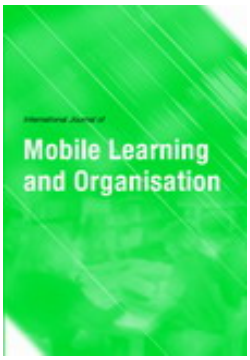

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Scenario-based mobile application design for young dual-language learners: evidence from factor analysis

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Abstract: This article aimed to provide new insights into critical factors to consider when developing a scenario-based mobile application (SBMA) for dual-language learners (DLLs). It is intended to investigate the factorial structure of the SBMA for young students in an elementary school context using exploratory and confirmatory factor analysis (CFA). The convenience sampling method was used to recruit 1,040 in-service teachers to complete the internet-based questionnaire. For half of the respondents, exploratory factor analysis (EFA) was conducted to identify the factors for SBMA design for young DLLs, and CFA was used to ascertain the model fit. The EFA identified five factors from 32 items, and through CFA, the results indicated that the five factors obtained from the EFA were validated: 1) application attribute; 2) lesson content; 3) immersive environment; 4) learning strategy; 5) instructional use. The findings shed light on how SBMA could be designed for DLLs.

Keywords: dual language learner; DLL; factor analysis; mobile application; primary school student; scenario-based learning; SBL; scenario-based mobile application; SBMA; confirmatory factor analysis; CFA; exploratory factor analysis; EFA.

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1 Introduction

Aside from increasing the chances of landing a good job or advancing in one's career, learning more than one language allows students to engage with the world more immediately and meaningfully, particularly for children who learn English and their native language at the same time while attending elementary school (Brutt-Griffler and

Jang, 2019; Savage and Pace, 2020). Several research studies in dual language education provide clear evidence that fostering bilingualism in young learners is exceptionally beneficial, as they are not overwhelmed by the task of communicating their abstract thoughts and feelings in their target language (Hammer et al., 2014; McCabe et al., 2013; Song et al., 2022; Wong and Samudra, 2021).

Young dual-language learners (DLLs) in Thailand have received considerable attention as a result of the National Language Policy (BE 2018-2021), which incentivises using Thai as the national and official language and learning English to increase competitiveness in global markets by using the mother tongue as a comprehensible input (Office of the Royal Society, 2018). In the current study, DLLs are defined as children aged six to eight years old who learn English as a foreign language (FL) while also developing Thai as their first language in lower elementary schools. As is already known, these DLLs were born entirely in the 21st century and grew up with smartphones and tablets as part of everyday life. Therefore, it can be said that children nowadays are exposed to mobile touchscreen devices at a young age. Not surprisingly, research on the use of technology in primary schools to improve DLLs' language abilities is abundant and becoming more prominent (e.g., Al Mosawi and Wali, 2015; Neuman et al., 2018; Wong and Neuman, 2019; Wong and Samudra, 2021).

Mobile applications (henceforth, apps) have the potential to provide learners with practical and systematic steps to learn languages (Gafni et al., 2017; Klimova and Zamborova, 2020; Loewen et al., 2019; Nushi and Eqbali, 2017) or ample exposure to new vocabulary words, sentences, and basic grammar through the use of their own portable devices, thereby facilitating bilingual development (Fatimah et al., 2021; Ghorbani and Ebadi, 2020; Gonulal, 2019; Kohnke, 2020). On the one hand, numerous studies suggest how to develop mobile language learning applications for adolescent/adult learning (Ekoç, 2021; Lee et al., 2021; Ng et al., 2021; Rosell-Aguilar and Qian, 2015; Tu et al., 2020; Zhang and Zou, 2020). On the other hand, there has not been enough research done on creating mobile educational apps for young DLLs.

When designing mobile apps for children, it is critical to remember that pedagogical principles are as important and influential as technology. Scenario-based learning (SBL) approaches can support mobile learning researchers and teachers interested in exploring their practice with the creation of mobile learning for young people (Andrews et al., 2015). SBL, as defined by Errington (2003), is an educational approach that involves the implementation of scenarios to achieve desired learning intentions. In L2 learning environments, SBL stimulates learners and influences positive outcomes (Celen and Akar-Vural, 2009; Hsu, 2006; Miccoli, 2003; Ntelioglou, 2006). Scenarios were then included in the mobile app design for DLLs to allow them to practise communication in an authentic context using real-world scenarios (Mehall, 2021).

The literature indicates that the use of scenario-based instruction might require particular revisions to the curriculum in order to match this method to the language programmes (Almazova et al., 2021). To create an engaging experience for learners, various elements of SBL must be considered: authenticity, challenge, story, choice, roles, role-playing, setting of the scenario, scenario characters, and scenario learning objectives (Smith et al., 2018), while Errington (2005) suggests that they frequently include common factors such as role-playing, problem-solving, demonstration of taught skills, the exploration of an issue, and contemplation of outcomes.

