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MOVEMENT-INTEGRATED LEARNING AND STUDENTS' LEARNING FOCUS IN MATHEMATICS: A SINGLE-SUBJECT STUDY

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ABSTRACT

The learning focus is a critical element that greatly contributes to success in math, especially in subjects that require sustained attention and symbol manipulation, such as Single Variable Linear Equations (SVLE). Although numerous studies have examined the effects of physical activity on learning attention, few have used a single-subject design in the Movement-Integrated Learning of math lessons. This study seeks to explore the effect of Movement-Integrated Learning on the learning focus of a highly physically active student during SVLE instruction. In the present case, the design used was the qualitative A-B SSR design with a sample size of one seventh-grade student purposively chosen for the study. The instruments used included the focus observation sheet, which assessed both on-task and off-task behaviors at 5-minute intervals; field notes, which described the learning environment; and a semi-structured interview that sought to determine what the students learned. Data collection was done during three conventional sessions and five movement-integrated sessions. The qualitative data analysis entailed data reduction, presentation, and concluding remarks, in addition to SSR between-condition analysis in terms of level, trend, stability, and phase contrast, supported by triangulation. Baseline data revealed unstable, declining attention levels and an inability to sustain concentration. Interventions exhibited stable increases in attention levels, more prolonged periods of concentration, and no overlap with the baseline stage; hence, a functional link between exercise and increased attention regulation was established. This implies that by strategically incorporating movement into teaching designs, the latter can be used to regulate students' attention, especially among students who exhibit high levels of motor activity.

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INTRODUCTION

Learning focus, a necessary prerequisite of effective mathematics instruction, involves concentration, working memory utilization, and symbol utilization, which represent abstraction and are regulated by executive functions that predict academic success (Giuriato & Lovecchio, 2025). Learning skills discussed above involve constant dynamics and sensitivity to the environment. Engaging in cognitive processes physically enhances the quality of attentional responses (Giuriato & Lovecchio, 2025), while physical exercises such as BrainDance can help learners concentrate more on educational materials (Chiang & Griego, 2017). Nonetheless, learning mathematics requires not only attentional response but also agentic engagement, which refers to the proactive regulation of one's own learning (Mbhiza & Nkambule, 2025). Individual components should also be considered; for instance, variations in how information is processed visually, audibly, or kinesthetically (Eval Setiawan et al., 2025; Umar et al., 2025). As noted in Montessori theory, movement is the primary mechanism for integrating cognitive, motor, and socio-emotional aspects, rather than interfering with the learning process (Gundo & Agnes, 2025). Consequently, all methods outlined above demonstrate that attention is acquired rather than inherent.

However, despite these observations, sustaining attention in everyday classroom settings continues to pose challenges. On the contrary, many students become distracted when they realize that learning involves mere information delivery; nearly half report their inability to pay attention for the entire 45-minute period (Shuwara et al., 2025). This indicates a critical gap in the conventional learning process, which calls for creating opportunities for students to play an active role in making sense of mathematics. Several interventions have been proposed to address the issue. As studies have revealed, kinesthetic learners are highly responsive to motion-based learning and discovery. Students in inclusive classroom settings tend to develop an extrinsic motivational attitude and thus require appropriate instruction (Namlı, 2024). Moreover, investigations in early childhood education demonstrate that the purposeful application of motion in teaching, guided by backward design, enhances the quality of the learning experience (Vujičić et al., 2020).

Movement-Integrated Learning (MI), defined as the deliberate infusion of physical activity at any intensity into regular classroom time, has emerged as a structured and scalable response to these challenges (Vazou et al., 2020). MI encompasses diverse forms, including movement breaks, academically-infused lessons, opening activities, and reward-based movement, and can be categorized as student-driven, teacher-driven, or researcher-teacher collaborative in design (Vazou et al., 2020). Evidence consistently shows that physically active learning increases attentiveness, enjoyment, peer collaboration, and retention (Gundo & Agnes, 2025), and that MI interventions tend to raise physical activity levels and improve academic outcomes without harming achievement even in less favorable conditions (Vazou et al., 2020). There is evidence that college students experience better focus, socialization, and emotional engagement in movement-based classes than in traditional classroom settings, with moderate-to-high effect sizes (Rhoads et al., 2021). Moreover, active exercise breaks can positively affect learners' self-control and make learning more enjoyable (Chatzopoulos et al., 2023). Teachers who regularly incorporate movement into their teaching demonstrate greater confidence and more positive attitudes toward physical activity in the teaching process (Eklund et al., 2025). Nevertheless, there are caveats about integrating movement into education. Reduced physical activity during online classes correlates with poorer outcomes (Merino-Campos & Del-Castillo, 2025), indicating that cognitive gains are achieved only with a proper pedagogical structure and consistent incorporation of physical activity. In addition, there is a negative correlation between physical activity, academic success, and gaming addiction (Ilhan, 2024).

