Effect of Educational Technology on Students' Foreign Language Anxiety: A Thematic Literature Review

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Abstract

Foreign language anxiety (FLA), as a common affective filter, has impeded the language learning process. In order to reduce the FLA, researchers have explored several methods via enhancing language learning settings. Technology as a crucial tool in improving the learning environment has been considered on this topic as well. However, the results of these empirical studies are inconsistent. After reviewing 24 relevant experimental and quasi-experimental research articles from 2016 to 2021 and calculating the effect size for each article, it is evident that 46% of studies reported that technology-assisted instruction significantly decreased FLA, and 54% had no significant effect on FLA. Therefore, this paper aimed to examine the overall effect size on the topic and explore the moderators that caused these inconsistent results through examining five potential moderators (technology type, using methods for integrating technology into a foreign language classroom, exposure duration of technology in experimental groups, FLA type and target language) from the reviewed studies, which are based on the sources of FLA (Young, 1991; Yan & Horwitz, 2008). Two moderators (using methods for integrating technology into foreign language classrooms and target language) were found to get significant predictions on the effect of technology on students' FLA, $p<0.05$. These findings provide educators, researchers, and practitioners a new direction for future research on different methods of teaching the target language using suitable technology in the classroom.

Keywords: foreign language learning, educational technology, foreign language anxiety

1. Introduction

FLA is defined as "a distinct set of beliefs, perceptions, and feelings in response to foreign language learning in the classroom" (Horwitz, Horwitz & Cope, 1986, p.130), which is a situation-specific anxiety inhibiting the language learning process (Horwitz, 2001; Elaldi, 2016; Horwitz, Horwitz & Cope, 1986; MacIntyre & Gardner, 1994). High FLA levels block the students' foreign language learning and achievements (Horwitz, 2001; Horwitz, Horwitz & Cope, 1986; MacIntyre, 2017). For instance, learners with high FLA perceive themselves as incapable of interacting effectively in the target language (Ellis, 2008) and unwilling to use the target language in front of others (Horwitz et al., 1986; Khajavy, MacIntyre, & Barabadi, 2018). FLA as a common experience hinders most foreign language learners from learning (Dewaele, 2002; Liang & Kelsen, 2018; Zheng, Wang, & Chai, 2021). In order to reduce FLA and improve foreign language performance, many instructors and researchers have explored the FLA sources that are relevant to learning settings. The theoretical framework of this study is premised on Young' s (1991) and Yan & Horwitz' s (2008) claims on FLA sources, which relate to learning settings, to explore how educational technology affects FLA. Five primary sources are followed (Young, 1991; Yan & Horwitz, 2008): (1) personal and interpersonal aspects (e.g., self-belief, interpersonal interaction); (2) cultural and regional diversity; (3) class organization; (4) learning strategies; and (5) interest and motivation in target language learning. These five factors are the theoretical cornerstone of the current study.

Since technology plays a crucial role in the educational field (Sarieva & Zoran, 2008), the effects of advanced technology on education, especially on foreign language learning, have attracted a substantial amount of research over the decades (Alyaz & Genc, 2016; Schaefer, Salbego & Lorenset, 2019; Dzhumayov, 2020; Zhang & Zou, 2020), particularly in the COVID-19 period. Technology was deemed to enhance the learning settings and improve

foreign language learning achievements (Hawamdeh & Soykan, 2021). More specifically, educational technology enhanced foreign language learning settings via three features. First, educational technology has no geographical restrictions (Zhang, Wang, & Zhang, 2020). Through the internet platform of educational technology, foreign language learners can get more opportunities to communicate with native speakers of the target language. Second, educational technology provides students more collaborative learning practises both in and out of the classroom with their teachers and peers than before, which is essential for foreign language acquisition (Marden & Herringtron, 2020; Manegre & Gutierrez-Colon, 2020). Third, educational technology can afford real-time feedback for students and teachers (Loncar, Schams, & Liang, 2021). This immediate feedback can help students construct individualised learning patterns that increase their learning motivation and give teachers opportunities to monitor the learning dynamics of their students.

