely experience difficulties in implementing these learning tools strategically and effectively into planning and learning activities (More & Travers, 2013).

Therefore, it is essential that teachers have the tools to evaluate the strengths and limitations of apps so they can provide children with high quality software features such as content (developmentally appropriate) and accessibility (used by children with a range of abilities) to maximise educational benefits (Hillman & Marshall, 2009; More & Travers, 2013). Close

attention should also be paid to app design so that the use of tablets encompasses children's learning through thoughtful engagements and productive learning outcomes (Falloon, 2013). There is also a need to provide teachers with the time and tools to analyse the suitability of apps for their individual learning environments (Powell, 2014).

The current focus on how digital tools such as tablets and apps can be used to support learning languages other than English is significant and timely due to the heightened emphasis of Asian languages such as Mandarin in the Australian Curriculum (Lo Bianco & Slaughter, 2009). Policy makers aim to prepare students in terms of cognitive development and intercultural understandings to provide them with a competitive edge in an increasingly globalised world (Australian Government, 2011; Deloitte Access Economics, 2016). Teaching Chinese in the classroom has become a compulsory component in the language curriculum descriptors from foundation level (preparatory year) to grade 10 (ACARA, 2016). This is aligned with the Australian Government's mandate of ensuring 40% of grade 12 students are studying Mandarin within a decade (Australian Government, 2013).

In the first years of school (prep to year 1) children will be expected to learn how to identify Mandarin words of familiar objects, common Mandarin characters and words in Pinyin, reproduce the tones, identify characters as a form of writing and recognise Pinyin as the spelled-out sounds of spoken Mandarin. Children also create stories, songs, and rhymes in Mandarin by the end of year two (ACARA, 2016). In order to prepare children for Mandarin learning on entry to school, the Australian Government aims to support pre-schoolers' "learning of a language other than English through the use of digital technology such as iPads and apps" (Australian Government, 2013). However, due to the rising availability of early language learning apps on the market it is important to evaluate the benefits of these apps for second language learning. To date, little work has been done to provide clear criteria from which to determine the benefits and limitations of apps for teaching second language learners (Falloon, 2013; Kim & Kwon, 2012).

Recent studies have begun to evaluate mobile apps for non-English speaking learners (Chen, 2016; Kim & Kwon, 2012; Martín-Monje, Arús-Hita, Rodríguez-Arancón, & Calle-Martínez, 2014). Chen (2016) conducted a study that developed a theory-driven rubric to evaluate seven English language learning apps for non-English speaking adults. The first theory underpinning Chen's (2016) evaluation rubric is social interactionist theory. This describes how social and contextualised interactions with others such as caregivers and teachers are key for learning communication skills. Chen (2016) highlighted that language learning apps should provide clear feed-

back and self-correction features. The second theory underpinning Chen's (2016) app evaluation framework is Krashen's (1988) affective filter hypothesis that allows users to be engaged, motivated, and active participants by removing potential barriers to language learning such as self-consciousness and anxiety.

Underpinned by these theories, Chen (2016) highlighted seven key app evaluation criteria that score English language learning apps on a rating scale of one to ten. These include content quality (learning skills and goals), pedagogical coherence (clear links to outcomes), feedback and self-correction (assessment data), motivation (engagement), usability (easy navigation), customisation (personalisation of learning), and sharing (collaboration). The findings of Chen's (2016) review showed wide variation in the learning features provided by each of the apps. For example, the "Dulingo" app scored highly on all criteria except customisation and the "Speak English" app scored well on usability but poorly on sharing and collaborative features and customisation for individual learning needs. However, overall the seven apps scored above a pass with the highest scoring app gaining 50 out of 70 points indicating areas where app design could be enhanced. Chen (2016) concluded that it would be difficult to find a 'one-size fits all' app to meet adult learner needs but highlighted the potential benefits of these multimodality apps to be integrated into language programs to allow the practice and enhancement of language skills.

In addition, the instructional language used in an app should be carefully considered when parents, caregivers, teachers, and policymakers introduce apps and tablets to foster second language learning in the school and home contexts. The issue over whether children's native language should be used when teaching a second language in classrooms has been debated for over half a century (Richards & Rogers, 1986). There has been a tendency to favour second language exclusivity because this is believed to be the most effective way of learning a second language (Pham, 2015; Tian & Macaro, 2012; Turnbull & Dailey-O'Cain, 2009). However, according to Ellis' (1986) native language equals second language hypothesis "native language acquisition is the same as second language acquisition" (p. 9). This hypothesis argues that native and second language learning share a similar acquisition process in that the second language learning environment needs to occur as similar to the real second language learning environment as possible.

