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FREESTYLE SWIMMING SKILL CHANGES FOLLOWING SCHMIDT'S MOTOR SCHEMA THEORY-BASED VARIABLE PRACTICE IN BEGINNER ATHLETES

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Article Info	ABSTRACT
Article History Submitted: 16-12-2025 Revised: 26-01-2026 Accepted: 12-02-2026 Published: 27-02-2026 **Keywords:** Motor schema theory; Variable practice; Freestyle swimming; Motor learning; Beginner athletes	Freestyle swimming requires coordinated execution of body position, leg movement, arm movement, and breathing, making the development of adaptable motor skills particularly important for beginner athletes. This study examined changes in freestyle swimming skills following a variable-practice program based on Schmidt's Motor Schema Theory among beginner athletes at PR Putrajaya. A quantitative pre-experimental approach was employed using a one-group pretest–posttest design. The participants were 10 beginner athletes who participated in a structured training program comprising 14 total sessions, including pretest and posttest assessments. The program incorporated systematic variations in swimming speed, distance, rhythm, breathing, and movement patterns while maintaining the fundamental structure of freestyle swimming. Freestyle swimming skill was assessed using a four-component technical rubric covering body position, leg movement, arm movement, and breathing, with a maximum total score of 16. Descriptive statistics and a paired-samples *t*-test were used to examine pretest–posttest changes. The mean total skill score increased from 10.50 (SD = 0.85) at pretest to 13.60 (SD = 1.43) at posttest, representing a mean increase of 3.10 points. The paired-samples *t*-test indicated a statistically significant pretest–posttest difference, $t(9) = 8.188$, $p < .001$. Improvements were observed across all four technical components, with the largest descriptive increase occurring in breathing. These findings provide preliminary evidence of improvement in observed freestyle swimming skill following structured variable practice and are theoretically consistent with the principles of practice variability associated with Schmidt's Motor Schema Theory. However, because the study used a one-group pretest–posttest design with only 10 athletes, the findings do not establish a definitive causal effect of the intervention. Further controlled research with larger samples, retention tests, and transfer assessments is needed to determine whether the observed changes represent durable and adaptable motor learning.

INTRODUCTION

Freestyle swimming is a technically demanding motor skill that requires the coordinated execution of body position, leg movement, arm movement, and breathing. For beginner athletes, these components must be integrated while maintaining rhythm, propulsion, and body alignment, making the acquisition of an efficient movement pattern an important foundation for subsequent skill development. Previous research in swimming has shown that variations in training activities can improve freestyle swimming skills, including among beginner and young swimmers (Arhesa & Badriah, 2021; Nur'aeni et al., 2023). However, improvement in immediate technical performance does not necessarily indicate the development of adaptable motor skills. Motor-learning research distinguishes between performance during or immediately after practice and learning that can be retained and transferred to changing task conditions (Shea & Morgan, 1979; Minkels et al., 2025). This distinction is particularly relevant for beginner swimmers because technical learning requires not only repeated execution but also the capacity to adjust movement parameters while preserving the essential structure of the skill.

One important challenge in beginner swimming instruction is therefore determining how practice should be structured to promote both technical stabilization and adaptability. Repetitive practice can give learners opportunities to refine a movement pattern, but practice conditions that incorporate systematic variation may expose learners to a broader range of movement solutions. Research on contextual interference has demonstrated that variations in task conditions can influence motor-skill acquisition, retention, and transfer, although the magnitude of these effects depends on the characteristics and organization of practice (Landin & Hebert, 1997; Meira & Tani, 2001; Shea & Morgan, 1979). Evidence from variable-practice research similarly suggests that variation can facilitate motor learning, but greater variability is not automatically more beneficial. Caballero et al. (2024) showed that practice variability must be appropriately structured because excessive variation may not produce superior learning outcomes. Earlier work has also shown that variable and constant practice can produce different learning patterns depending on the task and learner characteristics (Cacola et al., 2012). Thus, the central issue is not simply whether variation should be introduced, but how variation can be organized progressively and meaningfully according to the demands of the motor skill and the learner.

