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# Can Music Support Calculation Skills? A Pilot Study Using Electrophysiological Measures*

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## Abstract

The purpose of this study is to electrophysiologically assess the effect of an individualized education program supported with musical activities on the success of primary school students with computational difficulties. A mixed-methods design consisting of qualitative and quantitative methods was employed as the research model. The research group consists of four students with mild special learning difficulties and learning difficulties in mathematics, among the students attending the third and fourth grades at a primary school in Kütahya city center. By examining the primary school mathematics curriculum, 12 mental processing gains were identified for addition and subtraction, one of the third-grade mental processing gains. An assessment form, training module, and math songs were prepared in line with these acquisitions. An assessment form was applied to the participants as a pre-test and post-test to determine the effect of the training module and math songs on the students' success.

Additionally, electroencephalogram (EEG) of the participants were recorded before and after the training module, and math songs were applied for 12 weeks. During the EEG recordings, 10 questions were asked to the participants that would enable them to make mental operations. The power densities of the EEG data were calculated using the Welch method in the MATLAB. To analyze the qualitative data of the research, descriptive analysis technique was used. As a result of the study, when the effects of the evaluation form of the participants' mental processing skills were examined, it was seen that the training module and math songs positively affected the mental processing skills of the students. In addition, it has been shown that the prepared training module and math songs increase the success of the participants, supported by electrophysiological evaluations.

**Keywords:**

Computational Difficulties, Electroencephalography, Mathematics Teaching, Mental Operations, Mathematics Learning Disability

## Introduction

While learning can be defined as the acquisition of knowledge, the problems that arise when the individual has difficulties acquiring knowledge can also be

expressed as learning difficulties (Korkmazlar, 1999). Learning difficulty is a structural and developmental problem that occurs in reading, written expression, arithmetic and academic, although mental development is generally expected. Geary (2004) argued that although the potentials of individuals measured by intelligence tests are normal or above normal, the failure to achieve the expected achievements in standardized achievement tests and the persistence of this difference in success for two years is an indication that individuals have mathematical difficulties. Mathematics is a challenging course that includes different areas such as arithmetic, solving arithmetic problems, geometry, algebra, probability, statistics, and calculation. This situation requires the use of skills such as quantity perception, symbolic analysis, memory, visuospatial capacity, logic related to various basic skills.

The difficulty experienced in any of these skills or using skills together is expressed as a Mathematics Learning Disability (MLD) (Karagiannakis et al., 2014). These students having MLD and have poor academic performance need to put more effort into their learning processes than their peers (Bintaş, 2007). After students with MLD develop their mathematical skills and adapt to the general education system, methods suitable for their learning characteristics should be adopted to follow the topics in the mathematics curriculum at the same level as their peers (Woodward & Montague, 2002). In addition to receiving their education as full-time inclusive students in regular classes, students with MLD also benefit from support education classroom service in mathematics lessons within the scope of special education (Mutlu, 2016). Individuals with MLD have differences compared to other students and different aspects from individuals with this diagnosis. In line with these differences, an Individualized Education Program (IEP) is prepared for students with MLD.

IEP is a program prepared by a team of experts, including a classroom teacher, for students with special needs, in which different experiences, environments, staff and working hours are required for the individual to display the physical, social, affective, and cognitive behaviors needed for the social norms that are expected to show (Özyürek, 2004). The IEP preparation team is formed according to the school's facilities where the student is located. Although the members legally required to be in the team have been determined, an IEP team is generally formed at schools, including the classroom teacher, guidance teacher, field teachers who teach the other lessons, and the school administrator (Diken, 2014). According to Olson and Platt (2004), IEP is a written record of the services to be provided to students with special needs. Besides, it was concluded that the participants found themselves inadequate in many areas, their self-confidence was built following special education, their attitudes towards mathematics became positive, they observed progress related to the processing skills of students, and supported students in terms of memory skills and retrieval (Temur, 2021).

When all these educational processes are examined in the context of music, it is seen that music might be important for people at every stage of their lives. People live with music from infancy to old age. Almost every child is born with average musical abilities and talents in other academic fields. For this reason, music is an effective and important technique used to support the development of language, motor and cognitive functions as well as improving children's musical abilities (Crncec, Wilson and Prior, 2006). The use of music in mathematics teaching increases academic success. There are many studies showing that music increases mental capacity, and accordingly, the use of music in mathematics teaching increases the academic success of students. Especially in basic mathematics education, the use of music and math songs is very important ( Whitehead, 2001).

Yoshida (2005), in his study "The Role of Music in the mathematical performance of high school students with moderate learning disabilities", investigated the effect of listening to music in the background during the math tests of students with learning disabilities, and revealed that music positively affects the mathematical performance. In addition to academic success, music also contributes to students at many points.

De León-Esparza (2019) shows that individuals tend to increase their understanding of the lesson while listening to their favorite music, which reflects a higher level of attention and better focus during lesson practice.

