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Mobile-assisted language teaching: A systematic review with implications for Southeast Asia

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ADB Working Paper Series

**MOBILE-ASSISTED LANGUAGE
TEACHING: A SYSTEMATIC
REVIEW WITH IMPLICATIONS
FOR SOUTHEAST ASIA**

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Abstract

Like the rest of the world, COVID-19 created a sudden move to online modes of learning in Southeast Asia that highlights the need for updated teacher training to adopt computer- and mobile-assisted learning/teaching techniques. The changes in technology provide a multimedia platform that revolutionizes how people can interact through ICT, including for education. The results of mobile-assisted language learning (MALL) on student performance have not been overwhelmingly positive. Yet, the use of technology-based instruction tools seems inevitable. The proliferation of ICT technologies including Internet, broadband, and mobile technologies will continue to increase and offer advantages to tap into. How are teachers—the workers in the educational service sector—affected by technological change? Education systems in Southeast Asia can benefit from mobile-assisted language teaching (MALT) in ways that address the specific obstacles that are faced by countries in the region. This systematic review considers the topics that have been covered in the literature on MALT for content analysis. The implications will be considered for educational contexts in Southeast Asia. The different strategies that are employed with ICT and/or mobile technology differ from traditional classroom learning. The findings of the systematic review suggest that the existing research is constrained by the type of technologies studied, with a bias towards existing technologies.

Keywords: computer/mobile-assisted language teaching, education technology, Southeast Asia

JEL Classification: I20, O29, O33, O35

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1. INTRODUCTION

The cultural and historical richness of Southeast Asian countries means that a large population is educated in many different languages. The education policy in Southeast Asian countries has the common feature that national languages are emphasized in curriculums (Liddicoat and Kirkpatrick 2020). Yet, several countries allow for more than one official language of instruction. Except for Indonesia, English language instruction is also mandatory as a second language starting in early primary school in the rest of the ASEAN region (Liddicoat and Kirkpatrick 2020). Universities in Southeast Asia are also focusing on improving their higher education through internationalization strategies (Salihu 2020; Zein et al. 2020), which suggests the need for a common language of instruction, i.e., English. The challenges that are presented in language education in Southeast Asia can be better addressed through new technologies of mobile-assisted language teaching (MALT).

COVID-19 strained education services, leading to learning losses around the globe. Many traditional classrooms adapted to COVID-19 by moving to online modes of learning. In some education systems, the use of ICT- and mobile-assisted language learning (MALL) applications has ameliorated some of the losses. The application of computer and mobile technology will have long-lasting implications for teaching even after COVID-19 has receded from crisis levels. Although these gains are limited to those districts and households that have the means to supply computers and mobile technology, the lessons will be applicable as more and more classrooms and individuals adopt the technologies.

Mobile phones and tablets have proliferated since the introduction of smart phone technology just over a decade ago. The technology provides a multimedia platform that revolutionized how people can interact through ICT, including for learning. The results of MALL on student performance have not been overwhelmingly positive (García Botero et al. 2019). Yet, the use of technology-based instruction tools seems inevitable. Technology is primarily adopted because it increases efficiency or offers new features or functions, which economists refer to as “increased utility.” While most studies have focused on learning aspects of MALL, this study aims to understand how teachers are affected by the introduction of technologies in the classroom.

Widely adopted in the analysis of mobile-assisted education, the TPACK Framework focuses on the intersection of Technology, Pedagogy, and Content Knowledge for understanding MALL/MALT (Yang and Kuo 2020). These three perspectives make up the main areas related to mobile-assisted learning/teaching. Pedagogy, including content knowledge, involves the interaction between teachers and students with understandings of what the role of each is. With the introduction of new technology, these roles change and must be adapted for changing environments. How are teachers—the workers in the educational service sector—affected by technological change? How are teachers trained to adapt to these new mobile-assisted environments?

Systematic review methods allow for the quantitative synthesis of multiple studies using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) using the strategy that identifies Population, Intervention, Comparator, Outcomes, and Settings (PICOS) (Barba-Martín et al. 2020; Moher et al. 2009; Selçuk 2019). By adopting the PRISMA framework, this literature survey uses a systematic review (i) to understand what kind of research exists on mobile apps used in language education, (ii) to understand how they have been integrated into the classroom through teacher training, and more importantly, (iii) to understand how MALT can be better integrated

into teaching and learning interactions. The implications of the study will focus on how teacher professional development would need to incorporate the new computer and mobile applications into lessons for language learning, especially when public–private partnerships are involved in delivering related education services. The study focuses on the content analysis of research related to mobile-assisted language teaching (MALT).

