OSTINATO: Journal of Music Study and Research
Vol. 2, No. 1, Juni 2026, pp. 13-26
P-ISSN 3124-5889 E-ISSN 3123-917X
https://ostinato.silatene.org/index.php/index/en

Addressing Temporal Instability in Drum Learning through Deliberate Practice: An Educational Intervention Study

Piter Sembiring[1], Marsel Ridky Maulana[2]
[1,2] Art Education, Postgraduate School, Universitas Pendidikan Indonesia, Indonesia

Article Info

Article history:

Received: Mei 25, 2026
Revised: Jun 1, 2026
Accepted: Jun 8, 2026

Keywords:

Deliberate practice
Drum learning
Rhythmic control
Temporal stability
Timing accuracy

ABSTRACT

This study investigates the development of rhythmic control in drum learning through deliberate practice. The study addresses temporal instability, a common problem in early drum performance characterized by rushing, dragging, and inconsistent timing during repetitive execution. A qualitative educational intervention design was employed involving 15 students aged 9–12 years in a private drum learning setting. Data were collected through observations, performance recordings, and interviews across four instructional cycles. The findings indicate that rhythmic control develops through structured and error-focused practice rather than repetition alone. Tempo reduction, pattern segmentation, and immediate feedback enabled students to identify timing errors, improve temporal stability, and maintain synchronization with the metronome. Across the intervention, students demonstrated greater self-correction, improved timing awareness, and more consistent rhythmic performance. The findings suggest that rhythmic control involves not only tempo accuracy but also temporal self-regulation and integrated musical understanding. This study contributes to music education by proposing a developmental framework for rhythmic control in drum learning. The findings may serve as a pedagogical reference for drum educators in designing systematic instructional strategies to support rhythmic development and self-regulated learning.

Corresponding Author:

Piter Sembiring,
Art Education, Postgraduate School
Universitas Pendidikan Indonesia,
Jl. Dr. Setiabudi No.229, Isola, Kec. Sukasari, Kota Bandung, Jawa Barat 40154,
Email: piter.sembiring@upi.edu

1. INTRODUCTION

Drum learning entails the integration of rhythmic control, motor coordination, and sustained attentional regulation during performance (Barbaresi et al., 2024; Park & Kim, 2021; Pranjić et al., 2024). In authentic learning contexts, students are frequently required to execute repetitive rhythmic patterns while maintaining alignment with external tempo references, such as metronomes or accompaniment tracks. Under such conditions, the ability to sustain temporal stability becomes a central challenge. Empirical observations suggest that students often experience a loss of timing control during repetitive execution, which manifests as rushing, dragging, and inconsistencies in pattern delivery. Notably, these difficulties persist even among students who demonstrate adequate technical proficiency. This indicates that rhythmic control in real-time performance extends beyond technical competence and involves higher-order regulation of cognitive and motor processes.

Preliminary classroom observations conducted prior to the intervention revealed recurring timing difficulties among students during repetitive drum exercises. Several students unintentionally accelerated the tempo after only a few measures, while others struggled to regain synchronization once timing deviations occurred. One student remarked, "I knew I was no longer following the click, but I did not know how to return to the correct tempo." Another student explained, "When I made one mistake, I kept thinking about it and lost my concentration." These observations suggest that temporal instability in drum learning is not solely a technical issue but is closely related to attentional regulation and timing awareness during performance

These performance challenges may be conceptualized as disruptions in temporal control, defined as the capacity to regulate timing consistently across successive cycles of movement. In drum performance, temporal control requires the coordination of multiple limbs while simultaneously maintaining attentional alignment with an external tempo (Brooks et al., 2025; Clayton et al., 2020; Karageorghis et al., 2019). Research in music cognition indicates that temporal precision is grounded in the interaction between perceptual timing mechanisms and motor synchronization processes (Ladda et al., 2020; Repp & Su, 2013). When this interaction is compromised, performers are more likely to exhibit temporal instability, particularly in repetitive contexts that impose sustained attentional demands. Consequently, errors such as rushing and loss of rhythmic consistency become increasingly prevalent. These observations underscore the need to reconceptualize rhythmic control as a dynamic and actively regulated performance skill.

Rhythmic control is widely recognized as a foundational component of musical performance, particularly in percussion contexts where temporal precision directly determines performance quality (Carrer et al., 2023; Carrillo et al., 2024). Research on sensorimotor synchronization further demonstrates that accurate timing depends on the integration of perceptual and motor systems, enabling performers to align their actions with temporal cues (Cheng et al., 2022; Feng et al., 2022; Proksch et al., 2020). Moreover, repetitive execution places sustained demands on attentional regulation, increasing the likelihood of performance inconsistency over time (Kasuya-Ueba et al., 2020; Slater et al., 2018; Tierney et al., 2020). In this regard, rhythmic control should be understood as an active process of temporal regulation rather than a static measure of accuracy.

In many instructional contexts, drum practice emphasizes repetition of rhythmic patterns without systematically addressing specific timing errors. Although repetition may improve familiarity with the material, it does not necessarily lead to stable rhythmic control. Previous studies have shown that unguided or unstructured practice often fails to produce consistent improvements in performance accuracy (Bae et al., 2025; Danielsen et al., 2024; Ericsson & Harwell, 2019). Without targeted intervention, students may continue to reproduce the same timing inaccuracies during practice. This suggests that the effectiveness of practice depends not only on repetition, but also on how practice is structured to address specific performance deficiencies. Consequently, there is a need for practice approaches that explicitly focus on correcting temporal instability and improving rhythmic consistency.