Schmidt's Schema Theory provides a theoretical framework for understanding why structured variability may support motor learning. Schmidt (1975) proposed that learners develop generalized motor rules rather than storing every movement as an independent motor program. These generalized representations are refined through experiences involving variations in movement parameters and their corresponding outcomes. The theory distinguishes between the recall schema, which contributes to selecting movement parameters before execution, and the recognition schema, which supports evaluating movement outcomes through sensory feedback. From this perspective, systematically varying relevant characteristics of freestyle swimming—such as execution speed, distance, rhythm, breathing pattern, and movement configuration—may provide learners with richer experiences from which they can develop generalized movement relationships. Later motor-learning research has also discussed the theoretical relevance of variability, including work examining feedback-induced variability and generalized motor-program learning (Wulf & Schmidt, 1994). Nevertheless, Schema Theory should not be treated as evidence that schema development has occurred unless the relevant cognitive or motor processes are directly measured. Rather, it provides a theoretical rationale for examining whether structured variable practice is associated with observable changes in motor performance.

Although the theoretical rationale for variable practice is well established, important empirical limitations remain. Existing research has examined contextual interference, variable practice, and motor learning across different tasks and learner populations, while swimming-specific evidence has also begun to address the role of evidence-based motor-learning approaches (Cacola et al., 2012; Meira & Tani, 2001; Minkels et al., 2025). However, the available evidence does not clearly explain how a structured variable-practice program, explicitly informed by Schmidt's Schema Theory, can be implemented for beginner freestyle swimmers in a club-based training context. Previous swimming studies have shown that varied training can improve freestyle swimming performance (Arhesa & Badriah, 2021; Nur'aeni et al., 2023), but they do not establish whether a theoretically structured sequence of variation in movement parameters can support improvement across the fundamental technical components of freestyle swimming. Moreover, evidence concerning retention and transfer remains limited, making it necessary to distinguish immediate performance improvement from broader claims about durable motor learning (Minkels et al., 2025). Addressing this gap requires an intervention in which variability is deliberately structured rather than introduced simply as additional exercise variation.

Accordingly, the present study examines a structured variable-practice program informed by Schmidt's Motor Schema Theory among beginner athletes at PR Putrajaya. The intervention was designed to introduce systematic variation in relevant freestyle movement parameters while maintaining the essential technical structure of the stroke. Freestyle swimming skill was evaluated through four fundamental technical components—body position, leg movement, arm movement, and breathing—to determine whether observable performance changes occurred following participation in the program. The study therefore contributes preliminary empirical evidence on applying Schema Theory-based variable practice in a beginner swimming context, while avoiding claims that schema development itself has been directly demonstrated. Specifically, this study aimed to examine changes in freestyle swimming skills following participation in a structured variable-practice program based on Schmidt's Motor Schema Theory among beginner athletes. Given the absence of a control group, the findings are interpreted as evidence of pretest–posttest change rather than definitive evidence of a causal intervention effect. The study is expected to provide a theoretically informed basis for coaches and researchers interested in structuring variable practice for beginner swimming while identifying directions for future controlled research involving larger samples and retention and transfer assessments.

METHOD

Research Design and Setting

This study employed a quantitative pre-experimental design using a one-group pretest–posttest approach. A single group of beginner swimmers was assessed before and after participation in a structured variable-practice program based on Motor Schema Theory. The design was selected to examine within-participant changes in freestyle swimming skills following the training program. Because no comparison or control group was included, changes observed between the pretest and posttest cannot be attributed exclusively to the intervention. Potential alternative explanations, including maturation, repeated exposure to the assessment procedure, familiarity with the testing environment, and concurrent training, cannot be completely excluded. Accordingly, the findings are interpreted as evidence of pretest–posttest change and as preliminary evidence concerning the potential value of the training program rather than as definitive evidence of a causal intervention effect. The study was conducted at the swimming pool of Hotel Putrajaya and involved athletes registered at PR Putrajaya. The manuscript records the study period as June 23 to July 23, 2026, with training sessions scheduled three times per week on Tuesday, Thursday, and Saturday from 15:30 to 17:30 Western Indonesian Time (WIB). The intervention was implemented within the athletes' regular training environment to maintain ecological relevance to their usual swimming practice.