On account of the advent of technology in education, many empirical studies have examined the relationship between educational technology and FLA sources to examine the impact of educational technology on FLA (Li, Liu & Zhang, 2020; Bashori, Hout, Strik & Cucchiarini, 2020). Accordingly, four kinds of relationships between technology and FLA sources are proposed. First, novel technical learning settings have influenced students' personal and interpersonal facets and their learning strategies. For example, they have more opportunities to interact with other peers and teachers and are encouraged to construct individual learning patterns through the adaptive learning functions of educational technology (Simonova, Utemov, & Moskvin, 2017), which impacts the personal and interpersonal aspects of FLA sources. Second, educational technology can stimulate students' interest and motivation in the target language, which has a strong interplay with FLA (MacIntyre, 2017). Likewise, novel and exciting technology games can promote students' interests and motivation (Chen & Wu, 2021) to reduce FLA. Third, educational technology has necessitated reorganising foreign language instruction, including class organisation and learning strategies, in order to impact FLA (Young, 1991). According to Mehring (2016), integrating technology into the EFL classroom has facilitated a shift from a teacher-centered pedagogy to a student-centered pedagogy, which can reduce students' FLA (Gok, Bozoglan, & Bozoglan, 2021). Fourth, educational technology removes geographical boundaries, which provides more opportunities for students to experience the target language cultures. With the 5G network and cutting-edge technology (e.g., VR or AR), foreign language learners can get immersive learning experiences, like immersion in the target language country, to better understand different foreign language cultures than before, which will mitigate their FLA. Although these four relationships coming from the previous studies provide a holistic view of the positive effect of educational technology on reducing FLA, there are still some studies with no statistically significant results. For instance, Terantino (2014) detected that there was no significant difference in students' FLA levels or changes between the technology (online classroom) exposure group and the control group (face-to-face classroom); and Poza (2011) pointed out that students communicate with native speakers through computer settings with a high FLA, which is the same as the traditional classroom. Actually, even though some different studies find the same significant positive effect on the topic, the same results are based on different aspects of the topic as well. For example, Zheng, Wang and Chai (2021) reported that the sequence of using video technology between high-English-level students and low-level ones causes different extents of FLA reduction; York, Shibata, Tokutake, & Nakayama (2021) pointed out that there is a statistically significant difference between video and other advanced technologies in reducing FLA. These consistent and multifaceted results make the researchers unable to quickly compare the findings (Ozkale & Koc, 2020). Therefore, it is essential to have a synthesis or meta-analysis on this topic, providing an accurate and thematic review of these different quantitative studies.

The current study aims to examine the accumulated empirical data on the effect of educational technology on students' FLA through a thematic literature review. Because it can present a systematic and accurate result from the inconsistent results on the topic, and investigate whether there are some moderators that contribute to inconsistency in outcomes by discussing and comparing the five potential moderators (technology type, using methods for integrating technology into a foreign language classroom, exposure duration of technology in experimental groups, FLA type and target language), which are based on the sources of FLA (Young, 1991; Yan & Horwitz, 2008). According to the aim of this study, the following research questions are formulated: The research questions are as follows: (1) What is the effect of technology on students' FLA? (2) Which moderators contributed to the inconsistencies in the effect of technology on FLA? (3) How do the moderators predict the effect of educational technology on FLA?

2. Method

Considering the purpose of the current study was to compare the previous research about the effect of educational technology on FLA and to explore the potential moderators, a meta-analysis method was constructed with the software Comprehensive Meta-analysis (CMA) version 2.0. To avoid missing some papers, we used two search strategies

manually. First, we conducted a backward search (Card, 2015) to scan the reference list of all the review papers to find out the other relevant articles. Second, we used a forward search to examine the review publications that cited key articles on the effect of technology on FLA.

