

태국 여학생들의 고음 발성 능력 향상을 위한 교수·학습 개발

Developing Teaching Exercises to Enhance High Note Formation in Female Thai Students

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Abstract The purpose of this research was to develop a set of vocal exercises to support healthy high-note formation in Thai female singers, whose voices are often more sensitive than male voices. The methods combined qualitative and quantitative approaches with an experimental component. Experts in Thai linguistics and professional singing selected 23 Thai words from an initial pool of 189, based on articulators that avoid strain when sung at C5. Vocal exercises were arranged according to six consonant groups, combined with single and long vowels, and practiced using major scales from A3 to F4. The study was conducted as a case-by-case intervention over 12 sessions across six weeks. The results showed statistically significant improvement in participants' high-note singing techniques, with average performance increasing from 39.33% (pre-test) to 73.33% (post-test). All participants successfully reached C5, and 80% (n=5) consistently exceeded C5 without vocal strain. The conclusion indicates that the developed exercises are effective for enhancing high-note singing in Thai female students. Suggestions include adapting the exercises for broader use across different linguistic groups and investigating long-term vocal health outcomes.

Key words: female singers, healthy voice, Thai phonetics, vocal exercises

초록 본 연구의 목적은 남성보다 더 민감한 경우가 많은 태국 여성성악가들의 건강한 고음 형성을 지원하는 발성 연습 세트를 개발하는 것이다. 연구 방법은 질적 연구와 양적 연구를 실험적 요소와 결합하여 수행되었다. 태국 언어학 및 성악 전문가들은 초기에 선정된 189개의 태국어 단어 중에서 C5 음을 부를 때 무리를 주지 않는 조음 기관에 기반하여 23개의 단어를 선정하였다. 발성 연습은 6개 자음군에 따라 구성되었으며, 단모음과 장모음을 조합하고 A3부터 F4까지의 장음계를 사용하여 연습하였다. 본 연구는 6주 동안 총 12회 세션에 걸쳐 사례별 중재 형식으로 진행되었다. 연구 결과, 참가자들의 고음 발성 기술이 통계적으로 유의미하게 향상되었으며, 평균 성취도가 사전 평가 39.33%에서 사후 평가 73.33%로 증가하였다. 모든 참가자가 C5 음에 도달하였고, 80%의 참가자(n=5)가 성대에 무리를 주지 않고 안정적으로 C5를 초과하는 음에 도달할 수 있었다. 결론적으로 본 연구에서 개발된 발성 연습은 태국 여성 학생들의 고음 발성 향상에 효과적임을 나타낸다. 제언으로는 다양한 언어 그룹에 맞춰 연습을 확장 적용하고, 장기적인 성대 건강에 대한 추가 연구를 수행할 것을 제시한다.

주제어: 여성성악가, 건강한 목소리, 태국어 음성학, 발성 연습

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I . Introduction

The impact of the human singing voice is mediated by several factors, with vocal quality playing a pivotal role in effective communication. Singing conveys stories, emotions, and feelings powerfully and concurrently (Juslin & Västfjäll, 2008). The voice arises from vibrations in the tissues and muscles opposite the larynx, situated between the base of the tongue and the top of the trachea (Suárez-Quintanilla et al., 2023).

Vocal cords housed within the larynx are activated through speaking or singing, causing vibrations that generate sound waves. These waves are modified by the resonant cavities of the nose and mouth, producing unique sound levels and tones for each individual (Khambata, 1977). Recent observations reveal that many singing teachers emphasize vocal quality and the aesthetics of singing, but often overlook potential challenges faced by singers. The surge in singing contests and television shows since 2000 highlights the growing popularity of singing in Thailand, reflecting diverse listening preferences and an expanding singing industry (Chanasongkram, 2017). This trend underscores the importance of adapting teaching methods to accommodate a broader range of vocal styles and pedagogical challenges.

Singing competitions evaluate a range of vocal qualities, including accuracy in vocal level and tone, personality, stage presence, rhythm, melody, and technique. Singers are expected to articulate high notes clearly and perform correctly in the Thai language, which demands extensive practice (Hongtao & Li, 2022). Each type of singer faces different demands, training requirements, and vocal effects due to their unique styles and experiences (Pestana et al., 2017). Ewer (2014) notes that mastering high notes is crucial for technical proficiency and for conveying the emotional expression intended by the songwriter. Moreover, research highlighted in *The Journal of Voice* discusses how through rigorous training, singers can enhance their ability to express a broad spectrum of emotions, moods, and even complex linguistic messages (Watts et al., 2003).

Physical differences between males and females contribute to natural variations in their vocal ranges. Female singers often face greater challenges and are more prone to vocal difficulties, experiencing voice health issues more frequently than their male counterparts (Boltežar & Bahar, 2014; Hunter et al., 2011; Tepe et al., 2002). Proper vocal techniques are thus crucial for reducing the risk of vocal injuries among female singers. The concept of the ‘mixed voice’ or ‘mixed register’ describes a transition zone in vocal ranges, with males typically having a lower range. This mixed register, often referred to as the bridge or *passaggio*, spans from D4 to G4 for males and A4 to B4 for females (Sell, 2017). According to C. Ware’s (1998) Two-Registers Theory,

the highest note in the female mixed register is C5. Achieving notes above these ranges presents challenges for both genders, requiring dedicated practice and vocal training.