Unfortunately, such a natural second language learning of Mandarin environment is difficult to achieve in non-Chinese heritage backgrounds such as in the mainstream educational context in predominantly monolingual countries like Australia. Furthermore, English speaking children are

unlikely to receive Mandarin support at home. Therefore, Mandarin learning apps that provide instruction in English may be beneficial for children. This is because English speaking families would be empowered to participate in second language learning and scaffold young children's interactions with Mandarin learning apps at home when instructions are given in English. In fact, the value of native language use in the second language learning classroom has been supported in the language education field (Swain, Kirkpatrick, & Cummins, 2011; Wang, 2001) being underpinned by socio-cultural theory (Brooks, Donato, & McGlone, 1997) and cognitive processing theory (Ellis, 2005).

One of the key factors in both the socio-cultural and cognitive processing theories is the significant role of scaffolding that supports a learner to achieve their full potential (Mitchell & Myles, 2004; Wray, 2006). For example, it is possible that a child's knowledge and understanding of their native language such as English can be viewed as a pre-conditional scaffolding. This first language knowledge and understanding can potentially better facilitate early learning of Mandarin through technologies in that clear instructions and a familiarised language environment remain. This theoretical perspective provides a rationale for why selecting Mandarin learning apps that contain a child's native language for instruction is preferable for early learning of a second language.

The present study extended the prior work by Chen (2016) and had two aims. The first aim was to develop a practical checklist that can assist preschool educators to differentiate which types of second language learning apps for young children might be the most effective learning tools in terms of content quality and usability. Key evaluation criteria described by Chen (2016) such as incorporating formative and corrective feedback and ensuring quality of content (e.g., vocabulary, usability, and engaging visual design) have also been highlighted as key criteria in previous studies (Falloon, 2013; Henning, 2014; Hillman & Marshall, 2009; Jonas-Dwyer, Clark, Celenza, & Siddiqui, 2012; Kim & Kwon, 2012). In addition, we added the criterion of *cultural awareness* (see Table 1). The importance of providing social and cultural contexts for language learning to help consolidate intercultural understandings, such as the extent that early language learning resources contains content and activities around cultural symbols, food, and music, have been emphasised by Nemeth and Simon (2013). Furthermore, Hillman and Marshall (2009) highlight that learning apps for young children should include a global perspective and model respect for cultures, fostering global citizenship, other languages, communities, and individuals.

The second aim of the present study was to apply the newly developed checklist to evaluate Mandarin learning apps designed for pre-school children. Mandarin was the focus language of this review because it is a key language being offered by the Australian curriculum on entry to school. Also, as the targeted young learners of the present study were most likely to come from a non-Chinese heritage background with English as the native language, Mandarin learning apps with English-based instructional features were selected in this review. The present study will be the first to our knowledge to develop a checklist based on key criteria adapted from Chen's (2016) work to evaluate Mandarin learning apps designed for English speaking pre-school children. By analysing the scores of each app for each criterion it will be possible to highlight the limitations and strengths of the various Mandarin learning apps. Moreover, the checklist will enable teachers to evaluate and select appropriate apps to support learning for the children in their classroom. In turn, this approach will empower teachers to utilise tablets as part of a wider educational strategy to support young children's learning of Mandarin.

METHOD

App Search and Screening

Potential apps for review were identified by searching the Australian iOS App Store on 8th November 2016 with the keywords "learn Chinese" and "learn Mandarin". Search filters were applied for the categories as follows: Platform (iPad only), Price (Any price), Category (Education), Presentation (By relevance), Age (5 and under), and Location (Australian iOS App Store). The "learn Chinese" search terms yielded 126 apps and the "learn Mandarin" search terms yielded 29 apps. All of the 29 apps from the latter search had also been found in the "learn Chinese" search. There were thus a total of 126 apps that were subjected to screening.

