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Impact of Dynamic Assessment on Matriculation Students' Learning Potential in Thermochemistry

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Abstract

Dynamic assessment is a form of assessment that emphasizes the development of students' learning potential rather than solely focusing on scores. This study aims to examine the effects of implementing dynamic assessment procedures on students' learning potential in the topic of thermochemistry. The sample consisted of 10 students enrolled in a matriculation-level program, selected through purposive sampling to represent three achievement categories which are high, moderate, and low performers. The study adopted an interventionist dynamic assessment model divided into three phases, which are pre-test, individual face-to-face mediation, and post-test, which were implemented over a period of three weeks. Two sets of questions were used as achievement test instruments to determine both the actual and potential developmental levels of the students. From the pre-test and post-test scores, descriptive analysis and learning potential score (LPS) were calculated for each student to determine students' learning potential. The findings show that dynamic assessment procedures can assist students across all performance categories in developing their learning potential in thermochemistry. Moreover, dynamic assessment offers an accurate depiction of students' learning potential, which conventional assessments lack. As a result, dynamic assessment and LPS are highly suitable for adoption in Malaysia's assessment practices, especially in transitioning from assessments that merely measure achievement to those evaluating learning potential.

***Keywords**: Dynamic Assessment, Zone of Proximal Development (ZPD), Learning Potential Score (LPS), Matriculation, Thermochemistry*

INTRODUCTION

Despite ongoing efforts to reform assessment practices in Malaysia, student achievement is still predominantly evaluated through conventional examinations that emphasize final scores rather than learning potential. Such assessments offer little clarity about students' capacity for development, particularly in conceptually demanding subjects such as thermochemistry, where abstract concepts and procedural problem-solving are central to learning.

In thermochemistry, students often struggle to develop conceptual understanding because learning is frequently reduced to formula memorization rather than meaningful engagement with energy changes and enthalpy relationships (Vo et al., 2022). These challenges are further compounded by

variations in students' performance levels, which conventional assessments are unable to adequately capture developmental readiness and learning potential.

One assessment approach that addresses this limitation is dynamic assessment, which is grounded in Vygotsky's sociocultural theory and emphasizes mediation within the zone of proximal development (ZPD). Unlike conventional assessments that focus on static outcomes, dynamic assessment integrates assessment and instruction to examine how students respond to support during problem-solving.

Although previous studies have demonstrated the effectiveness of dynamic assessment in enhancing learning potential, existing evidence is largely drawn from language education contexts (Poehner & Lantolf, 2013; Barabadi et al., 2018; Kamrood et al., 2019; Yang & Qian, 2020; Abdolrezapour & Ghanbari, 2021; Zare et al., 2021; Ghaemi & Houshangi, 2021). Empirical research on the application of dynamic assessment in STEM subjects, particularly matriculation-level chemistry, is still lacking. Moreover, the extent to which dynamic assessment differentiates learning potential across students with varying performance levels has not yet been sufficiently explored.

LITERATURE REVIEW

1. Vygotsky's Sociocultural Theory and ZPD

This study is grounded in Vygotsky's sociocultural theory, which conceptualizes learning as a socially mediated process. Interaction with more knowledgeable individuals leads to cognitive development, which the learner then internalizes (Vygotsky, 1978). This process takes place within the Zone of Proximal Development (ZPD), defined as the gap between students' independent performance and their performance with guidance.

In this context, learners' responsiveness to mediation indicates their learning potential. Students with similar actual developmental levels may exhibit different ZPD sizes, depending on how effectively they benefit from mediated support (Poehner, 2008). Consequently, ZPD provides a theoretical basis for examining developmental change beyond static performance measures.

2. Dynamic Assessment

Dynamic assessment (DA) operationalizes the concept of ZPD by integrating assessment and mediation into a single process. Unlike conventional assessments that focus on static outcomes, DA examines how learners respond to support during problem-solving to reveal their potential developmental level (Poehner & Lantolf, 2005).

This study adopts an interventionist dynamic assessment approach using a pre-test–mediation–post-test (sandwich) format. This model enables a systematic examination of developmental change by comparing students' independent performance with their mediated performance. This study particularly benefits from the interventionist approach, which quantifies learning gains and ensures equal mediation for all participants.

3. Mediation in Dynamic Assessment

Mediation is a key part of dynamic assessment. It is when a more knowledgeable person helps a learner do something they can't do on their own (Vygotsky, 1978; Poehner, 2008). Learners who are not yet autonomous but are responsive to mediation tend to demonstrate the greatest developmental gains (Poehner & Lantolf, 2013).

