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Technology Anxiety and Class Size as Boundary of Instructional Effects in L2 Pronunciation: A Moderated Mediation Model

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***Abstract*—Although pronunciation instruction has been shown to improve L2 learners' pronunciation performance, the indirect and moderating effects of learner differences, class size, and technology anxiety on this relationship remain underexplored. Previous studies have primarily focused on direct instructional effects, while anxiety has been an underexplored mediator, and the moderating roles of technology anxiety and class size have received limited attention. Therefore, this study investigates whether learner anxiety mediates the relationship between pronunciation instruction and learner performance, and technology anxiety and class size moderate the relationships among instruction, anxiety, and performance. A moderated mediation model was tested by employing structural equation modeling with data from 349 English learners at a public university. The results show that learner anxiety does not mediate the relationship between pronunciation instruction and pronunciation performance. Technology anxiety does not significantly moderate any relationship in the model. Class size significantly moderates only the relationship between learner anxiety and pronunciation performance. This study contributes to the literature by showing how psychological and contextual factors shape pronunciation performance. It also offers pedagogical implications for optimizing environments for pronunciation learning.**

***Index Terms*—class size, pronunciation instruction, learner anxiety, moderated mediation, technology anxiety**

I. Introduction

Pronunciation plays a crucial role in second-language (L2) learning because mispronouncing a word in the second language can not only undermine motivation to learn but also, more seriously, lead to errors in other language-learning skills (Hodgetts, 2020). Therefore, Lorch (2016) argued that the first stage of L2 learning should focus on accurate pronunciation. As a result, teaching pronunciation to enable L2 learners to pronounce accurately has received considerable attention from researchers. Effective pronunciation instruction includes helping learners distinguish similar sounds through minimal-pair drills (Celce-Murcia et al., 2010) and developing the habit of accurately pronouncing target sounds through listening (Larsen-Freeman, 2000). In addition, providing feedback on learners' pronunciation and reinforcing it through verbal or non-verbal praise are crucial (Saville-Troike, 2006). The pronunciation instruction highlights the potential value of systematically teaching pronunciation in L2 classrooms.

Despite this consensus, empirical findings regarding the effectiveness of pronunciation instruction remain inconsistent. Some studies report improvements in learners after segmental pronunciation training (Rogers & Dalby, 2005; Bent et al., 2007; Collins & Mees, 2013). Other studies show only significant progress when learners are taught with suprasegmentals (Tanner & Landon, 2009; Derwing et al., 2014; Saito & Saito, 2017). Besides, integrating technology into pronunciation learning leads to learner progress in segmentals and suprasegmentals (Rogerson-Revell, 2021). These discrepancies suggest that teaching pronunciation input may not fully explain the outcomes of L2 learners' pronunciation learning since it can influence learners through mediated learner differences and under specific contextual conditions (Pawlak, 2023).

However, most studies in this field are correlational, mainly examining the direct relationships between factors such as beliefs (Jarosz, 2023), anxiety (Szyszka, 2011), motivation (Nagle, 2018), willingness to communicate (Baran-Łucarz, 2014), aptitude (Saito et al., 2019), and working memory (Simard et al., 2020). Although these studies have examined how mediating factors—learner differences—can strengthen, weaken, or even reverse the effects of pronunciation instruction on learner performance, elements such as technology anxiety and class size can serve as modifiers, altering the effectiveness of teaching strategies across different learning contexts. By overlooking both mediating relationships and moderating conditions, current studies risk oversimplifying the complexity of teaching impacts. In addition, these studies might have provided an incomplete picture of how teaching and learning processes work in today's real classrooms.

From a theoretical standpoint, the complexity of pronunciation learning cannot be fully explained by a single

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framework; it can involve the interplay of multiple dimensions. One important perspective comes from some social psychologists who have considered language anxiety as a "personality trait" (Gardner & MacIntyre, 1993, p. 5). They suggest that emotional factors can interfere with language acquisition by restricting learners' ability to process input and participate actively in communication (MacIntyre, 2017). However, emotional factors alone do not account for all variations in learning outcomes. It can depend on several different factors such as cognitive load. It highlights the balance between instructional demands and learners' cognitive capacity. This can either support or hinder performance, especially in environments where technology is involved (Mitchell et al., 2019). In addition, interactional and sociocultural perspectives also emphasize classroom conditions that include active classroom participation, opportunities for interaction, and engagement (Ellis & Sheen, 2006). All of these factors shape how learners experience and develop their pronunciation skills (Mitchell et al., 2019). When considered together, these perspectives suggest that L2 pronunciation learning unfolds through a complex interaction of internal and external factors, rather than following a simple instruction.