Thanks to music education received, according to some studies the communication of individuals can be healthier, regular, effective, and productive (Uçan, 2005). Also, integrating mathematics with music does not require musical practice or expensive equipment (Edelson & Johnson, 2003). Turan (2006) revealed that musical studies contributed to the social, physical, and mental development of students with special educational needs, but also to the development of students' self-confidence, their self-confidence in other areas where they feel lacking in success and increase their academic success. In addition, music is very effective in developing children's mental capacities and comprehension skills. Thanks to the correct and appropriate use of music in the education of children with MLD and the need for special education, positive effects can occur on these children. Especially the educational processes of children with MLD can be supported by musical stories and songs (MEB,

2014). When the relationship between music and mathematics considered, it is seen that musical activities can offer children different opportunities to support basic mathematical skills. Santos-Luiz and colleagues (2016) revealed long-term associations between music training and academic achievement with music students performing academically better than non-music students. In addition, there might a developmental sequence in the acquisition of basic mathematical skills. At this point, by supporting children's use of a mathematical language with musical activities, a facilitating effect can be created in the acquisition of mathematical thinking and concepts (Dikici, 2002). Moreover and Cheek and Smith (1999) and Wetter and colleagues (2009) found a positive relationship between being engaged in music activities and overall academic achievement. Mehr and colleagues (2013) studied the effectiveness of music training enhancing spatial abilities and mathematics. Thus, studies seem to indicate a relationship between music, intelligence, and learning with music potentially positively contributing to child's brain development. Shaw claimed that music positively affects learning, especially mathematical and some abstract concepts (Shaw, 2003). However not all studies agree on the educational advantage of additional musical activities. Sala and Gobet (2017) revealed that compared to random-effect sizes the impact of music training was very small, with a slightly greater effect size on memory-related outcomes. They concluded that music training did not reliable enhance children's academic skills, making additional studies indicated to understand the nature and origins of the relationship between music and mathematics. According to Sığırtmaç (2005), children can support their ability to match mathematical concepts, using tone of voice, pairing sounds with each other, and matching sounds and instruments one-to-one through musical activities. The names of the children participating in the activities can be used in rhythm studies. In addition, objects can be grouped according to their sounds to develop classification skills in mathematics. While conducting a study on children, a long process may be necessary for children to hear, learn, remember, and repeat to behave according to the prepared model. The use of rhythms and melodies in songs facilitates keeping counting in mind instead of memorizing. Also, during participating in the group learning activities, the students are able to increase their motivation (Hima, 2019). While performing a mental workload, music can have a very important role in affecting the attention and concentration state of the brain (Teixeira, 2018). In this study, it has been concluded that the designed math songs have a facilitating effect on the retention of what has been learned by shortening the process required for the acquisition of mental operations acquisitions. In addition, it has been concluded that the math songs designed in this study have positive effects on mathematics teaching. This result is parallel with the results of the study by An (2013) examining the teachers' methods of integrating music into regular mathematics lessons and the effects of music-mathematics interdisciplinary lessons on primary school students' mathematical abilities in modeling, strategy, and practice. In this study, the education process of the training module, which was prepared by considering the facilitating educational functions of music with students diagnosed with MLD and had calculation difficulties, was supported by mathematical cubes, number base blocks and musical activities that embody mathematical operations. In this context, mathematics songs were prepared by taking expert opinion by acquiring mental addition and subtraction from the primary school third-grade mathematics lesson.

In the context of the relationship between the brain and learning, it is seen that the primary purpose of using brain research in education is to enable educators to comprehend what kind of potential the brain has, what it can do, and which emotions can cause what kind of effects on the brain (Caine & Caine 1990). Interdisciplinary studies aiming to explain how learning takes place in the human brain aimed to understand the nature of learning, examining how one cell connects with another during learning, which parts of the brain are active during this time, and tried to understand how the events in these regions are related to each other (Goswami, 2004). Cognitive neuroscience provides measurements of brain activities using some tools such as Functional Magnetic Resonance Imaging (fMRI) and EEG to interpret brain activities occurring in different states of mind and to understand how cognitive functions are (Dündar, 2014; van Bueren et al., 2021). Studies showed that the human brain constantly produces electric current at very low intensities and spreads the electric current it creates in waves. These bioelectrical potentials, obtained from the brain's neural activities, can be measured using EEG (Tosun, 2004). EEG is expressed as a collection of spontaneously occurring neuroelectric events in regions close to the brain surface (Levy, 1984). EEG is a tool that records the electrical activities in the brain, and electrical effects in the brain can be measured with the help of electrodes connected to different parts of the scalp (Sousa, 2001). These measured values are analyzed and interpreted by experts.

This research aimed to support the IEP, prepared for primary school students with calculating difficulties and musical activities, and reveal the expected difference in these children's mathematical achievement and mental activities.

First, students with computational difficulties among the ones who are diagnosed with mild MLD and

have applied to special education and rehabilitation centers are determined voluntarily, and it is aimed to electrophysiologically evaluate the effect of IEP, supported by musical activities, on the success of these students with computational difficulties. The research questions of the study are as follows:

1- What is the effect of the designed IEP on the success of primary school students with computational difficulties?

2-What are the situations encountered during the implementation process of the designed IEP with children having computational difficulties?

3-Is there any difference between the EEG data of the children who received IEP supported by musical activities and the EEG data of the children who received IEP only?

In this sense, it is thought that the results of this study will contribute to the literature and provide information about the mental processing performance of children with MLD. In addition, it is thought that the IEP prepared for these students with MLD will support the planning process and shed light on further studies to be conducted in the field.