One such approach is deliberate practice, which emphasizes structured, goal-oriented activities aimed at improving specific aspects of performance through focused attention and immediate feedback (Ericsson & Harwell, 2019; Sembiring et al., 2025). Unlike unguided repetition,

deliberate practice requires continuous self-monitoring and iterative error correction, thereby strengthening the regulation of performance at a micro-level (Hambrick et al., 2020; Miksza, 2011). In music education, deliberate practice has been associated with the development of technical precision and performance consistency, particularly in relation to complex motor and cognitive demands (de Bruin, 2022; Jossberger et al., 2025; Passarotto, Worschech, et al., 2023; Worschech et al., 2023). However, performance variability often remains evident in repetitive drum performance, where rushing, loss of control, and inconsistent pattern execution continue to occur despite repeated practice.

Although deliberate practice has been extensively discussed as a mechanism for performance improvement, existing studies have primarily focused on its effects on technical achievement, expertise development, and performance outcomes. Less attention has been given to how rhythmic control develops progressively during drum learning, particularly when students experience temporal instability such as rushing and dragging. Consequently, the developmental pathway through which learners move from unstable timing toward stable and musically expressive performance remains insufficiently explained. Addressing this gap is important because understanding the process of rhythmic development may provide more specific pedagogical guidance than outcome-oriented descriptions of practice effectiveness alone.

Despite growing evidence regarding the role of deliberate practice in music learning, existing studies have largely examined its contribution to general performance improvement, technical proficiency, and expertise development. However, little is known about how deliberate practice functions as a mechanism for regulating temporal instability during repetitive drum performance. Therefore, this study not only examines the role of deliberate practice in developing rhythmic control but also seeks to identify the developmental stages through which rhythmic control emerges. The study conceptualizes rhythmic control not merely as rhythmic accuracy, but as an adaptive process of temporal self-regulation that develops through iterative cycles of error detection, correction, performance monitoring, and stabilization. Accordingly, this study aims to examine how deliberate practice supports the development of rhythmic control in drum learning, particularly in addressing temporal instability and rushing behaviour during repetitive performance.

2. RESEARCH METHOD

2.1. Research Design

This study employed a qualitative educational intervention design to investigate the development of rhythmic control through deliberate practice in an authentic drum learning environment. The intervention was implemented through four iterative instructional cycles that incorporated planning, action, observation, and reflection. The design enabled the researchers to examine progressive changes in students' timing regulation while capturing the cognitive, behavioural, and performance-related processes associated with temporal control. Special attention was given to manifestations of temporal instability, including rushing and loss of control during repetitive performance.

2.2. Research Setting and Participants

The study was conducted in a private drum learning setting at Favore Music, Bandung, involving 15 male students aged between 9 and 12 years. Participants were selected using a convenience sampling technique, as they were actively enrolled in regular drum lessons. All participants had acquired foundational drumming skills, including simple rock beat patterns, basic rhythmic exercises, and fundamental coordination techniques. However, classroom observations indicated persistent difficulties in maintaining stable tempo during repetitive performance activities, particularly when playing with a metronome. Participants were therefore selected because they represented learners who had developed basic technical competence but continued to experience temporal instability. The selected age range represents a developmental stage in which motor coordination and attentional control are still evolving, making it particularly relevant for examining the development of rhythmic control (Kim, 2023). The learning environment provided a naturalistic context in which repetitive

rhythmic practice regularly occurred. The demographic characteristics of the participants are presented in Table 1.

Table 1. Participant Characteristics.

Variable	Description
Participants	15
Gender	Male
Age range	9–12 years
Learning level	Beginner to early intermediate
Learning setting	Private drum lessons

Source: Author, (2026).

2.3. Data Collection

Data were collected through multiple qualitative sources to ensure depth and methodological rigor. First, non-participant observations were conducted during instructional sessions, focusing on timing control, coordination, and behavioural responses during repetitive rhythmic tasks. Second, performance recordings were obtained to document temporal patterns, particularly instances of rushing, dragging, and fluctuations in rhythmic consistency. Third, semi-structured interviews were carried out to explore students' awareness of timing errors, attentional focus, and perceived challenges during practice. Field notes were systematically maintained to capture contextual interactions, instructional adjustments, and emergent learning behaviours. The integration of multiple data sources enabled triangulation and strengthened the credibility of the findings (Creswell & Clark, 2017).

2.4. Research Instruments and Assessment Indicators

To support the observation and analysis process, the researchers developed a set of assessment indicators focusing on key dimensions of rhythmic control. These indicators were used to guide classroom observations, performance analysis, and interview interpretation throughout the intervention. The indicators focused on tempo accuracy, rhythmic consistency, groove-oriented performance, self-monitoring, and temporal self-regulation.

Table 2. Rhythmic Control Assessment Indicators.

Aspect	Indicator	Evidence Observed
Tempo Accuracy	Ability to maintain synchronization with the metronome throughout performance	Stable tempo with minimal deviation from the metronome pulse
Rhythmic Consistency	Ability to perform rhythmic patterns without significant rushing or dragging	Consistent beat spacing and reduced timing fluctuations
Groove-Oriented Performance	Ability to maintain a steady rhythmic feel during repetitive playing	Continuous pulse, natural body movement, and stable rhythmic flow
Self-Monitoring	Ability to recognize timing errors during performance	Verbal acknowledgment of errors and corrective responses
Temporal Self-Regulation	Ability to adjust performance independently without teacher intervention	Real-time tempo correction and sustained rhythmic stability

Source: Author, (2026).

Based on these assessment indicators, specific success indicators were established for each instructional cycle to evaluate students' progression in rhythmic control development throughout the intervention process.

Table 3. Success Indicators Across Instructional Cycles.

Cycle	Success Indicator
Cycle 1	Students demonstrate awareness of tempo deviations and timing errors
Cycle 2	Students reduce rushing and dragging during short rhythmic patterns
Cycle 3	Students maintain rhythmic stability across extended repetitions and begin self-correcting errors
Cycle 4	Students demonstrate autonomous tempo regulation and maintain groove-oriented performance with minimal instructional support

Source: Author, (2026).

