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Harmonizing the Mind: Music Education, Education Neurosciences, and Frustration Tolerance Enhance Creativity in Thailand

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ABSTRACT

Objective: Thailand, known for its rich musical heritage and diverse culture, stands to gain significantly from these insights. "Mor Lam" and "Luk Thung" are examples of traditional songs that have always been an integral part of the nation's culture. Hence, the main objective of this research is to investigate the correlations, both direct and indirect, between Frustration Tolerance (FT), Education Neurosciences (EDN), Music Education (MED), and Creativity (CR) among music students in Thailand. **Methodology**: A systematic survey was implemented, incorporating a seven-point Likert scale to elicit nuanced responses from a heterogeneous sample of respondents. The data were analysed utilising the SEM-PLS advanced statistical programme. Four hundred usable responses were obtained from pupils via random sampling. **Results**: There were direct correlations identified among MED and CR, EDN and CR, and MED with both EDN and FT. Additionally, it was determined that EDN and FT served as substantial mediators in the connection between MED and CR. In contrast to FT, the mediation effect of EDN was considerably more pronounced. **Novelty**: the research examines the correlation between frustration tolerance, education neurosciences, and music education within the unique cultural context of Thailand. **Implications**: The study's results hold potential value for policymakers and educators alike, as they should consider the following insights when formulating policies, designing curricula, and allocating resources: Furthermore, in the realm of education, the capacity to manage frustration and music may positively impact mental health and therapy across the nation.

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1. Background

During the mid-1990s, cognitive neuroscience researchers grew dissatisfied with laboratory studies of learning and cognition and investigations of learning problems conducted outside of natural teaching contexts. They began to focus more on the intricacies of cognition and learning within authentic educational environments. Educational neuroscience is an emerging field of study that investigates the correlation between the mind, brain, and education. A new understanding of the relationship between brain science, particularly neuroplasticity, and education has emerged because of the convergence of multidisciplinary research fields and the advancement of brain science. Educational neuroscience is a multidisciplinary domain that seeks to comprehend the influence of education on the brain and to apply research discoveries regarding the neural processes underlying learning to educational policy and practice (Thomas, Ansari, & Knowland, 2019). This is since, if the brain is regarded as a biological organ, learning activities require it to be in an ideal or healthy condition. Consequently, education is intricately linked to the field of neuroscience (Ching et al., 2020). Furthermore, neuroscience can investigate, validate, and substantiate psychological theories and the influence of psychology on education in an indirect manner.

Art education constitutes a significant component of aesthetic education, which encompasses dramatic expression, literature, music, and dance. Music has the irreplaceable function to carry cultural content for societies (Zhang & Su, 2023). Once upon a time, it was widely accepted that the purpose of music education was to foster the aesthetic sensibilities, appreciation, and creative aptitude of students. An analysis of art education from the perspective of educational neuroscience demonstrates that music education fosters not only cognitive functions but also physical development, affective expression, and social identity in children. Music enrichment activities contribute to the development of social identity and overall well-being among children, while also enhancing their physical and mental health. Concurrently, the diversity of activities in music education can foster children's imagination and creativity, thereby facilitating their holistic development, while the positive effect of music education on brain plasticity can inspire children to learn and improve academic performance. In summary, music education has the potential to enhance the development of brain functions through the utilisation of brain structure plasticity. This can result in improved internal cognitive abilities and external behavioural performance in children, thereby facilitating the establishment of social identities and fostering enduring success and accomplishments.

Amidst the advent of artificial intelligence (AI), big data, and cloud computing, researchers are allocating an exceeding quantity of resources towards the investigation of emotions. This is due to the fact that emotions are intrinsic to the human condition and exert a substantial influence on various aspects of our daily lives, including cognition, communication, learning, and decision-making (Mattayaphutron, 2021; Meixiong, 2023). Furthermore, research has demonstrated that emotions significantly influence the creative process of college students, specifically by enabling them to engage in multiple forms of creation. Improvisation in music is one such instance. College music education, society at large, and parents have collectively advocated for the development of their children's creativity, given that music composition demands an elevated degree of ingenuity. Enhanced musical progress and development among students is directly attributable to

increased creative thinking, which in turn generates superior work. The inventiveness of students has not increased in a measurable way since the implementation of the educational reforms. Czajkowski, Greasley, and Allis (2022) posit that the presence of tension and anxiety among students may impede the development of their musical creativity. Emotions have been the subject of psychological investigation for centuries, owing to their evident influence on the generation of creative output. Ekman's theory posits that the fundamental human emotions consist of joy, sorrow, apprehension, indignation, astonishment, and abhorrence. An element of human psychology that has garnered substantial research attention is the diversity of emotional experiences and identifications that individuals are capable of. Given that the creative processes of college students are significantly influenced by their emotional lives, it is imperative to adopt an emotional perspective in order to fully grasp this phenomenon.