The disparities in singing capabilities primarily arise from practice, which necessitates not only potential and effort from the students but also effective teaching methods that prioritize vocal quality and health. Good vocal quality involves several factors, including proper singing practices to prevent potential injuries to the vocal cords. In recent times, there has been a notable increase in vocal problems among the general population, often due to improper voice use (Doscher, 2023). Common issues include hoarseness, difficulty singing, sore throat, laryngitis, and pharyngitis, leading to a loss of ability to hit high notes (Bo, 2021). Equally, professional vocalists often encounter vocal difficulties if incorrect techniques are employed. Common issues include pharyngitis, laryngitis, and vocal nodules, prevalent among many performers (Chapman & Morris, 2021). The misuse of vocal techniques can lead to inability to sing high notes without risking injury to the vocal cords, primarily due to misunderstandings about proper voice use (Aaen et al., 2024). The most effective prevention strategy is to avoid incorrect voice use altogether.

Internationally recognized singing programs focus extensively on correct vocal production. These institutions emphasize techniques designed to minimize injury risk during practice and enhance overall vocal quality (Pabon et al., 2014). Such training improves vocal quality during performances and expands singers' capabilities (Santelli, 2023). Language plays a crucial role in shaping singing styles due to differences in linguistic structures, including unique pronunciations, alphabets, and vowels. These elements affect vocal registers and resonances, requiring modifications to align with language-specific characteristics, further complicating the integration of pitch and melody. Mastering high-quality singing in Thai, for instance, necessitates a comprehensive understanding of these linguistic nuances (Latartara, 2012). While there are numerous studies on singing techniques, combining medical and linguistic knowledge remains underexplored. Research like the study of vocal quality disorders among elementary school teachers in the Dusit area, and the effectiveness of voice therapy for vocal nodule patients at the Ramathibodi Hospital's Speech Clinic, highlight the potential benefits of integrating speech exercises in vocal training. This research therefore aims to enhance the singing capabilities of female students aged 18-25 through a mixed-method approach. By integrating the Thai linguistic system with medical principles, the study seeks to develop safe training options for students when singing in high registers, particularly above B4, to prevent potential vocal injuries. Establishing these exercises will benefit vocal education in Thailand, enabling students to strengthen their voice production safely and effectively.

II. Literature Review

Vocal resonance is the process by which the vocal folds vibrate and cause the air column above them to vibrate as well. This vibration is amplified by the resonating cavities of the body, such as the chest, throat, mouth, nose, and sinuses (Sundberg, 2001). The different resonating cavities can be activated to produce different vocal qualities. For example, low pitches and open sounds are often associated with the chest and lower body, while high pitches and closed sounds are often associated with the head and face. The placement of the voice refers to how the vocal folds interact with the resonating cavities. When the vocal folds are placed in the chest, the sound is produced with a lot of chest resonance. When the vocal folds are placed in the head, the sound is produced with a lot of head resonance. The quality of the voice is also affected by the shape of the vocal tract. For example, a narrow vocal tract will produce a brighter sound, while a wider vocal tract will produce a darker sound.

Vocal resonance, crucial for both singing and speaking, amplifies sound and creates a pleasant vocal quality. The process works like this: vocal folds vibrate at a natural frequency based on their length, thickness, and tension. This vibration travels up an air column that resonates at the same frequency. The body's resonating cavities, like sinuses and the mouth, amplify this vibration. Finally, the shape of your vocal tract, formed by your tongue and mouth position, influences the sound quality. The good news is that vocal resonance can be improved through practice and training exercises (Stemple & Dietrich, 2011).

Fixed formants are the characteristic resonant frequencies of the vocal tract that are responsible for the different vowel sounds (Sundberg, 2001). They are also known as overtones or rings. Sundberg also stated that the frequencies which are most successful in travelling through the vocal tract are called resonance for formant frequencies. The first three formants are the most important for distinguishing between vowels. The first formant (F1) is the lowest formant and is responsible for the overall vowel quality. The second formant (F2) determines the frontness or backness of the vowel, and the third formant (F3) determines the height of the vowel. The shape of the vocal tract affects the frequencies of the formants. For example, a narrow vocal tract will produce higher formants, while a wider vocal tract will produce lower formants. The tongue also plays a role in shaping the vocal tract, and by moving the tongue forward or backward, we can change the frequencies of the formants. The control of formants is an essential component of good singing. By learning to control the shape of the vocal tract, singers can produce clear and resonant vowels.

Articulation and vowel modification is also crucial to the formation of specific speech sounds. The essential organ which creates this specific sound is the mouth. The air and vibration pass through the vocal tract and are shaped by the articulators into recognizable speech sounds. Movable articulators are structures that can move and allow us to shape the sound, (i.e. the jaw, the lips and other facial muscles, the tongue, the soft palate - the soft, movable tissue constituting the back of the roof of the mouth - and the pharynx). Fixed articulators are those that cannot be moved by muscles, namely the hard palate and teeth. The hard palate is a thin, horizontal bony plate of the skull, located in the roof of the mouth, which spans the arch formed by the upper teeth. It forms a partition between the nasal passages and the mouth. Vowel modification is the tuning of vowel formants which means the vocal folds resist the breath strongly enough to make a closure of vocal folds and also produce a richer tone (Doscher, 2023). Vowels in singing are also needed to be modified or substituted because of the limitations of the human voice (Thummarattana, 2015). Some vowels are hard to pronounce when female singers sing in high notes with mixed registers.