2.5. Instructional Procedure: Cyclical Deliberate Practice

The instructional intervention was organized into four iterative cycles, each designed to progressively support the development of rhythmic control. The design of these cycles was informed by principles of deliberate practice, which emphasize focused attention, immediate feedback, and systematic error correction Ericsson & Harwell (2019), as well as reflective practice frameworks that integrate planning, action, observation, and reflection (Kemmis et al., 2014). Each cycle addressed specific aspects of temporal regulation, with increasing complexity and performance demands. The instructional cycles implemented in this study are summarized in Table 4, Table 5, Table 6, and Table 7.

Table 4. Cycle 1: Developing Awareness of Temporal Instability (8 March, 2026).

Phase	Description
Plan	Simple repetitive rhythmic patterns were introduced at a moderate tempo using a metronome. The primary objective was to expose timing inconsistencies without immediate correction.
Action	Students performed continuous rhythmic patterns while maintaining alignment with the metronome.
Observations	Frequent instances of rushing, inconsistent beat spacing, and loss of tempo alignment were observed. Students showed limited awareness of their timing deviations.
Reflection	Instruction emphasized developing awareness of temporal instability. Students were encouraged to listen critically and recognise deviations from the intended tempo.

Source: Author, (2026).

Table 5. Cycle 2: Targeted Error Correction (10 March, 2026).

Phase	Description
Plan	Practice tasks were designed to isolate specific timing-related issues, such as hi-hat consistency and bass drum placement.
Action	Students engaged in slow-tempo practice with immediate corrective feedback after each attempt.
Observations	A reduction in extreme timing errors was observed, although inconsistencies persisted during extended repetitions. Awareness of rushing began to emerge.
Reflection	Students demonstrated improved control in short sequences but struggled to sustain consistency. Instruction focused on extending stability over longer durations.

Source: Author, (2026).

Table 6. Cycle 3: Stabilization of Rhythmic Control (16 March, 2026).

Phase	Description
Plan	Longer repetitive patterns were introduced, with gradual tempo increases while maintaining accuracy.
Action	Students performed extended repetitions, focusing on sustaining tempo consistency and attentional control.
Observations	Rhythmic stability improved, with fewer occurrences of rushing. Occasional lapses remained under increased cognitive demand.
Reflection	Students began to internalise timing control and demonstrated greater self-regulation. Instruction emphasized maintaining focus and reducing attentional drift.

Source: Author, (2026).

Table 7. Cycle 4: Consolidation and Performance Integration (17 March, 2026).

Phase	Description
Plan	Rhythmic control was applied in more complex and musically meaningful contexts, including groove-based performance.
Action	Students performed with increased autonomy, integrating timing control into continuous playing with minimal intervention.
Observations	Performances exhibited greater temporal stability, reduced rushing, and improved consistency. Control appeared more sustained and reliable.
Reflection	Students demonstrated a more stable and conscious regulation of timing. Rhythmic control emerged as an integrated performance skill rather than an isolated ability.

Source: Author, (2026).

2.6. Data Analysis

Data were analysed using thematic analysis following the procedures outlined by (Braun & Clarke, 2021). The analysis involved systematic coding, categorisation, and the development of themes related to rhythmic control development. Initial codes included temporal instability, rushing behaviour, attentional fluctuation, and performance consistency. These were subsequently organised into broader themes reflecting stages of rhythmic control development across the instructional cycles. The analysis aimed to provide an interpretative account of how deliberate practice supports the regulation of timing in drum performance.

3. RESULTS AND DISCUSSIONS

3.1. Temporal Instability in Early Drum Performance

The initial phase of the instructional process revealed significant challenges in students' ability to maintain rhythmic control when performing with a metronome. As presented in Table , students demonstrated notable difficulty in sustaining temporal stability during repetitive rhythmic execution. Despite initial alignment with the given tempo, most students gradually lost synchronization, resulting in observable timing deviations. A predominant pattern identified was rushing, where students progressively accelerated beyond the intended tempo. This tendency became more pronounced over time, particularly after the first few bars of performance. These findings indicate that early drum performance is characterized by unstable temporal regulation rather than consistent rhythmic control.

A closer examination of performance behaviour showed that rushing was the dominant issue among participants, occurring in 12 out of 15 students. In contrast, three students exhibited dragging, particularly during the middle phase of performance, after initially maintaining stable timing. This suggests that temporal instability does not emerge uniformly, but develops as attentional demands increase during repetition. Furthermore, students often displayed signs of panic and confusion once they deviated from the tempo, which further disrupted their ability to recover. In repetitive contexts, the breakdown of timing control was not limited to isolated errors, but extended into continuous instability across subsequent cycles of performance.

Students' responses to repetitive tasks further highlighted limitations in rhythmic consistency. When instructed to repeat the same pattern, most students reproduced similar errors without significant improvement, indicating a stagnation in performance. Many students paused briefly during execution in an attempt to re-align with the metronome, suggesting partial awareness of timing discrepancies. However, this self-correction was inconsistent and often required external cues from the instructor. Observationally, students exhibited behaviours such as shifting gaze, hesitation, and physical tension, which reflect disruptions in attentional focus. These patterns suggest that the inability to sustain rhythmic control is closely linked to attentional instability during repetitive performance.

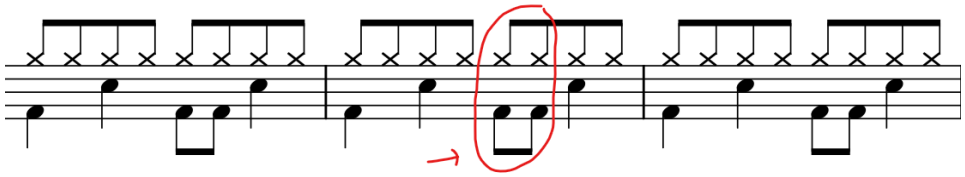
From a cognitive perspective, students' awareness of timing errors varied considerably. While some students were able to recognise that they were ahead of the tempo shortly after beginning the task, others continued playing without awareness of their deviation. Verbal responses indicated that students perceived synchronisation with the metronome as challenging, particularly when minor errors occurred early in the performance. Several students reported losing focus after a small mistake, which led to further timing breakdown. One student explained:

"When I heard the metronome, I realized I was playing ahead of the beat, but I did not know how to get back to the tempo."

