

# The Impact of Drilling and Metacognition on Cambridge A2 Level Mathematics of Senior High School Students in Indonesia: Basis for an Action Plan

Paul B. Banan<sup>1</sup>; Renalyn D. Ramos<sup>2</sup>

<sup>1</sup>Graduate Program – School of Teacher Education, The National Teachers College, 629 J. Nepomuceno Street, Quiapo, Manila, Philippines

<sup>2</sup>Graduate Program – School of Teacher Education, The National Teachers College, 629 J. Nepomuceno Street, Quiapo, Manila, Philippines

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**Abstract:** This study evaluated the relationship and predictive influence of drilling and metacognitive learning strategies on Indonesian senior high school students enrolled in the Cambridge A2 Level Mathematics programme. Using a mixed-methods explanatory sequential design, the study examined self-regulated learning and metacognition through quantitative and qualitative approaches. Quantitative data were collected through pretest and posttest evaluations, while students' perceptions and learning experiences were explored through interviews. Findings revealed that students initially demonstrated a moderate level of mathematical performance and showed significant improvement after the intervention. Statistical analysis indicated a significant increase in achievement, suggesting that the combined use of drilling and metacognitive strategies positively contributed to students' learning outcomes. Regression analysis showed weak and non-significant relationships among drilling, metacognitive awareness, and mathematical achievement. Qualitative findings indicated that drilling enhanced procedural fluency, while metacognitive techniques supported deeper understanding and improved problem-solving skills. Based on these findings, a contextualized action plan was developed to support the enhancement of instruction in Cambridge A2 Mathematics.

**Keywords:** Cambridge A2 Level Mathematics, Drilling Techniques, Self-Regulated Learning, Metacognition, Mixed-Methods Study, Mathematics Achievement.

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## I. INTRODUCTION

Human beings' power of reasoning is highly determined by their level of education, especially in the area of mathematics, which is considered to be a basis for advanced learning and problem-solving. Senior high schools (SHS) in Indonesia are faced with the challenge of modifying the teaching strategies to effectively cope with the high-level demands of A2 Level Mathematics of the Cambridge curriculum, in which students are tested on applied mechanics, advanced problem solving, algebraic manipulation, and statistical measures (Cambridge International, 2023).

This research investigates the influence of two different types of learning techniques: metacognition, a renewed modern cognitive strategy, and drilling, a traditional rote learning approach, on the learning of A2 mathematics by students. Indonesia's performance in mathematics is a good example of how long overdue such a study is. As less than 18%

of Indonesian students had a minimum competence, while no one had an advanced competence in Mathematics, Indonesian students had an average mathematics score of 366, far below the OECD average mathematics score of 472 (OECD, 2022).

Such discrepancies underscore the need for applied approaches that will enhance higher-order thinking, while also reinforcing basic skills. Recent work reports that metacognition, the ability to plan, monitor, and evaluate one's own learning, is necessary to enhance mathematics achievement and self-regulated learning. While Reyes M. and Reyes C. (2024) indicated that metacognition strategies improved learners' recall and problem-solving skills, Amien S. & Hidayatullah, M (2023) found that Indonesian students who employed the strategies demonstrated higher levels of motivation and academic results.

Drill provides the repetition and practice needed to reinforce basic mathematical concepts, but it is not enough in

itself to develop a deep understanding. Through metacognitive training, it can reduce the gap between procedural fluency and conceptual mastery for more balanced mathematics learning outcomes (Aziz et al., 2024; Werdiningsih et al., 2022).

The present research builds on these findings by investigating the impact of an integrated teaching approach on the CA2 Mathematics performance of Senior High School students in Indonesia. The study aims at providing guidance to teachers and policy-makers in relation to how to improve mathematics education, reduce discrepancies in performance, and make space for students to develop a solid foundation, as well as striving for both lower and higher order performances by means of integrating traditional practice and reflection in practice.

## II. MATERIALS AND METHODS

### ➤ *Participants*

Fifty-two students participated in the intervention; thirty completed all quantitative measures, and six were purposefully selected for follow-up interviews. To increase ecological validity (Creswell & Creswell, 2022), the study was conducted within a regular classroom. The qualitative subset was stratified by pretest and posttest scores into high-, average-, and low-achieving pairs to capture diverse mathematics experiences and enrich the quantitative outcomes. Purposeful sampling is ideal for qualitative research, as it selects a limited number of information-rich participants to provide deep insight into the studied phenomenon (Poth, 2021; Saldaña, 2021). Quantitative participants were selected based on maximum variance sampling for qualitative participants with respect to the range of attainment. Data saturation was the point in the data gathering process at which no new themes emerged from collected interview data, and an adequate understanding of a phenomenon was achieved (Guest G. et al., 2020). All participants were studied voluntarily, and students and their parents or guardians provided written informed consent. Participant identity was protected by using coded IDs.