Therefore, most previous studies have primarily focused on examining the direct impact of pronunciation instruction on pronunciation outcomes or considering learner-related factors individually, such as anxiety, motivation, and working memory. However, it remains underexplored whether pronunciation instruction can influence pronunciation ability through psychological mechanisms, particularly pronunciation anxiety. At the same time, the role of classroom contextual factors, such as technology anxiety and class size, in moderating the relationships among pronunciation instruction, anxiety, and pronunciation performance has received limited attention. In particular, it is still unclear whether these effects are positive or negative, strong or weak, in specific teaching contexts. Methodologically, most previous studies have examined isolated relationships or have focused mainly on direct effects. Few have considered multiple variables simultaneously within an integrated research design. Consequently, there is a need for studies that use linear structural equation modeling (SEM) to examine the relationships among pronunciation teaching, pronunciation anxiety, pronunciation ability, technology anxiety, and class size.

To address these limitations, the present study proposes an integrated moderated mediation model. This model integrates instructional, psychological, and contextual factors in pronunciation learning. This model allows researchers to test multiple effects simultaneously. This study provides a clearer understanding of whether and to what extent pronunciation instruction influences pronunciation performance.

II. Literature Review

A. The Direct Effect of Pronunciation Instruction on Pronunciation Performance

Pronunciation instruction (PI) has long been regarded as an important part of L2 learning because mispronunciation can do more than reduce speech clarity (Sardegna & Jarosz, 2023). Simultaneously, it helps learners gradually improve their pronunciation in terms of intelligibility and accuracy. PI contributes to improving pronunciation awareness in L2 learners and leads to better Pronunciation performance (PP). In many classes, L2 learners need clear guidance from the teachers. This helps learners improve their awareness of the vocal organs and become familiar with the English phonological system, including segmentals and suprasegmentals (Jarosz, 2023). All these elements will help learners develop comprehensively in accuracy and fluency, as Waniek-Klimczak (2003) asserts. For that reason, pronunciation might be treated as an early instructional priority in L2 classrooms, particularly when learners need support in producing target-language sounds more accurately.

In practice, PI support can take different forms. Some techniques help the learners, such as teacher gestures and actions (Howatt, 1984), a series of listening and repetition exercises (Larsen-Freeman, 2000), habit formation in learners (Richards & Rogers, 2001), and minimal pair exercises (Celce-Murcia et al., 2010). In addition, teacher feedback is also an important part of the pronunciation teaching process, helping L2 learners pronounce effectively. Thanks to teacher feedback, learners can improve their pronunciation skills and enhance their L2 awareness (Zhang & Yuan, 2020). Teacher feedback can also foster the development of production and cognitive skills (Kennedy et al., 2014). Teachers' feedback remains central to the instructional process because learners often need explicit guidance to notice errors and adjust their pronunciation. Hence, pronunciation instruction is not limited to presenting phonological content. It also organizes how learners practice, how learners manage, and how learners refine their output through the teacher's feedback in the pronunciation classroom.

From the complexity given, pronunciation learning does not appear to follow a simple one-way path from teaching to performance. Effects of the pronunciation learning process may unfold through learner-related processes and under specific contextual conditions. Besides, PI consistently offers learners opportunities to notice phonological features, practice them repeatedly, and receive the teacher's feedback. In doing so, it may improve not only accuracy in segmental and suprasegmental production but also intelligibility in communication. On that basis, it remains reasonable to expect that PI will contribute positively to pronunciation performance and to what extent. Accordingly, the following hypothesis is proposed:

H3. Pronunciation instruction is expected to positively affect pronunciation performance.

B. Pronunciation Anxiety as a Mediating Mechanism

In addition to directly affecting pronunciation performance, pronunciation instruction may indirectly influence it through pronunciation anxiety (AN) as a learner-related factor (Pawlak, 2023). AN arises from specific language-learning

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contexts rather than general personality traits (Ellis, 2015). Consequently, high levels of anxiety tend to hinder language learning effectiveness and achievement. Common anxiety in learning pronunciation includes peer comparison (Bailey, 1983), spontaneous communication, fear of negative judgment, and language exams (Horwitz et al., 1986). Furthermore, high anxiety can limit working memory processing, reducing learners' ability to process input and absorb feedback (Sheen, 2008). Hence, anxiety does not affect all learners in the same way, as learners vary greatly in what they perceive: a task that is stressful for one learner may be comfortable for another (Horwitz, 2001). Pronunciation is an easily detectable aspect of L2 use because learners' errors are audible to teachers and peers; as a result, many learners feel stressed, embarrassed, or afraid of negative judgment when pronouncing in the target language.