Various instructional and institutional variables influence MI. Cognitive activation serves as a mediator in the relationship between intrinsic motivation and mathematical literacy, where mathematics anxiety disrupts the effect (Mutua & Obara, 2025). In addition, instructional quality can be predicted by teachers' self-efficacy in the goal-setting process and motivational processes (Pikk et al., 2025). Further improvements in this process can be realized through professional development that incorporates issues of equity and sociocultural context (Castro-Filho et al., 2022), while student quality of life influences their level of involvement in physical activities (Prünster et al., 2025). At the same time, teachers' readiness to facilitate learning is far from satisfactory, with many trainee teachers defaulting to a procedural approach to task design (Nmah et al., 2025). Nevertheless, culturally responsive training bootcamps, along with ongoing mentoring, represent viable ways of promoting more equitable access to STEM fields (Nmah et al., 2025). Accordingly, instructional design should be coherent with respect to learner profiles, instructional strategies, teacher skills and abilities, and the institutional framework (Mudaly, 2025). Besides pedagogical issues, various technological advancements have been developed in this regard, such as personalized applications (Alzboun et al., 2023), dynamic software tools, and GeoGebra. (Mollakuqe & Mollakuqe, 2025), STEM and AI-enabled platforms (Barbachoux, 2025), multimodal kinesthetic learning stations (Aloizou et al., 2025), eye movement modeling technology (Choi et al., 2023), as well as neurofeedback-based applications (NeuroMat).

Nevertheless, investigations into PA, technology integration, and cognitive activation have developed independently rather than concurrently. While studies of physical activity concentrate on executive functioning and health-related results (Chatzopoulos et al., 2023; Merino-Campos & Del-Castillo, 2025), investigations focused on technology emphasize conceptual knowledge and motivation (Alzboun et al., 2023; Mollakuqe & Mollakuqe, 2025), and cognitive activation research concentrates mostly on instructional effectiveness and literacy(Mutua & Obara, 2025; Pikk et al., 2025). Notably, little effort has been made to understand how movement integrates (MI) serves as a mechanism for sustaining attention during mathematical learning, especially when studying linear equations in one variable, and hence requires the maintenance of symbolic thinking throughout the process. Furthermore, the majority of studies use group experiments to provide information about the overall effect of a treatment intervention, an important method of investigation, yet one that fails to consider the individual variability related to attentional development (Ilhan, 2024). Single-subject research methodology, a useful technique for tracking individual attentional processes through time, has seen scant application in these fields (McKenna, 2022). This study sought to determine the influence of MI on the learning process of a student characterized by high physical activity and on his/her attention during the study of linear equations in one variable, using a single-subject research methodology.

METHOD

This study employs a qualitative approach with a Type A-B single-subject research (SSR) design. This design was selected because it enables an in-depth analysis of behavioral changes in an individual participant resulting from a specific intervention. Single-subject research allows applied researchers to draw causal conclusions about the relationship between an intervention and changes in observable dependent variables (Giuriato & Lovecchio, 2025)(McKenna, 2022). In the A-B design, Phase A (baseline) documents the student's learning focus under conventional instruction, while Phase B (intervention) captures changes following the implementation of Movement-Integrated Learning.

This study involved one research subject: a seventh-grade student at Muhammadiyah 5 Junior High School in Surabaya, Indonesia. The subject was selected through purposive sampling based on the following criteria: (1) high physical activity levels, including active workouts and taekwondo training; (2) a tendency to demonstrate low focus during conventional mathematics instruction; and (3) incomplete mastery of Single Variable Linear Equations (SVLE) material. A single subject was intentionally selected to enable an in-depth analysis of individual attentional dynamics in relation to the student's specific characteristics (Namlı, 2024).

There are three tools utilized in this study. Initially, a focus observation sheet was used to observe on- and off-task behavior at 5-minute intervals across 6 intervals in each 30-minute session, and this was done across all sessions, whether during baseline periods or interventions. The markers for on-task/off-task behavior were drawn from frameworks on executive function and attention (Giuriato & Lovecchio, 2025) and from active break interventions (Chatzopoulos et al., 2023). Secondly, field notes were used to observe the learning environment, responses to learning, and overall classroom dynamics across all sessions (Castro-Filho et al., 2022). Finally, semi-structured interview guides were designed to investigate learners' experiences and feelings about the intervention across the first, second, and third stages of the interviews, drawing on motivational interviewing (Namlı, 2024) and learning experience interviews (Cappello et al., 2024).