### ➤ *Methods*

Utilizing an explanatory sequential mixed-methods design, this study collected and analyzed quantitative data first before integrating qualitative data, which helped explain and expand upon the initial findings. This was a sensible multi-method approach, as it allowed for the analysis of both quantifiable differences in students' math ability and underlying learning experiences that aligned with these changes (Creswell & Plano Clark, 2023; Poth, C.N., 2021). In the quantitative phase, a single-group pretest–posttest design was used to assess mathematical ability before and after the implementation of drill metacognitive techniques with students. Research Questions 1 to 6 aimed at examining whether levels of achievement, differences between scores, the relationship and predictiveness of drilling strategies, and metacognitive awareness on mathematics achievement were examined by using descriptive statistics, paired-samples t-test, and Pearson product-moment correlation analyses. In the subsequent qualitative phase, student interviews and meaningful responses provided explanations of the

quantitative results. In this phase, the researcher explored students' perceptions and experiences with the strategies used in an effort to answer research Questions 7 and 8. A preliminary quantitative investigation revealed new trends in areas that had shown progression and weak statistical links, and the interview guide was revised to reflect these.

### ➤ *Instruments*

The semi-structured interview guide, the Likert scale questionnaire, and a standardized mathematics test were three research tools used in this study. A mathematics test was administered before and after the intervention to assess how well students perform in some topics of Cambridge A2 Mathematics. The Semi-Structured Interview Protocol Guide (IPG) provides a deeper insight into students' experiences and strategies, in contrast to the questionnaire, which was particularly based on a five-point Likert scale, measuring at least two variables. The questionnaire was adapted from existing metacognitive awareness and self-regulated learning instruments. Items were modified to reflect the learning experiences of students enrolled in Cambridge A2 Level Mathematics and to ensure relevance to the objectives of the study. By writing this method as well as metacognitive awareness that was found through meta-cognition (Kallio et al. 2016). These tools allow for the collection of both quantitative and qualitative data, which are necessary for an integrated approach.

### ➤ *Data Analysis*

The researcher performed descriptive and inferential statistics to analyze the quantitative data obtained from the survey, pre-test, and post-test. Mean and standard deviation were used to assess the students' mathematics proficiency, drilling techniques, metacognitive awareness, and introverted or extroverted thinking styles. Thus, for correlations and predictive analyses across variables, Pearson correlation and regression were used, while a paired-samples t-test was performed to explore the performance difference between pretest and posttest. Assumptions of linearity and normality (necessary for parametric analyses to be appropriate) were assessed before statistical testing. An analytical approach called theme analysis was used to analyze qualitative data gained from the semi-structured interviews as a means of identifying, organizing, and interpreting recurring phenomena in how students experience. Direct quotes from interview answers were transcribed, carefully coded, and sorted into thematic categories related to drilling methods, metacognitive awareness of mathematical learning experiences as per Braun & Clarke's (2022) methodology. Themes were examined, developed, and validated to ensure they aligned with the objectives of the study. The analysis found students viewed drilling and metacognition as complementary learning activities, but, at the same time, it concluded that their effectiveness in increasing math performance was limited due to uneven implementation of new methods by teachers, often constrained by a lack of teaching hours or heavy academic workloads. Joint analysis was then applied to combine quantitative and qualitative findings to generate meta-inferences and provide a richer account of the outcomes.

**III. RESULTS AND DISCUSSION**

This section presents the findings according to the study's research questions. To compare the means and determine the significance between variables, multiple linear regression was computed using IBM SPSS 26.0.

➤ *The Level of Students' Mathematics Achievement Before and After the Implementation of Drilling and Metacognition Strategies.*

The results shown in Table 1 show that before the implementation of the program, participants' baseline performance and score variability parameters were described using descriptive statistics such as mean & standard deviation.

Table 1 Students' Math Achievement before the Implementation of Drilling and Metacognition Strategies

Students' Math Achievement	Mean	SD	Verbal Interpretation
Pretest	41.43	8.15	Very Satisfactory
<i>Sub-variables</i>			
Fluency in Procedures	58.50	7.84	Outstanding
Conceptual Understanding	54.00	8.21	Outstanding
Mathematical Reasoning	43.50	8.67	Very Satisfactory
Problem Solving	28.50	7.95	Fairly Satisfactory
Higher Order Thinking Skills	22.65	8.09	Developing

- Note. Scale: 0-16 (Needs Improvement), 17-24 (Developing), 25-31 (Fairly Satisfactory), 32-37 (Satisfactory), 38-44 (Very Satisfactory), 45-75 (Outstanding performance).