1. National Education Association (NEA) of Thailand

Today, educators navigate a dynamic landscape where hybrid learning models have become the new normal. This shift presents a unique set of challenges, but also exciting opportunities, for fostering student engagement. The National Education Association provides a guide that outlines key concepts and practical recommendations for creating successful hybrid learning environments (Lewis, 2021). Hybrid learning is at the core of the NEA's guidance (Chantanasut, 2018). This approach merges elements of both in-person and online instruction, offering students flexibility in how they participate. The guide delves into two prominent models within the hybrid spectrum: hyflex and blended learning (Hjernøe, 2024). Hyflex allows for a more synchronous approach, empowering students to choose between attending sessions physically, participating virtually in real-time, or even engaging in a combination of both. Blended learning, on the other hand, leans more heavily on asynchronous learning, where online components seamlessly complement face-to-face instruction. Regardless of the specific model employed, the NEA emphasizes a singular, overarching goal: fostering student engagement.

However, achieving this goal requires moving beyond simply delivering content. The NEA champions pedagogical practices that actively draw students into the learning process, catering to their diverse learning styles. The guide encourages educators to become adept at identifying

how individual students learn best. This might involve utilizing visual aids for kinesthetic learners, incorporating hands-on activities for those who thrive through tactile experiences, or fostering collaborative work for students who excel in group settings. Furthermore, the NEA advocates for a shift away from passive learning approaches and champions active learning strategies that involve problem-solving activities, discussions and collaboration.

2. Gagné theory of learning and instruction

Mastering practical skills is crucial for music students. Gagne's (1988) model of instructional design provides a valuable framework for educators to create effective lesson plans for these skills. Gagne outlines nine key events for successful instruction. The first events aim to capture learners' attention and activate their prior knowledge. Following this, clearly stated learning objectives inform students about the specific skills they will acquire. An interactive discussion can then revisit relevant theoretical content. The remaining events focus on skill development and assessment. To solidify understanding, the instructor can demonstrate the entire process, offering helpful tips and explanations. This is followed by supervised practice and independent learner demonstration. While initial practice in a controlled environment is crucial, true skill transfer occurs when learners perform the under supervision in a real-world setting, gradually progressing towards independent practice. By following Gagne's structured approach, educators can create effective lesson plans that equip students with the necessary skills to confidently foster long-term knowledge retention and real- world application (Khadjooi et al., 2011).

The process of learning can be broken down into nine steps: 1) gaining attention - grabbing the learner's interest, 2) specifying objectives - clearly stating what the learner will achieve, 3) activating prior knowledge - connecting new information to what the learner already knows, 4) presenting new information - introducing the new content in a clear way, 5) guiding learning activities - providing support and resources to aid understanding, 6) eliciting responses - giving learners opportunities to practice, 7) providing feedback - offering constructive criticism to improve performance, 8) assessing performance - evaluating mastery of the new skill, and 9) reviewing and transferring - reinforcing learning and encouraging application in new situations.

III. Method

The study was a mixed methods study, which means that both quantitative and qualitative methods were used. The quantitative data was collected through an experiment, and the qualitative data was collected through interviews. The study was conducted in four phases. The first phase was an experiment conducted to find singing problems in Thai female singers aged 18-25 years. This age group was selected because the vocal folds have reached full physiological maturity by age 18, yet retain optimal elasticity and trainability until around age 25, making them an ideal population for investigating high-note formation and vocal training outcomes. We interviewed 23 singing professional teachers about the problem of high notes singing in Thai female singers. We also conducted an experiment to find singing problems from female students aged 18- 25 years who study at university and have singing experiences. We found all 16 problems of high notes singing in Thai female students. The researchers first generated a comprehensive list of 189 words by selecting consonants and vowels across all six places of articulation, ten manners of articulation, and the full range of Thai vowel types; these words were then used in an expert-validated test to assess potential risk of vocal-cord injury during high-note singing. The result was identification of 23 key words for further analysis. The third phase was a subsequent experiment to evaluate the 23 Thai words to prove that they could produce high- quality voices by professional Thai female singers. Finally, the experiment was conducted with five students as a case study over a period of six weeks to develop high-quality voices for the students.

The research population was purposively selected and divided into groups: 1) twenty-three professional vocal teachers; 2) twenty-five students with more than 5 years of experience in studying or singing, or studying at a music university, majoring in singing at the undergraduate level; 3) three Thai linguists; 4) twelve expert singers; 5) three professional Thai female singers; 6) five student participants fulfilling the following criteria: university students with non-music major, Thai female singers, aged 18-25 with at least 3 years experience of singing lessons. The students underwent voice level measurement by experts and were required to perform in a major scale and to sing basic songs correctly. The volunteers needed to commit to 16x30-minute sessions, 2 times a week for an 8-week period and to practice at home for 15 minutes per day, 3 times a week throughout 8 weeks. All volunteers provided informed consent to be included in this study, and the strictest ethical procedures were upheld.

