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Rhythmic Auditory Stimulation in Gymnastics Learning: Enhancing Movement Creativity in Primary School
Gymnastics through Music-Based Pedagogy

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ABSTRAK

Physical education in elementary schools often focuses on a mechanical and repetitive approach, particularly in gymnastics, which limits originality and fluency in developing movement creativity.

This study was conducted at Prapatan Elementary School in Majalengka to test the effectiveness of the Rhythmic Auditory Simulation (RAS) intervention in enhancing student creativity through music-based pedagogy.

This study used a one-group pretest-posttest experiment by isolating the direct impact of external stimulation on a homogeneous group of subjects.

To ensure internal validity, the research design was strengthened through constant control of audio tempo standardization and the elimination of visual instructions from the teacher.

The results of data processing showed an average N-Gain score of 35%, indicating a statistically significant increase in motor creativity despite limited intervention effectiveness.

Due to the limited effectiveness, this indicates that internal constraints in the form of students' biological motor skills in middle childhood and the short duration of the intervention, which was 3 weeks, caused the limited intervention.

This study contributes by proving the function of external audio rhythmic structures as action opportunities through an ecological dynamics paradigm that is able to manipulate children's kinetic movement space while simultaneously building a sense of psychological safety during activities.

This research offers a physical education curriculum model with a measurable motor behavior control instrument through the placement of music so that music plays a role not just as a background to create a classroom atmosphere.

Keywords: Ecological Dynamics, Movement Creativity, Rhythmic Auditory Stimulation, Primary School Gymnastics.

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INTRODUCTION

At the elementary school level, gymnastics education currently faces a crucial pedagogical barrier, with students' low motor creativity resulting from the dominance of rigid and conventional teaching methods.

This problem was evident during initial observations at SDN Prapatan 3, where 35 students demonstrated limited motor responses during gymnastics activities, with most tending to imitate movements demonstrated by the teacher.

Ideally, in a modern curriculum, PJOK (physical education, sports, and health) should be a dynamic medium that allows students to develop freedom of expression, originality, and problem-solving skills.

However, the field shows that gymnastics learning remains trapped in a teacher-centered approach, resulting in students simply imitating or following the movements demonstrated by the teacher.

This monotonous and conventional learning approach has been shown to significantly limit and hinder independent exploration, which can stimulate creative thinking in student activities (Rink, 2021; Ward et al., 2023). These challenges require that learning be not only adaptive but also provide a means of direct intervention to address students' motor limitations during physical practice.

Rather than focusing on theoretical digitalization that might distance students from the intensity of physical activity, pedagogy must provide solutions in the form of external media stimulation integrated with students' physical responses.

In this case, music is used as a relevant external medium because it has a rhythmic component that functions as a tempo-determining factor for body movements (Thaut & Hoember, 2025).

Neurostimuli from musical auditory cues function to break the rigidity of conventional methods through the mechanism of auditory-motor entrainment or auditory-motor synchronization (Shafron et al., 2022).

Based on this, this entreatment mechanism can offset the previously rigid imitation pattern centered on the teacher by waiting for and imitating visually demonstrated movement cues so that students' motor responses become automatically synchronized with the auditory rhythm, and replace the response command structure with a more anticipatory movement response.

This synchronization reduces students' psychological tension arising from rigid imitation of teacher demonstrations, transforming them into more fluid and flexible physical responses (Damm et al., 2020).

Based on this, in Indonesia, music and song-based movement activities have been proven to be able to develop gross motor skills more effectively compared to conventional demonstration and instruction methods (Kevin et al., 2024).

Based on this, the use of music has a function as a crucial instructional bridge by going beyond the mechanical limits of movement and song activities such as gymnastics to create a more creative and exploratory learning atmosphere.

In realizing such a learning environment, gymnastics learning in elementary schools should be based on children's play-based models and approaches and non-conventional pedagogical applications.

Students are placed as active agents who find adaptive customary movement solutions through dynamic interactions on these non-conventional approaches so that a response occurs between their bodies and environmental boundaries (Button et al., 2024; Chow et al., 2023).

In this case, a game-based learning approach that in practice relies on verbal instructions and is enriched by the presence of music which acts as the main stimulus that is open.