On the contrary, extant academic literature has exhaustively examined and deliberated upon the four primary determinants that exert an influence on students' creative capacities: negative affective states may be induced by the manner in which a student interacts with their parents (Frenzel, Daniels, & Burić, 2021). During periods of imbalance, the relationship between students and instructors has a substantial effect on both parties' capacity to engage in creative thought, according to Zhao and Zhou (2020). An inherent advantage of internal control and coordination is its capacity to cultivate innovation within the academic setting. It is of the utmost importance to acknowledge that the existing moderators of the correlation between negative emotion and creativity—emotion experience, emotion labour, and mental elasticity—require an exhaustive evaluation of factors both internal and external in nature. Furthermore, the relationship between negative emotions and creativity has received scant attention in the scientific literature, leading to a restricted comprehension of the underlying mechanisms that connect these two concepts. As a result, the precise nature of the correlation between negative emotions and creativity continues to be unknown. Extensive prior research has predominantly concentrated on investigating the adverse impact that negative emotions have on the productivity of creativity.

We propose that frustration tolerance be incorporated as a critical component into the intricate process of ideation so that these critical issues can be effectively addressed. There has been a lack of research looking into the relationship between students' creative abilities and their capacity to endure frustration, as well as the mediating role of emotion regulation in this association (Deng et al., 2022). Tolerance for frustration, which is commonly defined as the mental quality of maintaining one's resolve despite encountering challenges and unfulfilled aspirations, is an admirable psychological characteristic. A multitude of complex elements, encompassing both intrinsic and extrinsic components, significantly impact an individual's ability to persevere and navigate the challenges that arise in the context of tertiary education (Rashidi, Bowers, & Reyes Gil, 2023). Significant determinants include the student's heritage and experience, especially as they pertain to the field of music education. When an individual's level of frustration surpasses their capacity for effective management, it will impede their capacity to perform routine tasks and, consequently, hinder their ability to acclimatise to an unfamiliar environment. Given the circumstances, further investigation into the complex correlation between frustration

tolerance and creativity is imperative.

By utilising data collected from a representative sample of 400 students majoring in music at traditional universities and enlisted in prestigious music institutions, we offer a substantial contribution to the current corpus of knowledge concerning the impact of emotions on the creative problem-solving process. Our results unequivocally establish that negative emotions exert a significant and noteworthy influence within this framework. Through our scholarly inquiry, we shed light on the tactics through which students can overcome negative emotional states and maintain their dedication to musical education. Developing one's imagination may prove challenging for individuals who have difficulty articulating their emotions. Individuals who possess an increased inclination towards habitual reappraisal are more likely to recognise negative emotions with greater precision. This capability enables them to utilise coping mechanisms that target the root cause of the issue at hand and elicit innovative behavioural reactions. Not only is it critical for the intellectual development and consequent creativity of students that they regulate their emotions, but they must also acknowledge their ability to utilise frustration tolerance as a mechanism for recuperating from adverse emotional states. Based on the preceding discourse, the following research objectives have been established for the study:

To examine the influence of music education on the development of creativity.

To examine the potential mediating effect of frustration tolerance and education neuroscience on the association between creativity and music education.

2. Conceptual Framework

Germany serves as a significant hub for research in the field of music education and is regarded as one of the birthplaces of western classical music. The local music university was one of the institutions that implemented the mandatory education system that was instituted in Württemberg, Germany, in 1649. This policy laid a foundation for the subsequent growth and popularity of music education (Frandsen, 2020). In 1838, music education was initiated in American institutions. Prior to that, community music education was primarily conducted through singing schools, which established the foundation for the development of school music education in the United States. The Boston School Committee incorporated music instruction formally into the city's curriculum in 1838. Numerous individuals regard this as the inception of music education in American institutions. Following the establishment of the Music Research Institute in 1879, music education in Japan flourished during the Meiji Restoration. The Tokyo Music School, which exemplified the swift progression of school music education, had a profound influence on the development of music education theory and educational systems (Nishida, 2022). Prior to the establishment of the National Conservatory of Music, professional music education in modern China had undergone an extensive period of experimentation for approximately eighty to ninety years. This journey continued until the National Conservatory of Music was born, which officially established the inaugural higher music institution in modern China and ushered in a new era in the history of professional music education in China, paving the way for subsequent higher music endeavours. Concurrently, it mandates comprehensive development. It enhances and fortifies moral, intellectual, physical, and aesthetic education in a comprehensive manner. Furthermore, it mandates the enhancement of aesthetic education and the fostering of students' good aesthetic taste and humanistic attributes; the allocation of instructors for

music, physical education, art, and other disciplines; and the comprehensive execution of the prescribed curricula. This indicates that the State considers aesthetic education, specifically art education, to be of utmost significance; furthermore, it implies that more stringent criteria have been established for art.

To cultivate creativity, it is essential for individuals to possess the cognitive ability to integrate disparate components in original and unorthodox ways (Magistretti, Ardito, & Messeni Petruzzelli, 2021). Those who possess a creative disposition are generally distinguished by their curiosity, willingness to undertake ventures that involve inherent danger, ambition to overcome unique challenges, and openness to encounters that have not yet been explored. As per the research outcomes reported by Bereczki and Kárpáti (2018), and Chang and Shih (2018), creativity can be described as a cognitive process through which individuals generate original concepts in uncharted domains, surpassing their current knowledge base. The capacity to utilise previously acquired knowledge in novel circumstances is not constrained by any predispositions. In the domain of student cognition, creativity is a discernible attribute that empowers individuals to produce an abundance of alternative viewpoints, infuse entities with unprecedented and unique significance, and attain results that not only bring joy to the creators but also to their fellow students—all in a supportive setting that encourages cognitive introspection. A study conducted by Biasutti (2017) indicates that music students' cognitive abilities are significantly tested through the practise of improvisation. Considering the intrinsic diversity among individuals and the inherent fluctuation in creative processes, it is imperative to recognise and consider these complex elements when endeavouring to incorporate innovative concepts into the domain of music production. According to the scholastic research of Sigaki, Perc, and Ribeiro (2018), four distinct dimensions provide a comprehensive understanding of the concept of creativity. One of these elements is the novelty of the problem-solving approach. Furthermore, constructive diversity is of utmost importance, encompassing both the quantity and variety of proposed solutions. Furthermore, analytical capacity signifies the level of precision and particularity that is intrinsic to the solution. In conclusion, feasibility pertains to the practicality and sustainability of the suggested resolution in tangible, real-life contexts.