This emotional dimension matters because it can affect how learners respond to pronunciation instruction. High AN may reduce processing efficiency, particularly in low working memory. It also makes the learning process more difficult for learners to absorb corrective input. As Horwitz (2001) notes that learners differ in how they interpret classroom demands. In pronunciation learning, such variation is important because it helps explain the reason: the same instructional input may lead to different outcomes across learners. Pronunciation instruction may partly influence pronunciation performance by reducing learners' AN during the pronunciation process. Explicit instruction and supportive teacher feedback may make pronunciation practice less stressful and more relaxed. This argument also aligns with Pawlak's discussion of learner differences, which includes anxiety among the variables that may help explain how pronunciation instruction affects learning outcomes.

At present, however, much of the relevant research remains correlational and gives greater attention to direct relationships than to explanatory mechanisms embedded within an integrated model (Pawlak, 2023). As a result, there is still limited evidence on whether pronunciation instruction affects pronunciation performance indirectly through changes in learners' AN, particularly in the same or different directions and their degree of impact. This gap provides a comprehensive rationale for treating AN as a mediator in the present study, and the following hypotheses are proposed:

H1: Pronunciation instruction is expected to negatively influence pronunciation anxiety.

H2: Pronunciation anxiety is expected to negatively influence pronunciation performance.

H4: Pronunciation anxiety is expected to mediate the relationship between pronunciation instruction and pronunciation performance.

C. The Moderating Role of Technology Anxiety and Class Size in L2 Pronunciation Learning

In addition to the psychological factor, contextual conditions may influence how instructional effects unfold. Technology Anxiety and Class Size are two important contextual conditions in contemporary language learning environments.

Technology may provide opportunities to reduce anxiety and strengthen pronunciation learning. During the process of L2 pronunciation, learners often experience anxiety due to fear of making mistakes, fear of negative evaluation, or a lack of confidence when speaking in front of others (Ellis, 2015). However, technological developments in pronunciation have created many opportunities to alleviate anxiety. Technological developments effectively support pronunciation in the teaching-learning process, such as voice recognition software, pronunciation practice apps, and online learning platforms (Bueno-Alastuey & Gómez-Lacabex, 2022). Moreover, learners can be corrected for pronunciation errors without fear of being judged (Strik et al., 2008). In addition, technology also helps learners control their learning pace (Flege, 2009). These benefits suggest that when technology is used effectively, pronunciation instruction may be more effective at reducing pronunciation anxiety.

However, when learners experience technology anxiety (TECH), these benefits may be weakened. This may happen because learners who are not proficient in computers experience discomfort when using them (Chakim et al., 2023). This can negatively affect their learning, and lead to psychological pressure around the use of computers in their studies. Psychological pressure, considered a cognitive load, has been identified as a key mechanism linking TECH to learner anxiety (Puri et al., 2025). TECH is an individual's emotional fear of using or interacting with computers. Therefore, TECH is a significant barrier affecting computer use, learning, and ultimately the learning activities and academic achievement of students. Hence, further research is needed to examine the negative moderating effects of TECH on the relationships among pronunciation instruction and pronunciation anxiety, pronunciation anxiety and pronunciation performance, and pronunciation instruction and pronunciation performance. Therefore, the following hypotheses are proposed:

H5a: Technology anxiety is expected to weaken the negative relationship between pronunciation instruction and pronunciation anxiety.

H5b: Technology anxiety is expected to strengthen the negative relationship between pronunciation anxiety and pronunciation performance.

H5c: Technology anxiety is expected to weaken the positive relationship between pronunciation instruction and pronunciation performance.

In addition, class size (CS) represents an important contextual condition in pronunciation learning. It may influence how pronunciation instruction affects pronunciation anxiety, how pronunciation anxiety influences pronunciation performance, and how pronunciation instruction directly affects pronunciation performance. Aoumeur (2017) indicated that CS can affect learners' learning and performance, as well as teachers' instructional practices. In smaller classes, they tend to create a more supportive learning environment and pronunciation instruction is perceived as more effective (Finn

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et al., 2003). Learners are more engaged in practice actively and receive specific feedback. Consequently, although they are more likely to achieve better learning outcome, increased participation and exposure may also raise their anxiety levels due to more frequent performance in front of others (Raja, 2017). In contrast, in larger classes, learners typically have fewer opportunities to speak, limited chances to practice, and receive less individualized feedback from teachers. As a result, their anxiety may not necessarily increase, and CS may not be significantly associated with learners' anxiety (Moneva et al., 2020). When the level of pronunciation instruction remains constant, its impact on reducing anxiety and improving performance may vary across CSs. Accordingly, the following hypotheses are proposed:

H6a: Large class size is expected to weaken the negative relationship between pronunciation instruction and pronunciation anxiety.

H6b: Large class size is expected to weaken the negative relationship between pronunciation anxiety and pronunciation performance.