Through the instruction of certain movement dictations, music has a role to empower children to use rhythm through autonomous forms of physical expression (Damanik et al., 2023).

The importance of this research is in line with the demands of 21st century skills, bringing the integration of music-based learning in particular can improve the creativity aspect through divergent thinking indicators and motor originality.

Through rhythmic stimuli that are used flexibly, students can build the confidence necessary in solving movement challenges independently and spontaneously.

Many studies have discussed the development of creativity and psychomotor activities, but there has been no research that discusses learning that prioritizes the creativity of elementary school-age children with their learning environment.

Research by Suherman et al., (2024) suggests that the reflective learning approach is effective in improving movement skills and the ability to participate in gymnastics creatively through choreography arrangements. However, the study has a fundamental difference from this study: first, the subject of the study is a prospective social service teacher, and not focused on elementary school children who are in a very different phase of motor development and creative-cognitive conditions; And second, the study used verbal reflective discussion as the primary stimulus, rather than the rhythmic and auditory motor mechanisms of music as relied upon in this study. This raises questions about the effectiveness of the reflection-based approach if applied directly to children who are in the motor development phase, as well as opening up opportunities to test whether sensory-based stimuli will be more effective than verbal-based stimuli.

On the other hand, the current global research trend is dominated by the use of digital as a stimulus for student movement variation (Zhang et al., 2024).

This digital-based approach has drawn criticism for placing too much emphasis on the visual aspect, but failing to accommodate the kinesthetic experience that takes place in the field (something that children really need in the motor development phase).

In contrast to gestures in digital media, direct kinesthetic experiences allow the child's motor system to receive feedback simultaneously and in real time, so that it can facilitate self-correction in a short period of time and problem-solving that involves complete physical involvement, and this is something that cannot be realized through visual cognitive stimulus alone.

This places this research in the global research on ecological dynamics that prioritizes that movement creativity can arise from the direct and reciprocal relationship between students' perceptions and learning actions in a real physical environment, as well as being a representation of both digital and purely cognitive movements that are forced from the outside.

The novelty of this research is not only in the use of music in general in the classroom, but in the deconstruction of the role of music from simple background accompaniment to specific audio characteristics that are arranged as interventions in structured groups.

Through this approach, the elements of music are: tempo manipulation (fast-slow); rhythmic synchronization (constant beat); and dynamics (volume accentuation) were systematically analyzed in this study as the main stimulus that maps the variation in students' motor responses.

This study is in line with the findings of Septika et al., (2025) physical activity stimuli whose structure can shape early childhood motor development, by translating auditory structure into real physical actions.

Among these aspects, tempo has a role as the main control variable that is modified on various sides to observe its direct influence on the quality of movement.

Fast tempo is used to trigger exploratory movements as well as rapid position shifts, thereby encouraging a wider range of motion within a certain time constraint, while slow tempo, is used to trigger movement to be sustainable and controlled with a major emphasis on posture, balance, and the elaboration of movement details.

By systematically modifying and replacing these two types of tempo, this study maps the relationship between auditory tempo and the dimensions of motor creativity, namely smoothness and originality at a fast tempo and flexibility and elaboration at a slow tempo.

This mapping structure is in line with the findings of (Kholiq, 2025), who explains that rhythmic gymnastics models can develop and can be observed as basic motor skills in early childhood systematically and structurally through movement exercises with musical rhythms.

So that this research makes a new theoretical contribution in the psychomotor realm, especially about auditory structures that can control physical exploration spaces and trigger movement originality during the developmental phase of students in elementary school.

From a scientific perspective, Rhythmic Auditory Stimulation (RAS) has the basis of rhythmic stimulation ability to bypass complex cognitive abilities by overcoming the rigidity of movement.

When the rhythm of music enters through an auditory stimulus, the signal is directly channeled to the motor areas of the brain without having to wait for slow verbal processes (Pranjić et al., 2024).

This process causes the motor nervous system to constantly align the frequency of movement with the external tempo heard by auditory-motor entrainment.

In the context of movement creativity, nerve synchronization can decrease functional tension in the presental cortex which is an area of the brain that usually triggers self-censorship, anxiety, and fear of making the wrong move.