To search for suitable articles, this study used the following keywords were used in the search strategy: keywords related to educational technology ("technology-assisted*," "computer-assisted*," "mobile learning*," "Smart-phone*," "online learning," "distance learning," "web-based software*," "social networking sets, *" "artificial intelligence*," OR "virtual reality*" etc.). AND keywords related to FLA ("foreign language anxiety*," "English learning anxiety," "English speaking anxiety," "English reading anxiety," "English writing anxiety," "English listening anxiety," OR "affective various*" etc.), but excluding motivation and any other emotion changing, except anxiety. Subsequently, the keywords were typed into 6 databases, including 5 English-language databases and 1 Chinese-language database. The English databases are ERIC, Web of Science, Google Scholar, Research Gate and SAGE. The Chinese database is CNKI.

Additionally, three authors coded these 24 studies individually according to a predefined coding schema with the following information: (a) descriptive information (e.g., authors (each study only writes the first author's name and year of publication)); (b) sample characteristics (e.g., sample size); (c) research design (e.g., the different methods, technology types, and exposure duration used in the experimental and control groups); (d) the type of outcome measure (e.g., different types of FLA, foreign language listening anxiety, foreign language speaking anxiety, foreign language reading anxiety, foreign language writing anxiety). After finishing coding, the percentage of total agreement is about 85%, which means the coding result is reliable (see Table 1).

In order to find suitable data to answer the research questions from the reviewed articles, there are seven inclusion criteria for screening the articles: (1) publication must focus on the effect of technology on students' FLA; (2) publications must be published between Jan. 1st, 2016 and Jan. 1st, 2021; (3) research must discuss the effect of technology on students' FLA, excluding other affective changes (e.g., motivation or engagement etc.); (4) A study must include experimental or quasi-experimental research; (5) A study must have an experimental group and a control group, or at least one group including pre-test and post-test for FLA (pre-test is before using technology, and post-test is after using technology); (6) A study must have enough statistical information to calculate effect size (e.g. sample size, mean, SD, t-value, or p value, etc.); (7) The samples are normal students. Studies that failed to fulfil any of these inclusion criteria would be excluded both from the abstract and full-text screening periods. Of the 24 studies that met the inclusion criteria, 21 are journals, 3 are theses; 2 are in Chinese and 22 in English from the six databases.

Studies with significant results are more likely to be published, leading the results of meta-analysis to overestimate the average effect size (Rothstain, Sutton, & Borenstin, 2006). Each study was examined for publication bias. The purpose of publication bias analysis is to evaluate whether a large number of papers were missed or were not included in a meta-analysis (Rothstein et al., 2006). In order to assess the publication bias of this research, first, we inspected the funnel plot (see Figure 3). This funnel plot shows a rough symmetric distribution, which has some outliers obviously. Then we conducted two tests: the Bgger and Mazumdar rank correlation test (Begg & Mazumdar, 1994) and Egger' s regression test (Egger et al., 1997) for the funnel plot asymmetry. The first test indicated evidence for asymmetry, $p< 0.05$. However, the second test showed that there was no publication bias in this research ($p > 0.05$). Because of the difference in results from these two tests, we conducted a Trim and Fill analysis to test the publication bias again. Trim and fill is an approach for modifying the estimated combined effect size by imputing missing effect sizes in order to make the funnel plot symmetric (Duval & Tweedie, 2000). After analysis, the result of Trim and Fill analysis revealed that there were no missing studies identified and they needed to be added. Thus, there is no publication bias in this meta-analysis study.

This study employed the software Comprehensive Meta-analysis (CMA) version 2.0 to calculate the effect size (Borenstein et al., 2009) for the meta-analysis. The raw means, standard deviations and sample size of the experimental group and the control group in each study were picked up to calculate the effect size. Because the high heterogeneity required researchers to consider both sampling error and the diversity between different studies in the random-effect model (Borenstein et al., 2009), this study focuses on the random effect (e.g., Hedges' g) over the fixed effect in the analyses, as there is significant heterogeneity between different articles ($p<0.05$). After that, using sub-group analysis to explore which and how the potential moderators predict significantly the effect of educational technology on students' FLA.

