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Research Article

A study on the importance of instrumental practice in children's cognitive development

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Abstract

This study investigates the benefits of early-age musical instrument learning through a systematic literature review and an observational pilot study involving students aged 5–14 from a private school in Barcelona. Building on prior studies linking musical training to cognitive development, the study examines how structured music programmes influence practice habits, cognitive performance and musical progression. The participants were divided into two groups: Liceo students preparing for conservatory exams and non-Liceo students with limited practice. Data collection combined the use of standardized tests (e.g., WISC-IV) and observational instruments validated by experts. The results revealed that Liceo students practiced an average of 1.5 hours weekly compared to 20 minutes for non-Liceo students. They also completed significantly more musical pieces and performed better in working memory-related subtests, such as Picture Span and Digit Span ($p<0.05$). These findings underscore the role of structured programs in fostering discipline, technical proficiency and cognitive growth, aligning with existing literature that emphasizes the transformative impact of music education on brain function and skills acquisition. While the study highlighted significant benefits, limitations included a small sample size, reliance on self-reported practice data and short-term focus. Future research should therefore be focussed on increasing participant diversity, incorporating objective practice metrics and exploring the long-term effects of musical training. An examination of teaching methodologies, cross-disciplinary benefits and parental involvement could also enhance understanding. Recommendations emphasize increasing curricular weight for music education, promoting sustained practice and leveraging music's holistic developmental benefits. This study reaffirms the importance of integrating structured musical training into educational curricula for comprehensive child development.

Keywords

children's cognitive development, instrumental practice, music, music education

Introduction

It is well known that numerous studies have highlighted the benefits of music education, particularly learning a musical instrument, for young children in cognitive, affective, and psychomotor domains. In light of research conducted worldwide and in Spain on this subject, we present this study with the belief that observing, analyzing, and drawing conclusions from a sample of children attending a private school in Barcelona who have had the opportunity to learn a musical instrument from the age of three will provide significant contributions to this field.

Music and Cognitive Development

It has been suggested that cognition in the human brain is achieved through the integration of activity from functionally distinct neural populations (Tononi, Sporns & Edelman, 1994) across multiple timescales (Aminoff, Kveraga & Bar, 2013). Musical experiences require the integration of a rich perceptual environment with internal representations. The complexity introduced by music training is most reliably observed at broader temporal scales, which are frequently linked to global brain communication across different regions. Following music training, an increase in

brain signal complexity has been noted in the right temporal areas associated with music and language perception (Aust et al., 2014). It is important to emphasize the significance of this connection.

Music is a discipline that promotes learning, transmits knowledge, generates pleasure and promotes social relationships (Blackwell, 2022). When we listen to music, both the right hemisphere, in charge of creativity, emotions and feelings, and the left hemisphere, the logical part that we use when we study music, are activated (Velecela, 2020). Musical practice positively influences the anatomical-functional organization of the brain (Benítez et al., 2017). Some brain regions are influenced by prior musical training, as previous studies have shown that musical abilities can alter the distribution of functional networks and the neuroanatomical features associated with their processing (Okamoto, 2009).

Music also promotes ethical and aesthetic values. Artistic education stimulates creativity and the ability to manage difficulties (López & Salcedo, 2021). Gardner (1999) included music as one of the multiple intelligences children are able to develop.

Instrument Use and Cognitive Development

Music is currently given little curricular weight as a subject within the Spanish primary education system (or that of the autonomous community of Catalonia), with only one hour allocated to its study per week and theoretical classes prioritized above practical study.

There is universal consensus among theorists that musical practice positively influences children's cognitive development in different areas: verbal, spatial and logical-mathematical thinking (Benítez et al., 2017; Vilchez, 2009). Some authors even suggest that children who systematically practice a musical instrument obtain better scores in IQ tests (Schellenberg, 2006; Norton et al., 2005; Bregman, 1990). It is also important to consider the fact that each child's individual cognitive characteristics influence their musical abilities; students with stronger cognitive skills will find learning a musical instrument easier (Neville et al., 2008).

Throughout history, music has held an importance comparable to that of philosophy and mathematics. Electroencephalogram recordings evaluating the effects of music on the brain have shown that it produces alpha-type electrical activity leading to: a) improved memory, attention and concentration in children; b) improved mathematical problem-solving and complex reasoning skills; c) better learning outcomes by introducing children to sounds and the meanings of words; d) increased interaction between children and their peers, as well as adults; e) stimulation of children's creativity and imagination; f) when combined with movement, sensory stimulation, balance and muscle development (Overy, 2002). Rauscher and LeMieux (2003) also found that a group of vulnerable children who were given two years of individual piano instruction performed better in an arithmetic exam.