In (Dietrich, 2024), reduced inhibitory activities can open up space for the emergence of kinesthetic flow conditions, which in this case in the form of children's body coordination will become more adaptive and flexible, thus allowing students to spontaneously design improvisation, variation, and originality of movements when performing gymnastics activities or auditory-based activities.

This field activity-based RAS intervention supports the achievement of the SDGs in the form of sustainable development goals.

With the contribution to SDG 4, namely quality education, the transition from conventional instruction to pedagogical that is inclusive, participatory and student-centered, as well as related to SDG 3 in the form of a healthy and prosperous life.

Therefore, this research has an urgency for sustainable development, and neurological mechanisms.

The formulation of the problem proposed in this study is how the application of Rhythmic Auditory Stimulation (RAS) through music-based pedagogy can affect the increase of movement creativity in students' gymnastics activities at the elementary school level?

METHOD

This study uses an experimental quantitative approach using a one group pretest-posttest design, by measuring the impact of intervention on students' movement creativity in gymnastics activities and converting psychomotor performance into objective numerical data results.

Experimental research has obtained official permission from the school as well as written consent from parents before data collection is carried out, as a form of complying with ethical standards for experimental research involving humans (Creswell & Creswell, 2020).

This research was conducted in a public elementary school, SD Prapatan 3 in Majalengka Regency, this school was chosen based on the availability of field audio facilities and the problem of limited existing gymnastics teaching media because so far the gymnastics learning applied is still conventional and instructional.

Sampling was carried out using a total sampling technique, namely as many as 35 students (N = 35) grade 4 were selected as samples that met the criteria.

The criteria are based on a full student attendance record, healthy physical condition for rhythmic activities, and not participating in extracurricular activities of movement or dance and gymnastics training outside of school (Cohen et al., 2020).

The characteristics of the subjects showed that they were in the same phase of development and gross motor coordination maturity that was middle elementary school age students, with an average age of 9-10 years.

The gender composition consists of 15 male students (42.86%) and 20 female students (57.14%), controlling this demographic factor is important because motor maturity in children of this age can also be influenced by gender differences.

All subjects were ensured to have a structured and uniform background of daily activities, which were limited to only 4 hours of physical activity in physical education lessons at school in one week, and no students were involved in sports clubs outside of school, structured physical exercises, or daily routines dominated by motor activities.

This similarity in physical activity background was verified through brief informal interviews with Physical Education teachers in schools before sample selection was conducted.

Intervention treatment is carried out systematically within a period of 3 weeks with a frequency of 2 times a week, so that there are 6 structured sides; lasted for two times 45 minutes from 07.30 to 09.00 WIB, the selection of time in the application of treatment was carried out to minimize the bias of migrants due to physical fatigue of students (Rink, 2021).

The location of the research in Majalengka Regency was chosen based on sociocultural considerations that are relevant to the music intervention itself, because in the area within the cultural scope of West Java or Sundanese the students are assumed to have informal exposure to rhythm, especially drum jaipong percussion through activities with cultural and community contexts.

This is expected to facilitate the involvement of motor auditory naturally compared to students who are completely unfamiliar with the music or rhythmic idioms used in the treatment.

The validity of the treatment was maintained by appointing one physical education teacher or sports teacher as a model instructor in the field, while the researcher acted as a supervisor of compliance with the instructional intervention module (Supriyadi et al., 2020).

The pretest stage as an initial experimental procedure begins through a test, where students perform gymnastic movements independently with the guidance of verbal counting only without the presence of external sound stimuli.

In the treatment stage, students receive gymnastics instruction that uses rhythmic auditory stimulus through music combined with dynamic traditional Sundanese genres, namely kendang jaipong with electronic children's pop music; The music has a 4/4 rhythm with the distinctive accent of the beat leaves in the 1st and 3rd counts. The tempo characteristics are set through several methods of incremental tempo enhancement before ending with a process stage that uses the same experimental musical accompaniment; namely using musical

accompaniment with tempo settings that have been proven to optimally trigger motor adaptation in students (Damm et al., 2020).