Qualitative data was collected by structured interview, observation and discussion. In this research, there were two main types of observation: direct observation, where we directly watched

participants warm up and sing, listening to their singing and noting their behavior. We also observed the participants via video recordings of the participants that we assigned as homework. Further data was gathered using evaluation forms, performance of a song for defining Thai female vocal problems (Khohn Jao Nam Dta), sets of Thai phonetic word exercises, songs for pre-test and post-test: Khohn Jao Nam Dta, a vocal problem evaluation form, personal improvement diary form, weekly student improvement report forms and Logic Pro and Melodyne sound analysis programs.

Quantitative data was collected in both a pre-test and post-test with repeated measures design. The dependent variable was the ability to reach a healthy voice in a high notes (C5). The independent variable was sets of Thai vocal exercise. For the pre-test, students used the words ma and the Thai pop song Khon Chao Nam Ta to measure participants' ability to sing high notes. During the experiment, 10 sets of vocal exercises using Thai words were performed. The post-test used the same tests and respondents as the pre-test.

Following identification of problems with vocal technique, we designed a series of exercises to address the difficulties encountered by singers. First, we studied the content and substance of the set of exercises to find the concept model, set the objectives, arrange the learning activities, prepare teaching materials, and evaluate the teaching materials. Then, we implemented the exercises after checking the consistency of all steps and evaluating the suitability of the exercises by experts. Finally, we created a student achievement assessment form, for self- assessment, expert assessment, and research. Ultimately, we developed a 12-week teaching plan in a hybrid learning format, with 2 sessions per week, 30 minutes per session. The sessions were conducted face-to-face and online. Students were required to complete homework and keep a Student Personal Improvement Diary throughout the experiment, which lasted for 6 weeks.

The effectiveness of the research intervention was assessed using a multi-tiered approach, combining self-assessment through pre-tests and post-tests, allowing for a quantitative comparison of students' performance before and after the experiment. Additionally, various qualitative factors were considered, including student engagement, knowledge acquisition, skill development, attitudes and perceptions, and feedback from specialists. This comprehensive evaluation approach provided a holistic understanding of the experiment's impact on student learning and identified areas for improvement in future educational practices by 1) measuring the quality of the voice when singing scales with a range of pitches from A3 to C5; 2) measuring the quality of the voice by singing the song Khohn Jao Nam Dta at the pitch of C5; and 3) record the voice to be evaluated by Logic Pro and Celemony by Melodyne Studio.

IV. Results

The study found the following problems in female students who have difficulty singing high notes: 1) voice cracking, 2) vibrato issues, 3) off-pitch notes, 4) wavering pitch, 5) breathiness, 6) vocal fatigue, 7) sore throat while singing, 8) shouting or strained voice, 9) forced voice, 10) neck tension, 11) body stiffness, 12) flat notes, 13) sharp notes, 14) lack of focus or missing resonator points, 15) self-imposed pressure, 16) stress when singing high notes.

We used Thai phonetics to create lesson practice for developing a high note for Thai female students. The Thai language has specific characteristics in the use of tonation and tone, including single-word words. There is a wide variety of vocalizations in Thai, with 44 diverse consonants, 6 articulators, and words with nasal sounds that make them sound sharp and pointed. There are also 32 vowels, both short and long, which result in a variety of mouth shapes. To create a set of high notes sound exercises, we selected consonants and mixed them with long vowels. An evaluation experiment was conducted using the Thai song *Khon Chao Namta* (Tears of a Woman), which has a vocal range up to C5. The lyrics of the song cover all Thai consonants, including bilabial, alveolar, palatal, velar, glottal, and vocal cord consonants. The selected lyrics also cover all Thai vowels, including simple, compound, short, long, and consonant cluster vowels.

1. Teaching plan creation

We selected two groups of words to create a set of exercises: the group of words with the highest efficiency and the group of words with efficiency. These two groups of words were chosen because they are diverse in the use of consonant bases and long vowels, and they are conducive to creating high-pitched sounds. This is in line with the opinions of three experts. The words that passed the efficiency assessment criteria at the high efficiency and highest efficiency levels had an average level of 7.50-9.66. All 23 words can be classified as follows:

Highest efficiency were m, n, l, r, and y. The consonants with high efficiency were p, b, f, m, s, j, ch, k, and kh. The majority of these consonants appeared in the following order, from alveolar, labial, palatal alveolar, soft palate, and hard palate, respectively.

From the experiment to select the best words for a set of exercises, 7 vowels were found to be most effective. These vowels were all single, long vowels, and included front, middle, and back vowels. It is an assessment from the tongue position. The vowels were also classified as closed or open, based on the height of the tongue. These vowels were found in all 23 words

that were tested by a group of students and evaluated by experts. From the experiment to select suitable words to create a set of exercises, 7 vowels were found in the group of 23 words. They are long single vowels, including /o:/, /i:/, /ɛ:/, /ɔ:/, /a:/, /u:/ and /u:/ . We created sets of Thai phonetic word exercises for creating a healthy voice in high notes by using articulation from front to back articulators, also from front vowels to back vowels.

In the development of a set of exercises to improve high-pitched sounds, we used a hybrid learning model with in- person and online interactions. We created a learning model that combines face-to-face learning with online learning. This model is flexible and adaptable, and it can be used to meet the needs of learners who may have different learning styles or preferences.

We designed a 6-week teaching plan that uses a combination of synchronous and asynchronous learning activities. Synchronous activities, such as online singing lessons via Skype, allow learners to interact with the instructor and each other in real time. Asynchronous activities, such as homework and diary writing, allow learners to learn at their own pace and send online report via Line application.