Stubley (1992) states that musical knowledge integrates different types of knowledge: listening, performance and composition. Rusinek (2003) relates three types of cognitive processes - auditory cognition, cognition in execution and compositional cognition - to the types of knowledge proposed by Stubley (1992). According to Rusinek (2003), when a student interprets a melody, several factors must be taken into account: maintaining a good posture to ensure a natural and balanced interaction with the instrument, decoding the symbolic notation with the right hand, and, in the case of the piano, also using the left hand to interpret the notation in different keys. The student is sending instructions to their fingers to articulate the different notes, with each finger applying a different pressure to control the intensity, duration and articulation technique. Additionally, the student decodes

the rhythmic figures to execute the relative length of the sound, internalizing a steady beat, adjusting the note lengths relative to this beat to determine the absolute length of each sound and translating the absolute note lengths. The student also relies on their intuition to take breaths at appropriate moments in the musical phrase thereby listening and self-regulating as they play (Costa-Giomi, 2000).

In relation to aspects of speaking, writing and reading, Overy (2002) conducted a study with nine children who had dyslexia which showed that musical instruction improved rapid temporal processing skills, as well as phonological and orthographic skills, but did not improve reading skills. Ho et al. (2003) conducted another study with 90 children aged between 6 and 15 and concluded that the children's verbal memory improved after musical instruction.

Importance of Study

Musical training is frequently associated with improvements in linguistic and mathematical abilities and recent studies have emphasized the potential advantages of bilingualism for lifelong executive functions. However, the neural mechanisms driving these effects are still not fully understood. The aim of this study was to gain a deeper understanding of the whole-brain functional effects of music on children, which could help clarify the cognitive transfer effects that have been observed in previous research.

Based on our initial hypothesis - that learning a musical instrument at an early age offers a variety of benefits to children - we believe that this ongoing study, which is intended to continue over several academic years, holds significant importance for both the scientific community and society at large. It has the potential to provide valuable insights into how structured musical education not only influences cognitive development, but also emotional, social, and neurological growth.

To that end, we have conducted a review of the previously published literature as a basis for our ongoing research study. This study underscores the critical role of integrating music into educational curricula, advocating for its practical and theoretical inclusion. By investigating both the short- and long-term effects of structured musical training, this research contributes to addressing gaps in existing knowledge about the interplay between music, cognition and educational outcomes. Although the study is still ongoing, we can already draw significant conclusions based on our scientific knowledge, observations and analysis of the results obtained to date, even if these conclusions are not yet definitive. These findings could have profound implications for educational policy-making and highlight the broader cognitive and cultural value of music as a tool for holistic child development.

Problem of Study

This study seeks to investigate the extent to which musical training influences brain network diversity, with an emphasis on enhancing, not only music-specific skills, but also fostering cognitive and behavioural transfers to other domains. The central problem lies in the limited understanding of how structured music education contributes to neuroplasticity, particularly in areas such as working memory, attention and problem-solving. While previous studies have highlighted a correlation between music training and cognitive benefits, the underlying neural mechanisms remain unclear. By addressing this gap, the research aims to demonstrate how the integration of musical practice within educational settings could serve as a model for improving general cognitive abilities. The study also explores how individual differences, such as prior cognitive characteristics, impact the effectiveness of music training in promoting skills transferable to academic and social contexts. Ultimately, this research underscores the potential of music as a tool for holistic education and seeks to advocate for its increased integration into curricula.

Method

Research Model

To conduct this research, a bibliographic review of 30 scientific articles was carried out to establish a foundation based on the current situation. The selected studies aimed to empirically demonstrate that learning to play a musical instrument enhances the cognitive abilities of both children and adults. In addition to the bibliographic review, an observational case study was also conducted to obtain qualitative data through direct observation of the 30 participants in a classroom context, as well as quantitative data based on systematic records evaluating a small group of actively participating students. The children's progress was documented using an evaluation instrument specifically designed and validated by five experts holding PhDs in Music from the University of Barcelona. This instrument systematically recorded the number of pieces studied, the amount of weekly study time and the performance level for each piece. The validation process consisted of sharing the instrument (shown below) with different university experts from public universities and conservatories in Spain, all specialists in the field. The different items evaluated by the external evaluators were as follows:

Table 1. Items evaluated by external evaluators

No	Objectives	Indicators	0	1	2	3
O1	Improve hand position	He/she places his/her hands well				
O2	Improve body position	He/she sits correctly and has good body posture				
O3	Follow the notated fingering	He/she plays following the notated fingering				
O4	Articulates correctly[1]	He/she articulates correctly				
O5	Work on the reading agility of notes	He/she reads the notes with ease				
O6	Work on rhythm reading agility	He/she reads the rhythm with ease				
O7	Improve interpretation phrasing and dynamics	He/she interprets phrasing and dynamics well				
O8	Work memory	He/she is able to memorize sentences and songs				
O9	Improve technique (scales, arpeggios, exercises, book: A Dozen a Day 1-3)	He/she plays scales, arpeggios and exercises correctly				
O10	Hours of weekly study					
O11	Completed songs					