Table 1 shows the overall mean score (41.43, SD = 8.152), which indicates adequate academic performance based on Cambridge-aligned descriptive interpretations.

Competency-based analysis of the pretest results revealed varying degrees of mathematics skill across all evaluated competency categories. Students performed significantly better in the competencies of procedural fluency and conceptual understanding, with mean scores of 58.50 and 54.00, respectively, both deemed relatively acceptable and aligned with the Cambridge interpretation guide.

Table 2 Students' Math Achievement after the Implementation of Drilling and Metacognition Strategies

Students' Math Achievement	Mean	SD	Verbal Interpretation
Posttest	46.87	12.06	Outstanding
<i>Sub-variables</i>			
Fluency in Procedures	61.50	9.80	Outstanding
Conceptual Understanding	56.25	10.95	Outstanding
Mathematical Reasoning	48.75	12.2	Outstanding
Problem Solving	39.00	13.45	Very Satisfactory
Higher Order Thinking Skills	28.85	13.09	Fairly Satisfactory

- Note. Scale: 0-16 (Needs Improvement), 17-24 (Developing), 25-31 (Fairly Satisfactory), 32-37 (Satisfactory), 38-44 (Very Satisfactory), 45-75 (Outstanding performance).

Table 2. The overall posttest mean score of 46.87 was significantly higher than the students' pretest mean score of 41.43, indicating excellent performance in practical application tasks. The results show that the participants improved their mathematics with respect to procedural fluency, conceptual understanding, and reasoning-based competence in all comparisons after introducing the intervention, as seen on the Competency-based Analysis of Post-test results. These findings corroborated research that has shown students can show variability in skills under varying assessment conditions (OECD 2023; Anggo et al., 2021), depending on earlier learning experiences or exposure to certain mathematics areas. For instance, Panadero (2021) explained that students generally perform differently in mathematical tasks as they have different levels of self-regulation and learning processes. That said, certain studies also reported opposing findings and highlighted that achievements of students are still dependent on their prior

knowledge, motivation, and individual differences in learning; not all classroom instruction or experiences can enhance higher-order mathematics performance across all students (Mulbar et al., 2021).

➤ *Significant Difference in Students' Mathematics Achievement between the Pretest and Posttest Results*

The paired samples t-test compared two related sets of scores (pretest and posttest math scores) from the same 30 students following drilling interventions combined with metacognitive instruction to determine whether there was a significant difference between pretest and posttest scores.

Table 3 Significant Difference Between the Pretest and Posttest Results for Students' Math Achievement

Students' Math Achievement	Mean	SD	Mean Diff.	t	df	p	H <sub>0</sub>	Verbal Interpretation
Before	41.43	8.15	5.44	2.44	29	0.021	R	Significant
After	46.87	12.06						

• Note.  $p < 0.05$ ,  $H_0$  = Null Hypothesis;  $R$  = Rejected

The table shows the scores increased from the mean of the pretest (41.43,  $SD = 8.152$ ) to the posttest score (46.87,  $SD = 12.059$ ), with a mean difference of 5.44. As the calculated  $p$ -value of 0.021 was less than the alpha significance level of 0.05, the null hypothesis is rejected. This result showed a statistically significant increase in student math ability when drilling and metacognitive strategies were utilized by students.

In the sense of meaning, the study found that systematic drilling assisted with a metacognitive strategy to merit students' progress in arithmetic. The amelioration in mean values demonstrated superior procedural fluency and conceptual understanding of students; however, the elevation in standard deviation displayed heterogeneity in benefits derived by beneficiaries from educational intervention. This indicated that while the method was generally beneficial, it did not always have the same effect on students' acquisition of metacognitive skills and their application.

Such results align with self-regulated learning (SRL) theory, as these three practices comprise forethought, performance and self-reflection phases that are crucial to

improving academic success (Panadero E., 2021; de Boer H. et al., 2023). Syaiful et al. (2022) and Prabawanto S. (2023) determined that teaching arithmetic with metacognitive strategies leads to improved student learning from rote memorization to more sophisticated processing at a cognitive level. Similarly, the researcher showed that metacognitive awareness improved students' problem-solving in difficult math problems as compared to a non-metacognitive approach (Mulbar U. et al., 2021).