The findings of the systematic review are that the research is still constrained in the types of technologies, pedagogical aspects, and content that are studied. The implications of these findings suggest how they would affect basic education quality in Southeast Asian countries. The region is undergoing rapid demographic and political change, including a rapid rise in youth populations, increasing rates of enrollment across different levels of education, and a greater number of students studying abroad (Salihi 2020). Education policy in the region tends to focus on national languages but also emphasizes foreign language education in a globalized environment, especially English and Chinese (Salihi 2020; Wright 2010; Yi 2021; Zein et al. 2020). While teaching methodologies that emphasize memorization and rote learning are de-emphasized, the approach is still common across Southeast Asia (Hallinger 2010; Idrus, Ng, and Jee 2014). The pupil-to-teacher ratio, an estimate for class size, is low compared to the global average and even in comparison to the average of OECD members (OECD 2022). Lastly, the physical geography of the region includes different land masses and topology that can add stress to student access and available infrastructure. Although pedagogy emphasizes the learner experience, this study finds that there is still much to be gained by focusing on how MALT affects interactions from the teachers' perspective.

2. SYSTEMATIC REVIEW

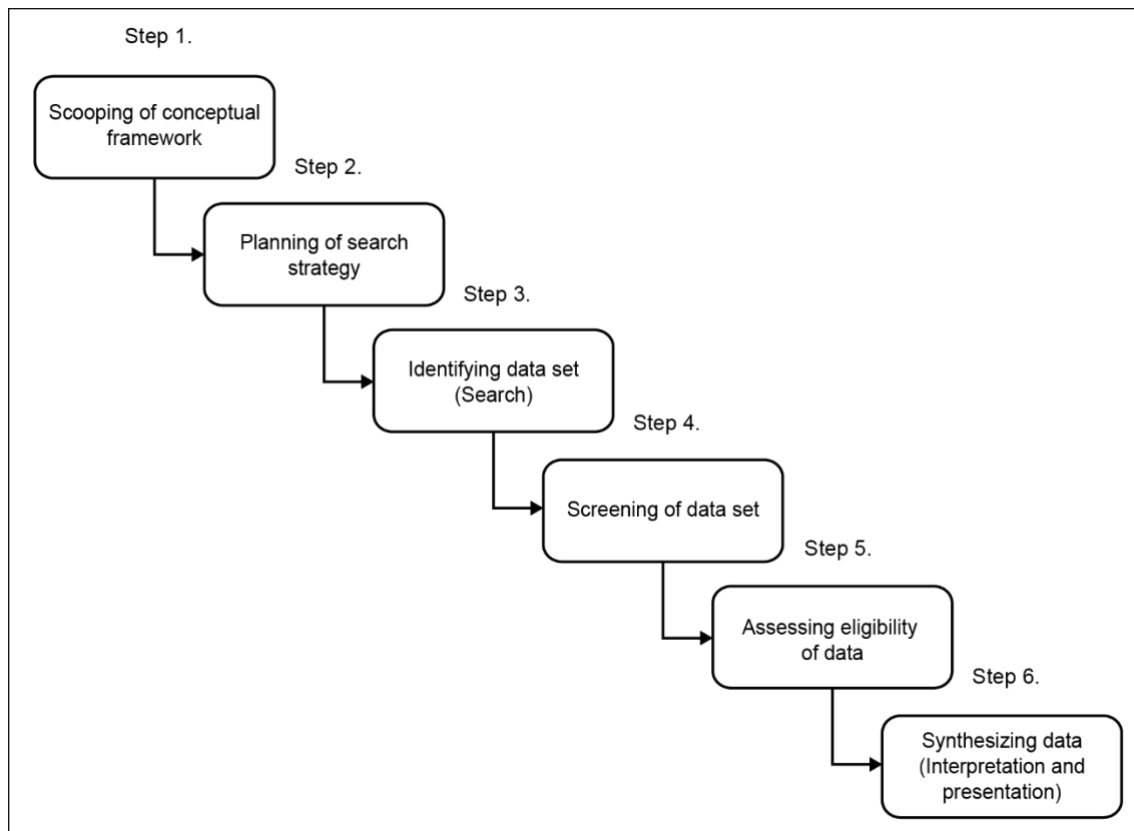
Tranfield et al. (2003) first applied the systematic review approach to reviewing literature in the social sciences using three main stages: planning, executing, and reporting. The main contribution of the method was ensuring a comprehensive, evidence-based review that would be replicable. Although the systematic review emerged from the biomedical field, it has been expanded to provide a framework for systematically providing a rapid review and analysis of the literature that provides evidence-based implications (Cartaxo et al. 2018; Higgins et al. 2019; Mallett et al. 2012; Moher et al. 2011). In contrast to traditional literature reviews, systematic reviews require the use of a planned, standard format applying the scientific method. The difference provides higher quality and sophistication with a comprehensive view of the research. The method should specify how to identify, select, and validate the data set of literature that is clear, recordable, and reproducible. Transparency of the process helps to minimize bias and errors that can arise when summarizing the evidence. Furthermore, there are several approaches to applying systematic reviews, including meta-ethnography, realist synthesis, thematic synthesis, framework synthesis, thematic summaries, and content analysis (Snijlsteit et al. 2012; Wong et al. 2015). This study adopts content analysis because it is transparent, replicable, and the most frequently applied to categorize each theme and to count its frequency to identify key findings (Snijlsteit et al. 2012).

2.1 Scoping and Identification of Studies

The systematic review method allows for the quantitative synthesis of multiple studies using the PRISMA framework including the PICOS strategy (Barba-Martín et al. 2020; Moher et al. 2009; Selçuk 2019). PRISMA makes the process explicit by outlining 27 steps that should be followed and delineating the Population, Intervention, Comparator, Outcomes, and Settings (PICOS) that are analyzed in the review (Selçuk 2019).