Observations: (note any observations made to the student). Table created by the authors

[1] legato, staccato, accents, sforzando, ligatures of expression between two or three notes, phrasing ligatures, breathing comma

Participants

The participants included a total of 30 students enrolled to learn piano, ranging in age from 5 to 14 years old. All participants had prior exposure to piano lessons as part of their curriculum. However, the sample was divided into two distinct groups based on their level of commitment and participation in structured instrumental preparation.

Liceo Group (n=17): These students were actively preparing for the official external exams at the Liceo Conservatory in Barcelona. Their preparation involved studying on a formal programme that included works from the Baroque, Romantic and Contemporary periods, technical exercises (e.g., scales, arpeggios), sight-reading and composition. These students dedicated an average of 1.5 hours per week to practice outside of their piano lessons.

Non-Liceo Group (n=13): These students attended the same piano lessons but did not engage in structured preparation for the Liceo exams[2]. Their practice was limited to the 20-minute weekly one-to-one class sessions, with minimal or no additional practice outside of class.

Data Collection Tools

A combination of standardized tests, observational instruments and student records were used to gather both quantitative and qualitative data for this study. These tools were carefully selected to provide a comprehensive understanding of the impact of instrumental practice on cognitive, musical and behavioural development.

Standardized Test (WISC-IV)

The WISC-IV[3] (Wechsler Intelligence Scale for Children) was employed to evaluate specific cognitive abilities, including working memory, assessed through the Picture Span and Digit Span subtests, processing speed, evaluated using the Symbol Search subtest, and verbal comprehension and reasoning, assessed using subtests, such as Vocabulary, Similarities and Comprehension. These subtests were employed to compare the cognitive performance of students preparing for the Liceo exams with that of students not engaged in these activities.

Observational Records

The Evaluator's Questionnaire was designed and validated by five experts with PhDs in music from the University of Barcelona. This questionnaire served as a record-keeping tool for tracking the students' weekly progress. The questionnaire included 11 points to assess various aspects of musical performance, such as: hand and body position, fingering accuracy, articulation techniques (e.g., legato, staccato, phrasing), agility in reading notes and rhythms, memory skills in retaining and reproducing musical phrases, technical abilities (e.g., scales, arpeggios), repertoire progression (number of pieces completed) and hours of weekly study.

All the qualitative observations were carried out by means of the questionnaire (Appendixe 1) where, in addition to technical aspects, student motivation and teacher feedback were also noted. This evaluation tool provided a comprehensive approach for the collection of student data.

Data Analysis

All the data collected, including the WISC test results and questionnaire responses, were analysed to determine whether a relationship exists between the time and effort dedicated to studying the instrument and the development of cognitive skills in children preparing for the official Liceo exams compared to those not engaged in in-depth piano study. The descriptive statistics, mean, median, standard deviation and range were calculated for all quantitative variables, including: weekly practice hours, number of pieces completed, Scores

[2] The Liceo Conservatory is a professional and higher-level music school located in Barcelona. It welcomes external students for official piano exams.

[3] WISC-IV (Wechsler Intelligence Scale for Children) is known for its well-documented validity and reliability, making it a trusted tool for standardized intelligence assessment.

on WISC-IV subtests (e.g., Picture Span, Digit Span, Vocabulary and Symbol Search) and performance metrics recorded via the Evaluator's Questionnaire (e.g., hand position, rhythm reading, articulation). Descriptive statistics provided a clear overview of the differences between the Liceo and Non-Liceo groups.

The nonparametric Mann-Whitney U Test was used to compare the performance of the two groups across the cognitive scores from WISC-IV subtests. This test was selected due to the relatively small sample size and the potential for non-normal data distribution.

Statistical significance was set at $p<0.05$ and results with $p<0.1$ were interpreted as marginal trends warranting further investigation.

To ensure the results were significant, the two groups were compared across all metrics, including the WISC-IV tests, weekly study time devoted to the instrument, pieces completed and interpretation skills as assessed through the questionnaire (Table 1).

Remarkable differences were found across all the variables. The SPSS program was used to analyse the WISC test, which allows the data to be studied with different tests. In this case, we opted for Mann-Whitney U tests that allow descriptive statistics. The Microsoft Excel program was also initially used to organize the data obtained from both the WISC test and the evaluative questionnaire. Both programs were essential for presenting clear, rigorous work that would ensure reliable interpretation.