In this study, mediation was implemented individually through cognitive, affective, and metacognitive strategies. These forms of mediation were applied flexibly and contingently to align with students' immediate needs, enabling the identification of both their Zone of Actual Development (ZAD) and ZPD through mediated interaction.

4. Learning Potential Score, LPS

Scores from standard examinations often fail to provide meaningful information about students' learning potential (Kozulin & Garb, 2002). To address this limitation, a formula was developed to determine what is known as the Learning Potential Score (LPS). This formula reflects how students respond to mediation provided during dynamic assessment procedures. Furthermore, it serves to distinguish between students with low learning potential and those with high learning potential.

$$LPS = \frac{2Score_{post} - Score_{pre}}{Score_{Max}}$$

$$Score_{post} = PostTest\ Score, Score_{pre} = Pre\ Test\ Score, Score_{Max} = Maximum\ Scor$$

Based on the LPS values obtained, Kozulin and Garb (2002) classified students into three categories: high scorers (LPS ≥ 1.0), mid-range scorers (0.72 ≤ LPS ≤ 0.99), and low scorers (LPS ≤ 0.71). An LPS equal to or greater than 1.0 indicates a statistically significant An LPS below 1.0 indicates a less significant change, not meeting the criteria for substantial developmental progress (Poehner & Lantolf, 2013). A high LPS value indicates that the mediation provided had a meaningful impact on the learner, while a low LPS implies that the mediation offered did not significantly influence the student's performance (Barabadi et al., 2018). Therefore, students can be classified based on the degree of benefit they gain from mediation, ranging from high to moderate to low.

The LPS offers a more comprehensive view of each student's learning potential because it is calculated individually (Kamali et al., 2018). It enables the differentiation of students based on their capacity for growth. For instance, students who obtain the same pre-mediation scores do not necessarily demonstrate equivalent developmental potential, as their responses to mediation can vary widely (Lantolf & Poehner, 2013; Abdolrezapour & Ghanbari, 2021). Yang and Qian (2020) also support this observation by noting the variability in how learners respond to the same mediational strategies.

The literature collectively underscores the necessity for assessment methodologies that reflect students' developmental responsiveness to mediation, rather than fixed performance outcomes. Grounded in this theoretical perspective, the present study adopts an interventionist dynamic assessment design to examine changes in students' learning potential in the thermochemistry topic.

METHODS

This study employed an exploratory classroom study design using a pre-test–mediation–post-test structure to investigate changes in students' learning potential.

1. Participants

A purposive subsample of ten participants was chosen for in-depth analysis based on predetermined performance criteria, although the study was carried out in an intact classroom of twenty students. The sample consisted of four students with low performance (G, H, I, J), three students with moderate performance (D, E, F), and three students with high performance (A, B, C).

All participants were in the second semester of a matriculation program and were approximately eighteen years of age. Purposeful sampling was used to represent different performance levels by utilizing students' Malaysian Certificate of Education (SPM) results and scores from previous topical assessments. In the previous topical test, high-performing students scored above 80 and received an A in SPM; moderate-performing students received a C with scores between 50 and 60; and low-performing students received an E with scores below 40.

For this exploratory dynamic assessment study, the comparatively small sample size (n = 10) was deliberate and methodologically appropriate. The study's focus was on examining individual developmental change within learners' Zones of Proximal Development (ZPD), rather than statistical generalization, which is consistent with interventionist dynamic assessment research. According to

Poehner (2008) and Lantolf & Poehner (2013), dynamic assessment prioritizes fine-grained analysis of learners' responsiveness to mediation over between-group comparisons, making small, purposefully chosen samples both necessary and acceptable. The study was able to capture significant variability in learning potential while preserving analytical depth and methodological coherence by choosing participants who represented different performance levels.

2. Instruments

An achievement test on thermochemistry was used as the assessment instrument for both the pre-test and post-test phases. Two parallel test forms with equivalent levels of difficulty were developed, one for each phase. There were two parts to each test. Section A had 10 multiple-choice questions, and Section B had structured questions.

The researcher developed the test items, drawing on over 20 years of experience teaching chemistry at the matriculation level. Two matriculation chemistry lecturers with more than 20 years of teaching experience reviewed the instruments to establish content validity and ensure equivalence in difficulty between the two test forms. The expert agreement score for content validity and item difficulty exceeded 80%, indicating that the instruments were valid and appropriate in accordance with established guidelines (Yusoff, 2019).

The Kuder–Richardson Formula 20 (KR-20) was used to verify the internal consistency of the multiple-choice items. The reliability coefficients were 0.74 for the pre-test and 0.68 for the post-test, demonstrating adequate to moderate internal consistency and meeting acceptable standards for exploratory classroom-based research (Ntumi et al., 2023).