The start of the review requires a plan (Figure 1: step 1) on how to first collect the data set of literature (Tranfield et al. 2003; Vivas and Gil 2015). According to the PICOS strategy, a set of keywords is chosen that returns the relevant sources of research while ensuring that nonrelevant literature is omitted from the data set (Figure 1: step 2). The next step is to identify the keywords that are actually used in the search criteria applied to the database query, i.e. Web of Science (Figure 1: step 3). While the first half of the process is automated in the search, the latter half is performed manually to ensure that the resulting data set meets the defined criteria as well as the refined criteria after reviewing the resulting data set. The rules applied to the selection, however, are similar in that they are meant to ensure that the data set is appropriate in content and in quality.

Figure 1: Systematic Review Framework



2.2 Selection of Studies

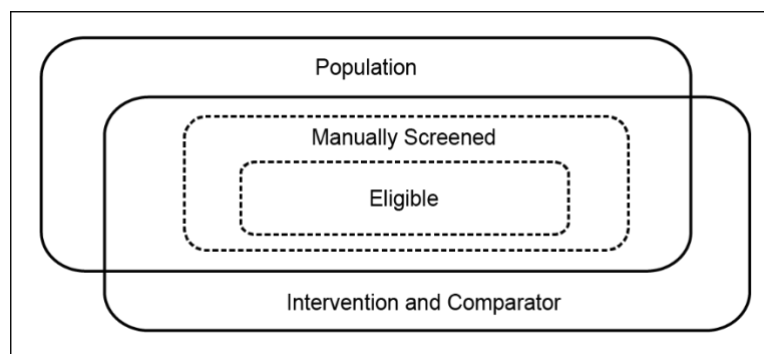
The selection of studies begins with defining the keywords to apply the PICOS strategy. The analysis of the data must predetermine how the research literature will be compared according to the PICOS framework (Table 1). Since the methodology comes from the biomedical field, the framework largely takes on a patient–treatment–outcome perspective.

Table 1: PICOS Framework

PICOS Strategy	
Population	Population or subjects of the research reviewed
Intervention	Intervention or treatment applied to the subjects or population
Comparator	Comparator variable that is being compared across the studies reviewed
Outcomes	Outcomes or results of the studies being reviewed
Setting	Settings or environments in which the studies reviewed were carried out

Once the initial data set is collected, the publications should be further narrowed down by a set of criteria (Figure 2). Systematic reviews focus on literature that is screened for quality of research, i.e., peer-reviewed research. Reviews often remove publications based on the quality of publications, e.g., non-peer reviewed journals or conference papers (Barba-Martín et al. 2020; Mallett et al. 2012; Selçuk 2019). Publications are chosen from English-language journals for practical reasons. The data set was further screened to ensure that the publications involved teacher-training or preparation for adopting mobile- or computer-assisted technologies for the classroom. Some publications that were generally related to classroom instruction but not language instruction were maintained in the final data set.

Figure 2: Selection Criteria Diagram



2.3 Interpretation and Presentation of Results

The third stage synthesizes the information in the resulting data set. While there are several approaches that can be adopted, this study uses content analysis because it is the most common (Snilstveit et al. 2012). The synthesis identifies main themes and patterns in the data set for the topics targeted by the study, i.e., teacher training for computer- and mobile-assisted technologies in the classroom. The themes are quantified to determine the common characteristics of the studies, especially according to the PICOS framework outlined. This approach also allows an analysis of themes that may be expected but missing from the research.

3. RESULTS

3.1 Mobile-Assisted Language Teaching Scope

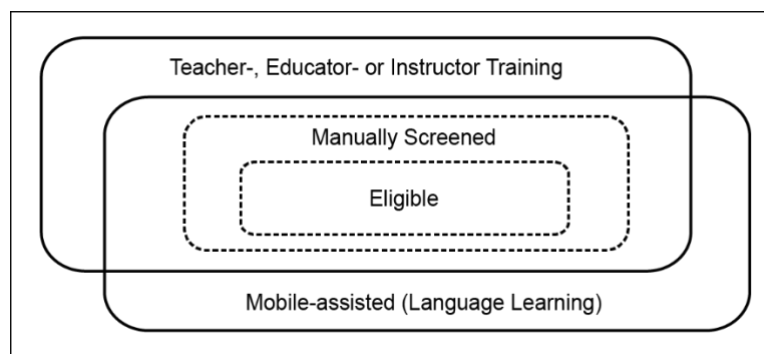
Although pedagogical theory emphasizes the learner perspective, this study focuses on educators. The education research literature refers to computer- and mobile-assisted learning, usually related to language learning, e.g., CALL or MALL. Based on the PICOS strategy (Table 2), the initial search criteria (SC₁) use the keywords to narrow down the eligibility of studies focusing on computer- and mobile-assisted language learning and teacher- and educator-related studies (Figure 3).