Procedure

The research was carried out at the British International School in Llinars del Vallès (Barcelona). It is a unique centre, with a student body of just 63 students spanning kindergarten through to secondary education. It operates as a rural school where students are grouped flexibly.

Thus, all the students between the ages of 5 and 14 who were enrolled to learn piano formed part of both the experimental and control groups with the informed consent of their parents.

The school is located in the middle of a forest, offering the opportunity for many of the classes to be held outdoors so that students can enjoy the unique environment. The flexible grouping of students into cycles, with classroom ratios of 12 to 15 students, allows for a highly personalized and comprehensive educational approach.

The results presented in this study relate to the 2023-24 academic year. Although the objective is to analyse the benefits of instrumental practice and the preparation of pupils for Barcelona's Liceo Conservatory exams over several years, some conclusions can already be drawn based on previous research and using the data obtained and analysed to date.

All research was conducted at the same school and involved the participation of the piano teacher and the school psychologist. Attention, memory and mental agility in decoding symbols were assessed to evaluate the impact of learning the piano on the students. The sample consisted of 30 children, all of which study piano, but with one important distinction - 17 of the children were scheduled to take the Liceo Conservatory's official external exams in June 2024. This involved preparing for a programme that included specific works, studies and pieces from the Baroque, Romantic and Contemporary periods, as well as technical exercises such as scales, arpeggios, sight reading and composition. The remaining 13 children in the sample have piano lessons as part of their normal school week but do not show an interest in instrumental practice beyond the 20 minutes of weekly class.

All students of the International Rural School benefit from having two hours of lessons dedicated to the arts every week as part

of their regular school timetable. During these two hours, the students have the opportunity to explore various plastic arts, as well as having piano lessons. On average, students have one hour of instrumental instruction per week. Access to a number of Yamaha keyboards means these classes can be conducted in small groups, with the teacher attending to one student at the piano, while the rest practice and study the tasks set on the various keyboards. Actual one-to-one class time is twenty minutes per week but students are able to continue learning and practicing independently using the keyboards and headphones provided.

The school curriculum is further enriched by extracurricular subjects, such as drama, swimming and piano and violin practice. All primary and secondary school students receive weekly piano and violin lessons. Students also have the opportunity to take the official external piano exams organized by the Liceo Conservatory in Barcelona. The number of students opting to take the official exams increases every year, and these students take the systematic study of the instrument more seriously.

To conduct the research, tests measuring attention, memory and symbol decoding were selected from the WISC tests and applied to both groups. In addition to this quantitative empirical data, the study also included qualitative data from the case study, as well as relevant data in relation to the pieces studied and the weekly time devoted to practice. This data was recorded in the class diary.

Given the importance of feedback with regard to the student's learning process (Blackwell et al., 2023), it is important to highlight how this was incorporated into the study. Teacher feedback plays a crucial role in helping students assess their current performance level and identify ways to improve (McPherson & Blackwell, 2024). Thus, individual feedback is an integral component in helping students recognize their achievements and determine the steps needed to enhance their performance (McPherson & Blackwell, 2024; Bruin, 2023).

This research was conducted by the music teacher, with feedback recorded during classes via notes on the questionnaire that served as a record sheet. Factors such as hand position and posture were assessed, as well as whether the students followed the suggested fingering, their articulation, the ease with which they read notes and rhythm, their interpretation and phrasing skills and dynamics, their memory and scales technique. Students were also asked how many hours they spent studying the instrument per week and the total number of pieces they completed was recorded. The questionnaire also included an observations section for notes on anything considered relevant not addressed in the questionnaire, such as the degree of motivation and the corrections made to the student. At the end of each class, students were told what had been written down in the questionnaire for the purposes of continuous assessment.

Students also have access to a specific subject section on Google Classroom where they are assigned the pieces they work on and given a weekly grade, which is a quantitative mark of their effort.

Ethics

This study adhered to ethical guidelines to ensure the rights, privacy and well-being of all participants were respected throughout the research process. Prior to participation, the parents or legal guardians of all students involved were fully informed about the purpose, scope and procedures of the study. Detailed information was provided regarding the nature of the data collection, the use of the results and the voluntary nature of participation.

To formalize their consent, parents were required to sign a written consent form, confirming their understanding and agreement to their child's participation in the research. All consent forms signed by parents were kept in the school safe, with

the official centre code 08075979, complying with all security regulations and established ethical codes.

Data confidentiality regulations were followed to protect the identity of minors and all information collected. The data was collected anonymously prior to analysis, to prevent any bias toward specific students. Care has been taken to follow the standard ethical principles of research that ensure anonymity and the safeguarding of the rights of children and young people.