H6c: Large class size is expected to weaken the positive relationship between pronunciation instruction and pronunciation performance.

To sum up, this study views pronunciation learning as a process shaped by both internal factors and external conditions. Accordingly, the study addresses the following research question:

How does pronunciation instruction influence learners' pronunciation performance through anxiety, and how do technology anxiety and class size moderate these relationships?

To answer this question, a conceptual model is developed to illustrate the proposed relationships among five constructs: pronunciation instruction (PI), anxiety (AN), pronunciation performance (PP), class size (CS), and technology anxiety (TECH), as presented in Figure 1:

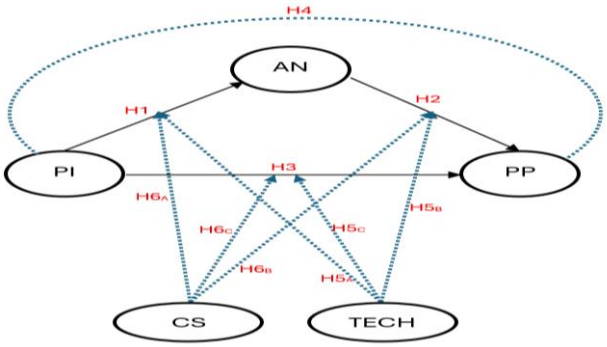


Figure 1. Conceptual Model of the Relationships of PI, AN, PP, CS, TECH

III. Research Method

This study used a quantitative research design with survey data to simultaneously examine the relationships among pronunciation instruction (PI), pronunciation anxiety (AN), pronunciation performance (PP), class size (CS), and technology anxiety (TECH). In addition, the PLS-SEM method was chosen because of its predictive ability. The objective is to explain pronunciation anxiety and pronunciation performance in terms of pronunciation instruction and contextual moderating factors. PLS-SEM focuses on maximizing the explained variance (R^2) of these two dependent variables. Therefore, PLS-SEM is well-suited to handle such complexity because it can estimate all relationships simultaneously without strict distribution assumptions (Hair et al., 2014).

A. Sample

A total of 354 non-specialized first-year students from one public university completed the questionnaire. A convenience sampling technique was used. Then, students who had participated in specialized pronunciation courses or possessed certificates from standardized tests were excluded from the sample. This removal helps to avoid bias caused by prior learning experience. After this screening process, the final sample comprised 349 students in the main phase of the research. The sample number was determined based on the sample-size calculation guidelines proposed by Hair et al. (2014). This sample also included a relatively balanced number of male and female participants, which helped improve the representativeness of the data and minimize possible bias related to gender distribution and contextual factors across the university.

B. Instruments

Researchers used online questionnaires via Google Forms as a data collection tool to test mediating and moderating relationships in the proposed model. The survey included five constructs:

Pronunciation instruction was developed from studies by Celce-Murcia et al. (2010) and Bryfonski and Ma (2020), focusing on measuring the level of instruction explicitness and teacher feedback. It included 14 items, with some typical statements such as: "The teacher explains how English sounds are formed (e.g., mouth or tongue position)".

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Pronunciation anxiety was developed based on Ellis (2015), reflecting anxiety aspects such as trait, state, and situation-specific anxiety. It consisted of 7 items, for example: "I feel nervous before I have to pronounce English sounds in class".

Pronunciation performance, developed from Jarosz (2023), included 16 items to assess segmental, suprasegmental, and intelligibility accuracy. Some illustrations are: "I can pronounce English consonant sounds accurately".

Class size consisted of 5 items, developed from Blatchford and Russell (2020), reflecting learners' perceptions of large class size, with typical statements such as: "My class is too large for the teacher to give individual attention".

Technology Anxiety also includes 5 items, developed from Langerock et al. (2025), to measure learners' challenging experiences and feelings with technology in pronunciation learning. A typical example is: "I feel anxious about using technology-based tools to evaluate my pronunciation".

C. Instrument Development and Validation

The survey questionnaire consists of 47 items to measure PI, AN, PP, CS, and TECH. Each question is measured on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The questions were initially designed in English and then translated into Vietnamese. To ensure accurate measurement, the questionnaire was reviewed and commented on by two pronunciation instructors. Next, the questionnaire was tested with two non-specialized first-year students to evaluate the comprehensibility of each statement.

A pilot study was conducted with 50 students, after adjustments based on feedback from pronunciation instructors and students. The pilot outcomes were tested with SPSS (V27) using Cronbach's Alpha and EFA. The results showed that all Cronbach's Alpha values were above 0.70 (Aldrich, 2018). This means that the scales had good reliability. All corrected item-total correlation values were higher than 0.30. Therefore, all items were acceptable and were kept for further analysis. The EFA results were also satisfactory. The KMO values were above 0.80, and Bartlett's test was significant at $p < 0.001$ (Aldrich, 2018). These results show that the data were suitable for factor analysis and the measurement scales were reliable.