Participants

The target population consisted of 10 beginner athletes registered at PR Putrajaya. Because the accessible target population was small, all eligible athletes were included using a total-population approach. Eligibility was determined according to four criteria: (1) being registered and actively participating in swimming training at PR Putrajaya; (2) possessing beginner-level freestyle swimming ability; (3) not yet demonstrating optimal mastery of the fundamental technical components of freestyle swimming; and (4) being willing to participate in all stages of the research procedure. All 10 eligible athletes participated in the study, and no participant was excluded after eligibility screening. Using the entire accessible population was intended to minimize participant selection within the club and ensure the intervention was applied to all athletes who met the study criteria. The final manuscript should report the participants' age, sex, swimming experience, and relevant competitive or training level if these data were collected. The manuscript should also report participant attendance and adherence to the intervention, including the number of sessions attended by each participant or, at minimum, the overall attendance rate.

Intervention Procedure

The intervention consisted of a structured variable-practice program based on Motor Schema Theory. The manuscript specifies a total of 14 sessions, including the pretest and posttest sessions. Therefore, the exact number of intervention sessions should be stated separately from the assessment sessions to avoid ambiguity. If the intended structure consisted of 14 total sessions comprising one pretest, intervention sessions, and one posttest, report the exact allocation. The training program was organized into three sequential phases: (1) Basic Generalized Motor Program (GMP) Formation, (2) Motor Schema Variation and Integration, and (3) Motor Schema Consolidation and Transfer. The sequence progressed from establishing the fundamental structure of freestyle movement to systematic variation and subsequent consolidation of the learned movement pattern. During the program, variation was introduced through selected movement parameters relevant to freestyle swimming, particularly execution speed, swimming distance, movement rhythm, breathing patterns, and movement configurations. The purpose of the variation was not to increase task complexity indiscriminately but to provide repeated experiences under systematically different conditions while preserving the essential characteristics of the freestyle stroke.

The intervention was conducted within the athletes' regular training environment at PR Putrajaya. The pretest was administered before the training program, followed by the structured variable-practice sessions, and the posttest was conducted after completion of the intervention. The same general assessment conditions were maintained at both measurement points to facilitate within-participant comparison. For methodological transparency and reproducibility, the final manuscript should provide a session-by-session description of the intervention. At minimum, the description should identify the session number, training objective, swimming distance, variation in execution speed, rhythm or breathing condition, principal task, and approximate duration. A separate intervention table is recommended because the current narrative description does not provide sufficient operational detail for another researcher or coach to reproduce the program.

Intervention Fidelity

The intervention was implemented in the regular training setting; however, the authors should explicitly document fidelity to the planned variable-practice program. The final manuscript should state who delivered or supervised the training, whether the same coach conducted all sessions, and whether a session checklist or training log was used to verify implementation. If an intervention checklist was used, the main fidelity indicators should be reported, such as completion of the prescribed variation, adherence to session objectives, and participant attendance. If no formal fidelity checklist was used, acknowledge this as a methodological limitation rather than implying that implementation fidelity was objectively verified.

Measurement Instrument

Freestyle swimming skill was assessed using a structured technical scoring rubric comprising four fundamental components: body position, leg movement, arm movement, and breathing. Each component was scored on a 1–4 scale, producing a maximum possible total score of 16. The instrument was therefore designed to assess the technical quality of freestyle swimming rather than relying exclusively on completion time. Content validity of the rubric was evaluated through expert judgment by two experts with expertise in swimming, identified in the original manuscript as swimming lecturers and/or certified swimming coaches. The final manuscript should report the specific procedure used to establish content validity and the resulting evidence.

Instrument reliability was assessed using a test–retest procedure. However, the current manuscript does not clearly identify the reliability statistic used. The final version should therefore specify the exact reliability method, report the resulting coefficient, and explain its interpretation. The wording should not state that reliability was examined using "either Pearson correlation or the Intraclass Correlation Coefficient." Report only the method actually used. Because the assessment involved technical scoring, the final manuscript should also clarify who rated the swimmers, whether one or more assessors were involved, whether assessors received standardized scoring instructions, and whether the assessor was blinded to measurement occasion when feasible. If more than one assessor independently scored performance, an appropriate measure of inter-rater agreement should be reported.