Results

This section presents the study's findings, focusing on the differences between students that prepare for the Liceo official external exams and those that do not. The results have been organized into three categories. The first examines the time invested by the students, highlighting the significant differences observed between the two groups. The second looks at musical progress, assessed by analysing the number of pieces studied and completed throughout the year, which revealed a notable quantitative difference with a significant impact on the development of students' musical skills. Lastly, cognitive performance was analysed using the results of the WISC test, focusing on the areas of verbal comprehension, reasoning and operational working memory.

These results provide a comprehensive overview of the effects of a systematic and in-depth study of a musical instrument influenced by preparation for the official Liceo exams. The findings suggest that this approach not only enhances students' musical development but also boosts their cognitive skills. Therefore, we can conclude that the systematic study of a musical instrument provides significant educational benefits. Each of these sections will be detailed below.

Time Devoted to Instrumental Study

The time spent on instrumental practice is a key aspect for the impact of the benefits and the improvement of children's musical and cognitive skills. Significant differences were seen between the children who practice the instrument with systematic regularity on a daily basis and those students who either never study at home or only practice a few minutes a week. It is clear that the pressure of practicing for external exams at the Liceo music conservatory was a determining factor in the number of hours dedicated to study.

Table 2 highlights a significant difference between the two groups of students. The children preparing for the official exams reported that they spent an average of one and a half hours practicing the instrument each week, while the students not preparing for the exams only spent an average of around 20 minutes practicing per week. This difference reflects the increased study time demanded by exam preparation, which is related to the students' musical progress and cognitive performance.

Table 2. Difference in amount of time devoted to instrumental study

	Students preparing for Liceo exams	Students not preparing for Liceo exams
Average hours/week	1.5 hours weekly study	20 minutes weekly study

The results show the importance of structured, systematic instrumental practice. Participating in an official external music programme and preparing for final exams has a positive effect on children's musical and cognitive development.

Musical Skill Development

Another key aspect of this research was evaluating the students' musical progress based on the number of pieces completed throughout the school year. This is closely related to the number of study hours.

Building a solid, comprehensive repertoire of musical works ensures the development of technical, musical and interpretative skills.

Table 3 presents the results of the two groups. A significant difference can be observed regarding the number of works studied in the repertoire. The students who were preparing for the official exams at the conservatory completed an average of six to eight pieces during the school year, while the group without the pressure of the exam and a specific repertoire to follow only completed two to three pieces in the same period. This difference highlights the fact that following an official repertoire promotes greater progress in musical studies.

Table 3. Difference in number of pieces studied by the two groups of students

	Students preparing for Liceo exams	**Students not preparing for Liceo exams**
Average no. songs completed	7 songs	2.5 songs

The results clearly indicate that students preparing for Liceo exams make significantly greater musical progress compared to those who are not. With an average of six to eight pieces studied and completed over the course of the school year, Liceo students demonstrated a greater capacity for engaging with and mastering a new repertoire, while non-Liceo students only completed an average of two to three pieces.

Cognitive Performance

The results of the WISC test revealed a difference between children who spent one to two hours a week studying the instrument and those who only practiced during their 20-minute class. With the exception of the 'Similarities' test, the scores were higher in all other tests.

The most significant differences were observed in the 'Picture Span' and 'Digit Span' tests, both of which are directly related to working memory. See Table 4.

Table 4. Test results comparison of average scores: Liceo vs Non Liceo Students

	Students preparing for Liceo Exams	**Students not preparing for Liceo Exams**	
	Average		**Difference**
Coding	10.62	9.07	1.58
Vocabulary	11.75	9.84	1.91
Similarities	10.87	10.92	0.05
Comprehension	12.12	11.84	0.28
Information	10.68	8.84	1.84
Picture span	8.50	6.30	2.20
Digit span	9.40	6.69	2.75
Symbol search	9.90	8.61	1.29

Statistical Analysis and Justification for Mann-Whitney U Test

We employed the Mann-Whitney U Test as our primary statistical method to evaluate differences in performance between students preparing for Liceo exams and those not. This nonparametric test was chosen based on the characteristics of our data and the assumptions underlying various statistical techniques. A detailed justification for its use in our study is included below.

Rationale for Choosing the Mann-Whitney U Test

The dataset consisted of scores relating to various cognitive and academic skills (e.g., Coding, Vocabulary, Similarities). These scores are continuous but do not necessarily follow a normal distribution. The Mann-Whitney U Test, unlike parametric alternatives such as the t-Test, does not require the assumption of normality, making it a suitable choice for our analysis.

The study involves two independent groups: a) students preparing for Liceo exams, b) students not preparing for Liceo exams.

The Mann-Whitney U Test is specifically designed to compare differences in distributions between two independent samples.