Another student reported:

"After making one mistake, I started thinking about the mistake instead of listening to the metronome."

Additionally, visual attention was frequently directed away from the auditory stimulus, with students focusing on hand movements rather than listening to the metronome. This suggests that attentional misalignment between auditory and motor processes contributed significantly to temporal instability. In addition, rhythmic patterns involving double kick figures appeared to place greater demands on coordination and timing regulation during repetitive performance.



Notation 1. Pattern representing areas of difficulty experienced by students (Author, 2026).

The performance tasks were conducted at a tempo of approximately 88 BPM using a 4/4 rhythmic pattern that incorporated eighth-note hi-hat subdivisions and double kick figures. Each student engaged in a 40-minute session, with a primary focus on repetitive practice, interspersed with short breaks to reduce physical fatigue. Despite the structured practice environment, students continued to experience difficulty maintaining consistent tempo over extended repetitions. These findings confirm that early-stage drum learners face substantial challenges in regulating timing during repetitive performance. Consequently, the results of Cycle 1 highlight the need for targeted instructional strategies aimed at improving rhythmic awareness and stabilising temporal control.

3.2. Rhythmic Control Development through Deliberate Practice

Following the identification of temporal instability in Cycle 1, the instructional focus in Cycles 2 and 3 shifted toward the development of rhythmic control through structured deliberate practice. As shown in table 8 and table 9 the intervention emphasized tempo regulation, targeted error correction, and the gradual refinement of performance through repeated practice. Students were initially guided to continue their performance despite errors, allowing them to develop awareness of timing deviations through sustained exposure. Over time, this approach encouraged students to become more attentive to the metronome, marking an important transition from externally driven correction to internally guided control.

During Cycle 2, deliberate practice was operationalized through controlled tempo reduction and the segmentation of rhythmic patterns into smaller, manageable units. The tempo was reduced from 88 BPM to approximately 80 BPM to allow students to engage more carefully with timing execution. Immediate feedback was provided during performance, with the instructor offering real-time guidance while playing alongside the students. This combination of verbal instruction and imitation enabled students to better align their motor actions with the auditory tempo. As a result, instances of rushing decreased, particularly after the initial adjustment phase, although minor inconsistencies remained during transitions.

Students' responses during this phase reflected a gradual shift in both performance behaviour and attentional focus. They became more cautious and deliberate in their playing, demonstrating increased effort to synchronise with the metronome. Importantly, students began to distribute their attention more effectively between listening to the tempo and monitoring their hand movements. This change was reflected in students' verbal responses. One participant stated:

"I stopped focusing on my hands and started listening to the click."

Another participant commented:

"When I listened more carefully to the metronome, it became easier to keep the rhythm steady."

While errors were still present, particularly during extended repetitions, students showed greater resilience in maintaining performance continuity. Rather than stopping entirely, they attempted to recover and realign with the tempo, indicating the emergence of early self-regulation processes.

Despite these improvements, limitations in sustaining rhythmic control were still evident in Cycle 2, particularly during longer performance sequences exceeding eight bars. While students were able to maintain stability in shorter segments, attentional fatigue appeared to contribute to recurring instances of rushing and occasional dragging. However, a notable development was the students' increasing ability to recognise these deviations. Several students explicitly acknowledged their timing errors and expressed a desire to repeat the task in order to improve accuracy. This indicates that deliberate practice not only influenced performance outcomes but also enhanced students' metacognitive awareness of timing control.

The progression observed in Cycle 3 further reinforced the role of deliberate practice in stabilizing rhythmic performance. As students demonstrated improved control at lower tempos, the instructional process gradually reintroduced higher tempo demands, ranging from 88 BPM to 100 BPM. This phase incorporated longer repetitions and increased performance complexity, requiring sustained attentional engagement. Interestingly, students responded positively to these challenges, reporting increased motivation and heightened concentration when performing at higher tempos. This suggests that the gradual increase in difficulty contributed to both technical development and learner engagement.

A significant transformation in Cycle 3 was the emergence of autonomous self-correction during performance. Students began to identify and correct their timing errors without direct intervention from the instructor. Observational data indicated that when deviations occurred, students actively adjusted their playing to return to the metronome, often without interrupting the performance flow. This reflects a shift from externally supported correction to internally regulated control. In addition, students exhibited improved emotional responses to errors, demonstrating composure and persistence rather than confusion or panic. Such behavioural changes further support the development of rhythmic control as an integrated cognitive and motor skill. Overall, the findings

from Cycles 2 and 3 demonstrate that deliberate practice facilitated a gradual transformation from unstable to more controlled rhythmic performance. The combination of slowed practice, segmentation of tasks, immediate feedback, and progressive tempo challenges enabled students to refine both their technical execution and attentional regulation. Furthermore, the presence of guided support alongside opportunities for independent correction fostered the development of self-monitoring and metacognitive awareness. These results suggest that rhythmic control is not merely a product of repetition, but emerges through structured and reflective engagement with performance tasks.

Table 8. Instructional Focus and Student Response in Cycle 2.

Aspect	Description
Tempo Adjustment	Reduced from 88 BPM to ~80 BPM
Instructional Strategy	Error isolation, segmented practice, immediate feedback
Student Response	Increased awareness, reduced rushing, improved focus
Remaining Issues	Instability during long repetitions (>8 bars)
Behavioural Change	Emergence of cautious playing and early self-monitoring

Source: Author, (2026).

Table 9. Rhythmic Control Development in Cycle 3.

Phase	Description
Tempo Progression	Gradual increase from 80 BPM to 88–100 BPM.
Instructional Strategy	Extended repetition, tempo variation, guided independence.
Performance Outcome	Increased stability, reduced rushing, longer consistency.
Cognitive Development	Self-correction, improved metronome awareness.
Behavioural Change	Increased confidence, reduced panic, sustained focus

Source: Author, (2026).