Two experienced chemistry lecturers independently scored the structured-response items using an analytic rubric they developed for this study, establishing inter-rater reliability. A moderation session was conducted prior to scoring to ensure consistent interpretation of the rubric. Pearson correlation coefficients for both the pre-test and post-test scores exceeded 0.80, indicating a high level of agreement between raters and confirming the reliability of the scoring procedure (de Raadt et al., 2021).

3. Procedure

This study adopted a pre-test–mediation–post-test design. Accordingly, the research procedure was divided into three implementation phases: the pre-test phase, the mediation phase, and the post-test phase. The entire study was conducted over a period of three weeks.

a. Pre-Test and Post-Test

The study was conducted in the classroom during regular instructional time and was part of the assessment process to evaluate students' mastery of the topic of thermochemistry. The researcher replaced conventional assessment methods with dynamic assessment procedures. As a result, all students in the class participated in the assessment using dynamic assessment techniques. However, only the scores of 10 students were selected for analysis, based on the sampling criteria established earlier. All students took the pre-test simultaneously, received individualized mediation, and then completed the post-test simultaneously as well. The topic of thermochemistry had already been taught and learned in regular classes before the pre-test, so the students could be tested on how well they understood the material.

A potential limitation of the pre-test–post-test design concerns familiarity effects arising from repeated exposure to similar assessment formats. Although parallel test forms with equivalent difficulty were used, some performance gains may have reflected increased test familiarity rather than solely the effects of mediation. Nonetheless, this influence was attenuated in various ways. First, the pre-test and post-test employed different item sets rather than identical questions, reducing direct recall effects. Second, the primary analytic focus of the study was not absolute score improvement but students' differential responsiveness to mediation, as captured through Learning Potential Scores (LPS). In a dynamic assessment framework, alterations in performance post-mediation are regarded as signs of developmental readiness within the ZPD, rather than mere rehearsal effects (Poehner & Lantolf, 2013).

Nevertheless, the possibility of partial practice effects cannot be entirely ruled out and should be considered when interpreting the findings.

b. Face-to-Face Mediation Phase

This phase constituted the core of the dynamic assessment procedure and was conducted through individual, face-to-face mediation grounded in the Zone of Proximal Development (ZPD). One-to-one interaction enabled the identification of each student's Zone of Actual Development and the provision of contingent mediation aligned with learners' immediate responses. Three broad forms of mediation were employed: cognitive, affective, and metacognitive, which are consistent with sociocultural and dynamic assessment principles. Rather than following a fixed sequence, mediation strategies were flexibly adjusted according to students' needs during problem-solving. An overview of the mediation categories and representative techniques is provided in Table 1.

Table 1 Types and techniques of mediation offered to students during face-to-face mediation sessions in the dynamic assessment procedure

Types of mediation	**Technique**	**Description**
Cognitive	Questions related to subject content	Questions that help them to explore the students' level of mastery
	Prompt	Verbal expressions or questions intended to help students activate their prior knowledge, identify errors, and reorganize their thinking processes
	Contingent response	A flexible response or feedback from the assessor that is adjusted according to the response demonstrated by the student
	Providing explanations in a structured and gradual manner	Presenting information or concepts in a logical sequence, beginning with fundamentals that are easy to understand, and gradually building toward more complex levels, according to the student's needs and abilities
Affective	Giving praise	Giving praise means expressing words of appreciation or recognition for a person's action, effort, achievement, or positive attitude
	Providing motivation and encouragement	Providing motivation and encouragement means offering support, enthusiasm, and emotional reinforcement to someone so that they continue to make an effort, do not give up, and achieve their goals, especially when they face challenges or lack confidence in their abilities
	Using a friendly and non-judgmental tone of language	Speaking or conveying information to students in a gentle, polite, and empathetic manner without blaming, belittling, or judging them negatively
Metacognitive	A question that requires students to provide justification	A question that requires students not only to provide an answer, but also to explain the reasons, justifications, evidence, or arguments that support their response
	A question designed to prompt students to reevaluate their thinking	A question designed to help students critically reconsider their thinking, answers, or assumptions, so that they can correct mistakes, reassess their choices or strategies, and construct a more accurate understanding