Although scenarios are effective in imparting both skills and knowledge and can be successfully enhanced with the application of technology (Smith et al., 2018), the impact of these elements on the design of mobile apps, perhaps, varies. With this in mind, gaining a better understanding of the factors affecting mobile application design, with a particular emphasis on scenario-based approaches for enhancing primary school pupils' dual language proficiency is critical for current academic research. Therefore, the study's objective is to use the EFA and CFA methods to investigate the factorial structures of a scenario-based mobile app (SBMA) for young learners in elementary school settings.

2 Literature review

2.1 Online SBL

SBL, which originated from situated learning theory, provides learners with a scenario descriptor, a set of realistic circumstances, an outline of events, or even the story of a human undertaking in a professional setting (Errington, 2010, 2011). Errington (2003) identified that scenarios bring human interactions in line with the world around them by incorporating real-world tasks with true-to-life challenges comparable to those encountered in daily life. Furthermore, scenarios foster a secure learning environment (Almazova et al., 2021). Even in a poor decision, respondents are not subjected to the consequences that might occur in a natural professional setting.

This SBL approach can help practitioners and researchers design online environments where learners work in groups or collaborate to achieve a goal (Naidu et al., 2007; Sheridan and Kelly, 2012). Students begin the lesson as actors, resolve challenges and tasks in the scenario, and remain in that mode throughout the lesson. Thus, they are free to experiment with various actions, access references and resources embedded in the digital scenario environments, make decisions, and experience the outcomes, as well as feedback in which they are informed whether their responses are correct and why (Clark, 2013). It can be concluded that through their storylines, scenarios arouse curiosity and drive learning, making them suitable for online learning environments (Solin, 2013).

Over the last two decades, there has been a proliferation of technology-mediated SBL studies documenting innovative practices in L2 classrooms. When properly designed, offline SBL participation can be transferred to the online environment without compromising the experience (Mehall, 2021). As a result, learners will benefit from the option of completing this course on their own schedule and at their own pace. In an online scenario-based environment for non-language programmes, engineering educators discovered that their student's value being better prepared for a real-life situation (Jaeger and Adair, 2017). In line with other studies (Sheridan and Kelly, 2012; Sorin, 2013), when pre-service teachers engage in online scenario-based instruction, they become immersed in real-world events and report prominent levels of learning outcomes in their self-assessments of their learning.

In language courses, for example, when seventh-grade pupils were allowed to use scenario-based interactive English videos as much as they wanted, it was found that online SBL was positively associated with student achievement and self-regulated learning behaviour (Taslibeyaz, 2020). Similarly, Almazova et al. (2021) reported that in the context of SBL, this innovative method could promote active learning and facilitate the development of communication skills in EFL training. Other researchers (Tang and

Taguchi, 2020), attempting to incorporate SBL into a digital game to teach formulaic expressions in Chinese as a FL, discovered that a combination of scenario-based digital games and explicit feedback significantly contributed to engaging learning. Despite this, most of these studies focus on secondary to tertiary-level classroom practices, with results that are not always generalisable or transferable to primary classrooms. This limitation strengthens the case for the current study, which aims to fill a gap in the literature.

2.2 Mobile application and DLLs

It is self-evident that 21st-century children spend long periods in front of touch screens, tapping, swiping, or interacting with audiovisual information and visualisation. Mobile devices are easier for young children to grasp and use than other electronic devices (e.g., PCs and laptops) due to their usability (Vatavu et al., 2015). The portable gadget is one device that has remained at the cutting edge of technology and education (Prince, 2017). Specific to DLLs, it provides scaffolded support to students, increasing their propensity to persist in tough situations and finish learning activities (Haydon et al., 2012). Additionally, research has demonstrated that when mobile devices are introduced into the learning setting, DLLs' engagement and sentiments positively regarding their English language use rise (Ross et al., 2020). This emphasises the fact that access to and use of specific mobile apps has a positive relationship with children's language comprehension (Booton et al., 2021). Numerous studies have indicated that instructional literacy apps substantially boost children's language abilities (i.e., Cho et al., 2018; Tsai and Tsai, 2018). Indeed, educational institutions, educators, and researchers have begun to employ portable devices to promote FL instruction (Elaish et al., 2019).

The rapid growth of vocabulary, grammar, pronunciation, and the emergence of reading and writing has been significantly enhanced, particularly for children aged three to eleven years old (D'Angiulli et al., 2004; Honig, 2007). Making use of these now-common tools could undoubtedly aid in the development of language and literacy skills in both first and target languages (Booton et al., 2021). For instance, Lake and Beisly (2019) used mobile apps to assist them in interacting with their students, creating relationships with children and families, and fostering bilingualism. Another study also found iPad apps have the ability to enhance the language acquisition and vocabulary development of 4-and 5-year-old students (Aldossary et al., 2021). This reinforces educators' view of the relevance of mobile apps for encouraging children's language learning, implying that teachers can use these apps to scaffold young learners' language development.

There is a plethora of mobile apps that are designed to support children's FL learning, as seen on the e-store platforms. In fact, the features of mobile apps for the effective design of language learning for young learners can vary considerably (Table 1). More importantly, because DLLs demonstrate a fundamental understanding of two phonological systems, vocabulary, and grammar, mobile apps are expected to be valuable educational tools for supporting dual language learning.