Frustration tolerance serves as an illustration of the adaptive capacity of individuals to resist deviant behaviour and maintain determination during challenges and setbacks, as stated in Zhang's Dictionary of Psychology. This exceptional quality empowers individuals to persist and surmount challenges with determination. The capacity to adeptly navigate setbacks and challenges. Clifford postulated in 1991 that an individual's propensity for undertaking risks and their reaction to setbacks are both influenced by their frustration tolerance. Students must have the capacity to persevere in the face of frustration in order to discover the meaning and purpose of their lives, navigate the challenges of duress, adapt to unfamiliar circumstances, and overcome obstacles (Bozkurt et al., 2020). This is consequential about the capacity of collegiates to overcome challenges and cultivate amicable connections with their fellow students. Clifford (1984) introduced the Theory of Constructive Failure as a conceptual framework to aid in the understanding and reassessment of the purposes fulfilled by setbacks and failures. Zhang (2023) argues that an inflexible prioritisation of the importance of success hinders people from appreciating the invaluable insights that are intrinsic in disappointment and failure. Within this framework, the term "frustration tolerance" pertains to the ability to maintain one's

commitment to pursuits in the face of challenges and setbacks.

In fact, music education will assume a significant role in the execution of aesthetic education and the advancement of high-quality education. Nonetheless, the expansion and advancement of music education are presently confronted with several obstacles. Some studies conducted in Thailand, for instance, have found that as academic pressure on students continues to rise, the proportion of music programmes in the curriculum progressively decreases. Furthermore, a number of international studies suggest that public funding for music education continues to decline (Gamage, Silva, & Gunawardhana, 2020). The may indicate that educational policymakers consider music education to be a superfluous extravagance that can be substituted for more critical educational requirements. Concurrently, research limitations and methodologies have contributed to a lack of understanding regarding the advantages of in-depth music study, while some scholars have argued that more experimental evidence is required to support the positive aspects of art education. Furthermore, the potential benefits of music education remain largely unexplored. The individual development model put forth by Bronfenbrenner demonstrates, in accordance with the ecosystem systems theory, that individuals are nested within a sequence of interdependent environmental systems, wherein the systems themselves exert an influence on and interact with individual development. While art education activities have historically contributed to the development of positive student and individual environments, the mechanisms governing their interaction with students remain ambiguous. Therefore, art education has acquired a degree of insignificance and diminished worth.

However, the complete realisation of the function of music education remains to be achieved. Although educational neuroscience research has identified several factors that can influence educational outcomes, including nutrition, motivation, health, and the capacity to improve student learning behaviours, it is crucial to acknowledge that learning can also be disrupted and impeded by external environmental changes. Consequently, the scientific community must examine the development of learning behaviours within this broader framework. Given these circumstances, a music education system that is exclusively theoretical is incapable of elucidating the intricacies of student learning development. Thus, this system fails to incorporate effective pedagogy and educational philosophy and is consequently unable to maximise the potential of music education. Hence, a field of study is immediately required to investigate and validate the significance of music education and its correlation with personal growth, as well as to advocate for the advancement of music education. These issues have been resolved through the application of innovative research methods and a greater degree of interdisciplinarity since the advent of neuroscience in music education.

Present studies in the domain of educational neuroscience encompass a range of topics such as investigating the neural processes underlying art processing; elucidating the neural mechanisms underlying art learning (Wonderlich, Bershad, & Steinglass, 2021); elucidating the impact of art education on cognitive and individual brain development; scrutinising the effects of art education on emotion and executive function; and investigating the potential therapeutic benefits of art education for somatic and psychological issues that may arise during childhood. In addition to that, this study aims to clarify the cognitive and cerebral characteristics of developing individuals with music developmental disorders, as

well as to facilitate early detection and intervention. In subsequent periods, as research methodologies and paradigms advance, research outcomes amass, and the theoretical framework is refined, art education neuroscience may furnish the empirical basis of neuroscience for policy formulation and practise; elucidate the indispensability of art education; ascertain optimal approaches to implement art education that cater to individual brain development patterns and foster brain growth; and disclose mechanisms by which to advance brain development.