The first step of screening removed duplicates or apps that had been included in the search results because they were part of a bundle that included a Chinese language app. Following screening, 55 apps remained and were downloaded and evaluated in a second screening step. The second screening excluded apps that (a) used Mandarin for instruction (9 apps) as Mandarin speaking children were the targeted users, (b) were not designed for learning Mandarin as the app names did not match the content (8 apps), (c) were

designed for teaching and learning traditional Chinese characters rather than simplified characters (2 apps), (d) were designed for learning a language other than Chinese (6 apps) where Mandarin was included in the app descriptions but the app focussed on other languages, and (e) did not function due to technical issues (2 apps). Following exclusion, 28 apps remained and were evaluated using the app evaluation checklist.

App Evaluation Checklist

As seen in Table 1, the checklist consists of six general criteria (interactivity, usability, cultural awareness, collaboration, language and literacy content, and learning outcomes) for evaluating Mandarin learning apps for English speaking pre-school children. Each of these general criteria was further divided into a range of key sub-criteria (1. *Interactivity*: individual participation, engagement, encouragement, problem solving, decision making; 2. *Usability*: age appropriateness, playfulness, ease of use, animations, accessibility, information sharing, social networking, technical performance, customisation; 3. *Cultural awareness*: sense to the Greater China region, sense to the world, social and cultural significance; 4. *Collaboration*: parent participation, teacher participation, peer participation; 5. *Language and Literacy Content*: pinyin and characters, speech, languages, character recognition, character writing, reading, comprehension, listening skills, speaking skills, word and sentence structure; 6. *Learning Outcomes*: outcomes, assessment, feedback, evaluation).

Each sub-criterion had a question that elaborated upon the criterion to be applied (see Table 1). For example, for the criterion “social and cultural significance” the question was “does the app show respect for all cultures, languages, communities, and individuals?” In another example, the criterion “Teacher participation” used the question “Does the app allow in-class support by teachers?” Through the application of the criterion label and associated question, each app could be scored for whether the sub-criterion was either present (score = 1) or absent (score = 0). Total scores were then calculated for each criterion by summing the number of sub-criteria that were scored as present. A total score for each app was calculated by summing each of the sub-criteria scores (max score = 34).

A trained research assistant with a PhD in Mandarin and English language learning scored the 28 Mandarin learning apps. To determine the reliability of the scoring, a second trained research assistant with a Master’s degree, who was also a Mandarin teacher, evaluated 14 apps that were randomly selected from the 28 apps. Cohen’s Kappa for the level of agreement

across the two raters was $\kappa = .62$ ($CI_{.95} = .56$ to $.70$, $SE = .035$), which represents a high level of agreement. As a result, all the evaluations made by the original rater were used for analysis.

Table 1
Evaluation Criteria of Mandarin Learning Apps for English Speaking Children

Criteria	Sub-criteria	Question	Score 0 = absent 1 = present
Interactivity	Individual participation	Does the app allow operation through touch screen behaviours (e.g., tap, swipe, drag)?	
	Engagement	Does the app contain features that attract a child's attention?	
	Encouragement	Does the app provide incentives and positive reinforcement?	
	Problem solving	Does the app require a child to solve problems?	
	Decision making	Does the app allow a child to decide among alternatives?	
Usability	Age appropriateness	Is the app appropriate for young children?	
	Playfulness	Is the app enjoyable to use?	
	Ease of use	Is the app easy to use (clear instruction/navigation)?	
	Animations	Does the app contain suitable animations?	
	Accessibility	Does the app have features to support children with special learning needs?	
	Information sharing	Can information be shared with parents or teachers?	
	Social networking	Can information be digitally shared with others?	
	Technical performance	Does the app perform well with no technical problems?	
	Customisation	Does the app allow for customised settings to meet personal needs?	

Table 1 Continued

Cultural Awareness	Sense to the Greater China region	Does the app promote understanding of the Greater China region?	
	Sense to the world	Does the app make references to the global community?	
	Social and cultural significance	Does the app show respect for all cultures, languages, communities, and individuals?	
Collaboration	Parent participation	Does the app encourage parent involvement?	
	Teacher participation	Does the app allow in-class support by teachers?	
	Peer participation	Does the app allow for multiple players?	
Language and Literacy Content	Pinyin and Characters	Does the app contain accurate audio and visual representations of pinyin and Chinese characters?	
	Speech	Does the app contain accurately spoken Mandarin?	
	Languages	Does the app use both English and Mandarin?	
	Character recognition	Does the app provide character recognition activities?	
	Character writing	Does the app provide character writing activities?	
	Reading	Does the app contain texts for reading?	
	Comprehension	Does the app contain comprehension activities?	
	Listening skills	Does the app require the child to listen to Mandarin?	
	Speaking skills	Does the app encourage the child to pronounce mandarin words?	
	Word and sentence structure	Does the app contain word order and sentence activities?	