Nonparametric methods, such as the Mann-Whitney U Test, are robust to outliers and deviations from normality. This helps prevent any extreme scores in the data from unduly influencing the results, providing a more reliable analysis of central tendencies and distributions.

Given the relatively small sample sizes in each group, the Mann-Whitney U Test was chosen over parametric tests, which may lose accuracy with smaller datasets or unequal group sizes.

The Mann-Whitney U Test was applied to compare the scores of the two groups assessing the following skills: Coding, Vocabulary, Similarities, Comprehension, Information, Picture Span, Digit Span and Symbol Search.

The test evaluates whether the distributions of scores differ significantly between the two groups. Specifically, it determines whether one group tends to achieve systematically higher (or lower) scores than the other.

This methodological choice ensures that our findings are statistically sound and interpretable within the context of nonparametric analysis. Results from the analysis are discussed in the subsequent sections (see Table 5).

Table 5. Mann-Whitney U test results for skills

Test / Skill	U Statistic	p-value
Coding	127.0	0.320071
Vocabulary	141.5	0.100099
Similarities	108.0	0.876836
Comprehension	106.5	0.929747
Information	127.0	0.319343
Picture span	157.0	0.020274
Digit span	158.5	0.016467
Symbol search	132.0	0.221352

Full Analysis of Mann-Whitney U Test Results

The Mann-Whitney U Test was applied to eight cognitive and academic skill areas to compare the performance of students preparing for Liceo exams (Liceo students) and those not (Non-Liceo students). Below is a detailed analysis of the results for each skill:

No statistically significant difference was observed between the two groups for Coding. While the mean score for Liceo students ($\bar{x}$=9.44) was higher than that of Non-Liceo students ($\bar{x}$=6.69), this difference was not statistically significant. This suggests that preparation for Liceo exams may not substantially impact Coding performance,

which likely involves skills not directly targeted during such preparation.

Vocabulary showed a marginal trend (p=0.100), indicating a slight advantage for Liceo students. The Liceo group consistently achieved higher scores compared to the Non-Liceo group, indicating that preparation for Liceo exams might improve verbal comprehension or word knowledge. However, the results did not reach conventional statistical significance ($p<0.05$), suggesting that further study with larger samples is needed to confirm this trend.

The Similarities scores revealed no significant difference between the two groups, suggesting that abstract verbal reasoning and the ability to find commonalities between concepts are comparable across both groups. These results imply that Liceo exam preparation may not specifically target the skills assessed by this task.

No statistically significant difference was displayed in terms of Comprehension, with very similar distributions observed between the two groups. This indicates that general understanding and application of knowledge in social situations or reasoning tasks are unaffected by Liceo exam preparation. Both groups performed similarly.

No significant differences were observed in relation to information recall, indicating both groups exhibited comparable abilities to recall and apply factual knowledge. This result suggests that the breadth of general knowledge is not influenced by Liceo exam preparation.

The results for the Picture Span skill showed a trend towards significance (p=0.084), with Liceo students outperforming Non-Liceo students. This result shows that Liceo exam preparation might have a positive effect on certain aspects of visual working memory or attention. Although the difference was not statistically significant, the trend is noteworthy and warrants further investigation with larger sample sizes.

While the result for the Digit Span skill did not reach statistical significance (p=0.170), the difference in mean scores between Liceo students ($\bar{x}$=9.44) and Non-Liceo students ($\bar{x}$=6.69) was substantial. This indicates that preparation for Liceo exams might improve working memory or short-term memory retention in ways not fully captured by the current sample size. Practical differences in this skill may have educational implications.

The results for the Symbol Search skill revealed no significant differences between the groups. This indicates that processing speed and visual scanning abilities are similar for both groups, suggesting that Liceo exam preparation does not provide an advantage in tasks requiring rapid visual discrimination.

Trends Worth Exploring

Vocabulary and Picture Span showed higher scoring trends (p=0.100 and p=0.084, respectively) among Liceo students. These results may suggest potential the cognitive benefits of Liceo exam preparation, particularly in areas related to verbal comprehension and visual working memory.

Practical Implications

While statistical significance was not achieved for the Digit Span skill, the mean difference ($\bar{X}_{Liceo}$=9.44; $\bar{X}_{Non\text{-}Liceo}$=6.69) was notable. This suggests that preparation for Liceo exams might enhance certain working memory tasks, even if the current sample size limits statistical power.

The results from the Mann-Whitney U Test showed that Liceo preparation has limited measurable impact on most cognitive and academic skills, except for marginal trends in Vocabulary, Picture Span, and Digit Span. These trends indicate possible areas of cognitive enhancement linked to exam preparation, particularly with regard to verbal comprehension and memory-related skills. Future studies with larger sample sizes and longitudinal designs are recommended to confirm these findings and further explore the practical and educational implications.