D. Data Analysis

Data was analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS, following a two-stage procedure (Hair et al., 2019). In the first stage, the measurement model was assessed to ensure the reliability and validity of the five constructs. They are indicator reliability (outer loadings), internal consistency (Cronbach's alpha and composite reliability), convergent validity (AVE), multicollinearity (VIF), and discriminant validity (the Fornell–Larcker criterion and HTMT ratio). In the second stage, the structural model, after bootstrapping, was evaluated to test the hypothesized relationships by examining path coefficients (β), their statistical significance (p-values), explanatory power (R^2), effect sizes (f^2), and predictive power (Q^2).

IV. Results

In this section, the researchers present the results of the conceptual model's analysis, which includes two main parts: the measurement model and the structural model in PLS-SEM analysis.

A. The Measurement Model

The measurement model was first assessed to ensure the quality of the constructs. All indicators showed that outer loadings exceed the recommended threshold of 0.70 (Hair et al., 2019), indicating satisfactory indicator reliability. In terms of internal consistency, both Cronbach's alpha and composite reliability values for all constructs (PI, AN, PP, CS, TECH) were above 0.70 (Hair et al., 2019). At the same time, all average variances extracted (AVE) values exceeded 0.50 (Hair et al., 2019). This confirms adequate reliability, and Convergent validity was also established. Discriminant validity was verified using both the Fornell–Larcker criterion and the HTMT ratio to lower than 0.85 (Fornell & Larcker, 1981). Specifically, the collinearity assessment is with VIF < 3.0 (Hair et al., 2019). Taken together, these results indicated that the measurement model demonstrated satisfactory reliability and validity, supporting its suitability for subsequent structural model analysis with bootstrapping.

B. The Structural Model

After Bootstrapping, the structural model was initially evaluated using path coefficients (β), significance levels (p-values), and effect sizes (f^2). Then, coefficients of determination (R^2) and predictive power (Q^2) were also evaluated.

(a). Direct Effects

The results of the direct effects in the structural model are presented in Table 1.

Table 1
Structural Model Results: Direct Effects

Hypothesis	Relationship	β	f^2	p-value	Result
H1	PI → AN	-0.093	0.004	0.254	Not supported
H2	AN → PP	-0.206	0.045	0.000	Supported
H3	PI → PP	0.305	0.040	0.001	Supported

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The direct effects show clear patterns in the relationships among pronunciation instruction, learner anxiety, and pronunciation performance in Table 1 as follows:

PI shows a negative coefficient with learner anxiety (β = −0.093). Although this indicates that increased PI input is associated with a slight reduction in anxiety, this relationship is not statistically significant (p = 0.254), with the effect size being negligible (f^2 = 0.004) (Cohen, 1988). This suggests that PI does not have a statistically significant effect on AN. Therefore, H1 is not supported.

In contrast, AN negatively affects pronunciation performance (β = −0.206, p < 0.001). These figures indicate that a high AN level is associated with poorer performance. Although this relationship is significant, the effect size remains small (f^2 = 0.045) (Cohen, 1988), being still stronger than the relationship between PI and AN. This suggests that AN is a stronger predictor of PP than PI is of AN. Thus, H2 is supported.

PI, on the other hand, demonstrates a positive and significant effect on PP (β = 0.305, p = 0.001). This indicates that PI directly enhances PP. Nevertheless, the effect size is also small (f^2 = 0.040) (Cohen, 1988) and slightly lower than the relationship between AN and PP, implying that while PI is beneficial, its influence is relatively limited. Therefore, H3 is supported.

(b). Mediating Effects

The results of the mediating effects in the structural model are presented in Table 2.

TABLE 2
STRUCTURAL MODEL RESULTS: MEDIATING EFFECTS

Hypothesis	Relationship	β	p-value	Result
H4	PI → AN → PP	0.019	0.302	Not supported

The mediation result in Table 2 reveals that the indirect effect of PI on PP through AN is very small and not statistically significant (β = 0.019, p = 0.302). This means that PI does not significantly improve PP by reducing AN. Therefore, AN does not mediate the relationship between PI and PP. Thus, H4 is not supported.

(c). Moderating Effects

The results of the moderating effects in the structural model are presented in Table 3.