The data were gathered through two consecutive phases. The first one included three regular learning lessons on (a) fundamental ideas of SVLE, (b) addition and subtraction activities, and (c) multiplication and division activities without performing movement activities. Data collection stopped once an initial stable behavioral pattern emerged, and this pattern served as the basis for comparison. Five intervention lessons incorporated well-structured movement activities, including (B1) fundamental-idea movement activity, (B2) addition and subtraction movement activity, (B3) multiplication and division movement activity, (B4) problem-solving movement activity, and (B5) review and enrichment movement activity. The movement activities were chosen based on the brainDance of Chiang & Griego, (2017) and the active break principles of Chatzopoulos et al. (2023), with required modifications in accordance with SVLE (Eval Setiawan et al., 2025).

The data analysis employed a qualitative approach, including data reduction, data presentation, and conclusion drawing with verification. The process of data reduction entailed summarizing and organizing observational and interview data with respect to relevant information on changes in the focus of learning. The process of data presentation involved using observation tables per session and graphical representations of progress in focus development, as required in SSR analysis (McKenna, 2022). About SSR analysis, the conditions involved four aspects: level change between phases, data overlap, trend change, and stability change (McKenna, 2022). Conclusions were drawn from the data analysis and were validated multiple times for consistency. Triangulation, used for validity purposes, involved cross-referencing observations and interviews (Castro-Filho et al., 2022). It is important to note that the A-B design is the most basic form of SSR analysis and lacks a withdrawal component or repetition.

RESULTS AND DISCUSSION

This section presents the results of research and in-depth analysis of changes in students' learning focus using a Type A-B single-subject research design. The analysis was conducted longitudinally by comparing behavior patterns between the baseline and intervention phases. Within the SSR framework, interpretation is based not only on differences in average scores but also on changes in levels, trends, data stability, inter-session variability, and possible phase overlap. This approach allows for a more comprehensive understanding of the dynamics of individual attention regulation.

Baseline Phase

The analysis began with the baseline phase to obtain an initial picture of learning focus patterns before the intervention was administered. This phase is important in SSR design because it provides a basis for comparison to assess treatment effects. Observations were conducted during three conventional learning sessions without movement activities, with on-task and off-task behaviors recorded in six five-minute intervals. Table 1 summarizes the observation data.

Table 1. Recapitulation of the Student's Focus in Baseline Phase

Session	Total On-Task (of 6 intervals)	Percentage
A1	4	66.7%
A2	4	66.7%
A3	3	50.0%

The number of on-task intervals increased to 4 out of 6 (66.7%) in the A1 and A2 sessions, while the on-task intervals reduced to 3 (50%) in session A3. The average number of on-task intervals was 3.67, and the total percentage was 61.1% during the baseline phase. However, upon examining the on-task patterns within each session, there is a lack of stability across all phases. In session A1, there were distractions at the beginning and end of the study periods; therefore, low readiness and reduced attentional control were observed at the end of the periods. The second and final periods saw distractions in session A2. In session A3, a more pronounced decrease occurred; there were two successive off-task intervals between the 5th and 15th minutes.

This decreasing trend can be attributed to traditional lecture-style instruction, which forces students to play an entirely passive role with very little physical involvement. It has been shown that passive instructional styles reduce attention endurance, especially among highly physically active students (Chatzopoulos et al., 2023). The inability to provide a legitimate means of expressing their excess energy during instruction will most likely result in off-task behaviors, which have been repeatedly observed in students who tend to process information kinesthetically (Eval Setiawan et al., 2025) Moreover, Shuwara et al. (2025) have observed that a substantial number of students experience difficulty sustaining focus beyond the 45-minute mark in a traditional setting, and that interactive engagement in instruction directly affects attentional capacity. This supports the baseline data for this study, as attention resources gradually declined over the sessions.