Session

Week

Phase

Tempo (BPM)

Duration

Stimulus Focus

Pretest

Baseline

No music (verbal counts)

2 x 45 minutes

Autonomous movement exploration without auditory stimulus

Session 1

Week 1

Treatment

100 110

2 x 45 minutes

Initial adaptation to constant beat

Session 2

Week 1

Treatment

100 110

2 x 45 minutes

Reinforcement of basic auditory-motor synchronization

Session 3

Week 2

Treatment

115 125

2 x 45 minutes

Increased movement variation following tempo acceleration

Session 4

Week 2

Treatment

115 125

2 x 45 minutes

Exploration of directional and level flexibility

Session 5

Week 3

Treatment

130 140

2 x 45 minutes

Stimulation of explosive movement and originality

Session 6

Week 3

Treatment

130 140

2 x 45 minutes

Consolidation of overall movement creativity

Posttest

Evaluation

Identical to experimental music accompaniment

2 x 45 minutes

Final measurement of movement creativity

Table 1.

Intervention Session Schedule

Direct observation was carried out to collect data on movement creativity carried out through video recordings of students' performances using an evaluation rubric on an interval scale of 1 to 5 (Likert Scale) which includes three main psychomotor indicators.

The fluency indicator measures how the quantity of variation of movement functions in a rhythmic sequence; flexibility indicators assess how the ability to change the direction and level of movement simultaneously; and originality indicators evaluate How the level of creation of unique and pure motion without imitating other peers (Torrents et al., 2021).

The objectivity and quality of the data are guaranteed through two stages of statistical standardization.

The technician was determined through Ali's assessment from 3 sports and music specialists by producing an Aiken-s V index range of 0.83-0.91 with a very valid category.

Meanwhile, reliability was tested against two observers using Cohen's Kappa statistics with a coefficient of $K = 0.86$ with almost perfect agreement level results (O'Donoghue, 2022).

Then all data were processed and processed using IBM SPSS statistical software version 26 with post-hoc Statistical Power analysis using G Power with a significance level of $\alpha = 0.05$ which showed that the measurement of a sample of 35 students provided very adequate statistical power for parametric analysis (> 0.80).

Internal validity threats can be controlled through short experimental durations to trim the natural maturation effect, as well as the use of different but equivalent tempo playlists between the initial and final sessions to trim the test effects (Thomas et al., 2022).

The researcher applied a single-blind observation procedure to minimize the subjectivity of the assessor when scoring on the recorded performance video.

Two raters scored the pretest video and poster in a random order with no access and no labels to the identity of the session so as to prevent expectation bias from affecting the score given, i.e.

In the context of gymnastics, the three psychomotor indicators are defined operationally through the aspect of fluency measured based on the number of functional movement transitions that students can perform in a single rhythmic count without pauses and repetition of the same movements; flexibility is measured based on the student's ability to change the level of motion and direction of motion in a continuous sequence of motion; as well as originality measured based on the proportion of movement elements that students perform that are not visible in the performance of other group students in the same session through cross-verification with the entire movement repertoire of the entire group of students.

The analysis stage was carried out through descriptive statistics to map the score profile, the Saphiro-Wilk normality test as a condition for the parametric procedure test, and the Paired Sample T Test which was used to verify the significance of the difference in the average score of students' creativity (Rahman & Angraeni, 2020).

The researchers also calculated Cohen's D to measure the magnitude of the practical effect of the musical intervention as well as perform an analysis of the N-Gain classified according to global standards into high, medium and low gang zones in determining in real terms the efficiency level of increased student movement creativity.

RESULTS

Data analysis starts from descriptive statistical mapping by numerically identifying the initial performance profile through the pretest and the final achievement through the posttest by measuring movement creativity.

Descriptive calculations showed a very significant improvement in the average score of movement creativity after the application of music-based RAS interventions.

The average number of students in the pretest session was 12.43 and then 16.86 in the post test, which shows a very significant increase with the distribution of data that became solid and homogeneous.

As students' minimum and maximum score ranges shift to higher thresholds, suggesting that a very significant improvement in motor ability after treatment supported by descriptive reporting is essential to prevent data bias in small sample sizes (Thomas et al., 2022).

A summary of these data is presented in table 2.