TABLE 3
STRUCTURAL MODEL RESULTS: MODERATING EFFECTS

Hypothesis	Relationship	β	f^2	p-value	Result
H5a	TECH x PI -> AN	-0.057	0.008	0.121	Not supported
H5b	TECH x AN -> PP	-0.032	0.001	0.607	Not supported
H5c	TECH x PI -> PP	-0.023	0.003	0.630	Not Supported
H6a	CS x PI -> AN	0.013	0.000	0.780	Not supported
H6b	CS x AN -> PP	0.164	0.035	0.005	Supported
H6c	CS x PI -> PP	0.078	0.008	0.121	Not supported

Regarding the moderating effects in Table 3, TECH does not significantly moderate any of the proposed relationships. The moderation of TECH between PI and AN is negative but non-significant (β = −0.057, p = 0.121) with a negligible effect size (f^2 = 0.008) (Cohen, 1988). These results indicate that a negative aspect of TECH can not change the effect of PI on AN. Similarly, the moderation of TECH between AN and PP is not significant (β = −0.032, p = 0.607) and shows no effect (f^2 = 0.001) (Cohen, 1988). The interaction between TECH and PI on PP is also non-significant (β = −0.023, p = 0.630), with a negligible effect size (f^2 = 0.003). These findings suggest that TECH does not alter the model's relationships, and its negative aspect does not moderate them. Therefore, H5a, H5b, and H5c are not supported.

CS presents a different pattern compared to TECH. The interaction between CS and PI on AN is negligible and non-significant (β = 0.013, p = 0.780, f^2 = 0.000), indicating no moderating effect. Similarly, CS does not significantly moderate the relationship between PI and PP (β = 0.078, p = 0.121), with the effect size being small (f^2 = 0.008). However, CS significantly moderates the relationship between AN and PP (β = 0.164, p = 0.005) with the effect size being small (f^2 = 0.035). The positive and significant interaction effect indicates that a large class size weakens the negative effect of pronunciation anxiety on pronunciation performance. This suggests that classroom context shapes how emotional factors affect learning outcomes. Hence, H6a and H6c are not supported, and H6b is supported. The most notable finding of this study is that CS significantly moderates the relationship between AN and PP, highlighting the critical role of learning context in shaping how emotional factors influence language outcomes.

(d). Model Explanatory Power and Predictive Relevance

This study examines two important indicators: R^2 and Q^2, to assess the quality of this model. R^2 indicates the proportion of variance in the endogenous constructs, like AN and PP. Q^2 simultaneously reflects its out-of-sample predictive relevance. These indicators provide additional evidence of the explanatory power and predictive capability of this model in this study (Hair et al., 2023):

As for Explanatory Power**,** the model explains 22.4% of the variance in pronunciation anxiety and 29.5% of the variance in pronunciation performance. These proportions indicate a moderate level of explanatory power. Additionally,

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the higher proportion of relatively higher R^2 values for PP indicates that the model is more effective at capturing performance-related outcomes than emotional factors, as shown in Table 4.

TABLE 4
MODEL EXPLANATORY POWER (R^2)

Construct	R-square	R-square adjusted
AN	0.235	0.224
PP	0.311	0.295

As for Predictive Power, the Q^2 values indicate moderate predictive relevance for both AN ($Q^2 = 0.153$) and PP ($Q^2 = 0.254$). According to Hair et al. (2023), Q^2 values above zero confirm the model's predictive relevance; values around 0.15 indicate a low level, and values around 0.25 indicate a moderate level. These results suggest that the model demonstrates adequate predictive capability, particularly for PP, as shown in Table 5.

TABLE 5
PREDICTIVE POWER (Q^2)

Construct	Q^2 (=1-SSE/SSO)
AN	0.153
PP	0.254

To sum up, the results indicate that the model achieves from small to moderate explanatory and predictive power. Particularly, this model predicts PP more strongly than AN. Although most relationships exhibit only small effects, CS emerges as the most influential factor, exerting a moderate impact on both AN and PP. This suggests that the model's predictive strength for performance outcome is driven more by contextual conditions, particularly class size, rather than by technology, as presented in Figure 2:

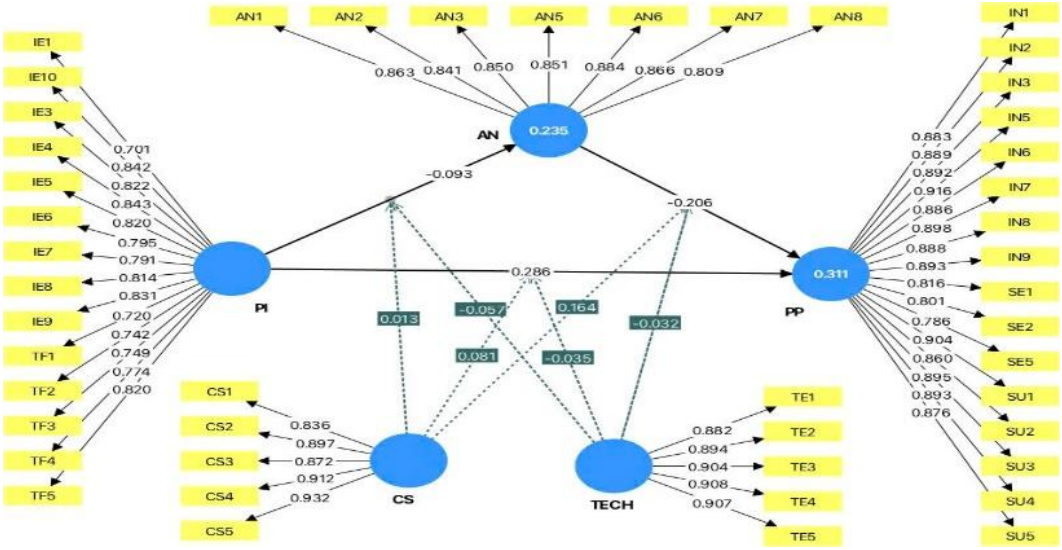


Figure 2. Structural Equation Model of the Relationships of PI, AN, PP, CS, TECH

V. DISCUSSION

The findings of this study provide several important insights into the relationships between PI, AN, and PP. The results show that PI did not directly reduce AN levels. This suggests that AN in pronunciation learning is not primarily shaped by PI but is influenced by a wider range of individual and contextual factors. AN can change depending on learners' emotions at different times, in different situations, and in different ways to interact with their surroundings, as Ellis (2015) stated. In addition, learner differences such as working memory, self-confidence, prior learning experiences, and aptitude (Edwards, 2017) may play a more substantial role in shaping AN than instructional input itself. This is also consistent with previous studies, which emphasize the roles of motivation (Nagle, 2018), communicative readiness (Baran-Łucarz, 2014), linguistic aptitude (Saito et al., 2019), and working memory (Simard et al., 2020) in L2 learning and performance. Overall, the effectiveness of PI appears to depend more on learner differences, of which AN is only one component. Therefore, AN should be understood as a relatively independent psychological construct that cannot be easily altered through instruction alone. AN was found to have a significant impact on PP. This finding is consistent with a large body of second-language acquisition research to emphasize the role of affective factors in language production (Ellis, 2015) because high levels of anxiety can disrupt cognitive processing, reduce attentional control, and discourage active participation. These elements ultimately limit learners' opportunities to practice and refine their pronunciation. As noted by fear of negative judgment (Horwitz et al., 1986), it intensifies anxiety and directly affects performance. PI also makes

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a strong direct contribution to PP, highlighting the central role of pronunciation instruction in developing accurate and intelligible pronunciation (Waniek-Klimczak, 2003). These findings also align with previous research, such as Szyszka (2011) and Gómez-Lacabex and Gallardo-del-Puerto (2023).

Notably, the absence of a mediating role suggests that AN is not the primary mechanism through which PI influences PP. As discussed above, AN is only one factor among many learner differences, alongside working memory, self-confidence, prior learning experiences, and aptitude (Edwards, 2017). Therefore, AN is not strong enough to act as a bridge between PI and PP. In other words, although AN influences PP, it is not the main pathway through which teaching impacts learning outcomes. Consequently, the mediating role of AN in this model is considered negligible. Therefore, the findings further suggest that the model demonstrates stronger explanatory and predictive capacity for PP than for AN. This implies that performance outcomes are more directly driven by instructional input and contextual factors, whereas learners' emotions remain influenced by broader individual differences beyond the model. In addition, this model's predictive relevance is more effective at forecasting learning outcomes than at forecasting emotional states. Hence, this reinforces the view that PI plays a more stable role and a measurable role in shaping PP. At the same time, AN is more variable and context-dependent.

A key contribution of this study lies in the moderating role of CS. The results show that CS does not play the same moderating role across all relationships in the model; rather, it moderates differently and selectively. Specifically, CS modulates how AN influences PP, consistent with previous literature emphasizing the contextual role of CS in shaping learning conditions (Aoumeur, 2017). CS can influence learner learning performance and teacher teaching practices. However, the findings in this study suggest that its role may be more modal and situational than previous results. CS becomes significant when considering how AN influences PP. Although CS is significant in the moderating relationship of AN on PP, it does not strongly impact learner anxiety levels. This supports the argument that AN is not strongly determined solely by class size (Moneva et al., 2020). Instead, AN appears to be a psychological factor influenced by many other classroom factors. Although learners may have fewer opportunities to practice and interact, the pressure to perform is often less immediate and less individualized. This may explain the results of this model because when the class is large, as in public universities, it can reduce the extent to which anxiety directly affects performance. Learners are less frequently placed in situations where their performance is closely observed or evaluated.