3.3. Stabilization of Rhythmic Control and Reduction of Rushing

The final phase of the instructional process demonstrated a substantial stabilization of rhythmic control across participants. As shown in Table 10, the majority of students no longer exhibited rushing behaviour and were able to maintain consistent tempo during repetitive performance. Specifically, 13 out of 15 students achieved stable rhythmic execution, while the remaining two students showed notable improvement but still required minimal instructional cues. The use of structural counting strategies, such as emphasizing beat placement in relation to kick and snare patterns, contributed to improved temporal awareness. This approach enabled students to maintain alignment with the metronome, even when experiencing momentary lapses in concentration.

Table 10. Rhythmic Control Stabilization in Cycle 4.

Aspect	Description
Performance Stability	Consistent tempo maintenance across extended repetitions
Timing Errors	Minimal rushing and dragging
Self-Regulation	Autonomous correction without instructor intervention
Musical Development	Groove-oriented and expressive performance
Learner Response	Increased confidence and performance autonomy

Source: Author, (2026).

The consistency of performance observed in this phase reflects a significant improvement compared to earlier cycles. Students were able to sustain rhythmic stability across multiple repetitions without experiencing breakdowns in timing. Unlike in previous stages, where performance deteriorated over longer sequences, students in Cycle 4 demonstrated the ability to maintain control throughout extended repetitions. In addition, the instructional environment, including verbal reinforcement and supportive feedback, appeared to enhance students' confidence and engagement. This suggests that rhythmic stability was not only achieved technically, but also supported by positive learning conditions.

A notable outcome in this phase was the near-complete reduction of both rushing and dragging. Observational data indicated that these timing errors, which were prominent in earlier cycles, were no longer consistently present during performance. When minor deviations occurred, they were brief and did not disrupt the overall flow of playing. This indicates that students had developed a more stable internal sense of timing, allowing them to regulate their performance more effectively. The disappearance of persistent timing errors highlights the effectiveness of the cyclical deliberate practice approach in addressing temporal instability.

Another key development was the emergence of real-time self-regulation during performance. Students demonstrated the ability to recognise timing deviations immediately and correct them without external intervention. Verbal responses such as acknowledging missed timing and requesting repetition indicate an increased level of metacognitive awareness. Importantly, students no longer stopped playing when errors occurred, but instead adjusted their performance dynamically to return to the intended tempo. This shift from externally guided correction to autonomous regulation represents a critical indicator of advanced rhythmic control. In addition to technical improvements, students' performance exhibited enhanced musicality and expressive quality. Their playing became more groove-oriented, with body movement naturally aligning with the rhythmic structure. This suggests that rhythmic control had progressed beyond mechanical accuracy toward a more embodied and musical form of performance. Students appeared more relaxed and confident, responding to challenges with composure rather than hesitation. The increased willingness to experiment with higher tempos further reflects their growing confidence and engagement in the learning process.

3.4. Discussion

The findings from Cycle 1 revealed substantial temporal instability among participants during repetitive drum performance. Twelve of the fifteen students demonstrated rushing behaviour, while three students exhibited dragging after initially maintaining synchronization with the metronome. Observational records further indicated that timing deviations became more pronounced as repetitions continued, suggesting increasing attentional demands over time. Several students reported difficulty maintaining focus once a timing error occurred, and some were unable to regain synchronization without external guidance. These findings suggest that temporal instability in early drum learning is closely associated with limitations in attentional control and sensorimotor integration during repetitive performance. This interpretation is consistent with previous research indicating that synchronization with external tempo cues depends on predictive timing mechanisms that are still developing in novice performers (Abalde et al., 2024; Damm et al., 2020; Levitin et al., 2018). Extended repetition further increases attentional demands, which may contribute to fluctuations in timing accuracy. In this respect, rhythmic control can be understood as a cognitively regulated capacity rather than a direct outcome of repetition.

The progression observed across Cycles 2 and 3 illustrates how structured deliberate practice supported the refinement of temporal control. Students gradually demonstrated reduced rushing, improved synchronization with the metronome, and increased awareness of timing deviations. The use of reduced tempo, segmentation of rhythmic patterns, and immediate feedback enabled learners to focus more precisely on timing execution and error correction. As students became increasingly attentive to the metronome, they also demonstrated greater resilience when errors occurred, often attempting to recover without interrupting performance. These findings indicate that rhythmic improvement emerged through structured and error-focused practice rather than through repetition

alone. This interpretation is consistent with evidence suggesting that task simplification and augmented feedback facilitate motor learning by reducing cognitive load and enhancing movement accuracy (Healy et al., 2024; Sigrist et al., 2013). In music learning contexts, deliberate practice has been shown to be particularly effective when directed toward specific performance limitations (Passarotto, Kopp, et al., 2023). The present findings extend this perspective by demonstrating its role in addressing temporal instability during drum learning.

A notable development concerned the emergence of self-regulation during performance. By Cycle 3, students increasingly demonstrated the ability to recognise and correct timing deviations without external prompts. Observational data showed that when synchronization errors occurred, students often adjusted their playing in real time and returned to the metronome without stopping the performance. In addition, students displayed greater emotional stability and persistence when encountering mistakes. This transition from externally guided correction toward autonomous regulation suggests the formation of internal feedback mechanisms that support performance control. Such findings align with motor learning theories that describe expertise development as a gradual shift from external guidance to internally regulated execution (Liu et al., 2022; Reybrouck & Eerola, 2022; Stambaugh, 2017). The ability to maintain performance while simultaneously correcting errors further indicates a more integrated coordination between perception and action, which has been associated with higher levels of musical expertise (Colley et al., 2021; Criscuolo et al., 2022).