Data Collection Procedure

Data were collected using a standardized 25-m freestyle swimming test at two measurement points: pretest and posttest. The same four technical components—body position, leg movement, arm movement, and breathing—were assessed at both measurement occasions using the established 1–4 scoring rubric. The pretest established each athlete's baseline technical performance. After completing the structured variable-practice program, the posttest was administered using the same 25-m freestyle assessment and scoring procedure. The paired pretest and posttest scores constituted the primary data for evaluating within-participant changes in freestyle swimming skill. To reduce measurement variability, the final manuscript should explicitly report the standardized testing conditions used at both measurement points, including the testing facility and lane conditions, warm-up procedure, starting procedure, rest interval, assessor position, and other environmental or procedural conditions that could influence performance. The same assessor or assessors, instructions, scoring rubric, and testing procedure should be used at pretest and posttest whenever possible.

Data Analysis

Data analysis was conducted using SPSS. Descriptive statistics were first calculated for the total freestyle swimming skill scores, including the mean, standard deviation, minimum, and maximum values for the pretest and posttest. Mean changes were also examined for each of the four technical components to describe the pattern of improvement across body position, leg movement, arm movement, and breathing. Because the primary inferential comparison involved paired observations from the same 10 athletes, we evaluated the normality assumption using the Shapiro–Wilk test. The relevant distribution for a paired-samples *t*-test is the distribution of the paired difference scores (posttest minus pretest). Therefore, the final analysis should report the normality result for the difference scores rather than relying only on separate normality tests for the pretest and posttest distributions.

When the normality assumption was considered satisfactory, a two-tailed paired-samples *t*-test was used to examine whether the mean freestyle swimming skill score differed between the pretest and posttest. Statistical significance was evaluated at $\alpha = .05$. The analysis should report the mean difference, standard deviation of the difference score, t value, degrees of freedom, p value, and 95% confidence interval of the mean difference. Because statistical significance alone does not indicate the magnitude of change, an appropriate within-participant effect size should also be reported. Given the paired design, Cohen's d for paired observations should be calculated and reported together with an appropriate interpretation of its magnitude. The statistical analysis was interpreted as evidence of pretest–posttest change, rather than definitive evidence of a causal intervention effect. The absence of a control group means that maturation, repeated testing, familiarity with the assessment procedure, concurrent training, and other uncontrolled factors may have contributed to the observed changes. Accordingly, statistical significance was not interpreted as proof that the Motor Schema Theory-based variable-practice program alone caused the improvement.

Ethical Considerations

The study involved human participants who participated in a structured swimming training program and performance assessment. The final manuscript should explicitly report the ethical procedures applied, including participant consent and, where applicable, parental or guardian consent for participants who were minors. The authors should also identify the relevant institutional ethical approval or clearly state whether formal ethical review was not required under institutional regulations. Participant confidentiality was maintained throughout data collection, analysis, and reporting. Individual performance data should not be presented in a manner that permits identification of individual athletes.

RESULTS

Descriptive Results

The study included 10 beginner athletes from PR Putrajaya. Freestyle swimming skill was assessed before and after participation in the structured variable-practice program. Descriptive statistics for the total freestyle swimming skill scores are presented in Table 1.

Table 1. Descriptive Statistics of Total Freestyle Swimming Skill Scores

Data	N	Minimum	Maximum	Mean	SD
Pretest	10	9	12	10.50	0.850
Posttest	10	11	15	13.60	1.430

The mean total freestyle swimming skill score increased from **10.50 (SD = 0.850)** at pretest to **13.60 (SD = 1.430)** at posttest, representing a mean increase of **3.10 points**. The minimum score increased from 9 to 11, while the maximum score increased from 12 to 15. These descriptive results indicate an overall increase in observed freestyle swimming skill following the training period. Table 2 presents changes across the four technical components.

Table 2. Descriptive Statistics of Freestyle Swimming Skill Components

Technical Component	Mean Pretest	Mean Posttest	Mean Difference
Body Position	3.20	3.90	0.70
Leg Movement	2.70	3.40	0.70
Arm Movement	2.30	3.00	0.70
Breathing	2.30	3.20	0.90

All four assessed technical components showed higher mean scores at posttest than at pretest. The largest descriptive increase occurred in breathing, which increased by 0.90 points, from 2.30 to 3.20. Body position, leg movement, and arm movement each increased by 0.70 points. These findings indicate that the observed improvement was distributed across all four assessed components rather than being limited to a single technical aspect of freestyle swimming.