In this context, the study results will contribute to the literature and provide information about the mental operations performance of children with MLD, supporting the re-planning of the mathematics learning processes of these students, that different educational programs can be developed for individuals with MLD with the methods used, and that various educational programs can be developed in the field. It is thought that it will shed light on future studies.

## Method

This study aimed to electrophysiologically evaluate the effect of IEP supported by musical activities on the achievement of primary school students with computational difficulties. In the study, with the support of IEP, which was prepared with musical activities for primary school students diagnosed with MLD and had calculating difficulties, the change in these students' mathematics achievement and mental activities was revealed.

### *Research Model*

This study aimed to evaluate the performances of the mental addition and subtraction operations of primary school students who were diagnosed with MLD and had computational difficulties in the third-grade mathematics lesson using the training module and math songs in the education process, and EEG recording was performed before and after the education process. Thus, many studies were examined. In this way, due to the multidimensional nature of events and phenomena, mixed design research was chosen as the research model, and qualitative and quantitative approaches were adopted. Mixed-pattern studies used both qualitative and quantitative methods to examine the research problem comprehensively and its many dimensions together (Yıldırım & Şimşek, 2013).

Leech and Onwuegbuzie (2009) argued that mixed research includes collecting quantitative and qualitative data on the same basic phenomena in a single study or more than one study series analyzing this collected data, synthesizing the findings, and then making inferences.

### *Research Process*

In the process of clarifying the research problem, first, a comprehensive literature review on MLD was conducted. Based on this, it is seen that students with MLD also have computational difficulties. One of the measures that can be taken to overcome the computational difficulties experienced by students with MLD is to include musical activities in IEP. After taking expert opinion, an evaluation form prepared by one of the researchers was used to determine students' mental processes with MLD. In developing the evaluation form, first, literature review was conducted. Then, the MEB 1-4 Grades Mathematics Curriculum (2017) was examined, and the achievements for third-grade mental operations were determined. As a result of this, 12 mental process gains were determined, eight of which were mental addition and four of which were subtraction. A multiple-choice draft evaluation form consisting of 24 items was prepared by these achievements. Expert opinion was taken to examine the content validity of this form, clarity in terms of language and expression, and intelligibility.

As the evaluation form were applied to the participants individually, the number of questions in the evaluation form was taken into consideration, and the evaluation form, which was prepared as multiple-choice, was re-prepared during the research process as an evaluation form consisting of open-ended questions by making various arrangements.

In addition to the evaluation form, a training module and math songs related to each achievement were prepared in accordance with the mental processing achievements, which took 12 weeks to be applied to each student. While the training module and math songs were being prepared, third-grade mathematics textbooks were examined, and activities were designed in accordance with the achievements of the course. The prepared training module and math songs were sent to the experts to obtain their opinion.

In line with the opinions and recommendations of the experts, the training module and the songs were reexamined, and necessary arrangements were

made. In designing math songs according to the third-grade acquisitions, it was prioritized that they should be suitable for mental processing gains and have fun content ideal for children. After completing the draft work of the math songs, the field expert was also consulted. After receiving feedback from the field expert, necessary arrangements were made, and the math songs took their final form.

Alpha, Beta, Theta, Delta, and total powers were calculated by performing Welch analysis of the participants' EEG data though MATLAB to evaluate electrophysiologically what effect the students' achievement and brain waves had when IEP supported by musical activities was applied to primary school students with computational difficulties in their mathematics learning processes.

*Study Group*

The study group consists of students diagnosed with mild level (20%) MLD and have learning difficulties in mathematics lessons among the students attending the third and fourth grades in primary schools located in Kütahya city center. The students in the study group were determined by the purposive sampling method. Students who attend special education and rehabilitation centers in Kütahya and have computational difficulties were determined. Four students were selected among these determined students on a voluntary basis.

*Data Collection Tools*

In the first semester of the 2018–2019 academic year, the evaluation form and training module were applied to four volunteer students aged 9–11 who were attending the Special Education and Rehabilitation Centers of the Ministry of National Education in Kütahya and were in compliance with the research criteria.

After the evaluation form, training module and math songs were prepared, the volunteer participants were determined according to specific criteria. During the determination, factors such as students' volunteering, mild (20%) MLD and difficulty in the calculation were effective. Before performing the application, one of the researchers informed the participants and their parents about the research topic and research process. Before starting the application, one of the researchers applied the evaluation form as a pre-test to four primary school students aged 9–11 with MLD and recorded the students' correct, incorrect, and blank answers.

Data on learning difficulties experienced by each student were obtained from special education teachers working in special education and rehabilitation centers. Then, interviews were conducted with the families of these students with MLD by setting appropriate meeting times. In the interviews with the parents, information about the study was given.

Before the research, although 10 parents were interviewed, five parents did not want their children to participate in this study, considering that they even came to the Special Education and Rehabilitation Center reluctantly. One of the five students who wanted to participate in the study voluntarily was diagnosed with epilepsy and, as a result of the data obtained during the study's EEG recording, was excluded. As a result of the interviews with the parents of the remaining four students, the necessary legal permissions were obtained from the students and their parents who wanted to take part in the study voluntarily.