Activity

Mean

Standard Deviation (SD)

Minimum Score

Maximum Score

Pretest

12 43

1 42

10 00

15 00

Posttest

16 86

1 18

15 00

19 00

Table 2.
Descriptive Summary of Students' Movement Creativity Scores (N = 35)

Figure 1.
Trend of Movement Creativity Score by Indicator (Pretest-Posttest)

A more detailed analysis of the indicators reveals a significant gap in the improvement in the 3 psychomotor indicators, as illustrated in Figure 1 with the results of the fluency indicator recording the sharpest upward trend, followed by flexibility, while the originality indicator shows the smallest improvement among the other indicators. This pattern shows that racial interventions have an impact on students' ability to generate a large amount of movement creativity and the ability to create unique forms of movement rather than the result of gradual imitation. It is also supported that originality may require a longer period or a more advanced stage in order to be fully realized.

The results of the normality test through Shapiro-Wilk analysis showed the results of the data with a significance value of 0.085 in the pretest session and a significance value of 0.110 in the posttest session ($p > 0.05$). With the results of the calculation of the significance value far above 0.05, the data distribution in this study was declared normal (O'donoghue, 2022).

By fulfilling this assumption of normality, it provides a strong foundation for researchers to proceed to the Hypothesis Testing stage to observe the pure impact of the treatment through the inferential Paired Sample T-Test.

Variable

Statistic

df

Significance (Sig.)

Conclusion

Pretest Score

0.946

35

0.085

Normally Distributed

Posttest Score

0.951

35

0.110

Normally Distributed

Table 3.
Summary of Shapiro-Wilk Normality Test Results (N = 35)

Hypothesis testing was conducted to verify the influence of applying rhythmic auditory stimulation through music-based pedagogy on the enhancement of primary school students' gymnastics movement creativity. Based on the Paired Samples T-Test results, a calculated t-statistic of -16.419 was obtained, with 34 degrees of freedom (df = 34) and a two-tailed significance value (Sig.

2 tailed of 0.000.

This significance value, which is substantially smaller than 0.05 ($p < 0.001$), firmly rejects the Null Hypothesis (H_0) and statistically validates the Alternative Hypothesis (H_a) (Cohen, et al., 2020). The direction of the mean difference, valued at -4.429, empirically proves that the music-based RAS intervention exerts a massive, directional positive impact on enhancing students' movement creativity from the baseline to the final condition.

Data Comparison

Mean Difference

t

df

Sig.
2 tailed

Conclusion

Pretest vs Posttest

4 429

16 419

34

0 000

H a Accepted Significant

Table 4.
Summary of Hypothesis Testing Results (Paired Samples T-Test)

The efficiency analysis of the post-treatment enhancement in students' movement creativity was calculated using the Normalized Gain (N-Gain) formula, converted according to Hake's (1998) global classification, whose continued validity and relevance for analyzing pretest-posttest intervention data has been reaffirmed in more recent psychometric literature (Coletta & Steinert, 2020).
The accumulative calculation results show an average N-Gain score of 0.35 (35%), which places the effectiveness of the intervention within the Medium Gain category.
This value does not occur in isolation but is driven by a healthy data distribution on the field, where the achievement distribution indicates that not a single student (0%) fell into the Low Gain category ($g < 0.3$).
A total of 28 students (80%) experienced an enhancement within the Medium Gain category ($0.3 < g < 0.7$), and 7 students (20%) successfully reached the High Gain category ($g > 0.7$), as summarized in Table 5.

Analysis Component

Achievement Value

Classification Coletta Steinert 2020

Data Interpretation

Pretest Mean Score

12 43

Baseline ability prior to musical intervention

Posttest Mean Score

Final ability post musical intervention

N-Gain Mean Score

0 35

Medium Gain

Stable and consistent improvement

Table 5.
Summary of Cumulative N-Gain Effectiveness Analysis (N = 35)

Figure 2.
Trend of Movement Creativity Score by Indicator (Pretest-Posttest)