Table 1 Continued

Learning Outcomes	Outcomes	Does the app contain clear learning objectives and measurable outcomes?	
	Assessment	Does the app contain tests to assess learning?	
	Feedback	Does the app provide feedback on assessments?	
	Evaluation	Does the app provide a summary of learning outcomes?	

RESULTS

App Evaluations

The category and mean scores for each of the Mandarin learning apps are shown in Table 2. As can be seen, scores ranged from 9 to 23, suggesting that there was wide variation in quality across the apps. Moreover, the app “Fun Fun Girls” gained the highest score (23) but this score was still lower than the maximum possible score of 34. The mean score across the sample of apps was 14.68 ($SD = 3.70$) and only seven apps scored above 17, which is the score required if half the criteria are marked as present. As such, the typical app was limited in the extent to which it promoted the learning of Mandarin. The categories in which the apps generally scored best were interactivity, cultural awareness, usability, and language and literacy content. The apps generally scored lowest in the categories of collaboration and learning outcomes.

Examination of the sub-categories provides a further indication of which elements were most commonly present and absent in the apps. Figure 1 presents a block diagram that highlights these findings. Almost all apps were deemed to have interactivity features of individual participation and engagement; usability features of age appropriateness, ease of use, animations, and technical performance; cultural awareness features of sense to the world; and language and literacy content features of pinyin and characters, and speaking and listening skills. In contrast, most apps lacked certain features such as accessibility, social media access, customisation, teacher and peer participation, texts for reading, and evidence of learning outcomes.

Table 2 Category Scores of Mandarin Learning Apps for English Speaking Children									
App Name	Developer	Criteria						Total	
		Interactivity	Usability	Cultural Awareness	Collaboration	Language and Literacy Content	Learning Outcomes		
Fun Fun Girls - Chinese Songs and Learning for Kids	Fire One Company Limited	5	5	3	0	10	0	23	
Chinese Joy- Learning Chinese for Kids	DotSoft Ltdz	5	6	2	1	5	1	20	
Kids Learn Mandarin Free - A Fingerprint Network App	Fingerprint	5	6	0	2	7	0	20	
Preschool Chinese Learning with Roxy (Foreign Language Education)	HaStars	5	5	3	0	6	1	20	
Pacca Alpaca - Basic Language Learning and Educational Games for Children	Animal Tech Limited	5	5	2	1	5	2	20	
Kids Learn Vocabulary	Vocabulary Trip	5	4	1	0	7	3	20	
Learn Chinese with Miaomiao	Mark Media Corp	5	5	3	0	6	0	19	

Table 2 Continued								
App Name	Developer	Criteria						Total
		Interactivity	Usability	Cultural Awareness	Collaboration	Language and Literacy Content	Learning Outcomes	
Monki Hide & Seek - Language Learning for Kids & Toddlers	Monkimum SL	5	5	1	1	3	1	16
Little Spinner - Teaching Kids through Simple Pictures, Fun Sounds and Nursery	GM Ziady	5	4	3	0	3	0	15
Baby Discovers Languages	Génération 5	4	5	3	0	3	0	15
Children's Bilingual Picture Dictionary (9 Apps)	Lingyi Zhang	4	5	1	0	4	1	15
1, 2, 3 Count with me! Fun Educational Counting forms and Objects Puzzles for Beginners	Tatiana Churanova	4	4	1	0	4	2	15
Chinese Trip	VocabularyTrip	4	5	1	0	4	0	14
TinyGenius Flash Cards Games for Kids to Learn First Words	Gilberto Fernandez	3	4	2	0	5	0	14