An electrophysiological evaluation was made by performing an EEG recording before and after the training to see the effect of the training module, supported by musical activities given for 12 weeks, on the students' brain waves. In this evaluation, EEG data were analyzed by performing Welch analysis in the MATLAB. During these EEG recordings, 10 questions were asked to the participants to enable them to make mental operations. From the moment participant saw the question, EEG data were recorded when participant made a solution in participant's mind. Therefore, from the moment participant saw the question and started to think in participant's mind, the waves formed in the brain were recorded in the computer environment through the EEG device.

Before the EEG recordings, a sample recording was performed with the personnel in the EEG laboratory. Thanks to these sample recordings, the most suitable conditions for the research were provided by taking the neurologist's opinion. In this study, a unique database was obtained by recording the EEG data with a Nihon Kohden 1200 digital EEG device that can capture 16 channels with high quality and reliability.

Following the mental processing gains, 10 questions determined with the expert were asked by one of the researcher by showing question cards to the participants during the EEG recording, giving one minute for each question. After each one-minute question, a 30-second break was given, and then new questions were started. Because of this situation, the first 30 seconds of the recorded EEG data were taken from the moment the questions were asked.

Thus, five numerical values were obtained as Alpha, Beta, Theta, Delta, and total power from each question asked for each EEG recording of each student. Thus, a total of 100 data, including the first and last recordings, were obtained, five each consisting of 10

questions. As a result, 400 power data is obtained from four participants. Then, the data recorded with the digital EEG recording device were transferred to the computer environment and converted into forms on which appropriate analyses could be made.

*Analysis of Data*

*Analysis of quantitative data*

Various analysis methods have been developed for the classification of EEG signals. One of the most widely used of these analysis methods is the Welch analysis method, in which the power spectrum density is calculated using non-parametric methods (Faust, 2008). In the EEG analysis method, mathematical tools are used to analyze the data. The characteristics of the EEG signals to be analyzed can be found by the power spectrum density (Subasi et al., 2005). The power densities of the frequencies between 1 and 48 Hz of the EEG data were calculated using the Welch analysis method. Neurofax EEG System was used for EEG recording. In this study, it was deemed appropriate to conduct Welch analysis for the research data by the relevant field experts. Fast Fourier transform (FFT) algorithms based on Fourier transform are generally applied to these analyses. At this point, the Welch analysis is accepted as one of the well-known non-parametric power spectral density estimation analyses (Tosun, 2018). While analyzing the EEG data, MATLAB (MathWorks, USA) program was used. MATLAB is a high-performance software primarily written for technical and scientific calculations, including numerical computation, graphical data representation, and programming. General usage areas of the MATLAB program can be summarized as Mathematics and computational processes, algorithm development, modeling, data analysis, scientific and engineering graphics, and application development. Evaluating EEG data is a complicated task. The data obtained from EEG shots can be affected by several physiological conditions such as hunger, age, wakefulness-sleep state, and mental state. To get more reliable results in evaluating EEG data; during the EEG recording, the conditions required for the recording were tried to be provided in the best way, and the physiological conditions of the participants were also taken into consideration.

*Analysis of qualitative data*

To obtain information about each student in the study group, a literature review was conducted by one of the researcher. In the light of the information obtained, the one of the researchers made various observations before starting the application to know the environment he would practice. In this context, the observation technique was used to describe the behaviors occurring in any environment or situation in detail. The observation method can present one of the researchers with a detailed, comprehensive, and more extensive picture of behavior that occurs in any environment (Yıldırım & Şimşek, 2013). The researchers met the students and their families participating in the research before the study and talked with the participants before starting the practice and got used to the researchers. The researchers also chatted with the students before and after each application and had the opportunity to learn about the students' thoughts about the mathematics lessons and learning. During the observation, the researchers did not use any form. During the research process, 12 lesson hours with each student were recorded with a camera to record the students' performances during the application. First, the camera recordings were watched together with the researchers and experts. Then, the camera recordings were transcribed by the researchers. In the data analysis, the names of the research participants were not used. Instead, they were expressed as Participant 1, Participant 2, Participant 3, Participant 4. In this sense, the researchers met the students and their families who participated in the research and talked with the participants before starting the application and made them get used to the researchers. The researchers also chatted with the students before and after each application and had the opportunity to learn about the students' opinions about the mathematics lesson and learning.

Descriptive analysis techniques were used to describe and summarize the data obtained as a result of the researcher's observation in the training module and the application of math songs. The research data obtained in the descriptive analysis were first described systematically and clearly. These descriptions were then explained and interpreted by the researchers. The resulting cause-effect relationships were also examined, and some results were showed (Yıldırım & Şimşek, 2013). First, frequency tables were prepared and analyzed in the analysis of the data obtained with the evaluation form. With these analyzed data, it is aimed to reveal what kind of change there is in the pre-test and post-test evaluations of the participants. In the pre-test and post-test, the participants' answers were specified as True or False, and individual assessments of each student were made.