For instance, within the temporal dimension, music exhibits the same level of precision and rigour as mathematics, as it progresses with exact timing, cadence, and tempo. Furthermore, Kulinski et al. (2022) discovered that in the presence of live music, the vagus nerve of attendees may experience an increase in activity while the sympathetic nerves are suppressed. This finding implies that attending a pianist's live performance may influence the audience's neural activity, potentially leading to a reduction in anxiety and the initiation of relaxation experiences. Moreover, it underscores the significance of social-environmental factors in relation to cognitive processes and listening tasks. Conversely, musical experiences may alter such neural activity. Furthermore, in a comparative trial, Schellenberg (2004) discovered that children in the music programme group exhibited more positive social adaptive behaviours after the programme, and that children in the drama programme group had significantly higher IQs than the control group. In a comparative study, Haslbeck et al. (2020) discovered that after only 20 days of interactive music training, children's language proficiency improved significantly. Furthermore, the researchers discovered a positive correlation between music training and changes in functional brain connectivity plasticity, indicating that music training can enhance higher cognitive abilities during childhood. According to Braun Janzen et al. (2022), the limited number of studies that have been undertaken have established the groundwork for additional implementations of music training in education and medical rehabilitation. The authors clarify that informal music activities at home, school, and community settings, as well as instrumental music training, can exert a substantial influence on language and auditory development. In a subsequent longitudinal study, Müllensiefen, Elvers, and Frieler (2022) presented causal evidence supporting the notion that music learning can enhance language acquisition in children. The research focused on children between the ages of four and five and involved a six-month piano training programme. Vowel-based word recognition, consonant-based word discrimination, and matching responses to lexical pitch and musical pitch variations were all enhanced in comparison to the control group through piano training. Compared to the control group, the study confirms that music training can improve children's ability to recognise vowel-based words and words in general. The research validates the notion that music instruction can enhance children's capacity to develop language skills. Moreover, it suggests that piano instruction is not substandard in comparison to literacy instruction and may even be more effective in enhancing consonant discrimination.

Simultaneously, artistic endeavours such as training, performing, and playing transcend mere precision and aim for an infinite pursuit of exquisite expression. Brattico and Varankaitė (2019) discovered a positive correlation between the level of activation of the insula and the intensity of tremors induced by musicians listening to preferred classical music. This finding suggests that music may have this effect. This indicates that music performance training enhances emotional sensitivity and, consequently, the ability to perceive the underlying

emotions of the music; thus, the emotional performance of the music is improved. Recent research (Xu & Xu, 2023) utilised musically elicited emotional responses to investigate the effects of emotional states on creativity and self-efficacy. The study employed a 10-minute musical excerpt stimulus to evaluate the emotional states and creative self-efficacy of the participants. Mozart's Sonata in D major for two pianos elicited a positive emotion, Albinoni's Allegro in G minor induced a negative emotion, and a no-music condition served as the control group. The results of the study indicate that music can elicit specific emotional experiences and that emotional states can accurately predict creative self-efficacy. Various emotional experiences can potentially influence the creative self-efficacy of individuals in distinct ways, contingent upon the experience's intensity, frequency, and duration. Furthermore, it is noteworthy that the creative self-efficacy scores of subjects can be significantly influenced by the positive and negative emotions evoked by music during a 10-minute music listening condition. This suggests that even with limited exposure to music stimuli, individuals' expectations of their own creative capabilities can be substantially altered. In the meantime, a recent study conducted by Vasilopoulos et al. (2023) conducted a meta-analysis of previous research findings regarding the health effects of participating in performing arts activities that are based on music or dance. The findings revealed that out of the 18 domains examined, participation in performing arts was positively associated with health in seventeen of them. Specifically, nine of these domains—auditory, physical, cognitive immune function, mental health, physical fitness, and physical fitness—reported positive effects. Furthermore, the benefits of engaging in performing arts activities for children (0-9 years) and adolescents (10-19 years) have been substantiated through reasonable quality evidence in the following domains: auditory (music), body structure (dance), cognitive (music), and physical performance (dance). Research has substantiated favourable health consequences associated with even brief engagement in performing arts—30 minutes (acute participation) or 60 minutes (weekly sustained involvement)—with the most extensive health benefits derived from expressive dance, movement-based dance patterns, and singing. In summary, music education has progressively demonstrated its exceptional capacity to foster intellectual growth and facilitate brain development, thereby establishing an environment conducive to such activities. Therefore, it has become an unavoidable issue to consider how music education can be utilised to investigate, cultivate, and reconfigure the structure and function of the human brain to advance students' overall development.

In particular, the empirical study of music learning on brain plasticity concludes that brain plasticity is closely associated with music training, based on the findings of brain science research that investigated the primary characteristics of music education and music training on brain plasticity. In addition, the micro-functional effectiveness and macro-organizational structure of the human brain can be profoundly influenced by it. Furthermore, distinct forms of music training may influence the corresponding cerebral regions. However, it is important to note that while age does have a substantial impact on the plasticity of brain structure and function, both remain somewhat dynamically plastic throughout an individual's lifetime, and even in adulthood, the brain remains susceptible to modification.

Moreover, with respect to the correlation between music education and cognitive capacities, Blasco-Magraner et al. (2021) suggest that the provision of structured music education can significantly and favourably influence the growth of an individual's non-musical cognitive abilities. This is since music education activities require the integration of multiple brain regions to produce cognitive patterns in the brain of the individual. Hence, through musical activities

that stimulate and integrate the structures and neural activation patterns of these brain regions, music education has the potential to enhance the cognitive abilities of individuals. Moreover, due to their close relationship with human mental activity, musical activities can significantly moderate the impact of emotive factors on cognitive levels. In conclusion, the integration and convergence of various fields are central to the educational neuroscience-based innovation in music education. This endeavour aims to demonstrate the critical importance of music education in the development of the human brain, subsequently facilitating the creation of a more conducive learning environment for the brain, enhancing the teaching and modelling of music, and reassessing the evaluation system of educational neuroscience-based music education.