Despite the fact that research studies are being conducted to address more nuanced questions about the practical design of mobile apps for children's learning, a vast number of educational apps fail to provide developmentally appropriate support (Callaghan and Reich, 2018). In other words, applications designed explicitly for DLLs are restricted (Sadiq et al., 2019). Furthermore, as stated by Lu et al. (2014), countless learning apps are built solely by software developers without the involvement of subject-matter experts or instructional designers. Of course, it assumes that the usability of these educational apps does not meet the expectations of teachers. As an outcome, this study seeks to investigate the critical factors that led to the design of the SBMA for DLLs required by in-service teachers in order to fill the previously mentioned research gaps. The following are the overarching questions that will be addressed in this study.

1 What factors contribute to the scenario-based mobile application (SBMA) for DLLs?

2 Is the proposed model appropriate for creating the SBMA for DLLs?

Table 1 Attributes of mobile apps relevant to language learning

Category	*Examples*
Multimedia output	Auditory (sound effects, text-to speech, music, sound playback); visual (picture, animation, video); haptic (vibration); 3D (virtual reality).
Multimedia input	Auditory (microphone); visual (camera); haptic (touching gestures, drawing, tilt/movement).
Social interactivity	Competitive interactions; collaborative interactions; parasocial interactions; interaction prompts (e.g., real-time conversation prompts).
Language processing	Speech recognition; translation; multiple keyboards; spell check; predictive text; dictionary.
Motivational	Rewards; gamification
Autonomy	Independent use and accessibility; self-pacing; repetition
Personalisation	Feedback; adaptivity; analytics; settings; customisation
Automated assessment	Analytics for teachers/parents
Functionality	Saving/recording inputs; ease of editing
Portability and ubiquity	Use in multiple contexts
Context sensitivity	Augmented reality; QR code; location
Connectivity	Sharing; web

Source: Booton et al. (2021, p.4)

3 Research method

This is the first phase of a larger project to build the SBMA for DLLs at Thailand-based primary schools. A quantitative design was used to arrive at answers to the questions mentioned in the previous part. The following sections are the specific details of the research methods:

3.1 Participants

The calculation of G*Power suggested that 880 subjects would be an appropriate sample size for generalised analysis in order to detect an effect size of Cohen's d = 0.15 with 95% power (alpha = 0.05). Furthermore, Tabachnick and Fidell (2019) identified that sample sizes of over 500 were required for estimating reliable correlations. In this study, 1,040 elementary school teachers across the country were recruited. Among these educators, 520 responses were retained for EFA, while the rest were kept for CFA. There were 784 females (75.38%) and 256 males (24.62%) among those who responded, with an average of 9.29 years of teaching experience (SD = 7.11; range = 8 months to 31 years). The majority of teachers (474, 45.58%) worked in public schools, 284 in private schools (27.31%), 194 in demonstration schools (18.65%), 66 in Catholic schools (6.35%), and 22 in international schools (2.12%). Based on teacher reports, their institutions were located in the Bangkok Metropolitan Area (678, 65.19%), central (120, 11.54%), southern (96, 9.23%), northern (60, 5.77%), eastern (48, 4.62%), and Northeastern (38, 3.65%) regions of Thailand. It is imperative to note here that, as is the case in many other countries, teaching all areas of the primary curriculum is a general task for all Thai primary school teachers. Participants in the report have expertise in integrated learning management, as required by the Basic Education Core Curriculum BE 2551 (AD 2008) (Ministry of Education, 2008), as well as sufficient experience in teaching compulsory English and Thai subjects in elementary schools to share their perspectives for this study.

3.2 Instrument

Based on data from a thorough literature review and interviews, the content of a self-administered questionnaire was generated. Twenty primary school teachers and ten university lecturers with relevant teaching experience in teacher preparation programmes were interviewed in person. During the COVID-19 pandemic, educators were asked to reflect on their daily instructional tasks relevant to language teaching, use of mobile learning applications, and suggestions for internet-based language teaching for young learners. To address the question items, the key issues were coded and compared with data from published studies on online SBL (Almazova et al., 2021; Mehall, 2021; Tang and Taguchi, 2020; Taslibeyaz, 2020) and mobile application and DLLs (Booton et al., 2021; Elaish et al., 2019; Lu et al., 2014; Sadiq et al., 2019). The questionnaire, which was divided into three sections, contained a total of 74 items. There were seven questions about demographic, five dichotomous questions concerning experience integrating technology into classrooms, and 62 statements of rating scales relating to dimensions (Appendix), with a possible response range of five: 1 means strongly disagree, 2 means disagree, 3 means neither agree nor disagree, 4 means agree, and 5 means strongly agree.

3.3 Reliability and validity

To achieve a higher level of content validity, the above research tool was initially considered by five specialists in primary education (n = 3) and educational technology (n = 2). The experts were purposefully chosen based on academic criteria, which included the following:

a a PhD in English or a closely related field of study

b ten years of teaching experience or more

c the publication of at least three relevant research articles in the last five years.