*Validity and Reliability of the Research*

A literature review was conducted to ensure the validity of the questions in the Validity and Reliability Evaluation form. It was then prepared in accordance with the purpose of the research by taking the opinions of the relevant experts. The questions in the evaluation form were applied after the thesis advisor, faculty member, and field experts were determined that they could fully serve the purpose of the research. During the research process, additional measures

were taken to ensure the validity and reliability of the research findings. The researchers obtained permission from the National Education Directorate and the participants' families to conduct this study. Not to interrupt the research, the home environment, which is the environment where the participants can feel most comfortable, was determined as the practice environment. Camera recording was made to avoid data loss in the research, and the researchers converted the data into text. The study was approved by Kütahya Health Sciences University Faculty of Medicine Clinical and Laboratory Research Ethics Committee with the number 81469268-900 dated 13.06.2019. Before the EEG examinations, the participants in the study were informed about the research. Informed Voluntary Parent Consent Form, Parent Statement and Child Consent Form were signed by the participants' families.

**Study Results**

In the qualitatively designed part, the data obtained from the observation technique using video recordings were presented with the descriptive analysis method. In that part again, expert evaluation was made in the analysis of the EEG data taken while calculating the mind. It was presented within the framework of Welch analysis, one of the signal analysis methods, through the MATLAB program.

*Findings Regarding the Effect of the Designed IEP on The Success of Primary School Students Who have Computational Difficulties.*

An evaluation form was used to determine the effect of the designed IEP on the success of primary school students with computational difficulties. When the evaluation form findings were examined, Participant 1 correctly answered 18 of the 24 questions asked in the pre-test, which was the first application of the evaluation form. In the post-test, which was the second application of the evaluation form, it was observed that Participant 1 gave the correct answer to 20 questions out of 24, and as a result, the number of correct answers by Participant 1 in the evaluation form increased. Participant 2 correctly answered only three of the 24 questions asked in the pre-test, which was the first application of the evaluation form. In the post-test, which was the second application of the evaluation form, it was observed that Participant 2 gave the correct answer to 21 questions out of 24, and as a result, it can be stated that the number of correct answers by Participant 2 in the evaluation form increased. Participant 3 correctly answered nine of the 24 questions asked in the pre-test, which was the first application of the evaluation form. In the post-test, which was the second application of the evaluation form, it can be stated that Participant 3 gave correct answers to 21 questions out of 24, and as a result, the number of correct answers by Participant 3 in the evaluation form increased. Participant 4 correctly answered 14 of the 24 questions asked in the pre-test, which was the first application of the evaluation form. In the post-test, which was the second application of the evaluation form, it can be stated that Participant 4 gave correct answers to 21 questions out of 24, and as a result, the number of correct answers by Participant 4 in the evaluation form increased.

In the pre-test, which is the first application of the evaluation form, Participant 1 answered three questions correctly, Participant 2 answered nine, and Participant 3 answered fourteen questions correctly. In the post-test, which was the second application of the evaluation form, these participants gave correct answers to 21 questions out of 24. As a result, it is seen that the increase in the number of correct answers of all participants is significant.

The first 18 questions of the evaluation form consist of questions about the mental collection process, and the remaining six questions are prepared for the mind extraction process. When the prepared questions are examined, it is seen that the participants mostly have difficulties in mental operations, which are shown with number models and written side by side. In the post-test, all participants correctly answered the fifth and seventh evaluation questions, which were prepared using the representations of numbers with models. In addition, it was observed that the participants were wrong in the questions in which one of the totals and the result were given and the totals were not given. Likewise, the participants had several difficulties in the mind subtraction process, which asked the participants to find the subtraction and remainder by providing the remainder. In the light of the data obtained from the evaluation form after the 12-week training, it is clearly seen that there is a significant increase in the correct number of participants.

It was observed that the participants had more difficulties in mind subtraction than in mind addition processes. After the training given, there was a significant increase in the number of truths obtained from mind subtraction. As a result of applying the evaluation form as a pre-test, a total of 44 correct answers were obtained from four participants. In comparison, a total of 83 correct responses were obtained from the participants as a result of the application of the evaluation form as a post-test.

*Findings Regarding the Situations Encountered During the Implementation Process of the Designed IEP with Children with Computational Difficulties*

The situations related to each outcome were interpreted separately to determine the situations encountered during the designed IEP with children with

computational difficulties. Regarding the acquisition of mentally adding up two natural numbers, the sum of which does not exceed 100, the participants forgot to calculate the hand while doing the addition. In addition, the participants had difficulties while doing the addition operations given side by side. When they wrote the given numbers one under the other and added them together, they achieved the correct results by easily doing the operation.

Regarding the acquisition of mentally adding a three-digit number and a one-digit number, the participants made finger calculations while adding. As they did not know the representation of the numbers with the models by dividing them into units, tens and hundreds, they could not do the addition process correctly with the parts of the numbers indicated by the models. However, after learning the representations of numbers with models, they could correctly perform addition operations. Regarding the acquisition of mentally summing a two-digit number that is a multiple of 10 and a three-digit number that is a multiple of 100, the participants counted tens by 10 and counted one 10 less or more.

Regarding the acquisition of "Makes mental addition using the rounding strategy," the participants had difficulties rounding the numbers to the correct tens because they did not know how the numbers were rounded to the nearest tens.

Regarding the acquisition of "Makes mental addition by using the number pairs strategy," the participants made finger calculations while doing the addition with number pairs. It is seen that the participants confuse the place values when adding about the acquisition of "Makes mental addition by using the place values strategy." Regarding the acquisition of "Makes mental addition by using the adding on strategy," the participants could do the addition operations more easily and accurately as they could see the numbers concretely on the number bar in the addition processes given by the length model. In addition, the participants marked the given additions one by one using a pencil on the number bars and counted all the numbers without getting bored. Regarding the acquisition of "Makes mental addition by using the segmentation strategy," the participants had difficulty in separating the two-digit numbers using the segmentation strategy.