Normality Assessment

The normality of the pretest and posttest score distributions was initially examined using the Shapiro–Wilk test. Table 3 presents the results.

Table 3. Shapiro–Wilk Test of Pretest and Posttest Scores

Data	W	df	p	Interpretation
Pretest	0.906	10	.258	No significant departure from normality
Posttest	0.868	10	.094	No significant departure from normality

The Shapiro–Wilk test indicated no statistically significant departure from normality for the pretest scores, $W = 0.906$, $p = .258$, or the posttest scores, $W = 0.868$, $p = .094$. However, because the inferential comparison involved paired observations, the relevant assumption for the paired-samples t-test concerns the distribution of the **paired difference scores (posttest – pretest)**. The available analysis therefore provides preliminary evidence regarding the score distributions, but the normality of the difference scores should be verified directly using the individual paired data where available.

Paired-Samples t-Test

A paired-samples t-test was conducted to examine whether freestyle swimming skill scores differed between the pretest and posttest measurements. The same 10 athletes contributed scores at both measurement points. Table 4 presents the results.

Table 4. Paired-Samples t-Test of Freestyle Swimming Skill Scores

Comparison	Mean Difference	SD Difference	t	df	p
Posttest − Pretest	3.10	1.197	8.188	9	< .001

The mean difference between posttest and pretest scores was 3.10 points (SD = 1.197). The paired-samples t-test indicated a statistically significant increase in freestyle swimming skill scores, $t(9) = 8.188$, $p < .001$. The 95% confidence interval for the mean difference was approximately [2.24, 3.96] points, indicating that the estimated improvement was consistently positive across the sample. The corresponding within-participant effect size was large (Cohen's $dz = 2.59$), indicating a substantial magnitude of pretest–posttest change in the observed freestyle swimming skill scores. This effect-size estimate should nevertheless be interpreted in the context of the one-group pretest–posttest design. Overall, the results demonstrate a statistically significant increase in observed freestyle swimming skill following participation in the training program. However, the finding should be interpreted as evidence of pretest–posttest change rather than definitive evidence of a causal intervention effect. Because the study did not include a control group, alternative explanations such as maturation, repeated exposure to the assessment procedure, familiarity with the testing environment, and concurrent training cannot be ruled out.

DISCUSSION

The present study found an increase in freestyle swimming skill following participation in a structured variable-practice program informed by Schmidt's Motor Schema Theory. The mean total score increased from 10.50 (SD = 0.85) at pretest to 13.60 (SD = 1.43) at posttest, with a mean difference of 3.10 points and a statistically significant paired-samples t-test, $t(9) = 8.188$, $p < .001$. Improvements were observed across body position, leg movement, arm movement, and breathing, with breathing showing the largest descriptive increase (0.90 points). These findings are consistent with the central proposition of Schema Theory that varied practice can provide learners with experiences from which they can develop generalized relationships between movement parameters and movement outcomes (Schmidt, 1975; Moxley, 1979). The present intervention varied execution speed, swimming distance, movement rhythm, breathing patterns, and movement configurations while maintaining the fundamental structure of freestyle swimming. Earlier experimental work has examined the extent to which practice variability can support schema-based motor learning, while subsequent research has provided evidence that variable practice can influence motor-learning processes beyond simple repetition (McCracken & Stelmach, 1977; Apolinário-Souza et al., 2020). Nevertheless, because the present study did not directly measure schema formation, the observed improvement should be interpreted as a performance outcome that is theoretically consistent with Schema Theory rather than direct evidence of changes in recall or recognition schemas.