Based on the feedback, three-question items were removed due to unnecessary jargon and lexical ambiguity. Piloting was then used to test a near-final version of the questionnaire with a group of 50 respondents who were similar to the target population (Dörnyei and Taguchi, 2010), which helped us decide to remove eight items in order to improve the scale's Cronbach's alpha. Eventually, the alpha coefficient of the 51 rating-scale items was 0.973, denoting remarkably high reliability (Cohen et al., 2018).

3.4 Data collection and analysis

The covering letter with a QR code to the web-based questionnaire was sent to the researchers' coordinators, who were in charge of gathering data from primary school teachers in each region of the country in August-October 2021. The IBM SPSS Statistics for EFA and IBM SPSS Amos (26th version) for CFA were used to facilitate data analysis. The former was implemented to discover the underlying structure of a large set of variables. The latter was designed to generate a model by investigating factors, correlation matrices, covariance patterns, and residual or error values. According to earlier studies (Gonzalez et al., 2021; Teng et al., 2022), the goodness of fit of the models was investigated using a variety of statistics, including the chi-square (χ^2), degree of freedom (*df*), *p*-value, the ratio of χ^2 divided by the *df* (χ^2/df), the root mean error of approximation (RMSEA), the standardised root mean square residual (SRMR), the comparative fit index (CFI), goodness-of-fit statistic (GFI), and the Tucker-Lewis Index (TLI). As Hooper et al.'s (2008) advice for deciding model fit, values of between 2.0–5.0 for χ^2/df, less than 0.08 for RMSEA, less than 0.05 for SRMR, and equal to or greater than 0.90 for CFI, GFI, and TLI are considered acceptable.

4 Results

The research questions are addressed in two subsections:

1 exploratory factor analysis (EFA)

2 fitness of the measurement model.

4.1 Exploratory factor analysis

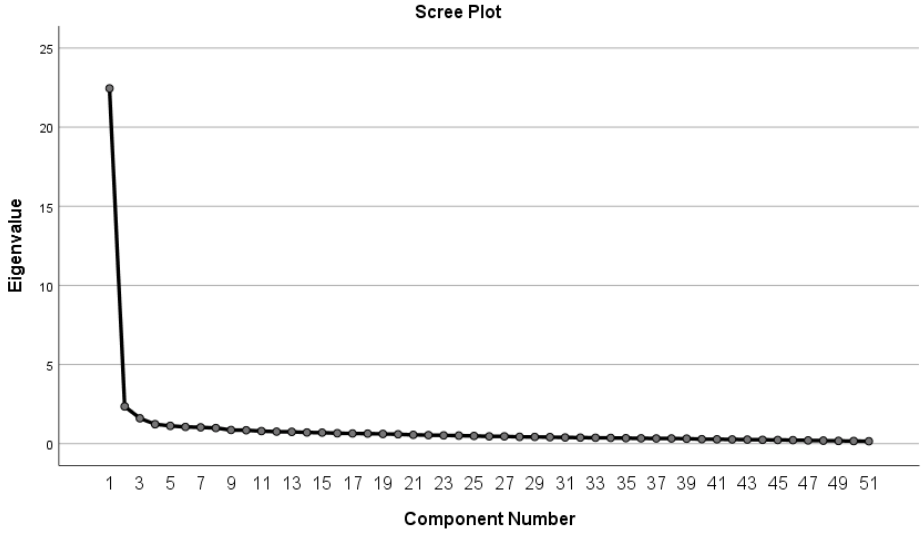
The results were revealed here to answer the first research question; the data collection of 520 questionnaires was analysed using the EFA method. Principal component analysis with varimax rotation and Kaiser normalisation was used to obtain conceptually similar and significant clusters of SBMA variables. Eigenvalues greater than 1.00 were calculated. The Kaiser-Meyer-Olkin (0.970) and Bartlett sphericity tests (χ^2 = 17,264.39, *df* = 1,275, *p* = 0.00) for sampling adequacy were significant, stating that the data were suitable for generalised analysis. Varimax rotation yielded seven significant factors from the 51 variables (Table 2).

Table 2 Total variance explained for SBMA factors

	Initial eigenvalues			*Extraction sums of squared loadings*		
	Total	*% of variance*	*Cumulative %*	*Total*	*% of variance*	*Cumulative %*
1	22.45	44.02	44.02	22.45	44.02	44.02
2	2.35	4.61	48.63	2.35	4.61	48.63
3	1.60	3.14	51.77	1.60	3.14	51.77
4	1.23	2.41	54.18	1.23	2.41	54.18
5	1.12	2.20	56.38	1.12	2.20	56.38
6	1.06	2.07	58.45	1.06	2.07	58.45
7	1.03	2.03	60.47	1.03	2.03	60.47