The participants did not know how to subtract through number models regarding the acquisition of "Makes two-digit numbers that are a multiple of 10 from two-digit numbers by mind subtraction." When subtracting two-digit numbers that are a multiple of 10 from two-digit numbers, they learned that the remainder would result from subtraction by placing a cross on the column representing each ten. Then, the participants could do the subtraction more easily and accurately when the subtraction operations were expressed with numerical models, and the given subtraction was concretized. Regarding the acquisition "Makes mental subtracting natural numbers multiple of 10 from three-digit natural numbers multiple of 100," the participants tried to perform the subtraction given as an addition operation, forgetting that they were doing subtraction while performing subtraction on natural numbers.

Regarding the acquisition of "Makes subtraction by using the strategy of adding on," the participants could not correctly remember which of the numbers given in the subtraction process is the subtractive number, which is the subtracted number, and which is the remaining number. In the subtraction operations, the researchers reminded the participants that the missing number can be found by adding the number and the remaining number in the questions asked to see the decreasing number by giving the number and remainder. Regarding the acquisition "Makes mental subtracting operations using the strategy of breaking numbers into parts," the participants made various mistakes while performing mental subtraction by using the strategy of breaking numbers into parts.

In addition, throughout the training process, Participant 1 was a very willing student in both the training module part and the singing math songs part of the research. Participant 2 was an introverted student who did not like to talk much, had a somewhat shy nature, but willingly participated in the training module and materials. Participant 3 was a shy student who was somewhat reluctant to do a training module, wants the activities to end quickly, but was eager to sing and learn math songs. Participant 4 could be defined as a student who both did not want to sing the math songs and participated in the training module activities reluctantly.

*Findings in Terms of Determining the Difference Between the EEG Data of Children Who Received IEP Supported by Musical Activities and the EEG Data of Children Who Only Received IEP*

The EEG data obtained from the participants were analyzed and interpreted to determine whether there was a difference between the EEG data of the children who received IEP supported by musical activities and the EEG data of the children who only received IEP. Welch analyses of the power data obtained from the participants during the EEG recordings were made in the MATLAB, and the data revealing the results were examined. As there is excessive Alpha activity in children with MLD, decreases in Alpha power are interpreted as an increase in mental activities in the brain (Chabot, 1996).

There was a change in Alpha, Beta, Delta, Theta and Total Powers obtained from the questions asked during the EEG recording of the participants. In Participant

1, there was a decrease in the values obtained from eight questions in Alpha power, and an increase in Beta power in four questions. In addition, delta strengths decreased in six questions. There was a decrease in theta power at five questions. Also, there was a decrease in total power in only two questions. In Participant 2, the values obtained from eight questions decreased in Alpha power. There was an increase in beta power again in two questions. Delta power decreased in seven questions. There was a decrease in theta power in four questions. There was a decrease in total power in seven questions. In Participant 3, the values obtained from only two questions decreased in Alpha power. However, a total of seven questions increased in Beta power. Delta power decreased in four questions. There was a decrease in theta power in the four questions. There was a decrease in total power in seven questions. In Participant 4, the values obtained from only two questions decreased in Alpha, Beta, Delta, Theta and Alpha power. Beta power increased by nine questions. Delta power decreased in one question. There was a decrease in theta power in one question. There was a decrease in total power in the three questions.

Alpha rhythm is seen in awake, ordinary, and calm people. During the sleep, the Alpha rhythm disappears. If the awake person directs his attention to something special, such as a mental activity, a higher frequency Beta rhythm occurs instead of Alpha waves (Yazgan & Korürek, 1996). As there is an excessive Alpha activity in children with MLD, decreases in Alpha power are significant as an increase in mental activities in the brain. Beta wave is the brain wave observed while awake. It is obtained mainly from the anterior parts of the brain (Başar, 2012). It also occurs when the human brain is exceptionally dense. When a person is exposed to too many external stimuli, an increase in beta waves occurs in the brain. Beta wave is active when eyes are open while listening, thinking, solving analytical problems, making decisions, making judgments, and processing the information around (Aydemir & Kayıkçıoğlu, 2009).

Alpha wave is important in learning and using information activities and it is seen that it decreases while the individual is performing thinking and problem solving processes. The beta wave seems to get stronger during analytical problem solving, judgment, decision making and audio listening (Ildız, 2007).

In this study, as excessive alpha activity is observed in children with MLD, decreases in alpha power and increases in beta power are significant as an increase in mental activities in the brain. If awake people direct their attention to something special, such as a mental activity, higher frequency Beta waves are formed instead of Alpha waves. The findings of the study revealed that when the participants are exposed to too many external stimuli, a decrease in Alpha waves and an increase in beta waves occur in the brain.

## Conclusion and Discussion

### *Conclusion and Discussion Regarding the Evaluation Form*

After the literature review of the evaluation form was made, the MEB first-fourth grades mathematics curriculum (2017) was examined, and the achievements for the third-grade mathematics course mental operations were determined. As a result of this examination, 12 mental process gains were determined, eight of which are mental addition and four of which are subtraction. A 24-item evaluation form consisting of open-ended questions suitable for these acquisitions was prepared. The following results were obtained from this evaluation form.