Table 2: PICOS Strategy

PICOS Strategy	
Population	Educators or instructors or teachers
Intervention	Mobile-assisted or computer-assisted learning
Comparator	Training on technology or applications
Outcomes	Effects of teacher training or learning or teaching practice
Settings	Education levels and country case

The selection criteria are defined to narrow down the scope of the literature first by automatically selecting the appropriate studies according to the keywords before manually screening the data set further (Figure 3). This process reduces the data set to the studies that are eligible to be reviewed thoroughly according to the purpose of the systematic review.

Figure 3: Selection Criteria Diagram Applied



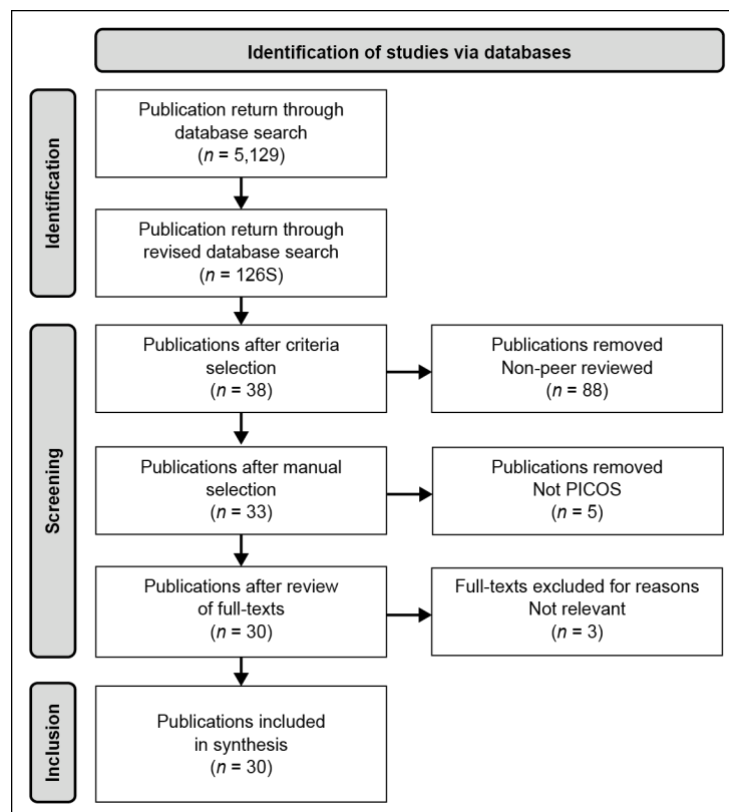
The data set of publications almost solely returned articles that mentioned language learning, which usually also mentioned learners and educators. So, the search criteria (SC₂) were refined. Since educators are almost always mentioned in research involving learning, the keywords chosen using the PICOS criteria were made more specific to the technology- and education-related activity, i.e., training on mobile-assisted teaching (Table 3). Language learning was removed from the search criteria because (i) it made the criteria overly restrictive, (ii) most of the publications in the final data set were still related to language learning, and (iii) the additional research tended to be general research on introducing the related technology to the classroom, which is incorporated into the final analysis.

Table 3: Keywords Used in Database Search

	Search Criteria SC ₁	Search Criteria SC ₂
Technology Keyword	Computer-assisted OR Mobile-assisted	"Computer-assisted" OR "Mobile-assisted"
Topic	Language	n/a
Population	Teacher* OR Educator*	"Teacher training OR "Educator training"
Context (intervention)	Teacher education	OR "Instructor training"

3.2 Literature Selection and Eligibility

Once the keywords were identified for the selection of the studies based on the PICOS strategy, the literature for the review could be identified. The initial search returned 5,129 publications that were reduced to 30 publications through the systematic review (Figure 4). Six of the articles that were removed were written in Spanish. Since the large majority of articles are in English, the results were not largely affected. Once the data set was identified using the PICOS strategy, the rest of the publications were screened. Following previous studies (Barba-Martín et al. 2020; Mallett et al. 2012; Selçuk 2019), this study eliminated nonjournal publications that are not peer-reviewed (88). Most of these were conference papers that focused on survey data of student perspectives, which are not expected to impact the outcome of mobile applications in language teaching. The five publications that were removed manually involved higher education subjects such as medicine or physical education (3), did not involve the target technology (1), and another was a book rather than a journal article (1). Other publications were removed from the final data set after review of the full texts because they focused on irrelevant technology (1), textbooks (1), or the learner only (1).