To observe the dynamics of creativity development in more depth, the end game score was outlined based on three main psychomotor creativity indicators classified based on validated enzymes (Coppola et al., 2024). A specific analysis of the indicators is presented in table 6 which shows that smoothness recorded the highest increase efficiency with the N-Gaun core of 0.46; followed by flexibility of 0.34; and originality with a score of 0.22. As visualized in figure 2, this difference appears to be a noticeable widening of the axis of smoothness and flexibility between the press and poster sessions while the axis of originality remains relatively narrow, this is a visual feature of the uneven development response on the part of the indicator. These differences in achievement provide insight that although auditory stimulation is instantly effective in stimulating the quantity of movement, a longer duration of intervention treatment is required to foster pure movement uniqueness in elementary school-level students (Torrents et al., 2021).

Psychomotor Indicator

Pretest Mean

Posttest Mean

N-Gain Value

Category Coletta Steinert 2020

Fluency

4 20

6 40

0 46

Medium

Flexibility

4 43

6 03

0 34

Medium

Originality

3 80

4 43

0 22

Low

Table 6.

Profile of N-Gain Score Achievement per Movement Creativity Indicator

Overall, field observations found and confirmed that the application of music-based rhythmic auditory stimulation had a moderate level of effectiveness in triggering students' movement creativity.

The achievement of this increase is operationally due to limiting factors such as the short duration of the intervention and the complexity of students' adaptation to the fast tempo in the final session (Damm et al., 2020). In line with this, the results of the observation data description recorded consistent changes in the motor behavior of most students or subjects in the field.

Students showed significant improvements in the aspect of body rhythm synchronization to the beat of music as well as flexibility in changing direction when moving, but their ability to create truly unique and new variations of movement was still very limited and tended to repeat pre-existing gymnastics archetypes.

DISCUSSION

In this discussion, it is examined in more depth why rhythmic auditory stimulation has proven to be very effective in rearranging student gymnastic movements at SDN Prapatan 3 Majalengka, and not just re-explaining the results that have been observed.

Neuromotorically, music-based rhythmic auditory stimulation acts as a temporal rhythm trigger that stimulates the supplementary motor area and cerebellum through the phenomenon of auditory motor entrainment (Damm et al., 2020).

This mechanism found a very supportive condition at the research site, namely that students in Sundanese cultural backgrounds have had familiarity formed informally with rhythmic musical instruments, one of which is the jaipong drum which is characterized by syncopation accentuation of strong beats so that experimental music is not a completely foreign auditory stimulus, but something that is in harmony with the rhythmic scheme that has been internalized in them.

This pre-existing rhythmic familiarity plausibly lowered the threshold for entrainment to occur, allowing synchronization between the auditory beat and motor output to be established more rapidly than would be expected in a culturally unfamiliar rhythmic context (Slamet et al., 2023).

This entrainment mechanism, however, did not exert a uniform effect across the three movement creativity indicators central to this study.

Its influence was strongest on fluency, the indicator with the highest N-Gain (0.46): a constant, predictable beat structure lowers the cognitive load required to initiate each successive movement, freeing children to generate a greater quantity of movement variations within a single rhythmic cluster rather than expending cognitive resources on timing alone.

Its influence on flexibility (N-Gain 0.34) operated more indirectly, primarily through the accent-based dynamics of the music, which cued children to shift movement plane and direction at specific downbeats, evident in the emergence of pivoted arm swings, torso twists, and patterned grapevine steps.

Its influence on originality (N-Gain 0.22) was the weakest of the three, suggesting that while entrainment successfully liberated children from dependence on the teacher's visual instructions and habitual imitation, the generation of genuinely unique, non-imitative movement forms depends on cognitive-creative processes that operate on a slower developmental timescale than the auditory-motor synchronization mechanism itself.

Within the framework of ecological dynamics, the formal auditory element consisting of a stable tempo structure ranging from 120 to 130 BPM (Beats Per Minute) acts as a primary affordance for primary school students aged 9–10 years.

This tempo range provides the most ideal action possibilities to manipulate children's spatial directions and bodily levels without overloading their cardiorespiratory capacity.

The children's cognitive flexibility is stimulated to chase the downbeat accentuations, which directly explains why the fluency indicator recorded the highest enhancement efficiency in this study.