Considering that the first 18 questions of the evaluation form consisted of questions related to the mental addition process and the remaining six questions were prepared for the mind subtraction process, it was observed that the participants had difficulties in mental operations, which were shown with numerical models and written side by side, among the most prepared questions. However, after the training, all participants were able to answer the fifth and seventh evaluation questions correctly, which was prepared using the representations of the numbers with the models in the post-test.

It was observed that the participants were wrong in the questions in which one of the totals and the result were given, and the totals were not given. Similarly, the participants had several difficulties in the mind subtraction process, which asked the subtraction and remainder to be found. It was concluded that there was a significant increase in the correct number of participants when considering the data obtained from the evaluation form after 12 weeks of training. Participants had more difficulties in mind subtraction than in mind picking. However, it was also concluded that after the training, there was an increase in the number of truths obtained from mind subtraction. While 44 correct answers were obtained from four participants because of the application of the evaluation form as a pre-test, a total of 83 correct answers were obtained from the participants as a result of the application of the evaluation form as a post-test. The difference between the pre-and post-training was determined through the evaluation form. In a study by Wisniewski and Smith (2002), the effectiveness of Touch-Math, a mathematics set that aims to teach mathematics to students more easily, in increasing the mathematics achievement of primary school third and fourth-grade students with special

needs were investigated. The students participating in the research taught mathematics for 14 weeks in the resource room for 45 minutes, 20 minutes of which were on the Touch-Math set. As a result of this research, a significant difference was observed in the duration, and correct answers of the tests applied to the students.

*Conclusion and Discussion Regarding Discussion the Training Module*

Some results were obtained in the designed training module, and the math songs were applied together. The findings of the evaluation form of mental processing skills of students with MLD revealed that the training module and math songs positively affect students' mental processing skills. In the study, it was observed that the participants' mental addition and subtraction performances increased. The study findings revealed that the mistakes made by the students in writing numbers and the problems they experience while performing mental operations have decreased significantly compared to the initial level. It is thought that this situation results from the prepared training module and math songs.

Another type of mistake that students with MLD and computational difficulties make the most is changing a transaction. At this point, the use of musical activities in mathematics teaching had a positive effect on learning operations from the mind. In addition, it was concluded that the math songs designed in this study had positive effects on mathematics teaching. In the study by Raghubar et al. (2009) the arithmetic performances of primary school third and fourth-grade students with and without MLD were compared. The study examined students' performances in multi-digit addition and subtraction. As a result, they found that students with MLD make more mistakes such as finding close values, moving the hand to another column, not carrying the hand, and not breaking a decimal point (Raghubar, 2009).

Another common mistake that students with MLD and computational difficulties make the most is changing a transaction. In addition, the use of musical activities in mathematics teaching had a positive effect on mental learning processes. In the study about the effect of the use of songs in elementary mathematics teaching, it was found that mathematics teaching supported by music activities using songs in primary school third-grade mathematics lessons resulted in a difference in students' attitudes toward music and mathematics, achievement scores, multiple intelligence areas and memory levels (Bütüner, 2010). In addition, it was reported that the use of songs in mathematics teaching had a positive effect on students' thoughts and opinions about the mathematics lessons. Shaw, Graziano, and Peterson (1999), "Piano and Computer Training Boost Student Math achievement." In their study, it was revealed that the mental abilities of children who received music education in early childhood developed. The contribution of music to the development of mental abilities is stated. Whitehead (2001), in his study "The Effect Of Music-Intensive Intervention On Mathematics Scores Of Middle And High School Students", obtained results indicating that the use of music in mathematics teaching increases academic achievement. He states that there are many studies showing that music increases mental capacity, and accordingly, the use of music in mathematics teaching increases the academic success of students. Especially in basic mathematics education, the use of music and math songs is very important.

Whitehead (2001) obtained results indicating that the use of music in mathematics teaching increases academic achievement. He states that there are many studies showing that music increases mental capacity. Accordingly, it is stated that the use of music in mathematics teaching increases the academic achievement of students. It is known that music contributes positively to the academic success of students of many levels.

Yoshida (2005), in his study "The Role of Music in the mathematical performance of high school students with moderate learning disabilities", investigated the effect of listening to music in the background during the math tests of students with learning disabilities, and revealed that music positively affects students' mathematical performance. In addition to academic success, music also contributes to students at many points. De León-Esparza (2019) shows that individuals tend to increase their understanding of the lesson while listening to their favorite music, which reflects a higher level of attention and better focus during lesson practice.

According to Sığırtmaç (2005), children can support their skills of matching mathematical concepts, using tone of voice, matching sounds with each other, matching sounds and instruments one-to-one with musical activities. In these rhythm works, the names of the children participating in the activities can be used. In addition, objects can be grouped according to their sounds to develop classification skills in mathematics. While conducting a study on children, a long process may be necessary for children to hear, learn, remember, and repeat to behave according to the prepared model. The use of rhythms and melodies in songs facilitates keeping counting in mind instead of memorizing.