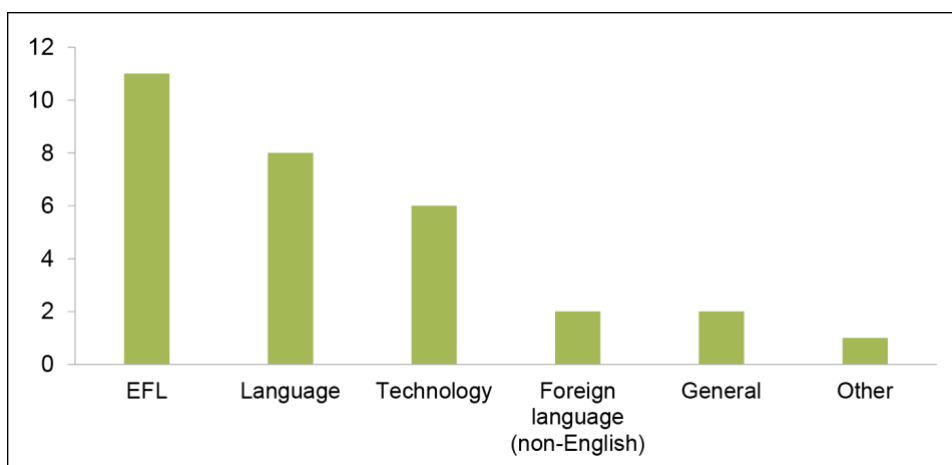
Figure 4: Systematic Review Selection PRISMA Flowchart

3.3 Content Analysis

The final data set of publications included in the synthesis are presented in Appendix A: List of Studies. The final data set is reduced to 30 English-language journal publications. The main themes that are identified as theoretical frameworks that have been applied to MALT in the classroom, language education—especially foreign language education—instruction, and general applications of mobile-assisted technologies to teaching. Other patterns are identified, including concepts, characteristics, benefits, impacts, beneficiaries, and gaps in the research.

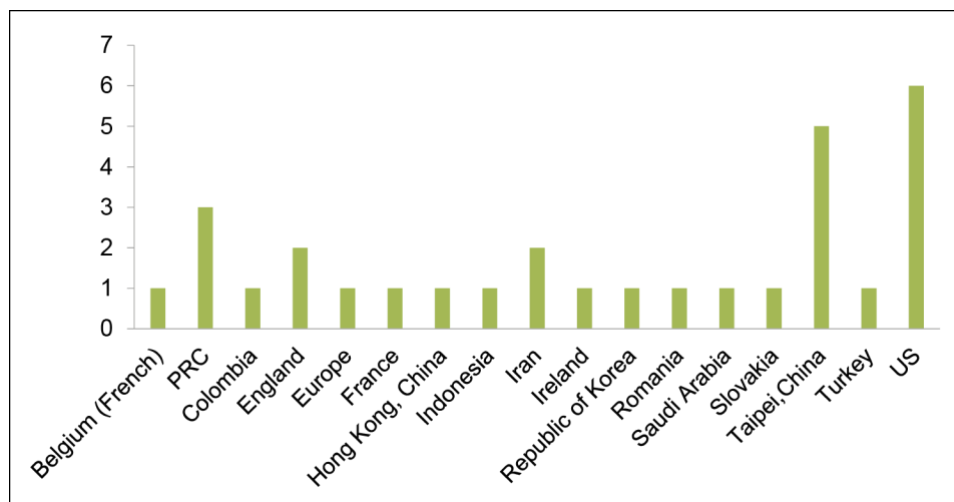
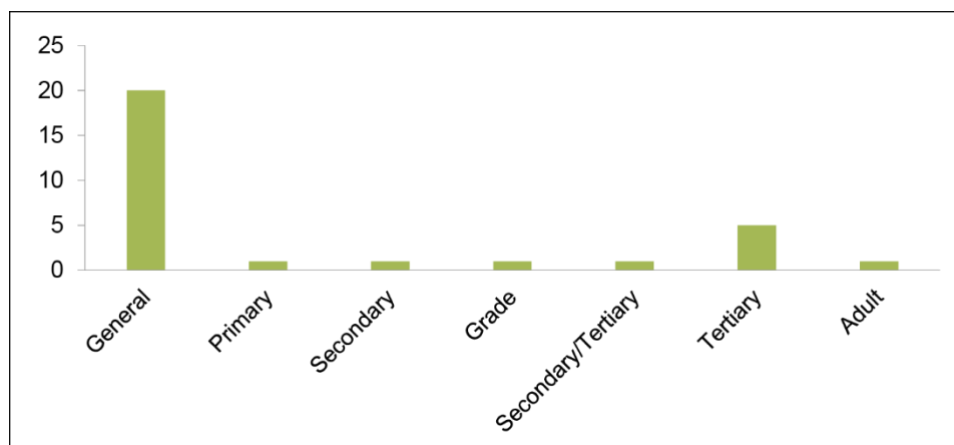
The most common topic or comparator that has been covered in the systematic review is English as a Foreign Language (EFL). A framework for understanding educational technology includes Technology, Pedagogy, and Content Knowledge (TPACK) (Snilstveit et al. 2012; Wong et al. 2015). Therefore, the contents are analyzed for these topic foci (Figure 5). Language learning is by far the most popular focus of mobile-assisted learning research, especially English as a foreign language. When specified, these studies also tend to focus on how to apply existing technologies, such as MS PowerPoint.