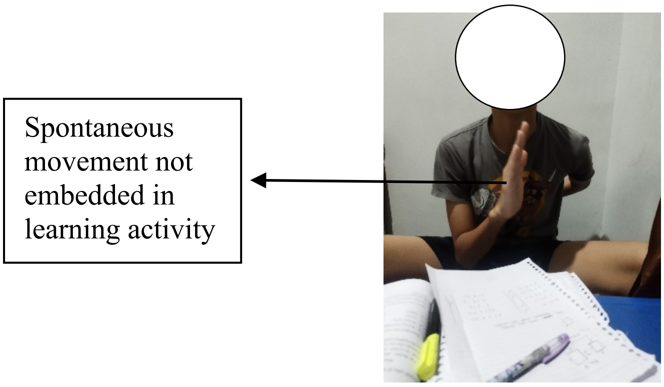


Figure 1. Subject Performing Tiktok Hand Movements

According to the visual representation at this stage (see Figure 1), the student is performing movements that align with TikTok trends during the lesson. It must be noted that such action should not necessarily be taken to indicate deliberate disruption; instead, it can be viewed as an involuntary regulation by the student's motor system, as the student was unable to obtain stimulation from the teaching environment. It is supported by neurocognitive theories of attention regulation, in which highly active motor systems require greater environmental facilitation to maintain concentration.

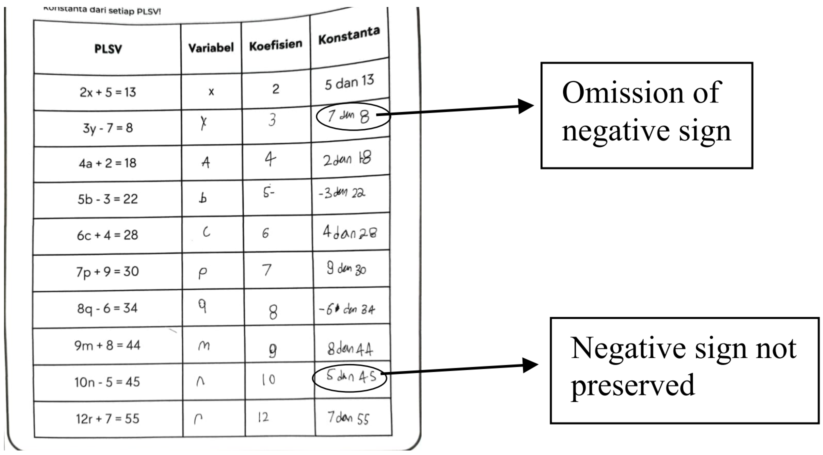


Figure 2. Student's Written Response During Baseline Phase

In addition to behavioral fluctuations, qualitative analysis of the student's written responses during the baseline phase also revealed limitations in symbolic processing. In the equations $3y - 7 = 8$ and $10n - 5 = 45$, the student identified the constants without preserving the negative sign, writing 7 instead of -7 and 5 instead of -5. The absence of this indicates an orientation more focused on observable numbers than on the deeper meaning embedded in the algebraic equation. This behavior is consistent with the results reported by Mutua & Obara (2025)on the effects of attention regulation on the quality of symbolic reasoning in math. Failing to regulate one's attention leads to a tendency to analyze equations based on surface information rather than their deeper structures. The pre-training stage, then, is characterized not just by a lack of concentration but also by shallowness in symbolic thinking due to insufficient attentional guidance.

Intervention Phase

The process was then extended to the second stage, known as the intervention stage. In the intervention stage, five learning sessions were conducted, during which specific movements were incorporated into the SVLE content. The data in this stage were collected using a rating scale ranging from 1 to 4 to capture engagement quality. This information is summarized in Table 2 below.

Table 2. Recapitulation of Student's Focus Scores in the Intervention Phase

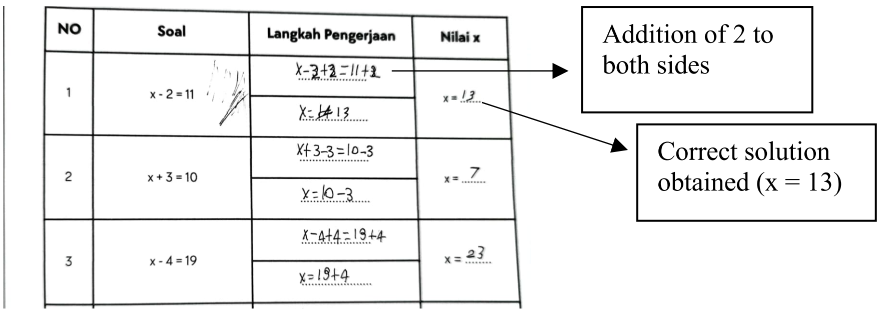
Session	Mean Score (Scale 1-4)	Category
B1	3.1	Moderate
B2	3.2	Moderate
B3	3.4	High
B4	3.3	High
B5	3.7	High

The mean focus score increased from 3.1 in session B1 to 3.7 in session B5, with an overall mean of 3.34. Though there was a slight drop in session B4 (3.3), there is an obvious upward trend for the overall data. The level of the intervention phase is clearly different from that of the baseline phase (conversion score: 2.4), indicating the intervention was effective right away according to SSR. There was also greater data stability during the intervention than during the baseline phase. The scores in the initial intervals of most sessions were quite high, showing that participants responded similarly to the movement at the beginning of each session. However, from sessions B3 to B5, scores in the middle and end intervals stabilized in the range of 3-4, and focus endurance extended to 20-30 minutes, a significant improvement over the baseline phase.