➤ *Level of Drilling Strategies Implemented during the Intervention Period*

This section quantifies the types of drilling techniques during intervention that relate to students' performance as measured by their Cambridge A2 Mathematics posttest score. This included structured surveys on repetition, guided exercises that required procedural reinforcement, and mastery tasks that measured the participant's drilling tactics. Drilling construct was measured using an 8-item subscale. In Table 5, items 1, 3, 5, 7, 9, 10, 11, and 13 evaluated the drilling construct because drilling was a separate behavioral dimension; the internal consistency reliability of those criteria was inferred separately. The drilling scale was highly reliable ( $\alpha = .834$ )

Table 4 Level of Drilling Strategies Implemented During the Intervention Period

Drilling Strategy Items	Mean	Verbal Interpretation
1	4.80	Strongly Agree
3	4.30	Strongly Agree
5	4.73	Strongly Agree
7	4.27	Strongly Agree
9	4.73	Strongly Agree
10	4.80	Strongly Agree
11	4.63	Strongly Agree
13	4.90	Strongly Agree
Overall Mean	4.65	Strongly Agree

• Note. Interpretation guide: 4.21–5.00 = Strongly Agree; 3.41–4.20 = Agree; 2.61–3.40 = Moderately Agree; 1.81–2.60 = Disagree; 1.00–1.80 = Strongly Disagree.

Table 4. The descriptive statistics revealed that participants perceived drilling activities to have been done most consistently throughout the intervention period (overall weighted mean score 4.65, interpreted as strongly agree). Items that related to repeated guided practice, procedural reinforcement, corrective feedback, and mastery-oriented mathematical activities had high mean scores. Consequently, this indicated that students experienced repeated mathematical practice tasks designed to enhance procedural understanding and knowledge of the structure of multiple types of mathematical operations.

➤ *Relationship of Drilling and Mathematics Achievement*

After establishing the descriptive level of drilling strategies, inferential statistical analysis was performed to determine whether there were significant relationships between methods of drill and students' results in the Cambridge A2 Mathematics posttest. Since the research used two continuous variables concerning their correlation, Pearson's product-moment coefficient was employed to measure the relationship between weighted mean scores of students' use beliefs in drilling tactics and outcome standards, such as post-test performance for mathematics.

Prior to conducting the correlation study, prerequisite assumptions for Pearson correlation were assessed to establish that the statistical process was appropriate. Correlation Analysis between Drilling Strategies and Mathematics.

Table 5 Relationship of Drilling and Mathematics Achievement

Variable 1	Variable 2	r	r <sup>2</sup>	p	H <sub>0</sub>	VI
Math Performance (Posttest)	Drilling Strategies	0.216	0.046	0.252	FR	NS

• *Note.*  $r$  = Pearson correlation;  $r^2$  = coefficient of determination; FR = failed to reject; NS = not significant.

Table 5 shows the results of the relationship between drilling and Mathematics achievement, indicating a weak positive correlation ( $r = 0.22$ ) that did not attain significance ( $p = 0.252$ ), leading to acceptance of the null hypothesis. The coefficient of determination ( $r^2 = 0.046$ ) demonstrated that drilling strategies explained only 4.6% of the variance in mathematical achievement. This means that, within the study context, differences in students' math achievement scores were not significantly linked to the amount of practice techniques used by teachers. Results also imply institutional, cognitive, and learner-type variables with mathematics performance, which were not examined in our study. Thus, the results should be interpreted with caution and do not constitute irrefutable evidence that the use of drills alone improved students' math proficiency.

The results show that, while drilling does increase familiarity with procedures, its use on its own has little effect on general math proficiency. This parallels the self-regulated learning model, which asserts that repetition of practice alone does not impact effective learning as much or more than

planning, observing, and assessing (Panadero E., 2021; Zimmerman

B.J., 2002). Similarly, Lipnevich and Panadero E. (2021) found that the impact of how students make sense of and engage with feedback is larger than how much practice they do. Yet this result goes against what we might call the belief in deliberate practice, which holds that because repetition is needed for performance enhancement, it can be delivered in an orderly and goal-directed way (Ericsson, K.A. et al., 1993). This point is emphasized by international benchmarks (OECD, 2023) that indicate the best learning outcomes require reported higher degrees of metacognitive control in practice, only offered through reflective-feedback-oriented approaches.

➤ *Level of Metacognition Strategies Implemented during the Intervention Period*

The level of metacognitive awareness during the intervention in participating students and their performance on the Cambridge A2 Mathematics posttest are presented below. Metacognitive awareness was measured using a standardized survey questionnaire focused on planning, monitoring assessment, self-reflection, and self-regulation during mathematical problem solving.