The TECH does not moderate the proposed hypotheses. This indicates that these negative influences may not be strong enough to alter the relationships among PI, AN, and PP. One possible explanation is that learners today are increasingly familiar with digital tools. They may reduce the anxiety typically associated with TECH. As a result, TECH may function as a neutral rather than disruptive factor in the learning process. Therefore, several studies emphasize its benefits to supportive functions in reducing anxiety through private practice and immediate feedback dominantly (Flege, 2009). This finding shows that TECH is not the influencing factor in the pronunciation teaching-learning process.

VI. Conclusions

This study investigates the moderated mediation model with 349 students, using the PLS-SEM method, which suggests that pronunciation learning is shaped by more than instruction alone. The model explains pronunciation performance more clearly than learner anxiety, indicating that learning outcomes are easier to capture than emotional processes within this framework, with class size as the moderating factor. These empirical findings contribute to our understanding of the pronunciation-teaching and learning process. Particularly, technological anxiety is not a barrier to technology-assisted pronunciation learning, so teachers should maximize the benefits of technology in teaching pronunciation. Educational institutions should design pronunciation classes with appropriate learning conditions, as a reasonable class size can create a better environment for pronunciation practice. This study also has limitations in the data collected through self-reports, the cross-sectional design, and the measurement of variables at a single time point. Therefore, future studies should collect data at multiple time points to improve the generalizability of the findings. Future models could incorporate additional learner differences to provide a more comprehensive understanding of pronunciation development in second-language acquisition.

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APPENDIX. QUESTIONNAIRE ITEMS

Construct	Item	Questions
PI	IE1	The teacher explains how English sounds are formed (e.g., mouth or tongue position).
	IE3	My teacher explicitly teaches pronunciation using minimal pairs (e.g., ship–sheep).
	IE4	The teacher practices contrasting sounds within the same sentence.
	IE5	The teacher practices contrasting sounds across different sentences.
	IE6	The teacher regularly uses listen-and-repeat drills to practice pronunciation.
	IE7	The teacher explicitly points out which syllable in a word should be stressed.
	IE8	The teacher explicitly teaches the rhythm of English.
	IE9	The teacher explicitly explains rising and falling intonation patterns.
	IE10	The teacher explicitly explains features such as stress, rhythm, and intonation.
	TF1	When my teacher corrects my pronunciation, I notice it.
	TF2	Hearing my teacher repeat my words with correct pronunciation helps me improve.
	TF3	I learn pronunciation better when my teacher clearly tells me what is wrong.
	TF4	My teacher gives frequent feedback on individual sounds.
	TF5	I receive pronunciation feedback to focus on word-level accuracy.
AN	AN1	I feel nervous before I have to pronounce English sounds in class.
	AN2	Before a pronunciation activity begins, I worry about how I will perform the pronunciation.
	AN3	I am afraid that others will think poorly of my pronunciation ability when I make mistakes.
	AN5	I avoid pronouncing English sounds because it makes me feel uncomfortable in class.
	AN6	I feel anxious during pronunciation drills or oral correction.
	AN7	I feel tense when the teacher evaluates my pronunciation.
	AN8	I feel anxious when I know others will evaluate my language performance.
CS	CS1	My class is too large for the teacher to give individual attention to each student.
	CS2	The number of students in my class limits my opportunities to practice.
	CS3	In my class, it is difficult for the teacher to correct everyone's pronunciation.
	CS4	Class size affects the quality of feedback I receive.
	CS5	Because of class size, I receive little pronunciation feedback.
TECH	TE1	I feel stressed when I have to rely on technology to practice pronunciation.
	TE2	I feel uncomfortable using pronunciation-learning technologies.
	TE3	I feel anxious about using technology-based tools to evaluate my pronunciation.
	TE4	It takes a lot of effort to use pronunciation technologies effectively.
	TE5	The features of pronunciation technologies are too complex for me.
PP	SE1	I can accurately pronounce English consonant sounds.
	SE2	I can accurately pronounce English vowel sounds.
	SE5	I can distinguish and produce similar English sounds.
	SU1	I use correct word stress when speaking English.
	SU2	I use sentence stress accurately to highlight important information.
	SU3	My speech rhythm sounds natural in English.
	SU4	I use intonation patterns that match my intended meaning.
	SU5	My speech flows smoothly without unnatural pauses or breaks.
	IN1	I pronounced individual sounds clearly during my speech.
	IN2	My consonant and vowel pronunciation helped others understand my words.
	IN3	My pronunciation at the word level and sentence level is accurate enough for others to understand.
	IN5	I used word stress clearly enough for others to understand my meaning.
	IN6	My sentence stress highlighted important information.
	IN7	My intonation helped convey my intended message.
	IN8	My speech rhythm and pausing made my speech easy to follow.
	IN9	The overall flow of my speech supported understanding.

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