Figure 5: Count of TPACK Topics



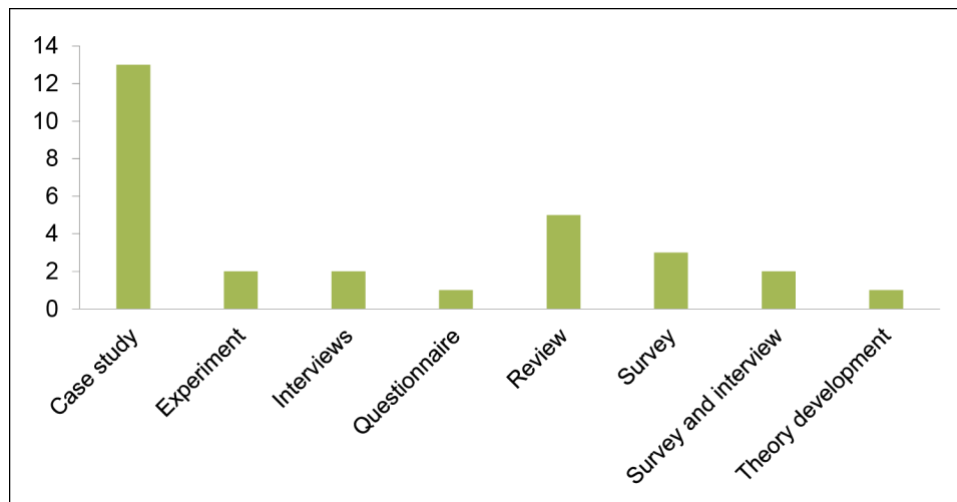
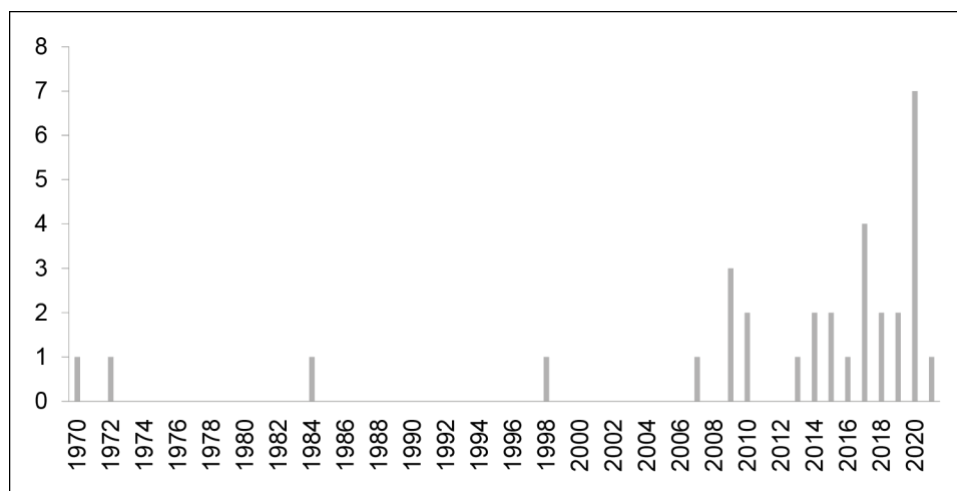
An evaluation of the content settings of the studies is considered from the country and education levels of the studies. The studies in the data set represent the geographical settings in many countries around the world, including countries from four continents (Figure 6). The People's Republic of China (PRC); Taipei, China; and the US are the top three countries that are represented. Of the 18 regions covered, seven countries are in Asia, and only one study is on Indonesia in Southeast Asia.

A distribution based on the level of education the studies focused on is presented (Figure 7). The majority of the studies focus on technology in the classroom generally or do not specify the level of education in the cases that were studied (20). Of the studies that did focus on a specific level of education, tertiary is the most common. Studies that focused on technology, e.g., platforms or analysis, were generally not associated with a particular level of education.

Figure 6: Count of Country Cases**Figure 7: Count by Level of Education Focused On**

The studies are broken down by the method of research that is applied (Figure 8). Of the quantitative studies, only 4 had more than 100 observations. Often these quantitative studies were still focused on single classes. The majority of the methods employed were qualitative. Yet, these studies also focused on narrow aspects of the technologies being applied.

Although the publications in the data set go back as far as 1970, the large majority of them are from 2009 onward after Apple introduced the iPhone in 2007 (Figure 9). With over two-thirds of the publications, the most common subject covered is language education, especially English as a foreign language, which makes up half of these. Language learning was the direct focus of 22 of the publications in the final data set. Half of these focused on English as a foreign language. Even when publications did not focus on language, they would often be related to communications in the subject field, e.g., how to use mobile technology for communications in the medical field. While the research spans many countries around the world including the People's Republic of China; Indonesia; the Republic of Korea; and Taipei, China in East Asia, a third of the research is focused on the US.

Figure 8: Count of Methodologies Employed**Figure 9: Frequency of Publications by Year**

The journals that include publications in the final data set are listed in Table 4. The frequency with which the publications appear in an individual journal is no more than three. Most of the journals that are included in this list focus on educational technology (13), general education or language instruction (5), or on foreign language or multicultural education (4). A number of journals have emerged focusing on the intersection of technology and learning, e.g., *Education and Information Technologies* and *Electronic Journal of E-Learning*. A few other journals that focus solely on technology rather than on education have crept into the list with individual articles appearing in them, i.e., *Quality & Quantity* and *System*.