	Rotation sums of squared loadings		
	Total	*% of variance*	*Cumulative %*
1	8.22	16.12	16.12
2	5.63	11.03	27.15
3	4.15	8.14	35.29
4	3.88	7.61	42.89
5	3.27	6.40	49.30
6	3.16	6.20	55.50
7	2.54	4.97	60.47

Figure 1 Scree plot for EFA with varimax rotation of the 51-item questionnaire



Since a reported cut-off point of 0.50 was set, and each factor typically contains at least three variables, the last two factors that failed to load were deleted. Figure 1 illustrates a line plot of the eigenvalues of the SBMA factors. According to the scree test, the findings support a distinct break between three and five factors. The five factors extracted from the pattern matrix (Table 3) were used for further analysis. The cumulative variance of

the five factors was 56.38%, and all of the communalities for each variable were greater than 0.30, with the majority being greater than 0.75. The five distinct factors containing the final 32 variables are named, respectively:

1 application attribute (AA)

2 lesson content (LC)

3 immersive environment (IE)

4 learning strategy (LS)

5 instructional use (IU).

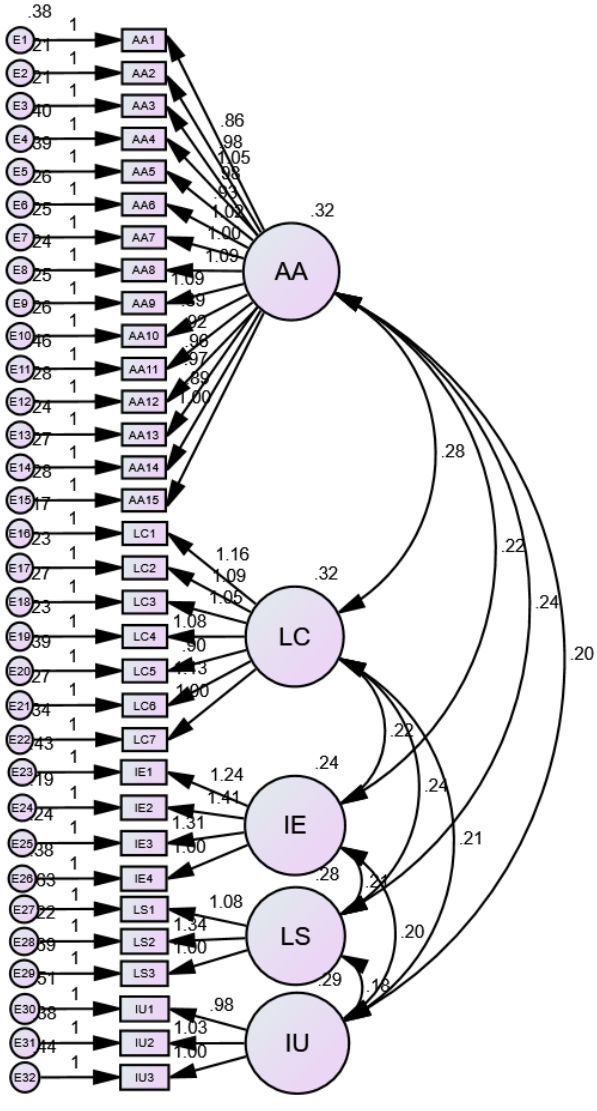
Table 3 Factor loadings and communality results

Item number	*Factors*					*Extraction communality*
	AA	*LC*	*IE*	*LS*	*IU*	
9	0.67					0.54
5	0.65					0.70
11	0.65					0.67
10	0.61					0.54
8	0.61					0.58
12	0.60					0.61
4	0.59					0.69
16	0.59					0.64
14	0.59					0.65
2	0.56					0.53
7	0.55					0.61
3	0.55					0.54
18	0.55					0.59
6	0.54					0.57
19	0.51					0.57
27		0.68				0.75
24		0.66				0.70
25		0.57				0.68
26		0.56				0.64
21		0.55				0.55
28		0.55				0.69
23		0.50				0.55
57			0.65			0.63
37			0.59			0.71
29			0.55			0.65
61			0.52			0.62
20				0.61		0.51
17				0.58		0.69

Table 3 Factor loadings and communality results (continued)

Item number	*Factors*					*Extraction communality*
	AA	*LC*	*IE*	*LS*	*IU*	
36				0.54		0.45
38					0.68	0.59
48					0.55	0.62
35					0.52	0.44
Eigenvalue	22.45	2.35	1.60	1.23	1.12	
% Explained	44.02	4.61	3.14	2.41	2.20	

Figure 2 The five-factor correlated model based on CFA (see online version for colours)



Cronbach's alpha coefficients were acceptable for the majority of the five factors in terms of internal consistency and reliability. AA, LC, IE, LS, and IU had values of 0.94, 0.90, 0.82, 0.69, and 0.66, respectively. Cronbach's alpha was 0.96 for the overall structure.