Table 6 Level of Metacognition Strategies Implemented During the Intervention Period

Metacognitive Awareness Items	Mean	Verbal Interpretation
2	4.60	Strongly Agree
4	4.50	Strongly Agree
6	4.67	Strongly Agree
8	4.57	Strongly Agree
12	4.63	Strongly Agree
14	4.67	Strongly Agree
Overall Mean	4.63	Strongly Agree
	4.61	Strongly Agree

• *Note.* Interpretation guide: 4.21–5.00 = Strongly Agree; 3.41–4.20 = Agree; 2.61–3.40 = Moderately Agree; 1.81–2.60 = Disagree; 1.00–1.80 = Strongly Disagree.

Table 6. The descriptive results revealed that the participants who had used metacognitive practices throughout the math learning task was 4.61, taken by means of a weighted mean rating that's interpreted to imply a strong level. Items for self-monitoring, reflective thinking, assessment of

mathematical answers, and awareness about the learning process all had high mean scores. These findings suggest that students had a stable engagement of reflective and self-regulated learning while doing arithmetic tasks during the intervention period. Supplementary data contained in Appendix T (pp. 246-253). (Descriptive Statistics of the Metacognitive Awareness – weight means, standard deviations, and interpretation table.

Table 7 Relationship of Metacognition and Mathematics Achievement

Variable 1	Variable 2	r	r <sup>2</sup>	p	H <sub>0</sub>	VI
Math Performance (Posttest)	Metacognition Awareness	0.152	0.023	0.423	FR	NS

• *Note.*  $r$  = Pearson correlation;  $r^2$  = coefficient of determination; FR = failed to reject; NS = not significant.

Table 7 shows a weak positive ( $r = 0.152$ ) but a non-significant relationship ( $p = 0.423$ ) with metacognitive awareness and achievements; the null hypothesis was retained. The coefficient of determination ( $r^2 = 0.023$ ) led to a variance of approximately 2.3% in the mathematics success scores. It

also shows that students had varying levels of planning, monitoring, evaluation, and self-regulation strategies during math learning activities.

Research showed that metacognition, such as planning, self-monitoring, and evaluation, plays an essential role in learning in general (Panadero E., 2021), especially relevant to the mathematics education context (Zimmerman B.J., 2002).

As noted by Lipnevich A.A. and Panadero E. (2021), metacognitive management is an important part of students' learning processes in relation to undertaking academic assignments. However, Schraw G. (1998) and OECD (2023), on the other hand, also emphasized that the academic achievement-metacognitive awareness link might differ depending on task difficulty or instructional settings, as well as consistency of strategy use during learning activities.

The current study explored the discovered alignment between students' metacognitive awareness and performance in mathematics that was present when the intervention was just started to result. The findings also provide insight that can be considered when designing educational interventions aimed at guided practice, self-regulation, and reflection on learning objectives.

Table 8 Predictive Influence of Metacognition and Drilling on Mathematics Achievement Using ANOVA

Source of Variation	df	SS	MS	F	p	H <sub>0</sub>	VI
Regression	2	197.366	98.683	0.663	0.524	FR	NS
Residual	27	4020.101	148.893				
Total	29	4217.467					

- Note. *df* = degrees of freedom; *SS* = sum of squares; *MS* = mean square; *F* = *F*-ratio; *H<sub>0</sub>* = null hypothesis; *FR* = failed to reject; *NS* = not significant.

ANOVA model produced an *F*-value of .663 and a *p* = 0.524, as shown in Table 8. The researcher failed to reject the null hypothesis since the *p*-value was above the 0.05 level of significance, which indicated that there is no statistically significant relationship between the combined instructional factors in this model and students' achieved mathematics scores.

with procedural fluency (Panadero E. 2021; Zimmerman B.J. 2002), self-regulated learning, and mathematics learning. Rosenshine B.(2012) describes that the guided practice and repetition of learning activities help support skill development while teaching. Likewise, Lipnevich A.A. and Panadero E.(2021) wrote about the evaluation of academic learning processes in students through self-regulation and feedback.

Conversely, as OECD (2023) and Schraw G. (1998) indicate, engagement in learning by students is a factor that complicates the relationship between pedagogical practices and strategies of implementation under specific conditions and academic success if it does not contribute to transformational change in how students approach difficult tasks.