The stabilization of rhythmic control observed in Cycle 4 provides further evidence that deliberate practice contributed to the development of temporal self-regulation. Thirteen of the fifteen students demonstrated stable tempo maintenance during extended repetitions, while persistent rushing and dragging were largely eliminated. Students were able to sustain performance at higher tempos and maintain synchronization over longer durations without continuous instructional intervention. These outcomes suggest that timing control had become more robust and less dependent on external correction. From the perspective of entrainment and temporal processing, repeated engagement with rhythmic structures may facilitate the alignment of internal timing systems with external tempo cues, resulting in greater rhythmic consistency (Emmery et al., 2023; Ross & Balasubramaniam, 2022). The findings therefore highlight the importance of gradual progression in instructional design, where increasing complexity supports rather than disrupts the consolidation of timing skills.

Changes in affective and behavioural responses were also evident throughout the intervention. Students who initially displayed hesitation, frustration, and confusion gradually became more confident and engaged in the learning process. Observational records indicated that students were increasingly willing to repeat challenging tasks, experiment with higher tempos, and persist following performance errors. These behavioural changes suggest that emotional regulation played an important role in sustaining rhythmic stability and performance improvement. Previous research has similarly emphasized the importance of supportive feedback and positive instructional environments in fostering motivation, attentional focus, and engagement in music learning (Blackwell et al., 2020; Cardenas, 2024; Shaheen, 2022). In the present study, guided interaction appeared to support not only technical improvement but also the development of a more stable and confident approach to performance.

A notable outcome observed in Cycle 4 was the emergence of groove-oriented performance. In this study, groove-oriented performance refers to the ability to maintain a stable rhythmic pulse while sustaining a continuous and musically engaging rhythmic feel during repetitive performance. Operationally, groove was identified through three observable indicators: consistent synchronization with the metronome, minimal occurrences of rushing and dragging, and natural body movement that remained aligned with the rhythmic structure. Observational records showed that students no longer focused exclusively on technical execution but began to demonstrate more relaxed body movements and sustained rhythmic flow throughout performance. Minor timing deviations were corrected without interrupting musical continuity, indicating that rhythmic control had progressed beyond mechanical accuracy toward a more embodied form of musical engagement. This interpretation is supported by embodied music cognition research, which argues that rhythmic understanding emerges through the interaction between perception, action, and bodily movement rather than through abstract timing processes alone (Dell'Anna et al., 2021; Leman et al., 2010; Leman & Camurri, 2006).

These findings suggest that effective rhythm instruction should incorporate both perceptual and physical dimensions of learning, enabling students to experience rhythm as an embodied musical process rather than solely a technical skill.

Based on the progression observed across the four instructional cycles, rhythmic control development may be understood as a progressive process consisting of eight interconnected stages: temporal instability, awareness of timing errors, targeted error correction, focused deliberate practice, self-monitoring, temporal self-regulation, rhythmic stability, and groove-oriented performance. These stages were derived from recurring behavioural patterns, observational records, performance outcomes, and participant reflections documented throughout the intervention. Rather than representing a reformulation of deliberate practice theory, the model provides an empirically grounded description of how rhythmic control developed within the context of drum learning. While deliberate practice explains the mechanism underlying improvement, the present model contributes a developmental framework that illustrates how learners progress from unstable timing toward stable and musically expressive performance. This framework may serve as a conceptual reference for designing rhythm-focused instructional practices in drum education.

4. CONCLUSION

This study demonstrates that rhythmic control in drum learning develops through a progressive process supported by deliberate practice rather than repetition alone. The findings indicate that temporal instability, particularly rushing and dragging, can be reduced through structured interventions involving tempo regulation, segmented practice, immediate feedback, and continuous performance monitoring. Across four instructional cycles, students developed greater timing awareness, self-monitoring abilities, temporal self-regulation, and ultimately more stable rhythmic performance. A key contribution of this study is the development of an eight-stage model of rhythmic control consisting of temporal instability, awareness of timing errors, targeted error correction, focused deliberate practice, self-monitoring, temporal self-regulation, rhythmic stability, and groove-oriented performance. This model provides a conceptual framework for understanding how rhythmic control develops in drum education and may serve as a pedagogical reference for designing rhythm-focused instructional practices. The study is limited by its relatively small and homogeneous sample drawn from a single instructional setting. Future research should examine the applicability of the model across different age groups, musical instruments, and learning environments. Practically, drum educators are encouraged to implement structured learning activities that emphasize rhythmic awareness, self-evaluation, and gradual tempo stabilization to support the development of sustainable rhythmic control.

ACKNOWLEDGEMENTS

The authors would like to thank the students and instructional staff of Favore Music, Bandung, for their participation and support throughout the implementation of this study. The authors also acknowledge Universitas Pendidikan Indonesia for providing academic support during the completion of this research.

REFERENCES

Abalde, S. F., Rigby, A., Keller, P. E., & Novembre, G. (2024). *A framework for joint music making: behavioral findings, neural processes, and computational models*. https://doi.org/10.31234/osf.io/kvhn5

Bae, S.-Y., Kwon, S., & Lee, J.-Y. (2025). The effect of a practice checklist on performance achievement, practice time, focal practice areas, and practice strategies of collegiate non-music majors enrolled in a beginning " Danso ," Korean traditional wind instrument class. *International Journal of Music Education*, *43*(1), 108–119. https://doi.org/10.1177/02557614241307346

Barbaresi, M., Nardo, D., & Fagioli, S. (2024). Physiological Entrainment: A Key Mind–Body Mechanism for Cognitive, Motor and Affective Functioning, and Well-Being. *Brain Sciences*, *15*(1), 3. https://doi.org/10.3390/brainsci15010003

Blackwell, J., Miksza, P., Evans, P., & McPherson, G. E. (2020). Student Vitality, Teacher Engagement, and Rapport

in Studio Music Instruction. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01007

Braun, V., & Clarke, V. (2021). Can I use TA? Should I use TA? Should I not use TA? Comparing reflexive thematic analysis and other pattern-based qualitative analytic approaches. *Counselling and Psychotherapy Research*, *21*(1), 37–47. https://doi.org/10.1002/capr.12360