3. Results

To answer the first research question, this study calculated the overall effect size of educational technology on students' FLA of 24 reviewed publications. Hedges' g for the effect sizes were examined under the random-effect

model. As shown in Table 2, technology has a significant positive effect on reducing students' FLA ($p < 0.05$). After combining 24 research effect sizes, the overall effect size is 0.382, which is small to medium (Cohen, 1988). In other words, there is a significant effect of technology on students' FLA, but the effect size is on a small level. Furthermore, to explore the inconsistent results. Q test was conducted for testing the heterogeneity in this study and got $p < 0.01$ (see Table 2). The I^2 statistic was 81.261, which means significant heterogeneity existed in the 24 articles (Higgins, Thompson, Deeks, & Altman, 2003). The high heterogeneity level between different studies means that there is significant heterogeneity between different reviewed publications. In order to explore which moderators predict this heterogeneity on the topic, the current study compared five potential effect sizes (e.g., technology type, using methods for integrating technology into teaching a foreign language; exposure duration of technology in experimental groups, FLA type, and target language), which are based on the sources of FLA (Young, 1991; Yan & Horwitz, 2008), in the random-effects model (see Table 1). A subgroup analysis was used to describe the statistics for each potential moderator. The result is that two potential moderators, using methods ($p = 0.006$) and target language ($p = 0.000$), significantly predict the heterogeneity of the topic (see Table 1), which means these two moderators significantly predict the effect of technology on students' FLA. Besides, the rest of the potential moderators (technology type, exposure duration of technology in experimental groups and FLA type), $p > 0.05$, have no significant prediction on the topic.

Table 1. Effect size and heterogeneity of each moderator

Technology type	Number of articles	Percentage	Effect size (d)	Heterogeneity p-value
CAL	11	46%	0.399	0.883
ML	13	54%	0.377	
Anxiety type				
SA	7	29%	0.215	0.227
WA	2	8%	0.278	
FLA	15	63%	0.456	
Method of using technology				
NC	1	4%	0.764	0.006**
SU	12	50%	0.249	
STU	11	46%	0.460	
Target language				
English	20	83%	0.287	0.000***
French	2	8%	0.686	
German	1	4 %	0.784	
Spanish	1	4 %	1.897	
Exposure duration				
T1	11	46%	0.335	0.443
T2	10	42%	0.467	
T3	3	12%	0.091	

Note. Technology type: all the technology apps are classified into three main categories, CAL= computer-assisted learning (Voice boards, Smart Class, multimedia instruction, online learning, and distance learning), ML=mobile learning(social networking sites, artificial intelligence applications in the smart-phone or i-pad, and AR/VR software, etc.). Anxiety type: SA= speaking anxiety, WA= writing anxiety, FLA= foreign language anxiety, (no reading and listening research was included in this review). Exposure duration: T1=less than one month, T2= from one month to six months, T3= more than six months. Method of using technology: NC= not in the classroom (the research does not take place in the classroom and the method only describe how the students finish the technology task), SU = the method describes how students use technology in the classroom, STU= the method describe how both students and teachers using technology in the classroom.

Table 2. The overall effect size

		95% Confidence Intervals				
Overall sample size	**Overall effect size (g)**	**Lower**	**Upper**	**Q-value**	**I^2(%)**	**p-value**
2066	0.382	0.234	0.530	122.738	81.261	0.000***

To answer the third research question, in this study, two moderators (the method of using technology in a foreign language classroom and the target language) that have a significant prediction on the topic (see Table 1) are compared by the effect sizes of each variation item. For the method of using technology, the effect size of STU is larger than that of SU. This larger effect size of STU is attributed to more teacher assistance than SU. The study with STU means there are interventions on how teachers and students use technology together in the class, but there are none in the study with SU, which merely describes how the students use educational technology in the class. Surprisingly, the study with the CN item had the largest effect size of these three variation items. The study with CN, which was conducted in a setting beyond the classroom setting, provided information on how to complete some learning tasks and exercises through educational technology for the student merely. Subsequently, another moderator is the target language, which includes four variations of the target language (English, French, German, and Spanish). When comparing the effect sizes of items in the target language moderator, it shows that the Spanish item gets the largest effect size, and the English item gets the smallest effect size. It implies that educational technology has the largest positive effect size of FLA when the target language is Spanish, compared to any other target language.