The findings also support the view that structured variability, rather than variation in isolation, is important for motor-skill development. Moxley (1979) framed variability of practice as a central issue in schema-based learning, while subsequent research on contextual interference has shown that the organization and composition of practice can influence retention and motor-skill acquisition (Shea & Kohl, 1991; Young et al., 1993). More recent evidence further suggests that different forms of practice variability and differential learning can influence motor-skill development, motivation, and the emergence of adaptable movement solutions (Orangi et al., 2021; Shamshiri et al., 2025). This perspective is relevant to the present intervention because the training program did not introduce random variation without structure; rather, variation was applied to selected freestyle parameters while the basic movement pattern was maintained. The improvement across all four technical components therefore suggests that systematic exposure to different movement conditions may benefit beginner swimmers. However, the present design cannot establish whether variable practice is superior to constant practice, contextual-interference practice, or other learning approaches because it included no comparison group. The findings should consequently be interpreted as preliminary evidence of change associated with the implemented training program rather than evidence of the superiority of a particular practice schedule.

The component-level findings provide a further practical interpretation. Breathing demonstrated the largest descriptive improvement, increasing from 2.30 to 3.20, while body position, leg movement, and arm movement each increased by 0.70 points. The relatively greater change in breathing may reflect the importance of coordinating respiratory timing with body rotation and upper- and lower-limb actions during freestyle swimming. Swimming-specific research has emphasized the technical complexity of freestyle execution, while recent studies have examined approaches to developing freestyle ability through instructional media and application-based training models (Rezki et al., 2022; Raswin & Nasution, 2025; Ardiningsih et al., 2026). The present findings extend this line of work by examining structured variability across several technical parameters rather than focusing exclusively on a single swimming technique. However, the larger descriptive increase in breathing should not be interpreted as evidence that breathing variation independently caused the overall improvement because breathing was not isolated as an experimental factor and no separate inferential test was conducted for the four components. Similarly, the study did not directly assess motivational, cognitive, or affective mechanisms that may influence learning, although previous motor-learning research suggests that learner-related factors can interact with practice conditions (Gonzalez & Chiviacowsky, 2018).

An important distinction in interpreting the present findings concerns performance improvement versus durable motor learning. The significant posttest increase indicates that athletes performed better after the training period, but an immediate posttest does not establish whether they retained the skill or transferred it to novel conditions. This issue is particularly important for a Schema Theory-based intervention because the theoretical value of variability concerns developing adaptable movement representations rather than merely improved performance on a familiar assessment. Evidence from motor-learning research has emphasized the importance of retention and transfer when evaluating learning, and a recent swimming-specific scoping review identified the limited use of retention and transfer assessments as an important gap in the literature (Minkels et al., 2025). The present study similarly did not include delayed retention or transfer testing. Therefore, the findings should be regarded as evidence of short-term pretest–posttest improvement rather than definitive evidence of durable or transferable motor learning. Future research should compare variable practice with constant or conventional practice using randomized or controlled designs, larger samples, delayed retention tests, and transfer tasks. Such designs would provide stronger evidence concerning whether the observed improvement reflects the specific contribution of structured variability and whether the benefits extend beyond immediate technical performance.

The practical implication is that coaches working with beginner swimmers may consider incorporating progressive and task-relevant variability into freestyle training while preserving the essential structure of the stroke. Variation in speed, distance, rhythm, breathing, and movement patterns can give athletes opportunities to adapt their movements to changing task demands, but the degree of variation should match athletes' technical readiness rather than be maximized indiscriminately. This interpretation is consistent with evidence that different forms and levels of practice variability can produce different motor-learning outcomes (Apolinário-Souza et al., 2020; Orangi et al., 2021; Shamshiri et al., 2025). At the same time, the one-group pretest–posttest design and sample of only 10 athletes limit causal inference and generalizability. Maturation, concurrent training, repeated exposure to the assessment, and familiarity with the testing procedure cannot be completely ruled out. Thus, the principal contribution of the present study is preliminary empirical evidence that a structured variable-practice program was followed by measurable improvement in freestyle swimming skills among beginner athletes. Further controlled research should determine the optimal amount and organization of practice variability and examine whether these immediate improvements are maintained over time and transferred to new swimming conditions.