The theoretical component has the following elements: source of energy (diaphragm, breath support or appoggio), vocal production (vocal cords function, vocal production process), the practical component has the following elements: vocal resonance (forwarding sound, balanced sound and deeper sound), articulation (articulator and phonic for singing), including the use of Thai articulators to combine with Thai vowels to create words and a set of high-pitched exercises of good quality.

The set of exercises was created by focusing on the students, using case-by-case problem solving and designing the arrangement of words used to create the set of exercises. This was done by selecting words in different bases that had been evaluated, using physiological and phonetic principles (bases) as the basis for creating the set of high-pitched exercises. The pronunciation order was arranged from the front of the mouth to the back, in 5 bases, as follows:

- 1) Lip base: mi: mo: pho: Py: fy: mu:
- 2) Alveolar base: ni: no: ri: li: si: ro: lu: lo:
- 3) Alveolar-palatal base: tɛi: tɛu: tɛo: tɛa: tɛo: tɛha:
- 4) Palatal base: jo:
- 5) Velar base: Kha: ku:

In the design of the vocal exercises for warming up the voice, we used a 5-note scale (for example, C-D-E-F-G-F-E-D-C). This is considered the standard of vocal warming up and has

a positive effect on the creation of vocal exercises. The use of this 5-note scale format makes it easier to see the students' problems during singing than singing many notes in a vocal warming up exercise.

<Table 1> The teaching plan

Lesson number	Content
1	Theory in singing Issue 1: Source of energy - diaphragm, breath support or appoggio Issue 2: Vocal production - vocal cords function, vocal production process Issue 3: Vocal register - chest voice, mixed voice and head voice Issue 4: Vocal resonance - forwarding sound, balanced sound and deeper sound
2	Knowledge about pronunciation according to Thai phonetics Issue 1: Components of Thai words Issue 2: Articulators and characteristics of consonants in Thai language (6 articulators in Thai phonetic)
3	Vocal exercise set no.1 Vocal exercise set using lip articulation no.1: /mi:/ /mu:/ /pɤ:/
4	Vocal exercise set no.2 Vocal exercise set using lip articulation no.2: /fɤ:/ /mo:/ /pho:/
5	Vocal exercise set no.3 Vocal exercise set using alveolar articulation no.1: /ni:/ /ri:/ /li:/ /si:/
6	Vocal exercise set no.4 Vocal exercise set using alveolar articulation no.2: /no:/ /ro:/ /lu:/ /lo:/
7	Vocal exercise set no.5 Vocal exercise set using alveolo-palatal articulation no.1: /tei:/ /teu:/ /tea:/
8	Vocal exercise set no.6 Vocal exercise set using alveolo-palatal articulation no.2: /teɔ:/ /teo:/ /teha:/
9	Vocal exercise set no.7 (1) Vocal exercise set using palatal articulation: /jo:/ (2) Vocal exercise set using velar articulation: /kha:/ /ku:/
10	Vocal exercise set no.8 Vocal exercise set combined all lip and alveolar articulation: /mi:/ /mo:/ /pho:/ /pɤ:/ /fɤ:/ /mu:/ /ni:/ /no:/ /ri:/ /li:/ /si:/ /ro:/ /lu:/ /lo:/
11	Vocal exercise set no.9 Vocal exercise set combined all alveolo-palatal, palatal and velar articulation: /tei:/ /teu:/ /teɔ:/ /tea:/ /teo:/ /teha:/ /jo:/ /kha:/ /ku:/
12	Vocal exercise set no.10 Vocal exercise set combined all lip, alveolar articulation, alveolo-palatal, palatal and velar articulation. Total 23 words: /mi:/ /mo:/ /pho:/ /pɤ:/ /fɤ:/ /mu:/ /ni:/ /no:/ /ri:/ /li:/ /si:/ /ro:/ /lu:/ /lo:/ /tei:/ /teu:/ /teɔ:/ /tea:/ /teo:/ /teha:/ /jo:/ /kha:/ /ku:/

Nine major scales are used to train each word. The exercise begins with the major scale in the A3 chord, which is A3-B3-C#4-D4-E4-D4-C#4-B3-A3. The exercise then ascends by semitones to the major scale in the F4 chord, which is F4-G4-A4-Bb4-C5. The highest note is C5.

We created a teaching plan <Table 1> based on the principles of hybrid learning system with homework and personal voice improvement diary. The purpose is to develop high-pitched voices using Thai bases as a foundation.

2. Lesson evaluation

The pre-test found that learners had different levels of awareness due to their diverse experiences. The results showed that learners were able to modify the words used to solve the problems of using and creating high notes healthily. This depends on the suitability of the basic sound conditions and the characteristics of each person's voice. These findings reflect that learners can adapt to their own basic sound context and analyze and apply to themselves appropriately. In addition, learners gained new knowledge from practical learning in conjunction with their own specific experiences. The details of this issue vary according to the experiences of each person. For example, some learners have a background in classical singing, while others have learned to sing through various media on their own. The important issue is the consistency of learning throughout the 5-year period of each person. These factors have a significant impact on the quality and characteristics of each learner's voice. The teaching was also developed based on the singing teaching system with a teaching plan as a guideline.