Table 2 Continued								Total
App Name	Developer	Interactivity	Usability	Cultural Awareness	Collaboration	Language and Literacy Content	Learning Outcomes	
Chinese Characters Guessing for Kids	Incase Education & Technology Co., Ltd.	5	4	1	0	3	0	13
Languages Words Lesson (bundle 11 apps)	Pinky Fox	3	4	1	0	5	0	13
The Forest Friends - Lit S28	Stella28	2	4	1	0	6	0	13
Talk in 3	Bilingual Learning, LLC	4	3	1	0	4	0	12
LinguPinguin FREE - English Chinese	Elevation GmbH	2	5	0	1	4	0	12
Kids Write Chinese - Learn to Write Chinese Characters with Fun	Lang-Huang Chung	2	4	0	0	6	0	12
Mandarin Chinese Vocabulary For Children	Charles Rice	2	4	3	0	3	0	12
Word Rabbit Chinese - flashcard	Sungwoo Lee	2	4	3	0	3	0	12

Table 2 Continued								
App Name	Developer	Total						
		Interactivity	Usability	Cultural Awareness	Collaboration	Language and Literacy Content	Learning Outcomes	
World Speak Chinese	World Speak	2	4	3	0	3	0	12
Baby Learn Chinese	SHIFT Interactive	2	4	3	0	3	0	12
Learn by Touch 7	Zhong Wen Li	2	4	3	0	3	0	12
TicTic: Learn Chinese (full version)	Tinon	2	4	3	0	3	0	12
My Child Knows Chinese Basics (free)	Critical Gameplay	1	4	1	0	3	0	9
Kids Read Chinese: Mandarin Chinese Flashcards for Kids	Lang-Huang Chung	1	2	0	0	4	2	9
Mean		3.43	4.36	1.75	0.21	4.46	0.46	14.68
Standard Deviation		(1.45)	(0.83)	(1.14)	(0.50)	(1.71)	(0.84)	(3.70)



Figure 1. Block chart showing the presence (colours) and absence (white) of each criteria and sub-criteria for each Mandarin learning app. Short titles of apps are shown (Table 1 gives full titles with apps presented in the same order).

Evaluation of Selected Apps

The seven apps that gained the highest ratings contained the majority of features listed in the checklist (Table 1). A description of the app content for each of the seven apps along with their benefits, limitations, and pedagogical values are detailed below.

Fun Fun Girls - Chinese songs and learning for kids. This app features selected English songs that are also represented in a translated Chinese version. It is a suitable tool for young learners to practice listening, speaking, writing, and reading skills. Basic characters in the lyrics such as “hand (*shou*)”, “head (*tou*)” and “happy (*kaixin*)” are introduced individually along with character stroke writing and listening activities. Each song contains three animated characters and a melody that is similar to a popular pre-school tune (sung in Australian pre-schools) called “if you are happy and you know it clap your hands”. This is a positive feature of the app as children may already be familiar with this song in English. Children can sing along initially in English before the second section of the song introduces the Chinese characters which are also introduced during the song and actions. The Chinese characters for “happy”, “hand”, and “head” are matched to the English words. The words are introduced by an animated character who sings the words repeatedly with accompanying body movement and gestures. The app contains quality animations and graphics that are visually engaging. However, the app lacked collaborative features and feedback about a child’s learning outcomes. This app can be used as part of a class activity guided by a teacher to review vocabulary learned (e.g., words for parts of the body). It can also be used by young learners independently although teacher or parental support and guidance are recommended.

Chinese Joy - learning Chinese for kids. This app has two versions, one with Mandarin as the instructional language and the other with English as the instructional language. The app focuses on learning basic vocabulary and character writing. It contains different units, each incorporating three games, a revision activity, and drawing and painting games for individualised learning. It also provides some information of the child’s learning outcomes. However, the pinyin system is not provided as part of the app’s content. The app’s design is beneficial because learning is assessed and monitored through the activities. The app requires parents and teachers to scaffold children’s vocabulary learning by helping them listen carefully to the words and repeat them. In sum, the content of this app is suitable for young learners but the activities require additional assistance by teachers or parents to support learning.

Kids Learn Mandarin Free – A Fingerprint Network App. This app introduces basic Mandarin vocabulary with games and simple character writing using animations to show and guide stroke order. Accompanying audio is in both English and Mandarin and new vocabulary is introduced through interactive activities. For instance, numbers from 1 to 10 are represented by animals that can be dragged into a digital notebook whilst the Mandarin pronunciation of the number is provided. Such an activity develops a relationship between input, interaction, and comprehension during the learning. However, the app is limited because it contains no assessment or feedback on learning and lacks features to support cultural awareness. The app is more suited for individual learning as there is no function to allow for multiple players or interactions with parents and teachers.