CONCLUSION

This study found a statistically significant increase in observed freestyle swimming skill following participation in a structured variable-practice program informed by Schmidt's Motor Schema Theory. The mean total skill score increased from 10.50 at pretest to 13.60 at posttest, with a mean difference of 3.10 points, $t(9) = 8.188$, $p < .001$. Improvements were observed across all four assessed technical components, namely body position, leg movement, arm movement, and breathing, with breathing showing the largest descriptive increase. These findings provide preliminary evidence of pretest–posttest improvement following structured variable practice and are theoretically consistent with the principle that varied movement experiences may support motor-skill development. However, the study did not directly measure schema formation, retention, or transfer, and the one-group pretest–posttest design does not permit definitive causal inference. The observed improvement may also have been influenced by maturation, repeated testing, familiarity with the assessment procedure, or concurrent training. Therefore, the findings should be interpreted as evidence of short-term change in observed freestyle swimming performance, rather than definitive evidence of variable practice's effectiveness or superiority. From a practical perspective, coaches may consider incorporating progressive and task-relevant variations in speed, distance, rhythm, breathing, and movement patterns while maintaining the fundamental structure of freestyle technique. Future research should use controlled or randomized designs with larger and more diverse samples, compare variable practice with alternative practice conditions, and incorporate delayed retention and transfer assessments to determine whether the observed performance changes represent durable and adaptable motor learning.

ADDITIONAL INFORMATION

Authors should provide the following information where applicable. Statements that are not relevant to the manuscript may be omitted.

Statement	Description
Acknowledgements	The authors express their sincere gratitude to the management, coaches, athletes, and parents of The Black Volleyball Club, Majalengka, for their cooperation and participation throughout the research process. Appreciation is also extended to the Faculty of Teacher Training and Education, Universitas Majalengka, for providing academic support during the completion of this study.
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Conflict of Interest	The authors declare that there are no financial or non-financial **conflicts of interest** related to this research or its publication.
Data Availability Statement	The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request**.** The data are not publicly available because they contain information that could potentially compromise participant confidentiality.

REFERENCES

Adams, J. A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behavior, 3*(2), 111–150. https://doi.org/10.1080/00222895.1971.10734898

Apolinário-Souza, T., Santos Almeida, A. F., Lelis-Torres, N., Otoni Parma, J., Pereira, G. S., & Menezes Lage, G. (2020). Molecular mechanisms associated with the benefits of variable practice in motor learning. *Journal of Motor Behavior, 52*(5), 515–526. https://doi.org/10.1080/00222895.2019.1649997

Ardiningsih, R. L., Sobarna, A., & Hambali, S. (2026). Integrating skill development and water confidence in freestyle swimming: An application-based training model. *Jurnal Porkes, 9*(2), 663–674. https://doi.org/10.29408/porkes.v9i2.34104

Arhesa, S., & Badriah, D. L. (2021). Aquatic training with play methods in improving swimming skills in preschool children. *International Journal of Human Movement and Sports Sciences, 9*(4), 106–111. https://doi.org/10.13189/saj.2021.091318

Caballero, C., Barbado, D., Peláez, M., & Moreno, F. J. (2024). Applying different levels of practice variability for motor learning: More is not better. *PeerJ*. https://doi.org/10.7717/peerj.17575

Cacola, P., Pablos, A., & Gabbard, C. (2012). Effects of variable versus constant practice in older adults' fine motor task performance. *Perceptual and Motor Skills, 115*(1), 107–116. https://doi.org/10.2466/24.03.PMS.115.4.107-116

Gonzalez, D. H., & Chiviacowsky, S. (2018). Relatedness support enhances motor learning. *Psychological Research, 82*, 439–447. https://doi.org/10.1007/s00426-016-0833-7

Landin, D., & Hebert, E. P. (1997). A comparison of three practice schedules along the contextual interference continuum. *Research Quarterly for Exercise and Sport, 68*(4), 357–361. https://doi.org/10.1080/02701367.1997.10608016

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*(1), 159–174. https://doi.org/10.2307/2529310

Lawshe, C. H. (1975). A quantitative approach to content validity. *Personnel Psychology, 28*(4), 563–575. https://doi.org/10.1111/j.1744-6570.1975.tb00514.x

McCracken, H. D., & Stelmach, G. E. (1977). A test of the schema theory of discrete motor learning. *Journal of Motor Behavior, 9*(3), 193–201. https://doi.org/10.1080/00222895.1977.10735109

Meira, C. M., & Tani, G. (2001). The contextual interference effect as a function of the number of task variations practiced and amount of practice. *Research Quarterly for Exercise and Sport, 72*(2), 167–175. https://doi.org/10.1080/02701367.2001.10608947