Educational neuroscience, a burgeoning interdisciplinary domain, investigates the relationship between cognition, education, and the brain. Its objective is to apply insights gained from research into the neural processes underlying learning in the brain to inform pedagogical approaches and educational policies. By doing so, educational neuroscience contributes to the advancement of innovation within the realm of education (Willett et al., 2020). Educational neuroscience theories and principles can assist us in further investigating the correlation between the development of music education and the functioning of the brain. This will enable us to conduct a more impartial analysis and enhancement of the merits and drawbacks of the present approach and decision-making in music education. Furthermore, it will provide insights into how to implement routine music education activities in a more scientifically rigorous manner. Considering this, we must integrate brain research and music education in accordance with the fundamental principles of educational neuroscience. However, for brain science and music education to be more effectively integrated, several disciplinary critical questions must be resolved. For instance, what are the general developmental trajectories of musical ability and the brain mechanisms that are associated with it? What patterns and characteristics of neural and cerebral network plasticity changes occur during the process of learning music? Besides artistic proficiency, what other cognitive outcomes does music education influence? To what extent does music education contribute to the resolution of somatic and psychological issues that may arise during the developmental years of children? Concerning the brain mechanisms underlying affective and executive functioning, what are the impacts of music learning on individuals? Concerning early identification and intervention, what are the cognitive and cerebral developmental characteristics of individuals afflicted with musical developmental disorders? And so forth. Determining the following issues in music education in light of brain science research will aid in the development of innovative teaching concepts and the enhancement of teaching methodologies (Wei, Karuppiah, & Prathik, 2022). For instance, investigating the manner in which procedural or declarative knowledge is obtained; scrutinising pedagogical approaches and tactics; scrutinising methods to enhance the content and engagement of music education curricula; investigating the manner in which music education adjusts to the unique cognitive development of each student; elucidating the function and consequences of music education on cognitive and brain development; explicating the critical phase of music learning and the advantageous outcomes associated with sensitive periods

Communication between the fields of cognitive science and music is not without its challenges. To begin with, scholars in these two domains approach music research from distinct vantage points and have distinct areas of interest. Moreover, they employ distinct research methodologies and logical frameworks, delving into unique research inquiries.

Second, there is no common professional discourse between the two disciplines. Scholars in brain science are preoccupied with the implications of recent discoveries in brain function, ranging from the autonomic nervous system to the forefront of basic research. On the other hand, music educators and researchers in the field of music are concerned with the inspiration and reference that these discoveries provide for the practise of music education. At present, there is a dearth of a functional language system within the realm of brain science. Educators are unable to scrutinise the outcomes of neuroscientists' external communication of their work (Derakhshan, Solhi, & Azari Noughabi, 2023), and it is challenging to directly apply esoteric laboratory terminology to inform music education practise. Consequently, these obstacles impede communication and exchange between the two disciplines. Conversely, substantial cultural disparities exist between the research domains. Brain science research is extremely minute, which is quite subtle in comparison to the macro complexity and development of music education practise. Furthermore, scientists specialising in the field of brain science operate within a laboratory setting that exudes an enigmatic scientific ambiance. Most of their research subjects are severed or incomplete brains. Their daily preoccupation lies in the potential revelations of novel insights within the domain of brain science, whereas the research endeavours pertaining to music education are intricate and pragmatic. When instructing music, educators are working with healthy individuals and living minds. Furthermore, as perceived by the research team, the majority of those presently preoccupied with the convergence of the two disciplines are scientists specialising in brain science. Conversely, scholars in the field of music are significantly behind in their implementation and awareness of the most recent findings from brain science.

The objective limitations create a disconnect and misunderstanding between the two disciplines, which impedes the transformation and application of brain science research findings to the field of music. To facilitate the application of brain science research findings to music education and mitigate the misinterpretation of brain science research in this domain, it is critical to promote the integration of brain science and music disciplines and establish an effective communication and mutual support platform between the two fields. In contrast, human culture has been divided into the humanities, sciences, technology, and the arts over the last two centuries, with science and technology having evolved into distinct disciplines. Knowledge barriers between disciplines create a significant obstacle to professional comprehension of other fields. The progression of science and technology has posed a growing challenge to accomplishing advancements and discoveries exclusively within one's area of expertise. To achieve the convergence and integration of the natural and human sciences, it is possible to follow the advice of Japanese brain scientist Hideaki Koizumi: "Initially, researchers in the natural sciences and the social sciences ought to consolidate a number of testable concepts; subsequently, natural scientists ought to assess the viability and preliminary evaluation of the concepts; and lastly, the natural scientists ought to modify the metric." As a result, it is imperative that we acknowledge the cultural distinctions between the two academic disciplines and make every effort to prevent misrepresentation. Establishing a standard discourse system and a systematic, two-way academic channel is necessary for misreading the two disciplines to facilitate unimpeded knowledge exchange and mutual understanding. The study has proposed the following hypotheses, which are depicted in the conceptual framework (Figure 1), considering the preceding discourse.