Preschool Chinese Learning with Roxy - Foreign Language Education. This consists of a bundle of six apps introducing vocabulary such as colours, numerals (1–10), parts of the face and body, animals, and types of fruit. Each app contains high quality sound and speech systems, animations, and pictures, and it also promotes cultural awareness to young learners. For example, it uses a panda as the dominant animated character in the games and activities. The app focuses mainly on the development of listening skills; and character writing is not introduced with the exception of character recognition for independent learning in either simplified or traditional form. Teacher and parent assistance is needed during the app activities.

Pacca Alpaca - Basic language learning and educational games for children. This app uses an Australian context for Mandarin language learning thus promoting aspects of cultural awareness. The app incorporates Australian animals and lifestyle activities (e.g., beach, barbeque, and scuba diving) and examples of Indigenous artefacts. Parents, caregivers, and teachers are provided with a detailed description about the app in English, and the app also contains a step-by-step guide of how to assist children's Mandarin language learning. The audio speech instructions are provided clearly in Mandarin by a child's voice. The navigation is easy to follow and the animations are visually engaging and attractive. However, feedback or assessment of children's learning outcomes is not provided. This app can be used for individualised or whole class learning and teacher and parent guidance is recommended when using this app.

Kids Learn Vocabulary. This app focuses on supporting vocabulary skills through listening and reading activities. It contains animations, pictures, and accompanying audio and sound in both English and Mandarin. It includes some assessment-related tasks that monitor and scaffold learning. For instance, learners have to respond to all the questions correctly in the game-based assessment activity in order to progress to the next level. This

app contains a reward system of three levels (bronze, silver, and gold), including multiple tasks to progress to the next level. It is recommended that parents and teachers actively guide learners to help them advance from one level to another. The navigation system is not always clear or easy to follow and the app has limited cultural and collaborative features. Overall, this app is more suitable for individualised learning with additional support and guidance from teachers and parents needed.

Learn Chinese with Miaomiao. This app focusses on character recognition and learning and has two sections. One section is titled 'Explore' that helps children learn character words for people, nature, and animals. The second section is titled 'Write' that provides activities for practicing stroke formation and character writing. The content is presented in a visually attractive way through colourful animations and pictures. The speech audio is produced by native Chinese speaking children. To encourage language output and promote engagement, the app encourages children to practice speaking Mandarin words by saying "do you want to try?" or "shall we read it?" The app does not contain assessment items to monitor children's progress in Mandarin learning and the activities would benefit from additional support of parents and teachers.

DISCUSSION

In recent years, there has been a rapid rise in the use of tablets for early childhood education and an explosion of language learning apps in the market. There has also been an increased emphasis on learning a second language in Australia to help prepare children for the future effects of globalisation. These factors drive the need to provide teachers with clear criteria that can be used to select quality second language learning apps to support early learning. Informed by established second language acquisition theories such as social interactionist the present study developed a second language learning app criteria checklist to evaluate Mandarin learning apps designed for English speaking pre-schoolers. The six evaluation criteria were interactivity, usability, cultural awareness, collaboration, language and literacy content, and learning outcomes. The application of this checklist revealed considerable variability between apps in terms of their quality and provision of educational features. In general, strengths included interactivity, most aspects of usability, cultural awareness, and language and literacy skills. Limitations were found for some aspect of usability (accessibility, information sharing, social networking, and customisation), as well as col-

laboration (parent, teacher, and peer participation), character writing, and learning outcomes (student feedback and assessment of learning).

The present findings suggest that although several apps incorporated a range of positive design features to support young children's Mandarin learning, limitations still exist in the content and features provided by these educational tools. For example, the "Fun Fun Girls" app scored highly on interactivity and literacy and language content but it lacked some usability features (accessibility, information sharing, social media access, and customisation) and did not contain important collaborative features for parent, teacher, and peer participation that are essential to assist in the scaffolding of children's language learning. It also lacked assessment or feedback features to determine what children have learnt or to inform future lesson planning. The apps that were shown to have the fewest educational features had clear deficiencies in usability, activities to promote and model cultural awareness, collaboration, literacy and language learning content, and feedback on learning.