4. Data Analysis

This study employed both descriptive analysis and the Learning Potential Score (LPS) to determine the changes that occurred. The data were analyzed using descriptive statistics by calculating the mean of the actual scores, the mean of the mediated scores, and the mean of the gain scores for each student performance category, as obtained from the pre-test and post-test. The actual score refers to the score obtained in the pretest, conducted before the students received face-to-face mediation. This score represents the student's actual developmental level, or ZAD (Zone of Actual Development). The mediated score, on the other hand, is the score from the post-test, which was given after the face-to-face mediation session. This score represents the student's potential developmental level, or ZPD (Zone of Proximal Development). The gain score is calculated as the difference between the mediated score and the actual score. Based on the actual and mediated scores, the LPS for each student was also computed. Students were then classified into three groups according to their LPS values as follows:

$LPS \geq 1.0$	−	*high potential*
$0.72 \leq LPS \leq 0.99$	−	*moderate potential*
$LPS \leq 0.71$	−	*low potential*

5. Ethical procedure

The researcher was involved in all stages of the study and concurrently served as the course lecturer who provided mediation during the dynamic assessment sessions. While this dual role may raise concerns regarding potential researcher bias (Herr & Anderson, 2015; Cohen et al., 2018), it is a common and methodologically acknowledged feature of exploratory classroom-based and dynamic assessment research, where instructional mediation constitutes an integral component of the assessment process.

The researcher served as both lecturer and mediator during the dynamic assessment sessions. To mitigate potential bias and improve the rigor of the methods, several methodological safeguards were implemented, including predefined participant selection criteria, masking of performance categories, external validation of instruments, and inter-rater scoring procedures. In addition to quantitative score analysis, mediation interactions were documented during face-to-face sessions to provide process-level evidence supporting interpretive transparency.

First, transparent and predefined criteria were used to select participants for analysis from an intact classroom, ensuring that inclusion was not influenced by subjective judgment. Second, students were not informed of their assigned performance categories to minimize expectancy effects and protect learner self-esteem, particularly among lower-performing students. Third, instrument development and scoring procedures were subjected to external validation. Two experienced matriculation chemistry lecturers independently reviewed the content validity and item difficulty, and two external raters used a standardized analytic rubric to score the structured-response items. Before scoring, a moderation session was held to ensure that everyone understood the rubric the same way. The result led to a high level of agreement between raters, which made it less likely that individual researchers' opinions would affect the outcome measures. In addition to quantitative score analysis, mediation interactions were documented during face-to-face sessions to provide process-level evidence supporting interpretive transparency.

Ethical precautions were also observed. All students received a briefing regarding the implementation of dynamic assessment as part of regular classroom practice, and written informed consent was obtained from those selected for analysis. Participation was optional, with guarantees that withdrawal would not impact academic standing. Pseudonyms were used in all analyses to preserve confidentiality and anonymity. These procedures provided a systematic audit trail of data generation and analysis collectively, supporting the credibility and trustworthiness of the findings while maintaining alignment with the interactive and mediation-sensitive principles of dynamic assessment (McGinn, 2018).

RESULT AND DISCUSSION

Table 2 shows how the actual scores, mediated scores, gain scores, and LPS for each student group in the thermochemistry topic compared to each other.

Table 2 Comparison of actual scores (SS), mediated ccores (SB), gain scores (SK), and LPS for each student category in the topic of thermochemistry

	High					**Moderate**					**Low**					
	A	**B**	**C**	**Min**	**SP**	**D**	**E**	**F**	**Min**	**SP**	**G**	**H**	**I**	**J**	**Min**	**SP**
SS	56	72	80	69.3	9.98	52	24	44	40.0	10.7	16	20	24	20	20.0	2.83
SB	80	92	96	89.3	6.80	76	56	64	65.3	8.22	36	40	44	36	39.0	3.32
SK	24	20	16	20	3.27	24	32	20	25.3	4.99	20	20	20	16	19.0	1.73
LPS	1.04	1.12	1.12			1.00	0.88	0.84			0.56	0.60	0.64	0.52		

Table 2 summarizes students' performance before and after mediation, together with their corresponding Learning Potential Scores (LPS), providing an empirical representation of developmental change within the Zone of Proximal Development (ZPD). In every performance category, the mediated scores were higher than the actual scores. This indicator shows that all of the students were responsive to mediation.

At the group level, high-performing students recorded the highest mean actual and mediated scores, reflecting stronger initial content mastery and higher post-mediation performance. However, gain scores revealed a different pattern: moderate-performing students demonstrated the largest mean gain, suggesting greater developmental movement following mediation. From a ZPD perspective, this pattern suggests that moderately performing students had enough prior knowledge to get the most out of mediation, but they still had some conceptual gaps in their ZPD that needed to be filled.