Table 4: List of Journal Frequency Among Eligible Publications

Journal Title	Frequency
<i>British Journal of Educational Technology</i>	3
<i>Computer Assisted Language Learning</i>	3
<i>Foreign Language Annals</i>	2
<i>Educational Technology and Society</i>	2
<i>Modern Language Journal</i>	2
<i>Arab World English Journal</i>	2
<i>Education and Information Technologies</i>	2
<i>Journal of the American Society for Information Science</i>	1
<i>International Review of Education</i>	1
<i>International Journal of Computer-Assisted Language Learning and Teaching</i>	1
<i>Asia Pacific Journal of Education</i>	1
<i>Journal of Multilingual and Multicultural Development</i>	1
<i>Teaching and Teacher Education</i>	1
<i>Hacettepe University Journal of Education</i>	1
<i>Australasian Journal of Educational Technology</i>	1
<i>Innoeduca-International Journal of Technology and Educational Innovation</i>	1
<i>Language Learning and Technology</i>	1
<i>Mier-Journal of Educational Studies Trends and Practices</i>	1
<i>Quality and Quantity</i>	1
<i>System</i>	1
<i>Computers & Education</i>	1
<i>Electronic Journal of E-Learning</i>	1
<i>Alsic-Apprentissage des Langues et Systems d'Information et de Communication</i>	1

4. DISCUSSION ON MALT INTEGRATION

The results of the systematic review identify how research has typically approached MALT. Most studies focus on language learning despite the scoping of the data identification removing it as one of the constraining conditions. Among these, there is also a heavy emphasis on EFL. The implication is that the type of language education that is reinforced through technology is basic language acquisition rather than complex language learning, e.g., literary analysis. The systematic review also suggests that the technology that has been the focus of this research is older, existing technological solutions that are applied to reinforcing existing modes of teaching. Thus, there seems to be a great deal of room for research into areas that incorporate new technologies such as AI or Big Data, which was the technological focus of only one study in the data set.

The pedagogical aspects tend to focus on the learner perspective. For example, early research also suggests that technology can be adapted to different development stages (Jerman 1970). Considering the TPACK model, these studies tend to adopt existing technological applications and focus on practical aspects of pedagogy. The pedagogy involves the intersection of teacher–student interaction. One study focuses on the delivery of lessons through project-based learning (Tseng and Yeh 2019). Another study focuses on the design of MALT using a practical rather than pedagogical model, using the ADDIE (Analyze, Design, Develop, Implement, Evaluate) model framework (Yeh and Tseng 2019).

There are a few studies that have focused on improving education systems generally (Chiappe et al. 2020; Derobertmeasure and Robertson 2014; Syaifudin and van Rensburg 2018; Yang and Kuo 2020). Some studies focus on general communication capabilities of technologies within and outside the classroom (Chiappe et al. 2020). Others study how existing technologies can be integrated into lessons widely (Syaifudin and van Rensburg 2018). One study took a broad view of integrating new technology for teaching evaluation (Derobertmeasure and Robertson 2014). Rather than focusing specifically on integrating computer- and mobile-assisted technologies into language learning, they have generalized lessons on the entire education system. Yang and Kuo (2020) was the only study that specifically examined how student teachers should adopt strategies of incorporating new technologies into the class.

The technology that researchers and administrators opt for is an important aspect of understanding MALT. While mobile applications are relatively new in the market, there are a number of applications that focus on language learning. The emphasis on research on MALT tends to be on in-house applications or older, existing technologies that do not fully incorporate mobile features. The application of MALT tends to focus on basic level language content and skills (Arnold 2007). Since most applications of MALL are applied at basic skills, this might be expected. This includes vocabulary and simple grammar structures (Kassem 2018). Duolingo, the most popular mobile education application currently available, recently launched an education and testing service. The service is explicitly limited to the basic and intermediate levels of foreign language learning (Ravenscraft, 25 May 2019). While language learning was a criterion for determining the final inclusion in the systematic review, the majority of research on mobile-assisted learning was language focused, especially on foreign language skills.

Current research on MALL/MALT focuses on how students and teachers adapt to existing technologies, often those that have been implemented on a wide scale. The technology offers efficiencies of scale that lessens the burden on both teachers and learners. Gamification of learning, especially with MALL, is increasingly popular (Schiefelbein Chounta, and Bardone 2019), but it has usually been applied to existing modes of teaching. Technology, however, regularly evolves and quickly. Many firms have been developing new apps in the education sector. These companies have gained large shares in the education market, even creating new innovative products. These firms focus on how to develop educational service software for learners. A popular approach to research focused on the attitudes towards technology, i.e., acceptance of technology by the learners or teachers (Nami 2020). Few of these publications, however, were published in peer-reviewed journals and were excluded from the final data set. Additionally, the quantitative studies in the data set have limited numbers of observations. Only four studies involved more than 100 observations (Arnold 2007; Kan and Tang 2018; Metruk 2020; Nami 2020), the highest had 381 observations (Nami 2020). The emphasis on qualitative research would benefit from a focus on newer technologies.