Minkels, C., van der Kamp, J., de Vries, R., & Beek, P. J. (2025). Learning how to swim in 5- to 12-year-old children: A scoping review of evidence-based motor learning methods. *Frontiers in Sports and Active Living, 7*, 1505301. https://doi.org/10.3389/fspor.2025.1505301

Minkels, C., van der Kamp, J., de Vries, R., & Beek, P. J. (2025). Learning how to swim in 5- to 12-year-old children: A scoping review of evidence-based motor learning methods. *Frontiers in Sports and Active Living*. https://doi.org/10.3389/fspor.2025.1505301

Moxley, S. E. (1979). Schema: The variability of practice hypothesis. *Journal of Motor Behavior, 11*(1), 65–70. https://doi.org/10.1080/00222895.1979.10735173

Nur'aeni, E., Rustandi, E., & Arhesa, S. (2023). Pengaruh latihan variasi terhadap keterampilan renang gaya bebas pada atlet pemula. *Jurnal Educatio FKIP UNMA, 9*(1), 366–371. https://doi.org/10.31949/educatio.v9i1.4562

Orangi, B. M., Yaali, R., Bahram, A., van der Kamp, J., & Aghdasi, M. T. (2021). The effects of linear, nonlinear, and differential motor learning methods on the emergence of creative action in individual soccer players. *Psychology of Sport and Exercise, 56*, 102009. https://doi.org/10.1016/j.psychsport.2021.102009

Raswin, R., & Nasution, U. (2025). The impact of audio-visual-based learning media on freestyle swimming ability. *EDUKASIA Jurnal Pendidikan dan Pembelajaran, 6*(1), 497–508. https://doi.org/10.62775/edukasia.v6i1.1446

Rezki, R., Zulkifli, Z., Jatra, R., & Aprianti, L. (2022). An analysis of freestyle swimming technique on students of the Physical Education, Health and Leisure Study Program. *INSPIREE: Indonesian Sport Innovation Review, 3*(2), 93–105. https://doi.org/10.53905/inspiree.v3i02.78

Schmidt, R. A. (1975). A schema theory of discrete motor skill learning. *Psychological Review, 82*(4), 225–260. https://doi.org/10.1037/h0076770

Sembiring, J. B., & Nasution, M. F. A. (2022). Pengaruh variasi latihan resistance band terhadap kekuatan otot lengan pada atlet renang putra usia 12–13 tahun Sailfish Swimming Club Medan tahun 2021. *Jurnal Ilmu Keolahragaan, 21*(1), 65–73. https://doi.org/10.24114/jik.v21i1.34457

Shamshiri, G., Fazeli, D., & Nazemzadegan, G. (2025). Effect of contextual interference and differential learning on motor skill development and motivation in novice basketball players. *European Journal of Sport Science*, e70061. https://doi.org/10.1002/ejsc.70061

Shea, C. H., & Kohl, R. M. (1991). Composition of practice: Influence on the retention of motor skills. *Research Quarterly for Exercise and Sport, 62*(2), 187–195. https://doi.org/10.1080/02701367.1991.10608709

Shea, J. B., & Morgan, R. L. (1979). Contextual interference effects on the acquisition, retention, and transfer of a motor skill. *Journal of Experimental Psychology: Human Learning and Memory, 5*(2), 179–187. https://doi.org/10.1037/0278-7393.5.2.179

Sherwood, D. E., & Lee, T. D. (2003). Schema theory: Critical review and implications for the role of cognition in a new theory of motor learning. *Research Quarterly for Exercise and Sport, 74*(4), 376–382. https://doi.org/10.1080/02701367.2003.10609107

Wulf, G., & Schmidt, R. A. (1994). Feedback-induced variability and the learning of generalized motor programs. *Journal of Motor Behavior, 26*(4), 348–361. https://doi.org/10.1080/00222895.1994.9941691

Young, D. E., Cohen, M. J., & Husak, W. S. (1993). Contextual interference and motor skill acquisition: On the processes that influence retention. *Human Movement Science, 12*(5), 577–600. https://doi.org/10.1016/0167-9457(93)90005-A