The upward trend throughout the entire intervention stage can be attributed to the regulatory effect of structured exercise on children with high motor activity. If the activity is legitimized in an educational context and incorporated into the teaching process, it ceases to function as a distraction and becomes a means of activating attention. The effect mentioned corresponds to Chiang & Griego (2017) study, in which the authors reported that the BrainDance technique increased students' attention to teachers and instructional materials. Moreover, according to Chatzopoulos et al. (2023), even very brief periods of structured exercise can improve inhibition and increase learners' satisfaction with the learning situation, thereby enhancing on-task activity. The minor decrease in B4 also falls within the adaptation literature framework, as cognitive-motor integration exercises typically plateau before further progress is observed (Giuriato & Lovecchio, 2025).

Figure 3. Subject Enthusiastically Follows Movement Instructions

The visual data collected during the intervention phase (see Figure 3) clearly indicate a significant behavior change that differs markedly from that observed in the baseline phase. Earlier movement behaviors that seemed like distractions were seen as systematic movements in conjunction with learning activities. Also, more frequent displays of positive affect and quicker responses to movement instructions suggest greater involvement in the learning process. This behavioral pattern lends support to the view that motor energy is disruptive not by nature, but rather because it was not accommodated in the teaching process. Similarly, Eklund et al. (2025) found that the consistent integration of movement into instruction led to greater behavioral engagement and a more positive attitude toward learning. The lack of overlap between baseline and intervention measures reinforces this view: as noted by McKenna (2022), such overlap is a clear sign of a functional association between the intervention and the resulting behavioral change (A-B SSR).



NO	Soal	Langkah Pengerjaan	Nilai x
1	x - 2 = 11	x-2+2=11+2 x=13	x = 13
2	x + 3 = 10	x+3-3=10-3 x=10-3	x = 7
3	x - 4 = 19	x-4+4=19+4 x=19+4	x = 23

Figure 4. Student's Written Response During Intervention Phase

In addition to behavioral measures of attentional regulation, the qualitative assessment of the student's responses during the intervention stage indicated greater accuracy in symbol use. While solving for x in the equation $x - 2 = 11$, the student demonstrated an understanding of the concept of inverse operations and successfully added 2 to both sides of the equation, giving $x = 13$. This stands out clearly from the baseline stage, where there were omissions in the negative symbol and a failure to write the transformation stages. Such accuracy can be attributed to increased attentional regulation in the intervention phase, which improved cognitive processing of the problem. According to Mutua & Obara (2025)Mutua & Obara

(2025), cognitive activation, which refers to the extent to which a student processes mathematical knowledge, is influenced by attentional regulation. With proper attention, a student is bound to pay more attention to the structural features of algebraic equations rather than their surface forms.

In summary, the results from both phases clearly indicate that the learning focus of highly physically active children is not simply an issue of discipline or motivation. From longitudinal data obtained, it is evident that a lack of movement regulation in children leads to motor energy being used as attention-disruptive energy. On the other hand, if such movements are incorporated into the teaching process with a defined instructional function, then motor energy will become the source of cognitive activation. Hence, rather than interpreting off-task movements as deviant behavior, they could be seen as a sign of unmet regulatory needs. The interpretation of such motor movements is supported by neuroscience research on embodiment and self-regulation of attention. Concerning math instruction, one can safely conclude that the notion of physical stillness as a prerequisite for concentration should be abandoned and give way to MILD as a differentiated approach (Namlı, 2024).

CONCLUSION

Based on the above analysis, it can be concluded that Movement-Integrated Learning positively increases students' focus during mathematics lessons. First, there was a fluctuating attention pattern and a decline in attention level; second, there was an increase in attention level and a higher mean score in the intervention phase. Also, the mean scores were more stable, and there was no overlapping of phases.

These results indicate a functional relationship between movement and improved attention regulation. It is important to note that learning focus cannot be defined only as stillness. When movement becomes an intentional part of the teaching process, it may serve as a regulating agent. Thus, a movement-based approach may be used by teachers when working with highly active learners.

In the present study, only one participant was included, which means that its generalization to other participants and conditions remains questionable. To improve generalizability, further research might involve a larger number of participants and compare results across different grades and mathematics subjects.

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