Drilling techniques and metacognitive processes, identified in previous studies as teaching strategies associated

Table 9 Predictive Influence of Metacognition and Drilling on Mathematics Achievement Using Regression Coefficients

Variable	Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	<i>p</i>	<i>H<sub>0</sub></i>	VI
	<i>B</i>	<i>SE</i>	<i>β</i>				
Constant	17.074	27.468		0.622	0.539	FR	NS
Drilling	5.909	7.205	0.204	0.820	0.419	FR	NS
Metacognition	.508	7.056	0.018	0.072	0.943	FR	NS

- Note. *B* = unstandardized regression coefficient; *SE* = standard error; *β* = standardized beta coefficient; *t* = *t*-test statistic; *p* = probability value; *H<sub>0</sub>* = null hypothesis; *FR* = failed to reject; *NS* = not significant.

Table 9 presents the regression coefficient analysis of student mathematical achievement variables with drilling techniques and metacognitive awareness as independent variables. Metacognitive awareness had a standardized beta coefficient of 0.018 with a *p*-value of 0.943, and drilling methods had a beta coefficient of 0.204 and a *p*-value of 0.419. The significance values associated with both predictor variables were greater than the 0.05 level of significance, which implies that neither was independent and significantly related to students' math achievement scores in isolation, because we did not reject any null hypothesis on either variable independently. The equation for the regression model indicated positive beta coefficients, confirming a directional relationship between predictor variables and arithmetic achievement. Studies that assessed instructional components, including drilling exercises, metacognitive awareness, and self-regulated learning processes, have already been connected with academic engagement and mathematics learning (Panadero, 2021; Zimmerman, 2002).

Tactics incorporated in mathematics instruction to promote procedural development and practice-based learning are wide-ranging, including guided practice or repetition (Rosenshine 2012). Likewise, Lipnevich A.A. and Panadero E.(2021) explained the role of self-monitoring, reflection on knowledge learned over a time period, and their feedback on self-regulation among students' academic learning processes. Conversely, according to OECD (2023) and Schraw G. (1998), the deployment of instructional techniques may not necessarily lead to achievement outcomes because learner engagement, consistent strategy application, as well as task-specific or domain-specific system attributes, potentially affect the link between instruction delivery and performance.

According to Flavell (1979), metacognition refers to knowledge about and regulation of cognitive processes involved in learning tasks. Related literature (OECD, 2023) also indicates that the quality of execution and in-classroom atmosphere, as well as support for implementation during academic tasks, can impact the effectiveness of instructional strategies. These perspectives provide the rationale for interpreting regression coefficients estimated in this study as such.

Table 10 Joint Analysis of Quantitative and Qualitative Findings

Quantitative Results	Qualitative Results	Sample Participants Feedback	Integration Nature	Meta-Inference with Interpretation
Improvement between Pretest to Posttest $t(29) = -2.444, p = 0.021$	Integrating Drilling and Reflection Strategically	Students look back for mistakes and to know where they need to improve, so metacognition is a direct hand-in-hand with drilling. (STU01)	Convergence	Integrated Reflective Practice Increases Performance. Note that the only change was self-monitoring of performance with reflective error correction after practice; therefore, posttest performance improves upon training as a function of repeated successful effort.
Notable improvement on the posttest	Awareness of Processes and Reinforcement of Skills	It's metacognition that helps me know where I am lacking, whereas drilling makes me well-oriented on difficult tasks. (STU03)	Convergence	Familiarity with mathematics is built by repeated practice. For example, frequent involvement in operations (with numbers) led to more effective responses from students while attempting problems due to improved confidence and procedural fluency.
Strong descriptive indices for metacognitive awareness and drilling approaches	Combined Learning Strategies: Positive Perception	Drilling builds the fundamental skills, while metacognition enables students to learn from their mistakes and select different strategies. (STU05)	Convergence	Both procedural and cognitive support are meaningful to students. Students reported that affording reflective learning alongside procedural practice deepened understanding and exam preparedness
Drill practices and math performance correlated weakly ( $r = .216, p = .252$ ).	Common Repetitive Overuse Without Deep Reflection	"I did a lot of drilling but often not thinking back on my errors." (STU04)	Expansion	Sole focus on Procedural Practice Produces Limited Conceptual Development. While repetitive problems did allow students to become more familiar with basic problem types, the conceptual understanding required for higher level mathematical success was not necessarily developed.
There was a small correlation between metacognitive awareness and achievement ( $r = .152, p = .423$ ).	Applying Metacognitive Regulation Inconsistently	"The syllabus was very fast paced, and there wasn't time to reflect on mistakes." (STU02)	Expansion	Reflective learning requires continuous cognitive involvement. Though students appreciated the value of metacognitive reflection, it did not exert a strong influence on their performance outcomes due to inconsistent implementation.
Non-significant regression results between metacognition and drilling	Time Constraints and Academic Pressure	Performing reflection was done under an environment where one learnt to balance mathematics subjects with other A-Level subjects, which	Expansion	Academic Context Affects Strategy Effectiveness. External academic demand and time constraints impeded students' ability to sustain reflective learning in an