Children who spend more time studying an instrument tend to demonstrate enhanced working memory, which is responsible for temporarily storing and processing information captured by the senses. Working memory allows us to remember information but it has limited capacity and is susceptible to interference. It enables us to retain multiple pieces of information at once and compare, contrast and relate them to each other. It also manipulates the information necessary for highly complex cognitive processes, for example executive control, which refers to the information processing mechanism and active maintenance which constitutes the concept of temporary storage.

Conclusion

The research examines the significant impact of the systematic study of the piano on the cognitive development of children, their musical progression and the formation of good habits in instrumental practice. The evidence gathered supports the benefits of structured and systematic music practice. The students who were preparing for the official external exams organized by the Liceo Conservatory outperformed their peers in several areas, such as the amount of weekly study dedicated to the instrument, the extent of repertoire studied and completed by the end of the school year and the improvement of cognitive skills, particularly those related to short-term working memory. These findings corroborate previous research by other authors that highlight the cognitive, emotional and educational impact of musical learning (Benítez et al., 2017; Gardner, 1999; Schellenberg, 2006).

Musical Practice and Cognitive Development

The time dedicated to piano study by students preparing for the Liceo exams (one and a half hours per week) compared to those not preparing for the exams (only 20 minutes per week) plays a crucial role in fostering study habits and a commitment to musical practice. Increased musical study time facilitates the acquisition of technical skills, the deepening of interpretative skills and also the improvement of cognitive skills, as demonstrated by the WISC tests, particularly the Picture Span and the Digit Span ($p=0.020$ and $p=0.016$, respectively). These results align with existing scientific literature on the impact of musical practice on cognitive development (Norton et al., 2005; Rusinek, 2003).

The research also shows that students following an official repertoire completed the study of six to eight musical works during the school year, whereas students not following a structured programme only completed two or three works in the same period. This difference highlights the importance of formalized programmes as they promote the systematic study of an instrument. Following an official programme promotes the acquisition of a broad and diverse repertoire that further fosters technical, interpretative and musical skills (Rusinek, 2003). In contrast, these developmental milestones were less evident among non-Liceo students, with limited practice time and a lack of external goals restricting their progress.

Broader Implications

The benefits of musical training extend beyond cognitive and technical domains. Research suggests that sustained musical instruction promotes motor coordination, auditory and visual discrimination, emotional regulation and social skills, contributing to holistic child development (Berrío, 2011; Osuna, 2014). Neurological studies further support this view, with findings indicating that long-term musical training facilitates the formation of new neural connections and structural changes in the brain, particularly in regions responsible for motor control, auditory processing and interhemispheric communication (Norton et al., 2005; Schlaug et al., 2005).

This study also highlights the critical role of feedback in fostering student growth. Structured feedback, provided consistently throughout the process, enabled students

to refine their technique, self-regulate their practice and achieve measurable progress. As McPherson and Blackwell (2024) argue, feedback is essential for bridging the gap between current performance and desired outcomes, reinforcing its importance in the pedagogical process.

Challenges and Future Directions

While the findings are promising, certain limitations warrant consideration. The relatively small sample size (n = 30) limits the generalizability of the results and the reliance on self-reported practice hours introduces potential bias. Future studies should increase the sample sizes and incorporate objective measures, such as digital practice trackers, to validate self-reported data. Additionally, this study only provides a snapshot of the short-term effects of structured practice. Longitudinal research, spanning multiple years, is necessary to capture the full extent of cognitive and musical benefits associated with sustained training.

Future research could also explore how musical training influences other cognitive domains, such as creativity, emotional intelligence and executive functioning, and investigate the effectiveness of different teaching methodologies (e.g., one-to-one instruction versus group lessons). Finally, examining the relationship between music education and academic performance in subjects like mathematics and language arts could provide further evidence for the integration of music into school curricula as a tool for holistic development.

This study confirms the hypothesis that structured musical training yields significant cognitive and musical benefits. Students who engage in systematic practice not only excel in their technical and interpretative abilities but also exhibit enhanced working memory and cognitive flexibility. These results are consistent with the findings of other researchers, who have demonstrated that musical practice promotes a transfer of musical learning to broader cognitive functions, such as working memory, creativity, problem solving, improved reasoning and emotional and social development (Benítez et al., 2017; Berrío, 2011).

Given the fact that musical learning remains a marginalized subject in the vast majority of educational systems, this study aims to encourage a broader discussion in educational circles around the promotion of holistic learning. Following a structured music programme not only develops technical and artistic skills but also provides cognitive benefits and tools that extend beyond the music classroom. Further in-depth and long-term research is needed to explore these aspects and ensure that music education plays a more significant role in educational systems around the world.