4.2 Fitness of the measurement model

The use of the second sample (n = 520) in Amos facilitated the CFA method. The CFA put to the test of the SBMA's 32-item five-factor model, which can be seen in the EFA result. Factor loading ranged from 0.86 to 1.09 for AA, 0.90 to 1.16 for LC, 1.00 to 1.41 for IE, 1.00 to 1.34 for LS, and 0.98 to 1.03 for IU employing the CFA (Figure 2). The CFA measurement model demonstrated an acceptable fit to the data across all fit indices: χ^2 = 1,285.62 (df = 454, p = 0.00), χ^2/df = 2.83, RMSEA = 0.06, SRMR = 0.04, CFI = 0.92, GFI = 0.86*, and TLI = 0.88* (note: almost but not quite at the threshold of 0.90). The 32-item parameter estimate had a p-value of 0.00, indicating statistical significance. It is possible to argue that the measurement model is adequate for forming the SMBA for DLLs.

5 Discussion

The current study aimed to investigate and validate the determining factors influencing the SBMA for DLLs. CFA confirmed the five-factor model for the 32-item survey form. The five factors were: application attribute, lesson content, immersive environment, learning strategy, and instructional use. The results found were discussed:

The first factor (application attribute) had 15 variables with factor loadings ranging from 0.40 to 0.77 and eigenvalues of 22.45. This mobile application's features were classified as follows: content design based on the national curriculum and in everyday life (items 3 and 9), a combination of two-language development (items 11 and 14), 20-minute educational activity (item 10), lesson interaction and feedback (items 4, 5, and 16), offline-mode and out-of-class support (items 8 and 12), multimedia and simulation (items 2 and 6), and cartoon-led gamification (items 7, 18, and 19). The findings advocated previous research findings (Booton et al., 2021; Pachler et al., 2010), supporting the most features of mobile apps required for language learning, which best fit into the categories of multimedia input/output, language processing, motivational, autonomy, personalisation, social interactivity, and portability and ubiquity (see Table 1).

Numerous studies have established a causal relationship between educational apps and children's literacy skills. Neumann (2018) reported that preschool children who spent 30 minutes a week for nine weeks using three commercially available mobile apps enhanced their letter names and phoneme knowledge. In the case of mobile phones, interactivity and feedback during lessons might occur on-screen. Due to its novelty in the digital realm, it might be stimulating for children (Cerezo et al., 2019). Another way to maximise learners' motivation and engagement is to incorporate gaming into learning and teaching activities. Gamification is the pedagogical integration of gaming mechanics and technologies into non-gaming educational situations in order to inspire and engage learners in the learning and teaching processes (Jong et al., 2021). When gaming scenarios are connected to course concepts, it effectively assists students in achieving their learning objectives. Vlachopoulos and Makri (2017) indicate that simulations establish a scenario-based environment in which students collaborate to apply prior

knowledge and practical skills to real-world situations while also enabling instructors to accomplish their own purposes. These also have a positive impact on learning goals and encourage students to actively explore their understanding by providing visual feedback. It is important to note that meaningful feedback is critical for students to achieve the objectives, reflect on misunderstandings, and transfer learning to different educational circumstances (Swanson et al., 2011). One could argue that the features of mobile apps have the potential to considerably enhance the success of DLLs' language acquisition.

The second factor (lesson content) generated seven variables with factor loadings ranging from 0.50 to 0.68 and eigenvalues of 2.35. The findings revealed five types of lesson content: downloadable and offline-mode content (items 24 and 25), progress tracking (items 27 and 28), scenario-based content (item 26), notification of incomplete tasks (item 21), and rewards for task completion (item 23). In contrast to traditional learning modes, mobile devices offer new ways of learning language through their unique features. For example, instead of paper-based reading, learners read lesson text on a screen, which allows them to track their reading in real-time and download it to their own portable devices to read in leisure time. Today, DLLs learn language lessons through repeated viewing and screen-based support (Neuman et al., 2018; Wang, 2017; Wu, 2015). The lesson content can include knowledge based on the core curriculum for basic education, but it can also be scenario-based, describing a language situation in which students can interact. As argued by Clark (2013), scenario-based lessons begin with the assignment. Learners are free to experiment with different actions and access resources embedded in the scenario environment as they progress through the learning process. If the offered scenario does not fit the learners' background or interests, instructors must change it or allow them to participate in scenario creation (Naruponjirakul, 2019).

There are numerous ways in which mobile apps could support the learning of lesson content. For instance, to alleviate the working memory burden by removing the need to remember current tasks and reminding young children to complete incomplete activities, notifications can be beneficial during the day's learning activities (Tabuenca et al., 2014). Following completion of the activities, Seah and Koh (2021) advocated incorporating rewards as motivators to improve the user experience. These serve as driving forces for language learning, encouraging students and resulting in successful outcomes (Hsu, 2006; Taslibeyaz, 2020).