4. Discussion

To reiterate, the purpose of this study is to investigate the effects of educational technology on students' FLA and find out the potential moderators through reviewing 24 articles. The result indicated a significant positive effect on this topic, but the overall effect size is small ($g = 0.384$, random model) (see Table 2). In other words, using educational technology in the foreign language classroom can alleviate the students' FLA significantly, but not to the extreme point. This small overall effect size is probably caused by the lack of longitudinal studies on this topic (Piniel & Csizer, 2015; Li, Liu, & Zhang, 2020). In this study, 46% of publications providing exposure duration in the research were less than one month, and merely 13% of publications gave more than six months of exposure duration research design. Because FLA is a complex emotional reaction (Rubio, 2017), which fluctuates over time (MacIntyre, 2017), it cannot be drastically reduced in a short period of time by technology. Therefore, the results of this review have a small effect size.

After calculating the effect sizes of 24 studies, it was indicated that 46% of the studies had a significant effect on decreasing FLA, and 54% had no significant effect on FLA (see Appendix A). To explore the reasons for this inconsistent result, this study calculated and compared the effect sizes of five potential moderators (technology type, using methods for integrating technology into a foreign language classroom, exposure duration of technology in experimental groups, FLA type and target language) based on the sources of FLA (Young, 1991; Yan & Horwitz, 2008). With the effect size calculated through Comprehensive Meta-analysis (CMA) version 2.0, it was found that two moderators (using methods for integrating technology into a foreign language classroom, target language) got significant predictions on the effect of educational technology on students' FLA. For using methods for integrating technology into a foreign language classroom, there are three variations (SU, STU and NC). Both SU and STU are designed in real foreign language classrooms, and NC is made in an out-of-classroom setting. The distinction between SU and STU is whether there is an intervention regarding how teachers use technology in the classroom or not. This difference between SU and STU provides a larger effect size of STU than SU. This means teacher assistance plays an essential role in this topic. According to the theoretical framework of this study, Personal and interpersonal interaction will change the FLA, which includes not only the interaction between the students, but also the interaction between the students and teachers. This finding follows a report on teacher-student interaction, which found that teacher feedback, guidance, and guiding methods for students could reduce FLA more than those that did not (Toyama & Yamazaki, 2021; Zarrinabadi & Rezazadeh, 2020). Likewise, the study with the CE item had the largest effect size compared to the other two variations. The students who are in this research can only be told how to finish the task of educational technologies beyond the classroom. Unlike classroom settings, these learning environments can improve students' autonomous learning (Lai, 2019) as well as increase their motivation. According to the theory of FLA sources in this study, improving motivation can mitigate students' FLA. The finding is in line with Warni, Aziz and Febriawan' s (2018) research, which indicated that using technology to learn English in the outside classroom can improve students' motivation and self-confidence better than the in-class form, which debilitates their FLA.

Furthermore, the target language got a significant prediction on the topic. Different target languages show different effect sizes. Spanish got the largest effect size in this study, and English got the smallest effect size. In terms of FLA sources, different cultures and regional diversity will influence the students' FLA. Thus, when analysing the different effect sizes on the different target languages, the mother language culture should also be considered. Most subjects who are learning Spanish, German, or French in this study as the target language are English-native speakers;

but when English is the target language, most subjects are Asian. English, German, Spanish, and French are all Indo-European languages, but Asian mother languages, such as Chinese or Malaysian, are very distinct from those four target languages. In other words, the mother language influences the target language and has a distinct impact on the effect of technology on FLA. If the learners' mother language is close to the target language, their FLA can be significantly lower than if the mother tongue is far away.

Considering FLA was related to some individual characteristics (Daubney, Dewaele, & Gkonou, 2017), such as gender or age, there are some limitations to this study. First, gender is excluded from the moderator analysis in this study because most of the reviewed publications did not provide enough relevant information to calculate the effect size on this topic. Second, this study did not include age as a potential moderator. Because there is little research that focuses on the lower age stage (e.g., children) or the higher age stage (e.g., those older than 25 years old) on the topic, and most of the studies focus on university students. Future studies can shed more light on providing statistical data on gender or different ages.