Auditory stimulation at this specific BPM frequency successfully constructs a learning environment rich in kinesthetic stimuli, prompting children to rapidly transition from one movement variation to the next.

This freedom to explore movement variations linearly reflects the core principle of the Orff Schulwerk approach, wherein rhythm functions as the primary catalyst to liberate children from the dictates of conventional gymnastics movements (Coppola et al., 2024; Torrents et al., 2021).

Although external music-based stimulation proved effective in triggering motor creativity, cumulative findings indicate that the class average N-Gain score was constrained at 35%, falling into the medium category.

This limitation of efficiency at an intermediate level demonstrates that while external auditory stimulation acts as a powerful catalyst, its effectiveness remains internally bounded by the students' innate motor maturity variables (Gallahue et al., 2021).

During middle childhood, the process of neural pathway myelination and sensory-motor integration is not yet fully mature enough to execute purely novel, original movements.

This biological constraint was further compounded by the relatively short duration of the experiment (3 weeks); consequently, the auditory stimulation was only capable of optimizing movement quantity (fluency and flexibility) without having sufficient time to foster the development of pure movement uniqueness.

As a result, when confronted with fast tempos exceeding 140 BPM, the children's neuromuscular coordination experienced cognitive distortion, causing their movements to revert to stereotypical patterns of Senam Pramuka or Senam Kesegaran Jasmani (SKJ) that they had previously memorized.

This study serves to bridge the methodological research gap left by previous investigations, such as that of (Suherman et al., 2024).

While the research by Suherman et al.

focused on a reflective approach to equipping pre-service teachers with the skills to design choreography structurally, the present study zeroes in on the practical implementation and actual kinetic responses of primary school children as the primary learners in the field.

The positioning of this study reinforces the notion that music-based pedagogy must not stop at the teacher's conceptual level; rather, it must be transformed into a direct stimulation method within basic gymnastics circuits. By focusing on children as the subjects, this research provides empirical evidence that adjustments in musical tempo can actively manipulate the difficulty level of children's motor coordination in real time.

This approach offers a novel instructional model within the primary school physical education curriculum, wherein music is positioned as a scientifically measurable instrument for controlling motor behavior, rather than merely a background sound to fill the classroom atmosphere.

From a psychological dimension, the successful optimization of movement variations is fully supported by the capacity of rhythmic auditory stimulation to establish psychological safety on the field at this public elementary school in Majalengka.

An auditory structure that is rhythmic and familiar to children's ears reduces mental blocks, negative affect, and motor anxiety when they are required to explore original movements in front of their peers.

When shyness and the fear of making mechanical errors are minimized by a relaxed classroom atmosphere, students gain a safe space to express their kinetic responses adaptively without feeling judged by rigid performance standards (Bravo-Fuentes, A., & Pastrano-Gavilanes, 2025).

This inclusive learning climate contributes directly to enhancing children's emotional well-being during physical activity, which in turn boosts their intrinsic motivation to engage actively in physical education units (Likesas et al., 2023; Minh, 2022).

It is this sense of psychological safety that underpins the children's courage to activate divergent thinking, allowing them to liberate their bodies from the doctrines of conventional visual instructions.

CONCLUSION

Based on the results and discussion, this study concludes that the application of the Rhythmic Auditory Stimulation (RAS) method through Orff music-based pedagogy significantly reconstructs students' gymnastics movement creativity at a public elementary school in Majalengka.

Neuromotorly, rhythmic auditory stimulation acts as a temporal pacemaker that deconstructs rigid and mechanical movement patterns into more expressive, fluid, and autonomous explorations of both locomotor and non-locomotor variations.

Audio characteristics within the ideal tempo range of 120 to 130 BPM are proven to provide the best affordance for primary school-aged students (9–10 years old) to manipulate directions and movement levels without triggering cognitive distortion or overloading their physiological capacity.

Nevertheless, this intervention yielded an enhancement in motor creativity that was constrained within the medium category, with an average N-Gain score of 35%.

This result confirms the presence of internal boundaries in the form of children's innate biological motor maturity during middle childhood, alongside experimental duration constraints (3 weeks) that limited the emergence of pure movement originality, particularly when confronted with fast tempos exceeding 140 BPM.