The third factor (immersive environment) had four variables with factor loadings ranging from 0.52 to 0.65 and eigenvalues of 1.60. Results indicated four immersive environment characteristics: culture (item 57), motivation (item 37), being active (item 29), and exercise (item 61). Immersive environments are digital learning environments that immerse users in a computer-generated scene (Lui, 2014). Mobile devices exhibit intriguing characteristics that may be advantageous in immersive learning environments (Dias et al., 2018). When language learners log into the scenario-based mobile app, they are allowed to investigate authentic, active learning environments relevant to lesson content in order to provide an immersive experience (Berti et al., 2020). Immersive environments also prepare students for long-term motivation and support them in completing tasks and exercises in a variety of language activities (Chang et al., 2012; Cheng and Tsai, 2020; Huang et al., 2019; Saminathan et al., 2020). For instance, Hwang and Chang (2011) observed that these digitally mediated learning environments not only increased students' enthusiasm and attitude toward learning, but also enhanced their

performance on a course about local culture. Hein et al. (2020) also posited that immersive applications might boost motivation and be well-accepted by students.

The fourth factor (learning strategy) had three variables with factor loadings between 0.54 and 0.61 and eigenvalues of 1.23. The outcomes included three learning techniques: peer competition (item 20), a quiz (item 17), and self-learning (item 36). The findings supported previous research (Taslibeyaz, 2020), proving that online learning in a scenario-based environment actively engages learners in using instructional strategies to achieve the goal. Peer competition, for example, can be employed to trigger intrinsic motivation in learning. According to Chen (2019), students in peer-competition groups demonstrated greater interest, value, and less conflict than those in individual groups. Other researchers (Hwang and Chang, 2016) discovered that the benefits of the peer competition-based mobile learning technique boosted students' interests and attitudes. However, self-study is still critical in the language acquisition process (Nushi and Eqbali, 2017). Even when learners study independently in order to complete educational activities, their intention to learn continues to grow (Tu, 2018). It also appears to increase learners' sense of responsibility by casting them in the role of an inquirer who takes individual and collaborative ownership of the learning (Celen and Akar-Vural, 2009; Meldrum, 2011; Seker, 2016).

The fifth factor (instructional use) contained three variables with factor loadings between 0.52 and 0.68 and eigenvalues of 1.12. Results indicated two methods of implementation as an educational material: use as a primary teaching aid by a teacher (items 35 and 38) and use in conjunction with other social media (item 48). Although the design of mobile apps is primarily intended for individual use outside of the classroom, mobile devices can be oriented to support teacher-led instruction in a range of methods. As So et al. (2020) argue teacher facilitation has traditionally been viewed as a critical component of the learning process, assisting students in achieving educational objectives. According to Vygotsky (1978), teachers should work in the child's zone of proximal development and scaffold their learning accordingly. Song et al. (2022) suggest that educators must participate in instructional activities to ensure DLLs' continued development in foreign and home languages. Another advantage of mobile apps for DLLs is connectivity (Booton et al., 2021), which allows learners to share their learning outcomes with other friends on their preferred social media sites. Since they can communicate with other people in real-time via text messaging, audio, and video chats on social media (Rosell-Aguilar, 2018), it makes sense to incorporate these features into the learning experience. According to Read et al. (2016), the use of social media is important for effective mobile learning development. This is because social media encourages students to be more proactive.

Mobile learning is reshaping traditional teaching and learning processes, resulting in the development of new pedagogies. The possibilities of mobile technology may be leveraged to create mobile applications that engage learners in collaboratively learning and practising language abilities (Kukulska-Hulme and Viberg, 2017). The study's findings should be of interest to both educators and mobile app developers. For instructors, recommendations are provided regarding the elements of this mobile application and others comparable to it in assisting with English and Thai language learning. The recommended design of this SBMA is based on the viewpoints of a vast number of primary school teachers from across the country. As a result, software designers might use this research finding as a guide when developing two-language learning mobile apps for DLLs in the future.

6 Conclusions, recommendation, and limitation

The present study aimed to determine the factors that must be considered when developing the SBMA for young DLLs. Out of the initial 51 items and the presence of seven components in the original scale, 32 items belonging to five factors were kept in the final version with adequate internal consistency and validity. The findings indicate that these components were, in general, the application attribute, the lesson content, the immersive environment, the learning strategy, and the instructional use. Notably, the current study builds on prior research by demonstrating that the findings can be generalised or transferred to elementary classes. Factors identified in the investigation serve as a guide for researchers and practitioners to build the SBMA for young learners aimed at enhancing dual language proficiency. Future research is encouraged to follow up on the study's results by evaluating the efficacy of the produced SBMA in classroom-based settings and examining elementary school students' Thai and English proficiency. This would enable researchers to investigate how the factors interact with one another and with language learning outcomes and draw more relevant conclusions from actual instruction.

There are limitations to this study that have to be taken into consideration. First, despite being meticulous in its method, the current study provides only a snapshot of the problem because it is limited to in-service teachers, excluding other groups of individuals, such as elementary school pupils or their parents, who may have a different perspective. Hence, interpretation and extrapolation of the findings require caution, as they are based solely on the teachers' perceptions, which may be influenced by the unique characteristics of the context investigated.

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Ethics statement

The participants' privacy and confidentiality were respected throughout the research process by adhering to the ethical guidelines issued by the university's ethics committees. Furthermore, the samples were informed that the online questionnaire survey was entirely voluntary and that they could withdraw from the investigation at any time.