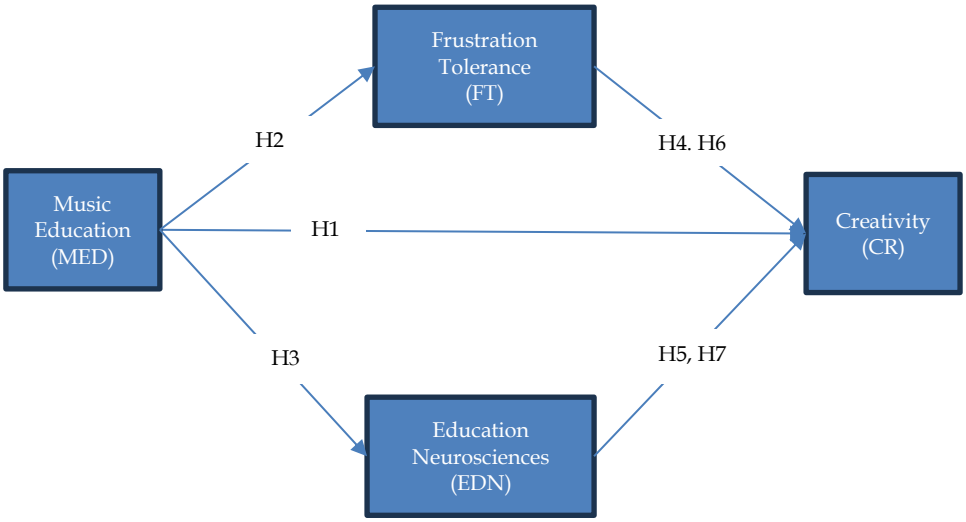

Figure 1: *Conceptual Framework*
Note: *MED: Music Education, EDN: Education Neurosciences, FT: Frustration Tolerance, CR: Creativity*

3. Methodology

The data for the research study were collected through a survey administered to individuals who were in the process of pursuing a major in music. The primary methodology utilised to gather data was a carefully designed questionnaire consisting of targeted inquiries that were precisely aligned with the objectives of the study. The respondents were given a Likert scale consisting of seven points. The scale ran from "1" (strongly disagree) to "7" (strongly agree) and was used to record their responses to each question. The investigation benefited significantly from the perspectives and experiences of music students, which were distinct. By employing random sampling, a sample that is representative of the population was obtained. A sample of 400 music majors was selected from the entire nation's population. This number was chosen due to its ability to reconcile usability and statistical significance. For the convenience of music students, the survey was conducted through both in-person and online means. The participants' understanding of the study's objectives facilitated the development of trust between the researchers and the students. We ensured the confidentiality of participant responses to promote openness. Every participant granted informed assent, thereby signifying their voluntary nature of the study. The data analysis is conducted utilising the SEM-PLS (Dash & Paul, 2021). During the data preprocessing phase of the analysis procedure, responses that were either overly succinct or devoid of specificity were omitted from consideration as they provided limited utility. Following this, convergent and discriminant validity, Cronbach's alpha, and composite reliability were evaluated to determine the accuracy and dependability of the measurement model. After verifying the sufficiency of the measurement model, an assessment of the structural model was performed to ascertain the interconnections among the constructs. To determine the statistical significance of these associations, bootstrap methods were implemented.

3.1. Demographics

The composition of the 400 music students included in the surveyed sample was ascertained through a demographic analysis. A total of 65% of the participants fell within the age range of 18 to 24 years. Gender representation was nearly balanced, with males comprising 48% of the sample, females comprising 50%, and only 2% identifying as non-binary or having other gender identities. About scholastic progression, it is critical to mention that 35 percent of the individuals being evaluated were seniors and 40 percent were juniors. According to the data, instrumental specialisation was the prevailing field, comprising a substantial plurality of 45 percent. Vocal specialisation subsequently followed.

4. Results

The initial stage of the SEM-PLS analysis involves the assessment of the measurement model (Zeng et al., 2021). During this specific stage of the research process, the survey items or indicators are validated to ensure they accurately measure the latent constructs they are intended to assess. By rigorously assessing these criteria, the measurement model establishes a strong basis for the subsequent evaluation of the structural model in the context of SEM-PLS.

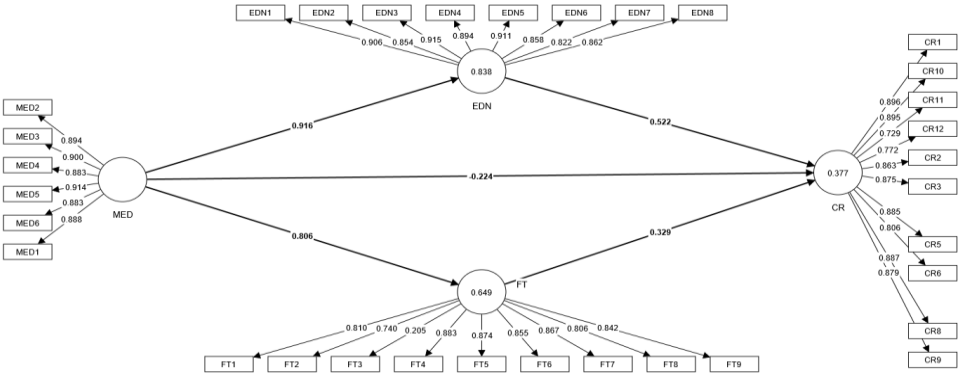

Figure 2: *Measurement Model*

Note: *MED: Music Education, EDN: Education Neurosciences, FT: Frustration Tolerance, CR: Creativity*