The teaching plan is a hybrid learning design, divided into 12 sessions over 6 weeks. This makes the teaching systematic and step-by-step, ensuring that all learners receive the same knowledge consistently, both online and offline. The duration of the experiment was a significant factor in the effectiveness of the practice set for developing healthy voices when singing high notes. The hybrid classroom was divided into two parts: in-person (onsite) on Mondays and online using the Skype platform on Thursdays for 6 weeks. Each session lasted 30 minutes. In the hybrid classroom, students were required to practice the assigned vocal exercises three times per week and submit homework in the form of a video recording of their practice. Students were also asked to rest their voices on Wednesdays and Sundays. In addition, the students' progress was recorded in a Personal Voice Improvement Diary at every onsite and online session.

All 23 words use different places of articulation. These words were used to create a set of

high notes singing exercises based on the principles of Thai articulatory phonetics. The exercises were arranged in order of articulation from the front to the back of the mouth, with five places of articulation. The arranging words in Thai according to the place of articulation and vowel shape in 10 sets of exercises was effective in improving high notes pronunciation. We started with words that have the frontmost place of articulation and closed vowels, and gradually moved to words with the rearmost place of articulation and opened vowels.

This is consistent with the medical principle of vocal cord adduction and Thai phonetics. Learners use a reflective practice or reflection process by evaluating themselves through daily learning logs and regularly completing homework. These reflect the success of learning, which requires behavior change to fit the predetermined learning format, thus achieving the set educational objectives. In addition, learners gain direct experience in integrating knowledge, ideas, experiences, and practical skills in each lesson. The motivation that arises in learners comes from the desire to gain knowledge and develop their singing potential for future use, which is a factor that drives their continued participation in the experiment.

<Table 2> Results of the pre- and post-test self-assessment

Student	Pre-test	Post-test
1	27.50	72.50
2	60.00	95.83
3	40.83	77.50
4	44.16	58.33
5	24.16	62.50
Total	196.65	366.66

3. Individual participant performance

From the study, it was found that participant 1 demonstrated a development in vocal range, starting from G4 prior to the experiment. Following the post-test evaluation, it was observed that there was a significant increase in vocal range, correlating to the level of C5. During the experimental sessions, it was noted that at times, the participant could reach up to the D5 range. There was an improvement in vocal quality, characterized by denser vocal texture, reduced breathiness, smoother and more consistent voice, indicating better control over vocalization.

From the study, it was found that participant 2 exhibited a development in vocal range, starting

from C5 prior to the experiment. Following the post-test evaluation, there was observed a significant increase in vocal range, correlating to the level of F5. Prior to the experiment, it was noted that the participant could reach up to the C5 range but experienced difficulties in terms of tensing up and confusion regarding vocal focal points. During the experimental sessions, it was found that at times, the participant could reach up to the F5 range. There was an improvement in vocal quality, characterized by significantly denser vocal texture, better vocal control, improved vocal focal points, and absence of tension while singing.

From the study, it was found that participant 3 demonstrated an improvement in vocal range, starting from Bb4 before the experiment. Following the post-test evaluation, there was observed a significant increase in vocal range, up to the level of F5. Observations before the learning sessions revealed vocal tremors and strain when reaching high notes, along with vocal breaks and hoarseness. However, during the sessions, the participant was able to develop to reach the F5 range. Additionally, there were issues with tensing up and confusion regarding vocal focal points, leading to more fatigue than usual. After the experiment, it was noted that the participant showed significant improvement in vocal quality. There were no longer issues observed as before the experiment, with significantly denser vocal texture, better vocal control, improved vocal focal points, absence of tension while singing, and no signs of fatigue during vocalization.

From the study, it was found that participant 4 exhibited an improvement in vocal range, starting from A4 before the experiment. Following the post-test evaluation, a significant increase in vocal range was observed, up to the level of C#5. Observations before the learning sessions revealed vocal instability, excessive breathiness, tremors when singing high notes, neck tension, vocal breaks, hoarseness, and signs of stress, agitation, and anxiety. Additionally, the participant had a tendency to mumble while speaking and singing. During the sessions, the participant was able to develop themselves, reducing tension and improving issues observed before the experiment. After the experiment, it was noted that the participant showed significant improvement in vocal quality. There were no longer issues observed as before the experiment, attributed to the participant's effort and understanding of integrating knowledge learned, both in terms of factual knowledge and vocal techniques. Throughout the learning process, the participant's stress and anxiety reduced, and at the end of the experiment, it was found that the vocal texture had significantly improved. The participant demonstrated better vocal control, understanding, and identification of their vocal origin points, absence of tension while singing, and no signs of stress whatsoever.

From the study, it was found that participant 5 demonstrated an improvement in vocal range,

starting from F4 before the experiment. Following the post-test evaluation, a significant increase in vocal range was observed, up to the level of C5. Observations before the learning sessions revealed vocal instability, excessive breathiness, tremors, unclear singing and speaking, soft voice, lack of self-confidence, neck tension when singing high notes, vocal breaks, hoarseness, and signs of stress, agitation, and anxiety. Additionally, the participant had minimal mouth movement and experienced muscle tension in the neck. During the sessions, the participant was able to develop themselves significantly, singing more clearly, reducing tension, and improving issues observed before the experiment. After the experiment, it was noted that the participant showed significant improvement in vocal quality. There were no longer issues observed as before the experiment, with markedly reduced stress and self-pressure. The voice had improved power and openness, with better balance in high notes, reaching up to the C5 range. However, the quality of high-pitched singing remained moderate. At the end of the experiment, it was found that the vocal texture had significantly improved. The participant demonstrated better vocal control, understanding, and identification of their vocal origin points, absence of tension while singing, and no signs of stress whatsoever.