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Appendix

Table A1 Survey questions

Item no.	*Questions*
1	The content in the dual language learning (DLL) app should be employed as a video narrative.
2	By incorporating multimedia, DLL apps can be made more engaging for primary school children.
3	Indicators used in Thai and English classes as appearing in the Basic Education Core Curriculum should be the same as those used in the DLL app.
4	The DLL app should give learners a way to interact with the lesson, like by answering questions, so they can learn more.
5	The DLL app should provide students with feedback, such as the correct answer to a quiz.
6	The DLL app's content should be shown as a simulation, for example, through a video demonstrating how people use language in real-life situations.
7	A cartoon figure or mascot should be employed as a lesson guide in the DLL app.
8	The DLL app should work even without internet access.
9	The DLL app's content should be appropriate for elementary school pupils to use in their daily lives, even if it does not correspond to the lesson's subject.
10	Each application's content should take no more than 20 minutes to learn and complete activities.
11	The DLL app's content should facilitate dual language (English and Thai) development.
12	Outside of the classroom, elementary school pupils can study the subject and complete activities in the DLL app.
13	In dual language learning app, animations or movies should feature cartoon characters rather than real people.
14	The DLL app's content and exercises should be integrated between Thai and English.
15	Content and activities in the DLL app should be separated into Thai and English.
16	Learners should be aware of the outcomes of the DLL app's activities.
17	Throughout the study of the content in the DLL app, learners should be required to complete quizzes on a regular basis.
18	Dual language activities should incorporate educational and entertaining games (edutainment).
19	The use of games or gaming (gamification) enables primary school children to concentrate more on the content of the DLL app.
20	Competing and comparing short activity with other classmates enables primary school children to have more fun while studying the content of learning apps.
21	There should be a notification system included in the DLL app unless the student has completed the activity or has utilised it for an extended period of time.
22	Students are encouraged to take a test at the end of each lesson to assess their progress.
23	In the DLL app, points earned by completing a quiz or activity should be added up to get rewards.

Table A1 Survey questions (continued)

Item no.	*Questions*
24	Certain types of content should be downloadable to learners' mobile devices.
25	Students must be able to access the DLL app's content even when they are not connected to the internet.
26	The DLL apps should be designed to resemble virtual places.
27	Students can use the DLL app to track their progress and see how well they did.
28	In the DLL app's back-end system, access times should be documented to analyse the learners' behaviour.
29	Using the DLL app should be an active learning experience.
30	The O-NET tests for Thai and English that are relevant to the content in the DLL app should be used to assess how well primary school students understand it.
31	Collaborative learning should be a goal of the DLL app.
32	The DLL app should be used exclusively in an onsite classroom.
33	The DLL app should be used exclusively outside of the classroom.
34	Teachers should be accountable for nothing more than encouraging learning using the DLL app.
35	Teachers should also be accountable for teaching the DLL app's content.
36	The DLL app should be created in such a way that learners can learn independently without the assistance of an instructor.
37	The settings depicted in various simulations serve to boost motivation for dual language education.
38	The primary medium of weekly learning should be the DLL app.
39	The DLL app should be used as a supplement to the weekly learning management.
40	The DLL app should only be used as an introductory lesson.
41	The DLL app should be used solely for the purpose of imparting lesson content.
42	The DLL app should be deployed only at the conclusion of the class.
43	The DLL app should be used at all stages of the educational process.
44	The DLL app should be capable of determining the average daily duration of use (for example, if the daily limit is exceeded, it will not be available until the next day).
45	The DLL app should have an equal amount of Thai and English content.
46	Each learning content should be a single continuous story.
47	Unless learners are able to use the application or grasp the content, teachers should be able to assist them.
48	The DLL app should be able to connect to more social media platforms, like Facebook, Twitter, and Instagram.
49	When students successfully complete each chapter or test and earn a passing grade, they can choose to post their outcomes on social media.
50	Using social media to share learning outcomes enhances learners' positive motivation.
51	Notifications in the DLL apps encourage users to return and complete the content.
52	Teachers should be able to plan activities on a single tablet (like an iPad) while using the DLL app.

Table A1 Survey questions (continued)

Item no.	*Questions*
53	Learners are not required to own a mobile device in order to study the lesson. The DLL app can be used on the teacher's mobile device.
54	Learners can review previously learned content as needed.
55	Learners can select interesting content without having to study it in chronological order.
56	Learners should be able to maintain the same order in which they learn from a textbook.
57	The simulation content's scene design should be congruent with the language's culture. For instance, the setting for learning Thai content should be authentically Thai.
58	Students should spend roughly 50–60 minutes per lesson studying and participating in activities.
59	The inclusion of scenes from dynamic simulations adds interest to the content.
60	The use of three-dimensional simulation scenarios aids in attracting learners.
61	Allowing learners to complete exercises while studying the content improves learning achievement.
62	In the DLL app, students can make their own avatars, which is like making game characters. They can use these avatars to learn about different types of content.