Quantitative Results	Qualitative Results	Sample Participants Feedback	Integration Nature	Meta-Inference with Interpretation
		takes away precious time from real deep contemplation. (STU01)		ongoing manner that is strategically practiced.
Success is only marginally predictable by drilling and metacognition.	Variability of Learners and Differences in Motivation	However, students who learn at a slower pace may struggle to realize the benefits of the strategies. (STU04)	Expansion	Individual learner differences affect the results of interventions. Variations in the pace of learning, motivation levels, discipline, and ability to manage negative emotions accounted for differences in achievement outcomes among participants.
Drilling and metacognition are generally regarded favorably, even when their correlations with achievement (on national math test scores) remain relatively modest.	Apparent Strategic Usage Versus Perceived Effectiveness	"Repetition was not enough for more difficult and abstract questions." (STU06)	Divergence	Positive Inferences Do Not Guarantee Strong Predictive Powers. While student perceptions of the tactics were positive, wide swings in implementation depth and consistency attenuated statistical associations found in quantitative analyses.
Substantial post-test gain with weak regression and correlation results	Need for Balanced Procedural and Conceptual Learning	While students still need to think through questions they have not seen before, drilling makes methods automatic. (STU02)	Expansion	Effective Mathematics Study Requires Balance Approach. Repeat practice is supplemented by analytical reasoning, reflection, adjustment and planning for success in Cambridge A2 Mathematics.

- *Note:* Anonymized participant codes (STU01–STU06) are used to maintain confidentiality and comply with research ethical standards.

This merged quantitative and qualitative information, achieving a fuller account of students' learning experiences. Qualitative data provided context for the reasons behind these findings, while quantitative results showed appreciable gains in attainment. Students' narratives suggested that whether or

not drilling and/or metacognition had a positive impact depended more on consistency, structure in instruction, and contextual features than on the weak statistical relationships between constructs. These findings indicate that drilling and metacognition are synergistic processes rather than independent determinants of mathematics learning. The study highlights the importance of balanced instructional design involving procedural practice and reflective learning to foster genuine understanding in complex mathematical contexts.

Table 11 Meta-Inference of Quantitative and Qualitative Data

Combined QUANTITATIVE and Qualitative Findings	Integration's Nature	Meta-inference from the Combined Data	Implication to the Action Plan/KPA
Posttest math achievement for students improved significantly, and participants reported that through the process of drilling and reflective correction, they were able to improve their familiarity with correct procedures as well as procedural fluency.	Convergence	Integrated reflective practice enhances mathematics achievement. Once combined with self-monitoring and looking through errors, practicing repeatedly became more effective.	In scheduled drills, inject guided reflection, corrective analysis, and self-monitoring into arithmetic preparation.
Even with positive attitudes toward drilling techniques and	Divergence	Positive perceptions do not automatically translate into	Conduct differentiated seminars and metacognitive coaching that focus

<b>Combined QUANTITATIVE and Qualitative Findings</b>	<b>Integration's Nature</b>	<b>Meta-inference from the Combined Data</b>	<b>Implication to the Action Plan/KPA</b>
metacognitive awareness, correlational and regression results remained weak/non-significant for students.		measurable achievement effects. The predictive correlations were limited for examples where implementation depth and quality varied widely, even though those responsible appreciated the tactics.	on executing strategies successfully rather than merely being aware of their existence.
Little correlation between drilling techniques and success, acknowledging reliance on memorization instead of deeper conceptual analysis.	Expansion	Procedural practice alone produces limited conceptual development. If students only practice procedures, they will be slowed down in their conceptual growth. Type and patterns of questions do not help in these high-level thinking & reasoning aspects.	Drilling and then reflective error analysis, guided questioning about the concept explored. Followed up by a strategy explanation exercise
Interview findings revealed inconsistent reflective participation (timing demand and academic load), a low-moderate relationship between metacognitive awareness and achievement.	Expansion	Reflective learning requires sustained and structured engagement. They do see the value of introspection; rather, it was that students did not apply metacognition consistently, as contextual pressures can overtake any student.	Integrate well-structured feedback cycles, self-checklists to guide student monitoring of their own progress, or periodic journals into math classes.
According to participants, constructing drills and metacognitive techniques utilized learner pacing, motivation, as well as discipline and emotional control.	Expansion	Individual learner differences influence intervention effectiveness. Different students, depending on motivation, self-control, and the speed at which they learn, respond positively to drilling and metacognitive techniques.	Plan your learner support sessions, need for intervention activities, or differentiation plan for pacing for the students who will require more scaffolding.
Even though the predictive ties between drilling, metacognition, and performance were weak, there was a notable increase on the posttest.	Convergence and Expansion	Effective mathematics learning requires balanced procedural and conceptual learning. It is more likely that a combination of procedural fluency, introspection, and flexibility over method, and conceptual reasoning all contribute to improved achievement than any single tactic.	Practicing adaptable problem-solving discussions, conceptual conversations, metacognitive coaching, and procedural exercises will greatly complement a more holistic approach to teaching.