When utilising partial least squares structural equation modelling, outrloadings, which are alternatively referred to as cross-loadings, are of the utmost importance in establishing discriminant validity. The values symbolise the interconnection that exists between an indicator and discrete constructs that were not its intended measurement. In an ideal world, the correlation between an indicator and its designated construct should be stronger than that between the indicator and any other constructs included in the model. Preferential treatment should be given to the placement of an object on its designated structure over its removal from other structures. When the condition specified above is fulfilled, it furnishes evidence that the indicator exhibits the strongest correlation with its intended construct compared to all other indicators. This further reinforces the notion of discriminant validity. The practise of monitoring cross-loadings is of the utmost importance, as increased cross-loadings may suggest concerns regarding the lucidity or accuracy of survey items. The existence of these intricacies may obfuscate the intrinsic characteristics of the constructs being assessed.

Table 1

Outer Loadings

	CR	EDN	FT	MED
CR1	0.896			
CR10	0.895			
CR11	0.729			
CR12	0.772			
CR2	0.863			
CR3	0.875			
CR5	0.885			
CR6	0.806			
CR8	0.887			
CR9	0.879			
EDN1		0.906		
EDN2		0.854		
EDN3		0.915		
EDN4		0.894		
EDN5		0.911		
EDN6		0.858		
EDN7		0.822		
EDN8		0.862		
FT1			0.810	
FT2			0.740	
FT3			0.205	
FT4			0.883	
FT5			0.874	
FT6			0.855	
FT7			0.867	
FT8			0.806	
FT9			0.842	
MED2				0.894
MED3				0.900
MED4				0.883
MED5				0.914
MED6				0.883
MED1				0.888

For measurement models to be robust, they must possess both validity and reliability. The consistency of results obtained from repetitive measurements performed under identical conditions constitutes the reliability of a measurement. Acceptable reliability in SEM-PLS is denoted by composite reliability values exceeding 0.70 (Zeng et al., 2021).

On the contrary, validity pertains to the preciseness of the assessments, guaranteeing that they accurately reflect the constructs under investigation. In assessing validity, convergent and discriminant validity are two crucial components. Considered to exist when the indicators associated with a particular construct share a significant amount of variance is convergent validity. In general, this is ascertained through the utilisation of the

Average Variance Extracted (AVE) metric, wherein values surpassing 0.5 are deemed acceptable.

Table 2

Reliability

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
CR	0.957	0.961	0.963	0.723
EDN	0.958	0.958	0.964	0.772
FT	0.914	0.941	0.934	0.626
MED	0.950	0.950	0.960	0.799

Discriminant validity is attained, in accordance with the theoretical framework proposed by Fornell and Larcker (Afthanorhan, Ghazali, & Rashid, 2021), when the square root of the average variance extracted (AVE) for a specific construct surpasses the correlations it has with other constructs. This procedure guarantees that every construct is distinct from one another and does not exhibit an overly strong correlation with other constructs. The relationship between validity and reliability is crucial for establishing a measurement model that is both valid and reliable. These two aspects are fundamental to credibility and trustworthiness.

Table 3

Validity

	CR	EDN	FT	MED
CR	0.850			
EDN	0.784	0.879		
FT	0.773	0.813	0.891	
MED	0.719	0.716	0.806	0.894

By illustrating the relationships between latent constructs, the structural model utilised by the SEM-PLS method reveals the hypothesised causal pathways within the research framework. The structural model examines the interactions between constructs, as opposed to the measurement model which investigates the relationships between indicators and constructs. The assessment utilises the path coefficients as metric values to determine the magnitude, direction, and importance of these relationships. Bootstrapping methods are often employed to ascertain the significance of these paths (Purwanto & Sudargini, 2021). An assessment of the model's predictive relevance, effect magnitude, and goodness-of-fit can ascertain its adequacy. Through the examination of the structural model, scholars can evaluate hypotheses, deriving conclusions, and formulating practical suggestions pertaining to the interconnections among constructs.

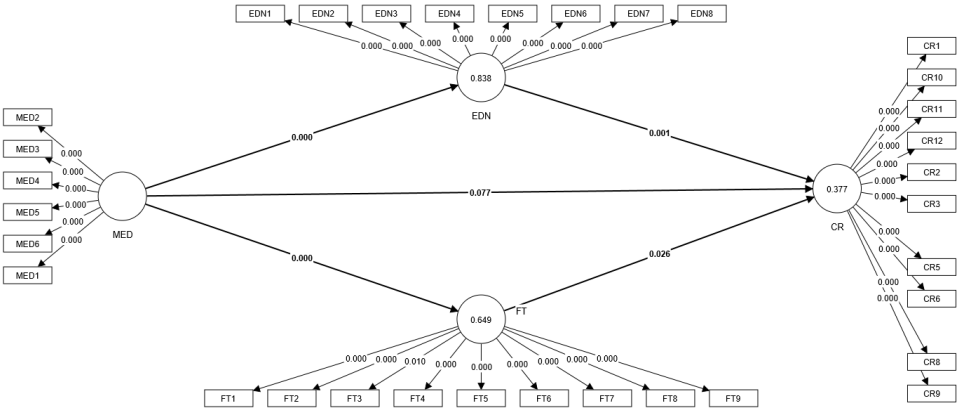

Figure 3: *Structural Model*

Note: *MED: Music Education, EDN: Education Neurosciences, FT: Frustration Tolerance, CR: Creativity*