It was interesting to note that none of the apps evaluated provided social networking features. It is possible that teachers may prefer to use an app that does not have social networking tools for sharing information due to reasons such as privacy and security. However, such restrictions will limit interactions among peers and interactions between students and teachers. These shared interactions can be a source of reward, motivation, and support for children. It is thus recommended that apps feature safe and secure means for sharing interactions in a way that facilitates engagement and learning. Adopting avenues of a collaborative approach between app developers, teachers, parents, and researchers has the potential to enhance the quality and design of second language learning apps for young children.

The present study also examined features of the apps that supported reading and writing in Mandarin. The pinyin system is the official Romanisation system for writing Mandarin using a Latin alphabet and computational character input. As such, it is an important component of Mandarin learning. However, it was found that *Chinese Joy – learning Chinese for kids* did not adopt pinyin but teaches words repetitively by providing listening input in a playful way. This approach may help young learners to comprehend words and phrases by listening to Mandarin. However, it does not facilitate any learning of the written form of Mandarin. The benefits and disadvantages of using written pinyin versus repetitive listening of words require further investigation.

The findings of the present study should be carefully considered in the light of certain limitations. Firstly, only one platform was used (Australian

Apple store) for the search criteria. A broader search is needed to evaluate language learning apps from other major tablet markets such as the Android Play Store. The criteria checklist used a dichotomous scoring system of 1 or 0. The checklist could be made more sensitive by adopting a graduated rating scale. However, a simple check list may be preferred by teachers or parents as a more efficient and practical way of determining the quality and desired features of a second language learning app. Indeed, it is possible for the present checklist to be further adapted to evaluate language apps other than Mandarin by customising the types of language and literacy skills listed in the sub-criteria (see Table 1). For example, the Australian Curriculum Authority (ACARA, 2016) lists several world languages (Arabic, Chinese, French, German, Indonesian, Italian, Japanese, Korean, Modern Greek, Spanish, Vietnamese) available for students to learn as a second language. As such, following further refinement and testing, the present criteria could be a useful tool to assist teachers and parents in selecting suitable language apps for learning in the classroom or outside class.

Based on the present results, it would be expected that an evaluation of language learning apps for languages other than Mandarin would yield similar outcomes. This is because there would exist common elements that guide the design of language learning apps regardless of the specific language to be learnt. In this respect, it would be expected that apps for other languages would score well on criteria associated with interactivity and some elements of usability and language and literacy content. Conversely, the present findings stress the need for language scholars and app developers to consider key elements that were generally lacking in the present evaluation of Mandarin learning apps. These included criteria associated with collaboration, learning outcomes, and some aspects of usability. By using the criteria developed in the present study (see Table 1), it may be possible to create language learning apps that are more comprehensive and better able to assist children in their learning.

Future research is needed to empirically test the effectiveness of second language learning apps for pre-schoolers through rigorous pre-post-test studies. It is also important to encourage app developers, language researchers, teachers, parents, children and policy makers to work together to help in the effective design of tablet based apps to support learning. In addition, helping equip teachers and parents with clear and practical advice on the selection of appropriate second language learning apps for school and home will be a positive step forward in supporting young children's early second language learning of Mandarin alongside their native language.

CONCLUSION

Realistically, it may not be possible to find a Mandarin learning app that fulfils all the criteria adopted in the present study. However, our work does provide an initial step forward in the empirical investigation and evaluation of Mandarin learning apps for English speaking pre-schoolers with the scope to examine languages other than Mandarin. In this sense, the significance of the current research is two-fold. First, it develops a comprehensive checklist for the evaluation of second language learning apps. This checklist that includes key evaluation criteria (interactivity, user-friendliness, cultural awareness, collaboration, language and literacy content) helps teachers and parents ascertain whether the second language learning apps provided to young children contain the best features to maximise learning. This criteria also provides a clear guide for app developers who embark on designing language learning apps for young children to ensure they consider these features during the process of developing these resources.

Second, the present study advances our understanding of the current pedagogical quality and content of Mandarin learning apps with more evidence of learning outcomes needed in all of the apps evaluated. The findings from this research highlight the need for encouraging collaborative relationships between teachers, app developers, and researchers in the design of early language apps. Most importantly the app evaluation criteria used in the present study has the potential to empower teachers and parents to select quality apps to support early Mandarin learning in the classroom or outside class.

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