V. Discussion

A new approach has been developed to specifically address the phonetic challenges faced by Thai female singers. This research introduced a series of vocal exercises designed to enhance the upper register while preventing vocal strain. These exercises were created based on the unique characteristics of Thai phonetics and subsequently implemented in an experimental setting. A structured 12-session, six-week lesson plan guided the training, aiming to strengthen the upper register, improve overall vocal quality, and ensure safe and effective vocal use, particularly in higher ranges.

The study unveiled a complex interplay between these sixteen vocal issues, rooted in three primary factors. Firstly, a lack of comprehensive understanding of the Thai vocal tract often led to vocal misuse, lack of control, and subsequent strain. This finding aligns with Sundberg's (2001) explanation of vocal resonance and its dependence on the shape and functionality of the vocal tract. The misuse of resonance cavities, as described by Stemple and Dietrich (2011), can exacerbate issues of vocal strain and limit vocal quality, further supporting the need for phonetic-based exercises. Secondly, deficiencies in high-note vocal techniques contributed to

challenges such as vocal flip, instability, pitch inaccuracies, and diminished resonance. This is consistent with Sell's (2017) assertion that mastering the mixed register is critical for transitioning between chest and head voices, especially for female singers. Additionally, Doscher's (2023) emphasis on proper vocal techniques to prevent injuries underscores the necessity of targeted training for high notes. Lastly, psychological barriers, including anxiety and fear, exacerbated physical tension, strain, and potential vocal damage. Juslin and Västfjäll's (2008) insights into the emotional mechanisms of singing provide further context for understanding how psychological factors can influence vocal performance and physical strain.

In order to develop high notes singing, words were used to create a set of exercises. These words were selected because they use a variety of places of articulation and long vowels, and they are conducive to producing high notes sound. The selection process, grounded in the principles of articulatory phonetics described by Sundberg (2001), demonstrates how controlling formants and resonances can improve vocal clarity and reduce strain. This is consistent with the opinions of three experts. The words that passed the efficiency assessment criteria at the very effective and extremely effective levels had an average score (X bar) of 7.50-9.66.

The use of a 5-note scale (such as D-R-M-F-S-F-M-R-D) as a standard for vocal warm-up exercises, with 10 sets of exercises using 23 selected words, was developed with a learner-centered approach. The exercises were designed to address and solve individual student problems. This is supported by Khambata (1977), who notes the importance of structured exercises in developing both physical and acoustic aspects of singing. Furthermore, Gagné's (1988) instructional model emphasizes the importance of sequenced learning to address specific skill deficiencies systematically. The study showed that following a 5-note scale using a major scale in 9 sets of exercises, starting with the major scale in the A3 chord (A3-B3-C#4-D4-E4-D4-C#4-B3-A3) and ascending by half-steps up to the major scale in the F4 chord (F4-G4-A4-Bb4-C5), all students were able to understand how to use the 5-note scale, even though they had no prior experience. The scale is made up of basic notes that are easy for students to remember and not too complex, which makes it easier to identify problems in singing high notes. In the experiment, it was found that students were able to memorize the notes easily and use them to sing the selected words in the high notes vocal exercise sets.

The design of the hybrid classroom was a response to the growing awareness of the need for flexible and adaptable learning environments in the wake of the COVID-19 pandemic. The NEA framework, as outlined by Chantanasut (2018), provides a strong foundation for hybrid teaching, emphasizing flexibility and student engagement in diverse settings. In this research,

it was shown to be an effective way to provide students with the flexibility they need to learn while also ensuring that they have access to high notes instruction. It does not create pressure or fatigue for students. Continuous learning can reinforce old skills and develop new skills. Homework and diary writing can help students evaluate themselves and be evaluated by teachers at the same time.

Discovery learning is a student- centered approach to learning that encourages students to learn by actively exploring and experimenting. In the hybrid classroom, students were given the opportunity to explore the assigned vocal exercises and experiment with different techniques. This helped them to develop a deeper understanding of the material and to improve their singing skills. This aligns with Gagné's (1988) cognitive focus on activating prior knowledge and guiding learning activities, ensuring that students build on their existing skills while addressing new challenges. In this research, private classes are still essential for developing singing skills and techniques, especially for solving case- by- case problems. In addition, students need to have a strong foundation in Thai articulatory phonetics and anatomy for singing before they can start developing their skills. This foundation will help them to understand how to use their vocal cords and other parts of their body to produce high notes.

Students delved into the complexities of vocal theory, the intricate relationship between the body and vocal production, and the nuanced characteristics of Thai phonetics. This knowledge served as a cornerstone for subsequent skill development. Concurrent with cognitive growth, the affective domain nurtured the emotional and attitudinal aspects of singing. Students were encouraged to explore their personal relationship with music, fostering a sense of appreciation, motivation, and confidence. Addressing potential challenges, such as technical difficulties or performance anxiety, was integral to creating a supportive learning environment. Simultaneously, the psychomotor domain emphasized the acquisition of physical skills through hands- on practice. A progressive sequence of exercises, aligned with the psychomotor sub- behaviors, enabled students to refine their vocal technique, enhance breath control, and develop accurate pitch matching.