The results of this paper have significant implications for students, instructors, school managers and researchers. First, the largest effect size of the out-of-classroom experimental research indicated that some mobile technology can not only be used in the classroom but can also be used out-of-classroom for the student' s learning, which will enhance students' foreign language learning processes (Szymkowiak, Melović, Dabić, Jeganathan, & Kundi, 2021) and alleviate FLA as well. Second, using technology in a foreign language classroom with teachers' assistance or guidance can have a larger effect on the topic than just considering how students use it in the classroom. Teachers' assistance in integrating technology into the classroom plays an essential role (Evmenova, Regan, Ahn, & Good, 2020) on this topic, which means teachers or school managers should pay attention to how to improve teachers' technological content knowledge (TCK) and technological pedagogical knowledge (TPK) to reduce students' FLA, rather than only offering advanced and novel technology in the classroom. Third, the different effect sizes of different target languages on the topic provide a hint for the other researchers. FLA is not only impacted by the technology, but also by the relationship between the learners' mother language and the target language.

5. Conclusion

In conclusion, the review of the 24 empirical studies conducted and the overall effect size calculated clearly shows that educational technology could significantly alleviate students' FLA. Moreover, the high level of heterogeneity between different reviewed studies means there are some moderators to predict the effect of technology on FLA. In this sense, five moderators (technology type, using methods for integrating technology into a foreign language classroom, exposure duration of technology in experimental groups, FLA type and target language) were examined in this study, and two of them (using methods for integrating technology into foreign language classrooms and target language) were determined to get significant predictions on the topic. Based on the review done, it is believed that the findings will contribute to the body of information concerning the impact of technology on students' FLA. Specifically, studies on the methods of using technology and different target languages in educational technology settings will need to be given due emphasis to create better pathways for differentiated instruction to meet the demands of today' s technology advancement in language learning.

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Appendix A

Characteristics of primary studies included in the analysis

Author (year)	Sample size	Technology type	Using method	Experimental duration	Target language	FLA type	Effect size(g)
Apple, 2020	101	CAL	STU	T2	Spanish	FLA	1.897
Bashori, 2020	167	CAL	SU	T1	English	FLSA	0.086
Cote, 2018	61	CAL	STU	T1	English	FLA	0.686
Duygu, 2020	64	CAL	SU	T2	English	FLA	-0.161
Ghanizadeh, 2018	124	CAL	STU	T3	English	FLA	-0.262
Hsu, 2021	48	CAL	SU	T2	English	FLA	0.716
Liu, 2021	332	CAL	STU	T2	English	FLA	0.010
Madzlan, 2020	54	CAL	STU	T2	English	FLSA	0.583
Shahi, 2016	60	CAL	NC	T2	English	FLA	0.764
Stephanie, 2021	60	CAL	SU	T3	English	FLA	0.686
Yang, 2016	229	CAL	SU	T1	English	FLSA	0.103
Alla, 2020	76	ML	SU	T3	English	FLA	-0.074
Ataeifar, 2020	30	ML	SU	T1	English	FLSA	0.416
Bollinger, 2017	147	ML	STU	T1	English	FLA	0.363
Keskin, 2016	39	ML	STU	T2	English	FLA	0.366
Lech, 2018	15	ML	SU	T1	German	FLA	0.784
Li, 2020	158	ML	STU	T2	English	FLA	0.627
Nuzulia, 2020	60	ML	SU	T1	English	FLA	0.337
Punar, 2018	21	ML	STU	T1	English	FLSA	0.801
Shakir, 2017	28	ML	STU	T1	English	FLWA	0.517
Shazly, 2020	30	ML	SU	T1	English	FLSA	0.369
Yuyet, 2020	60	ML	SU	T2	English	FLSA	0.234
Yavuz, 2020	47	ML	SU	T2	English	FLWA	0.080
Zou, 2019	55	ML	SU	T1	English	FLA	0.702

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