While performing a mental workload, music can have a very important role in affecting the attention and concentration state of the brain (Teixeira, 2018). In this study, it has been concluded that the designed

math songs have a facilitating effect on the retention of what has been learned by shortening the process required for the acquisition of mental operations acquisitions. In addition, it has been concluded that the math songs designed in this study have positive effects on mathematics teaching. This result is parallel with the results of the study by An (2013) examining the teachers' methods of integrating music into regular mathematics lessons and the effects of music-mathematics interdisciplinary lessons on primary school students' mathematical abilities in modeling, strategy, and practice.

*Conclusion and Discussion Regarding EEG Recordings*

The findings of the study revealed that the Alpha power of the participants decreased, and the Beta power increased at certain rates. As children with MLD have excessive Alpha activity, decrease in Alpha power are as important as an increase in mental activities in the brain (Chabot, 1996). Alpha rhythm is seen in awake, ordinary, and calm people. In the sleep state, the Alpha rhythm disappears. If the awake person directs his attention to something special, such as a mental activity, a higher frequency beta rhythm occurs instead of Alpha waves (Yazgan & Korürek, 1996). Alpha waves are thought to indicate a relaxed state of awareness that does not require concentration and attention. It is also the most common rhythm in the brain. Most people have an Alpha wave when their eyes are closed. It oscillates and the oscillation decreases as the eyes open for a different sound, excitement, or attention. Alpha waves are usually accompanied by beta and theta waves (Niedermeyer, 1999). The beta wave is usually released in situations such as active thinking and attention, problem solving or focusing on something. It can be blocked by motor activity or tactile stimuli (Sterman et al., 1974).

A decrease in the Alpha powers of the participants and an increase in the Beta powers were also observed at certain rates as a result of this study. A change was observed in Alpha, Beta, Delta, Theta and Total Powers obtained from the questions asked to Participant 1 during the EEG recording. Alpha power obtained from 10 questions directed to Participant 1 decreased in eight questions, while Beta power increased in four questions. Also, a decrease was observed in total power in two questions only. It is thought that the decrease in Alpha power, which is desired by Participant 1 to be willing and interested in the training module and math songs, is effective. Alpha power obtained from 10 questions directed to Participant 2 decreased in eight questions. There was an increase in beta power again in two questions. In addition, it is thought that the decrease in Alpha power, which is desired to exhibit high participation in the activities performed very willingly in the training module activities prepared by Participant 2, is thought to be effective. Alpha power obtained from 10 questions directed to Participant 3 decreased in only two questions, while Beta power increased in seven questions. Participant 3, on the other hand, was bored and unwillingly participated in the training module despite all the efforts of the researchers in the training module activities. However, Participant 3, who did not participate in the training module, willingly participated in math songs. It is thought that these situations effectively decrease the desired Alpha power in only two questions and the increase in Beta power in seven questions when considering the participants' individual differences. Alpha power obtained from 10 questions directed to Participant 4 decreased in only two questions, while Beta power increased in nine questions. Despite all the efforts of the researchers, Participant 4 got bored in the training module activities prepared and participated in the training module without much enthusiasm. It is thought that these individual differences are effective in the decrease in the desired Alpha power and the increase in the Beta power in a certain number when considering the individual differences of the participants.

Aker and Akar (2014) examined the effects of Turkish music makams through the analysis of EEG waveforms. For the application, 15 healthy individuals listened to Turkish music makams. The collected EEG data were separated into subbands by the discrete wavelet transform method. The power densities of each band were calculated using the power spectral density method. As a result of their analysis, they saw the effect of the authorities on the EEG signals in the beta band. At this point, it is seen that studies can be done in many areas with EEG measurements. By making EEG measurements in different fields such as education, medicine, engineering, marketing and advertising, meaningful results can be obtained from the activities in the brains of people, and suggestions and changes can be made about the systems from these results.

For primary school students with MLD to acquire skills for mental operations, first, activities that use various mathematical materials and embody the teaching might be indicated instead of only teaching math based on paper and pencil exercises. The concepts of numbers and operations, which form the basis of mental operations, are actually abstract concepts. For the children to understand these abstract concepts, teaching should be supported with concrete objects and tools. For children with MLD, training on mental operations should first start with activities related to addition. If they succeed in addition-related activities, subtraction-related activities should be started. In accordance with the individual educational needs of students with MLD, the educational process should be supported with mathematical songs when necessary. In addition, in the context of the findings obtained in

the study, it is recommended to do it through materials that provide modeling in the teaching of mental processing skills.

This study focused on revealing the difference expected to occur in these children's mathematical achievement and mental activities by supporting the IEP prepared for primary school students with computational difficulties with musical activities. Also, future research can be conducted to examine the different acquisitions at different grade levels at the primary school level. Based on this research, attempts can be made to educate children with MLD and solve the educational process problems. This study has some limitations. The main limitation of the study is that the number of students participating in the study is limited because it includes qualitative research, and the participants were from the same province. Future studies can enrich the existing findings employing qualitative and quantitative methods involving other provinces and involving more participants. In addition, based on this limited number of participants and because of the meta-analysis of Sala and Gobet (2017), we have to be very careful with the claims we make about music enhancing calculation skills. Future studies with more participants and different disciplines can be brought together to contribute to the field to study if music related activities can improve calculation skills in participants with MLD.

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