Brooks, J., Eleuteri, V., van der Werff, J., & Yamamoto, S. (2025). *Spontaneous rhythmic and tool-assisted drumming across variable tempo and technique in a captive chimpanzee*. https://doi.org/10.1101/2025.09.26.678729

Cardenas, R. (2024). Feedback Methods in the Music Classroom: A Review of Literature. *Update: Applications of Research in Music Education*, *43*(1), 30–38. https://doi.org/10.1177/87551233231186533

Carrer, L. R. J., Pompéia, S., & Miranda, M. C. (2023). Sensorimotor synchronization with music and metronome in school-aged children. *Psychology of Music*, *51*(2), 523–540. https://doi.org/10.1177/03057356221100286

Carrillo, C., Chang, A., Armstrong, H., Cairney, J., McAuley, J. D., & Trainor, L. J. (2024). Auditory rhythm facilitates perception and action in children at risk for developmental coordination disorder. *Scientific Reports*, *14*(1), 12203. https://doi.org/10.1038/s41598-024-62322-6

Cheng, T.-H. Z., Creel, S. C., & Iversen, J. R. (2022). How Do You Feel the Rhythm: Dynamic Motor-Auditory Interactions Are Involved in the Imagination of Hierarchical Timing. *The Journal of Neuroscience*, *42*(3), 500–512. https://doi.org/10.1523/JNEUROSCI.1121-21.2021

Clayton, M., Jakubowski, K., Eerola, T., Keller, P. E., Camurri, A., Volpe, G., & Alborno, P. (2020). Interpersonal Entrainment in Music Performance. *Music Perception*, *38*(2), 136–194. https://doi.org/10.1525/mp.2020.38.2.136

Colley, I. D., Varlet, M., MacRitchie, J., & Keller, P. E. (2021). Does Movement Amplitude of a Co-performer Affect Individual Performance in Musical Synchronization? *Music & Science*, *4*. https://doi.org/10.1177/20592043211031712

Creswell, J. W., & Clark, V. L. P. (2017). *Designing and Conducting Mixed Methods Research*. SAGE Publications. https://books.google.co.id/books?id=eTwmDwAAQBAJ

Criscuolo, A., Pando-Naude, V., Bonetti, L., Vuust, P., & Brattico, E. (2022). An ALE meta-analytic review of musical expertise. *Scientific Reports*, *12*(1), 11726. https://doi.org/10.1038/s41598-022-14959-4

Damm, L., Varoqui, D., De Cock, V. C., Dalla Bella, S., & Bardy, B. (2020). Why do we move to the beat? A multi-scale approach, from physical principles to brain dynamics. *Neuroscience & Biobehavioral Reviews*, *112*, 553–584. https://doi.org/10.1016/j.neubiorev.2019.12.024

Danielsen, A., Brøvig, R., Bøhler, K. K., Câmara, G. S., Haugen, M. R., Jacobsen, E., Johansson, M. S., Lartillot, O., Nymoen, K., Oddekalv, K. A., Sandvik, B., Sioros, G., & London, J. (2024). There's More to Timing than Time. *Music Perception: An Interdisciplinary Journal*, *41*(3), 176–198. https://doi.org/10.1525/mp.2024.41.3.176

de Bruin, L. R. (2022). Collaborative learning experiences in the university jazz/creative music ensemble: Student perspectives on instructional communication. *Psychology of Music*, *50*(4), 1039–1058. https://doi.org/10.1177/03057356211027651

Dell'Anna, A., Leman, M., & Berti, A. (2021). Musical Interaction Reveals Music as Embodied Language. *Frontiers in Neuroscience*, *15*. https://doi.org/10.3389/fnins.2021.667838

Emmery, L., Hackney, M. E., Kesar, T., McKay, J. L., & Rosenberg, M. C. (2023). An integrated review of music cognition and rhythmic stimuli in sensorimotor neurocognition and neurorehabilitation. *Annals of the New York Academy of Sciences*, *1530*(1), 74–86. https://doi.org/10.1111/nyas.15079

Ericsson, K. A., & Harwell, K. W. (2019). Deliberate Practice and Proposed Limits on the Effects of Practice on the Acquisition of Expert Performance: Why the Original Definition Matters and Recommendations for Future Research. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.02396

Feng, Y., Li, S., & Wei, Y. (2022). Design of a game-based learning environment for basic rhythmic patterns in music. In Y. Lu & C. Cheng (Eds.), *Third International Conference on Computer Science and Communication Technology (ICCSCT 2022)* (p. 19). SPIE. https://doi.org/10.1117/12.2661772

Hambrick, D. Z., Macnamara, B. N., & Oswald, F. L. (2020). Is the Deliberate Practice View Defensible? A Review of Evidence and Discussion of Issues. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01134

Healy, A. F., Kole, J. A., & Proctor, R. W. (2024). Principles of Expertise for Skill Learning. In *The Oxford Handbook of Human Memory, Two Volume Pack* (pp. 2090–2117). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190917982.013.72

Jossberger, H., Huovinen, E., Ritter, M., & Gruber, H. (2025). Conductors' views on individual practice activities. *Psychology of Music*, *53*(3), 321–336. https://doi.org/10.1177/03057356241311817

Karageorghis, C. I., Lyne, L. P., Bigliassi, M., & Vuust, P. (2019). Effects of auditory rhythm on movement accuracy in dance performance. *Human Movement Science*, *67*, 102511. https://doi.org/10.1016/j.humov.2019.102511

Kasuya-Ueba, Y., Zhao, S., & Toichi, M. (2020). The Effect of Music Intervention on Attention in Children: Experimental Evidence. *Frontiers in Neuroscience*, *14*. https://doi.org/10.3389/fnins.2020.00757

Kemmis, S., McTaggart, R., & Nixon, R. (2014). *The Action Research Planner*. Springer Singapore. https://doi.org/10.1007/978-981-4560-67-2