Several benefits are identified for teachers adopting computer- and mobile-assisted technologies for language and other topics. Some benefits are logistical. MALT allows for asynchronous learning (Liaw 2017), which also increases student independence (Lafford 2009; Lee and Martin 2020). This increases classroom efficiency, allowing teachers to focus on more advanced lessons. The backend computer processing enables data analytics, including student performance and course evaluation (Derobertmeasure and Robertson 2014; M.-H. Liu and Kleinsasser 2015). As Big Data are collected by these platforms and private companies, e.g., social media, the technology will also become more adaptive to the needs of teachers and learners, but this perspective is not covered in the existing research focusing on education.

5. CONCLUSIONS

COVID-19 may have forced classrooms to move online but all of the countries in Southeast Asia had been adopting new ICT technologies in just the past decade, including the Internet, broadband, and cellular technologies. Education systems in Southeast Asia can benefit from MALL/MALT in ways that address the specific obstacles that are faced by countries in the region. Computer- and mobile-assisted learning/teaching enables many of these distances over various terrains to be overcome. Moreover, the lessons for foreign languages may provide more reusable components through technology. Technology can provide increased efficiency. Efficiency of teaching may help rates of development, and new technology may help achieve higher efficiency of teaching. While small class size is a desirable characteristic for classroom instruction, it places higher pressure on the supply of qualified teachers. Lastly, the predominant approach to language teaching, i.e., rote memorization, may create an advantage for technology because repetitive activities are more easily automated. Thus, adopting MALT can provide several opportunities in Southeast Asia. The implications will be considered for classroom contexts in Southeast Asia. The different strategies that are employed with ICT and/or mobile technology differ from traditional classroom learning. These strategies, in turn, differ between educational environments in Southeast Asia and other parts of the world. While these possibilities have not been uncovered by the systematic review, the studies in the data set are unlikely to provide any greater insight given the limitations of the research on the topic.

The results of the systematic review within educational research suggest that movement in the intersection of MALL is hampered by limitations in approaches, i.e., assistive technologies. The findings of this study further suggest that there are synergies between the applications and Southeast Asian teaching styles. For instance, while rote learning has limited pedagogical value, its ability to boost learning achievements are enhanced when applied strategically like language acquisition. Efficiencies are also expected by increasing independent learning activities while simultaneously applying tailored lessons using AI algorithms. Individualized “attention” aligns with proximate zones of learning that boost educational outcomes. Variation of student profiles can also be met through the use of technology. Teachers will also be able to improve interactions with students and to engage in higher level learning activities, such as evaluation of comprehension.

One of the main omissions in the existing education research is the changing aspects of the role of the teacher when mobile-assisted technologies are introduced into the classroom. While the question is raised in education research (Syaifudin and van Rensburg 2018), it is not found associated with research on integrating MALT into the classroom. The research that mentions teacher training tends to focus on teacher-led forms of education. While this may be natural to assume in education research, the role of the teacher will change dramatically as technologies develop. The prospect of teacher automation is understandably intimidating (Dandalt 2021). Thus, the research exists but in areas that are adjacent to topics on teacher training for computer- and mobile-assisted learning. The research tends to focus on the interactions between the learner and technology (Hwang et al. 2020) or appears in engineering-oriented journals (Zhai et al. 2021).

Yet, one of the most powerful advances in technology generally is the use of Big Data analytics on large volumes of data that are generated by computer- and mobile-based interactions. Technology is most useful when it increases efficiency and provides new functionality. MALL/MALT applications have demonstrated that they have the potential to provide these benefits. MALL apps are inherently ICT-enabled, which means that they are ripe for providing Big Data. Yet, the studies reviewed tend to move away from Big Data analytics, focusing on narrow observations. None of the articles in the data set mention gamification in relation to teacher training. Further research should involve service providers that are capable of providing access to data but also requires ethics research to ensure no lapses occur. Moreover, much of the research that does focus on integrating teacher perspectives is occurring outside of education research, such as engineering (Wong et al. 2015; Zhai et al. 2021).

The limitations of this study involve scoping of the literature that naturally encompasses the literature from an educational perspective. Thus, the bias of educational research must be considered. If the research approached technological applications without considering the pedagogical aspects, i.e., purely from the technological aspects of applying new technologies, then the results may have found greater applications of newer technologies, such as AI and machine learning. The range of applications of mobile-assisted learning technology. This, however, is dependent on the technical language in the field that tends to limit research on how and where the technology is applied. Asynchronous learning that is independent of a teacher may be outside of the purview of the classroom but not outside the scope of the education system. Moreover, technology constantly evolves as it is adopted for implementation. By focusing on technologies currently used in the field, the research often becomes obsolete even as it is published.

Further study that builds on this area is necessary to enable a full appreciation of the technologies that are becoming available. Moreover, full integration of technological capabilities provided by new technologies also requires the input of educators, especially when it involves changing their roles. Rather than limiting research on teacher training based on existing teacher and student roles, research on education might start from the perspective of how technologies such as CALL and MALL can maximize learner achievements and where teachers can best facilitate activities. In the broader social sciences, the latest technologies are being examined to understand the additive and multiplicative aspects of automation to existing forms of labor (Phelps, 2020)—in this case, teachers.

APPENDIX A: LIST OF STUDIES

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