From a psychological dimension, the effectiveness of expanding movement variations was fully supported by the establishment of psychological safety on the field, where music successfully reduced students' motor anxiety and shyness while simultaneously constructing emotional well-being that triggered the children's courage to activate divergent thinking.

This study successfully bridges the methodological gap by positioning music as a scientifically measurable instrument for controlling children's motor behavior within the primary school physical education curriculum.

These findings carry a direct pedagogical implication for PJOK (Physical Education, Sports, and Health) teachers in Indonesia: tempo should be repositioned from a merely decorative accompaniment into a deliberate evaluative instrument embedded within lesson planning.

Rather than selecting background music arbitrarily to fill silence during practice, teachers can structure tempo progression as a diagnostic tool, a slower tempo range (100–110 BPM) may be used at the outset of a unit to observe and assess students' baseline synchronization and flexibility, functioning as an informal formative assessment of a student's readiness before progressing to more demanding stimuli.

As tempo is incrementally increased across subsequent meetings, teachers can simultaneously observe which students sustain fluency and coordination under greater temporal pressure and which require additional scaffolding, effectively transforming tempo manipulation into a built-in differentiation mechanism rather than a uniform, one-size-fits-all accompaniment.

However, this study's finding regarding the constrained development of originality under fast-tempo conditions (exceeding 140 BPM) also signals a practical boundary that teachers must observe: tempo should not be pushed indiscriminately for its own sake, as excessively rapid stimuli may compress the cognitive space children need to generate genuinely original movement, causing them to default to safer, more repetitive responses instead. Accordingly, PJOK teachers are encouraged to treat tempo as a calibrated instructional variable, deliberately paced, monitored, and adjusted according to observed student response, rather than a static playlist selected without pedagogical intent.

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Our users have seen the use of AI-generated text proliferate into education, certification, hiring and recruitment, social writing platforms, disinformation, and beyond. We've created GPTZero as a tool to highlight the possible use of AI in writing text. In particular, we focus on classifying AI use in prose. Overall, our classifier is intended to be used to flag situations in which a conversation can be started (for example, between educators and students) to drive further inquiry and spread awareness of the risks of using AI in written work.

Does GPTZero only detect ChatGPT outputs?

No, GPTZero works robustly across a range of AI language models, including but not limited to ChatGPT, GPT-5, GPT-4, GPT-3, Gemini, Claude, and AI services based on those models.

What are the limitations of the classifier?

The nature of AI-generated content is changing constantly. As such, these results should not be used to punish students. We recommend educators to use our behind-the-scenes [Writing Reports](#) as part of a holistic assessment of student work. There always exist edge cases with both instances where AI is classified as human, and human is classified as AI. Instead, we recommend educators take approaches that give students the opportunity to demonstrate their understanding in a controlled environment and craft assignments that cannot be solved with AI. Our classifier is not trained to identify AI-generated text after it has been heavily modified after generation (although we estimate this is a minority of the uses for AI-generation at the moment). Currently, our classifier can sometimes flag other machine-generated or highly procedural text as AI-generated, and as such, should be used on more descriptive portions of text.

I'm an educator who has found AI-generated text by my students. What do I do?

Firstly, at GPTZero, we don't believe that any AI detector is perfect. There always exist edge cases with both instances where AI is classified as human, and human is classified as AI. Nonetheless, we recommend that educators can do the following when they get a positive detection: Ask students to demonstrate their understanding in a controlled environment, whether that is through an in-person assessment, or through an editor that can track their edit history (for instance, using our [Writing Reports](#) through Google Docs). Check out our list of [several recommendations](#) on types of assignments that are difficult to solve with AI.

Ask the student if they can produce artifacts of their writing process, whether it is drafts, revision histories, or brainstorming notes. For example, if the editor they used to write the text has an edit history (such as Google Docs), and it was typed out with several edits over a reasonable period of time, it is likely the student work is authentic. You can use GPTZero's Writing Reports to replay the student's writing process, and view signals that indicate the authenticity of the work.

See if there is a history of AI-generated text in the student's work. We recommend looking for a long-term pattern of AI use, as opposed to a single instance, in order to determine whether the student is using AI.