Through the integration of these domains, the hybrid approach cultivated well-rounded musicians. Students not only mastered technical skills but also developed a deep appreciation for music, fostering a lifelong passion for vocal performance. The emphasis on both cognitive understanding and practical application ensured that learners were equipped with the knowledge and skills necessary to excel in their musical endeavors. By creating a comprehensive and engaging learning experience, the hybrid approach demonstrated its efficacy in promoting holistic student development within the realm of vocal music education.

In addition, the lesson plan and practice set were designed using a framework for classifying educational objectives. It helps to ensure that the learning objectives are aligned with the different levels of complexity. This ensures that students are challenged appropriately and that they are able to make progress in their learning. This will be discussed by the following. First, Imitation is important in the early stages of learning, as it allows learners to develop a foundation of physical and physiological skills. Second, Manipulation is used to help learners understand and respond to the complex phenomena involved in singing. Third, Precision is essential for learners to develop accurate skills. Fourth, Articulation occurs when learners become proficient in their skills and can perform them automatically. Finally, Naturalization is the highest level of skill development, at which point learners can perform skills without conscious thought. A blended learning approach that combines on-site and online teaching can also be used to support the development of all five sub- behaviors. For example, on-site teaching can be used to provide learners with opportunities to imitate and manipulate their skills, while online teaching can be used to provide learners with opportunities to practice their skills with precision and articulation. Naturalization of skills occurs over time with repeated practice, regardless of the teaching format.

The findings revealed a significant enhancement in the vocal cord strength of the female singers following the implementation of the Thai phonetic word sets. This improvement was evident in their ability to consistently produce C5 high notes during the post- test. The observed progress can be attributed to the systematic strengthening process of the vocal cords, achieved through repeated practice of the carefully designed vocal exercise sets. Additionally, the participants actively engaged in self- observation and maintained a Personal Voice Improvement Diary to track their progress and identify areas for improvement. Expert evaluations were also conducted throughout the training sessions to provide feedback and guidance.

The collaborative efforts of the participants, instructors, and experts facilitated a comprehensive learning experience for the female singers. This approach enabled them to acquire the necessary knowledge, analytical skills, and behavioral modifications to effectively manage their high note singing techniques. The structured training program not only enhanced their high note singing ability but also minimized the risk of vocal cord injury during high note singing. Moreover, upon mastering the proper high note singing techniques, the participants could apply these skills to a wider repertoire of songs with increasingly challenging vocal ranges and adapt them to various musical styles.

The study demonstrates the effectiveness of Thai phonetic word sets in improving the high note singing ability of female singers, vocal density, vocal quality and also volume modulation.

The structured training program, coupled with the collaborative efforts of participants, instructors, and experts, resulted in significant progress in vocal cord strength, high-note singing performance, and overall vocal health. These findings highlight the potential of Thai phonetic word sets as a valuable tool for enhancing the vocal capabilities of female singers.

VI. Suggestions

The results of the pre-test and post-test, using self-assessment, before and after the experiment, showed an increase in the numerical values of all five experimental students. This indicates that all students have improved. Each student has a different level of development, as evidenced by the SD (Standard Deviation) value of 11.66. This means that each student differs in their learning progress, experience, and basic singing skills. In addition, the average development of students increased from 196.65 units to 366.66 units, which is equivalent to an average percentage of 39.33% for the pre-test and 73.332% for the post-test. The difference between these average values is 34.002%, which shows a clear development of the students. However, given the small sample size ($n = 5$), the reliability of these findings is limited and caution should be exercised when generalizing these results to a broader population. Future studies should include a larger and more diverse experimental sample to enhance statistical power and generalizability of the findings.

The suggestions are; first, the experimental methodology presented in this dissertation possesses broad applicability beyond the current study. It can serve as a foundation for investigating vocal characteristics in diverse populations, encompassing male singers, different age groups, speakers of other languages, and individuals from various cultural backgrounds. Moreover, this research offers a framework for developing innovative vocal exercises through scientifically rigorous experimentation. Second, building upon the established methodology, researchers can explore the impact of vocal exercises on a range of vocal attributes, including voice quality, vocal range, endurance, and flexibility. This approach facilitates the development of tailored vocal training programs designed to meet the specific needs of individual singers and musical styles. Third, by comparing the efficacy of different vocal exercises across diverse populations, researchers can contribute to the development of more personalized and effective vocal training programs. This comparative approach can inform the creation of individualized training regimens that optimize vocal development and performance.

VII. Conclusion

In conclusion, this research demonstrates the effectiveness of integrating Thai phonetic principles with structured vocal training to enhance high-note singing in female Thai students. By addressing both physiological and linguistic aspects of vocal production, the study developed a comprehensive, hybrid learning approach that significantly improved students' ability to produce high notes while maintaining vocal health. The 12-session teaching plan, grounded in pedagogical theories and tailored to individual needs, enabled participants to overcome technical challenges and psychological barriers, achieving measurable improvements in vocal range and quality. These findings underscore the potential of culturally and linguistically informed vocal exercises to optimize singing techniques, offering a valuable framework for broader applications in diverse educational and cultural contexts.

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