Table 4

Direct Results

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
EDN -> CR	0.522	0.531	0.163	3.213	0.001
FT -> CR	0.329	0.328	0.170	1.936	0.026
MED -> CR	0.519	0.522	0.072	7.216	0.000
MED -> EDN	0.916	0.916	0.016	4.737	0.000
MED -> FT	0.806	0.808	0.037	.996	0.000

The correlations among Frustration Tolerance (FT), Education Neurosciences (EDN), Music Education (MED), and Creativity are elucidated by the findings. The p-value for the correlation between EDN and CR is 0.001 and the path coefficient is 0.522. FET has a positive effect on CR, as indicated by its p-value of 0.026 and coefficient of 0.329. The p-value of 0.000 and coefficient of 0.519 indicate that MED has a statistically significant effect on CR. The correlation between MED and EDN and FT is deemed statistically significant and positive, as indicated by the p-values of 0.000 and coefficients of 0.916 and 0.806, respectively. The significance of music education for creativity, education neurosciences, and frustration tolerance is demonstrated by these results.

Table 5

Mediation

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
MED -> EDN -> CR	0.478	0.486	0.151	3.177	0.001
MED -> FT -> CR	0.265	0.264	0.136	1.947	0.026

The findings illuminate the ways in which Education Neurosciences (EDN), Frustration Tolerance (FT), and Creativity are mediated by Music Education (MED). P-value = 0.001 and path coefficient = 0.478 indicate that the indirect effect of EDN mediating MED and CR is significant and positive. Imagination may be stimulated by the effects of music

education on educational neurosciences. FT has a positive indirect effect as a mediator between MED and CR; its coefficient is 0.26 and its corresponding p-value is 0.026. Creativity is enhanced through the development of frustration tolerance through music education. Statistically speaking, the MED to EDN to CR pathway is more efficacious than the MED to FT to CR pathway.

5. Conclusion

The primary objective of this research endeavour was to comprehensively examine the intricate interconnections among Frustration Tolerance (FT), Creativity (CR), Education Neurosciences (EDN), and Music Education (MED). Each of the numerous implications of the findings is of critical importance; however, this is particularly true when examined in the context of the Thai educational system. The robust positive correlation between Music Education and Creativity, along with the considerable influence that music has on Education Neurosciences and Frustration Tolerance, underscore the crucial role that music plays in promoting holistic educational growth. The discovery that educational music programmes (EDN) and music-related activities (FT) serve as intermediaries between music education (MED) and cognitive development (CR) illuminates an additional aspect of the manifold benefits linked to the integration of music into academic curricula.

Thailand, due to its diverse cultural heritage and extensive musical traditions, has a significant chance to gain considerable benefits from these observations. The traditional musical genres that are prevalent throughout the country, including the harmonious melodies of "Luk Thung" and the rhythmic cadences of "Mor Lam," have consistently formed a fundamental element of the nation's cultural identity. The research findings indicate that the integration of musical heritage into the educational domain may not only foster increased creative thinking but also facilitate a deeper comprehension of the foundational principles underlying neuroscientific inquiry and improve an individual's capacity to manage frustration more effectively.

5.1. Implication

The findings of this research have numerous ramifications for music education in Thailand, most notably, for the reassessment of the importance attributed to various elements within the country's educational framework. Based on the study's findings, it can be concluded that Music Education (MED) is significantly associated with Creativity (CR), Education Neurosciences (EDN), and Frustration Tolerance (FT). Consequently, the inclusion of music in the curriculum should not be neglected. Even so, it is critical to acknowledge it as a fundamental component that has the potential to significantly augment both cognitive and affective growth. By incorporating comprehensive music curricula into its educational framework, Thailand can capitalise on its abundant musical legacy to cultivate the ingenuity and perseverance of its youth, thereby revitalising its musical culture.

The profound interconnections among MED, EDN, and FT emphasise the importance of specialised training for professionals in the education sector. To ensure that students derive maximum benefit from the integration of music in the classroom, it is critical that instructors possess the necessary expertise and competencies to proficiently merge music, neuroscience, and pedagogy. Considering the data, it is critical to allocate resources

towards endeavours that centre on teacher preparation programmes with an emphasis on the interdisciplinary dimensions of music education. Moreover, it is critical to allocate resources in a manner that ensures fair and equal access to these benefits for people of all backgrounds. One potential approach to accomplish this is to guarantee adequate availability of relevant instructional resources and musical instruments at educational establishments situated in diverse geographical areas, encompassing both urban and rural locales. By implementing this strategy, it would ensure that every student in Thailand, regardless of familial status or cultural heritage, can experience the profound influence of music throughout their academic journey.

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