Kim, A. J. (2023). Differential Effects of Musical Expression of Emotions and Psychological Distress on Subjective Appraisals and Emotional Responses to Music. *Behavioral Sciences*, *13*(6).

https://doi.org/10.3390/bs13060491
Ladda, A. M., Wallwork, S. B., & Lotze, M. (2020). Multimodal Sensory-Spatial Integration and Retrieval of Trained Motor Patterns for Body Coordination in Musicians and Dancers. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.576120
Leman, M., & Camurri, A. (2006). Understanding musical expressiveness using interactive multimedia platforms. *Musicae Scientiae*, *10*(1_suppl), 209–233. https://doi.org/10.1177/10298649060100011O
Leman, M., Lesaffre, M., Nijs, L., & Deweppe, A. (2010). User-oriented studies in embodied music cognition research. *Musicae Scientiae*, *14*(2_suppl), 203–223. https://doi.org/10.1177/10298649100140S212
Levitin, D. J., Grahn, J. A., & London, J. (2018). The Psychology of Music: Rhythm and Movement. *Annual Review of Psychology*, *69*, 51–75. https://doi.org/10.1146/annurev-psych-122216-011740
Liu, W., Magalhaes, M. A., Mackay, W. E., Beaudouin-Lafon, M., & Bevilacqua, F. (2022). Motor Variability in Complex Gesture Learning: Effects of Movement Sonification and Musical Background. *ACM Transactions on Applied Perception*, *19*(1), 1–21. https://doi.org/10.1145/3482967
Miksza, P. (2011). Relationships among achievement goal motivation, impulsivity, and the music practice of collegiate brass and woodwind players. *Psychology of Music*, *39*(1), 50–67. https://doi.org/10.1177/0305735610361996
Park, J.-K., & Kim, S. J. (2021). Dual-Task-Based Drum Playing with Rhythmic Cueing on Motor and Attention Control in Patients with Parkinson's Disease: A Preliminary Randomized Study. *International Journal of Environmental Research and Public Health*, *18*(19), 10095. https://doi.org/10.3390/ijerph181910095
Passarotto, E., Kopp, B., Lee, A., & Altenmüller, E. (2023). Musical Expertise and Executive Functions in Experienced Musicians. *Brain Sciences*, *13*(6), 908. https://doi.org/10.3390/brainsci13060908
Passarotto, E., Worschech, F., & Altenmüller, E. (2023). The effects of anxiety on practice behaviors and performance quality in expert pianists. *Frontiers in Psychology*, *14*. https://doi.org/10.3389/fpsyg.2023.1152900
Pranjić, M., Braun Janzen, T., Vukšić, N., & Thaut, M. (2024). From Sound to Movement: Mapping the Neural Mechanisms of Auditory–Motor Entrainment and Synchronization. *Brain Sciences*, *14*(11), 1063. https://doi.org/10.3390/brainsci14111063
Proksch, S., Comstock, D. C., Médé, B., Pabst, A., & Balasubramaniam, R. (2020). Motor and Predictive Processes in Auditory Beat and Rhythm Perception. *Frontiers in Human Neuroscience*, *14*. https://doi.org/10.3389/fnhum.2020.578546
Repp, B. H., & Su, Y. H. (2013). Sensorimotor synchronization: A review of recent research (2006-2012). *Psychonomic Bulletin and Review*, *20*(3), 403–452. https://doi.org/10.3758/s13423-012-0371-2
Reybrouck, M., & Eerola, T. (2022). Musical Enjoyment and Reward: From Hedonic Pleasure to Eudaimonic Listening. *Behavioral Sciences*, *12*(5). https://doi.org/10.3390/bs12050154
Ross, J. M., & Balasubramaniam, R. (2022). Time Perception for Musical Rhythms: Sensorimotor Perspectives on Entrainment, Simulation, and Prediction. *Frontiers in Integrative Neuroscience*, *16*. https://doi.org/10.3389/fnint.2022.916220
Sembiring, P., Narawati, T., & Budiman, A. (2025). Implementasi Metode Gots dalam Pembelajaran Drum bagi Siswa Sekolah Dasar di Favore Music. *Jurnal Pendidikan Dan Teknologi Indonesia*, *5*(2). https://doi.org/10.52436/1.jpti.659
Shaheen, M. (2022). Self-Determination Theory for Motivation in Distance Music Education. *Journal of Music Teacher Education*, *31*(2), 80–91. https://doi.org/10.1177/10570837211062216
Sigrist, R., Rauter, G., Riener, R., & Wolf, P. (2013). Augmented visual, auditory, haptic, and multimodal feedback in motor learning: A review. *Psychonomic Bulletin & Review*, *20*(1), 21–53. https://doi.org/10.3758/s13423-012-0333-8
Slater, J., Ashley, R., Tierney, A., & Kraus, N. (2018). Got Rhythm? Better Inhibitory Control Is Linked with More Consistent Drumming and Enhanced Neural Tracking of the Musical Beat in Adult Percussionists and Nonpercussionists. *Journal of Cognitive Neuroscience*, *30*(1), 14–24. https://doi.org/10.1162/jocn_a_01189
Stambaugh, L. A. (2017). Effects of internal and external focus of attention on woodwind performance. *Psychomusicology: Music, Mind, and Brain*, *27*(1), 45–53. https://doi.org/10.1037/pmu0000170
Tierney, A., Rosen, S., & Dick, F. (2020). Speech-in-speech perception, nonverbal selective attention, and musical training. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *46*(5), 968–979. https://doi.org/10.1037/xlm0000767
Worschech, F., James, C. E., Jünemann, K., Sinke, C., Krüger, T. H. C., Scholz, D. S., Kliegel, M., Marie, D., & Altenmüller, E. (2023). Fine motor control improves in older adults after 1 year of piano lessons: Analysis of individual development and its coupling with cognition and brain structure. *European Journal of Neuroscience*, *57*(12), 2040–2061. https://doi.org/10.1111/ejn.16031