- *Note:* These meta-inferences were consistent with the action plan suggested and the KPAs of the study. The overall findings indicate expansion, contraction, and convergence in the quantitative phase compared to the qualitative data; thus, they suggest that a true integration of mixed-methods design prevailed over independent reporting of results.

The quantitative and qualitative data displayed patterns of growth, divergence, and convergence in mixed-methods integration. The principle of convergence was due to the fact

that both datasets indicated improved math ability derived from sustained practice and reflective learning. The extent to which the pupils highly rated both drilling and metacognitive methods, producing relatively weak predictive statistical links, produced divergence. The qualitative results identified learner-related differences, potentially inconsistent technique implementation, and contextual pressures that would not be captured in the quantitative phase alone, leading to expansion.

The KPAs and action plan proposed were directly guided by the evidence-based meta-inferences generated from

integrating quantitative and qualitative findings. The suggestions, based purely on the study findings, aligned with mixed-methods convergent, divergent, and expanded analytic approaches regarding learner coaching in conjunction with

#### IV. CONCLUSIONS

The integration of drilling techniques, along with metacognitive awareness in the Cambridge A2 setting, improved students' mathematical performance (the primary outcome) during that time period. While the intervention indeed produced significant improvements in posttest performance, individual components of drilling and metacognition were not predictive of achievement by themselves. Our qualitative results indicated that these strategies required ongoing application, reflective learning methods, and contextual features such as time constraints and academic workload for effectiveness. The findings underscore that mathematics learning is most effective when structured practice, procedural fluency, and timely feedback are integrated within a reflective and self-regulated learning process., which is in line with the Self-Regulated Learning paradigm. This study illustrates the

This implies that serial practice should always be combined with systematic metacognitive strategies such as reflection, self-monitoring, and error analysis in mathematics education. To promote procedural fluency, teachers might provide differentiated and guided learning experiences to students. To help students develop self-regulated learning habits, schools can also schedule ample time for reflective learning. Future studies should be longitudinal or experimental in nature, with larger samples and controls to explore the long-term effects of drilling versus metacognitive techniques on mathematical ability.

#### RECOMMENDATIONS

The researchers recommended that Math teachers be urged to continue using both guided practice problems and reflective learning technologies when teaching Cambridge A2 Mathematics. Teachers are also encouraged to provide instructional and pacing support, especially to students who have difficulty with higher-order problem-solving and conceptual application assignments. Students are also nudged to engage in reflective learning activities. Encourage school administrators and instructional supervision to assist with classroom-level strategies, integrating procedural reinforcement with activity reflection pairings. Schools and educational institutions need to enhance instructional programs that yield a proper mix of procedural fluency, conceptual comprehension, reflective learning, and higher-order problem-solving processes. Teachers are asked to provide more than instruction in procedural mathematics, and curriculum designers and educational policy makers are encouraged to promote instructional policies that foster metacognitive and self-regulated learning activities. Curriculum designers suggest that the learning resources of mathematics intertwine opportunities for reflective learning and practice with guidance. Parents can build reflective learning at home by prompting students to review mistakes, justify math solutions, and evaluate their learning approaches

concept-based inquiry; guided reflective activities, metacognitive journals, and differentiated pacing strategies were developed to reflect both instructional and learning needs identified through analyzing all of these dimensions. while practicing. It is encouraged that the study be repeated in samples with larger and more diverse participant groups in order to improve the generalizability of the findings.

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##### ➤ *Conflict of Interest*

The authors declare no conflict of interest

##### ➤ *Contributions of Individual Authors*

P.B.B. conceptualized the study, designed the methodology, and analyzed the collected data, while R.D.R. assisted in the conceptualization and interpretation of the data collected. The authors approved the final version of the manuscript.

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