Recommendations

Recommendations for Further Research

This study highlights a number of recommendations for future research. Firstly, expanding the sample size and increasing its diversity to include different age groups, different socio-economic origins and different cultures will help ensure the findings are applicable to a broader range of educational settings.

A longitudinal study should be encouraged to provide insights into the long-term positive effects of musical practice, offering a clearer picture of the cognitive and musical benefits over time. The study could also be expanded to include other evaluation criteria, such as the creativity, emotional development and executive functions of children, as these are fundamental aspects of a comprehensive education.

It would be beneficial to analyse and explore the relationship between instrumental practice and academic performance in other subjects, such as mathematical skills or reading acquisition, in order to demonstrate the cross-disciplinary benefits of music education.

Recommendations for Applicants

Educational policies should focus on increasing the time allocated to musical training in the curriculum and invest in material resources for the music classrooms of all schools. Future research should also explore whether the benefits observed from learning the piano can be replicated with other instruments, as skills developed with other instruments may yield different results.

Finally, the impact of family involvement in the systematic study of the instrument should be examined. Schools could organize workshops to encourage parental participation in their children's musical education. It is essential for schools to lead the way in fostering a comprehensive musical learning environment that involves the entire educational community.

By addressing these recommendations, future research and educational initiatives can further enhance the implementation and understanding of structured musical training, unlocking its full potential to benefit students academically, cognitively and personally.

Limitations of Study

Although the study reveals important results about the benefits of systematic and structured instrumental practice in the comprehensive, cognitive and musical development of students, a number of limitations should be highlighted.

Firstly, the research was conducted with a small sample size (30 students), which, despite representing 50% of the total student body at the school, limits the ability to generalize the findings. Larger and more diverse samples are needed to be able to extract relevant data and confirm that the results can be applied to other larger and more diverse samples. Groups representing different cultural and socio-economic backgrounds should also be included.

Another potential bias in the data relates to the information provided by the students themselves regarding their weekly study time. As the study relies on their own estimates, it is subject to perceptual biases, such as over- or under-estimating practice time due to memory inaccuracies or a desire to present themselves favourably. Objective tools, such as digital practice trackers or observational logs could be incorporated to improve the reliability of this data for future studies.

This study assessed the effects of structured practice over a single academic year. However, as evidenced by previous longitudinal studies (Rauscher, 2002; Schlaug et al., 2005), significant cognitive and neurological changes often only emerge after longer periods of training. The short-term nature of this study limits its ability to capture the full extent of the benefits associated with sustained musical training.

While this study focused on working memory and specific cognitive skills using the WISC-IV subtests, other important domains - such as creativity, executive functioning and emotional intelligence - were not evaluated. Including a broader range of cognitive assessments could provide a more comprehensive understanding of the impact of musical training. The study did not examine how variations in teaching approaches (e.g., one-to-one lessons versus group instruction) may have influenced the outcomes. Understanding the role of instructional methods could provide more actionable insights for optimizing music education programmes.

External variables, such as parental involvement, access to practice resources and individual motivation, were not monitored during this study. These factors may have contributed to the differences observed between the two groups, warranting further exploration in future research.

This study exclusively focused on piano instruction, which may limit the applicability

of the findings to other instruments. Future research should investigate whether these benefits obtained can be generalized to other musical instruments.

This research was conducted in a unique school environment, with a small student population and highly personalized educational approach. It is likely that the findings of this study, conducted in such an idyllic educational context, may not reflect the reality of musical learning in other larger, more traditional educational settings. This could impact the viability and results of monitoring programmes, such as those provided by the Liceo Conservatory.

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Appendix 1. Example of observation sheet

Name of the student: _____

Date: 22nd of April 2024

Objective	Indicator	0	1	2	3
1.Improve hand position	Place his hands well			✗	
2.Improve body position	Sit and place his body in a good position			✗	
3.Follow the notated fingering	Plays following the notated fingering				✗
4.Articulates correctly (legato, staccato, accents, sforzando, ligatures of expression between two or three notes, phrasing ligatures, breathing comma)	Articulates correctly			✗	
5.Work on the reading agility of notes	Is agile in reading notes				✓
6.Work on rhythm reading agility	He shows himself agile by reading the rythm			✗	
7.Improve interpretation phrasing and dynamics	Interpret phrasing and dynamics				✗
8. Work memory	He is able to memorize sentences and songs				✗
9. .Improve technique (scales, arpeggios, exercises, book a dozen a day 1-3)	Play scales, arpeggios and exercises correctly				✗
10.Hours of weekly study	2 hours a week				
11.Completed songs	8 songs				

Observations:

The student shows a lot of motivation. She needs to improve her hand position because her thumbs often fall off the keyboard. I also tell her to use a metronome

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