Importantly, LPS values revealed developmental distinctions that were not apparent from gain scores alone. For example, although student E recorded the highest gain score among moderate-performing students, their LPS remained below 1.0 due to a relatively low initial score. Conversely, student D attained an LPS of 1.0 despite a lesser gain, demonstrating that LPS reflects proportional developmental change rather than mere score enhancement. This finding underscores the role of actual developmental levels in shaping learning potential.

Within-group analysis further demonstrated the sensitivity of LPS in differentiating learners beyond performance categories. While all high-performing students attained LPS values indicative of high learning potential, variation emerged within the moderate- and low-performing groups. Two low-performing students achieved moderate LPS values, indicating latent developmental capacity that conventional assessment alone would not have identified. These patterns support the use of dynamic assessment as a means of operationalizing ZPD by revealing both inter- and intra-group differences in learning potential.

The excerpt data show the interaction between the researcher and one of the students during a one-to-one mediation session to explain how mediation in dynamic assessment activates the student's ZPD. The excerpt data is a direct translation from Bahasa Melayu to English without regard to the grammar rules.

L7 Researcher: Try to find the answer. [Cognitive – giving instruction]
L8 Student D: Wait.

L9 Researcher: How is it? Are you done? [Metacogntive – checking progress]
L10 Student D: Wait, sir.
L11 Researcher: Do it first. Let me know when you're done. [Cognitive – giving instruction]
L12 Student D: Okay. [writing]. I only know that q released is that one, sir.
L13 Researcher: Come, let me check. [Cognitive – giving instruction]. Erm, can you tell me what the basic principle in a calorimeter is? [C – asking a content-related question].
L14 Student D: q released is equal to absorbed.
L15 Researcher: Who releases the heat? [Cognitive - asking a content-related question].
L16 Student D: Erm [silent]
L17 Researcher: Do you know who releases the heat? [Cognitive—modifying the question]
L18 Student D: The aluminium that burns, right sir?
L19 Researcher: Yes, that's correct. Very good. [Affective – giving praise] Okay, now who absorbs the heat? [Cognitive – asking a content-related question].
L20 Student D: The calorimeter.
L21 Researcher: Only the calorimeter? [Metacognitive – asking a question to prompt evaluation].
L22 Student D: The water absorbs it too.
L23 Researcher: How do you know the water absorbs it too? [Metacognitive – asking a question to prompt justification].
L24 Student D: Because there is water in the calorimeter.
L25 Researcher: Okay, correct. [Cognitive – giving feedback]. So what you calculated earlier, was it correct or wrong? [Metacognitive - asking a question to prompt evaluation].
L26 Student D: It was wrong because I only calculated the heat absorbed by the calorimeter.
L27 Researcher: Hehe, clever [Affective – giving praise].

In Lines 7–12, the researcher initiates learning engagement by giving procedural instructions (L7, L11), while Student D responds with hesitation and delay ("Wait", L8–L10). The student's statement in L12 ("I only know that q released is that one") signals incomplete conceptual control, revealing awareness of an isolated formula without full understanding of its application. This moment marks the lower boundary of the ZPD, where independent problem-solving is not yet possible.

From Lines 13–18, the researcher shifts to cognitive mediation by posing content-focused and scaffolded questions about the basic principle of calorimetry (L13–L15). The student initially falls silent (L16), indicating a temporary cognitive impasse. Rather than providing the answer, the researcher rephrases the question (L17), reducing cognitive load while maintaining conceptual demand. This strategic mediation enables the student to retrieve relevant prior knowledge, leading to the correct identification of aluminum as the substance that releases heat (L18). This transition demonstrates movement within the ZPD, where understanding becomes accessible through guided support.

The researcher's positive feedback in L19 ("Yes, that's correct. Very good") functions as affective mediation, reinforcing the student's confidence and sustaining engagement within the ZPD. This encouragement stabilizes the student's emerging understanding and prepares them for deeper conceptual differentiation.

In Lines 19–21, the researcher extends mediation by prompting the student to evaluate their response regarding heat absorption. The follow-up question ("Only the calorimeter?" L21) shifts the interaction from recall to evaluative reasoning, nudging the student toward recognizing multiple components involved in heat absorption. This move reflects the upper boundary of the ZPD, where the student is encouraged to refine and expand their conceptual framework with minimal guidance.

This study examined the effects of interventionist dynamic assessment on students' learning potential in the thermochemistry topic. Overall, the findings indicate that dynamic assessment supported developmental progress across all performance levels, as reflected by increases in mediated scores and differentiated LPS. These results imply that static achievement measures alone cannot fully explain students' performance after mediation.

From a sociocultural perspective, the observed improvements indicate that mediation enabled learners to move beyond their actual developmental level toward their potential level of performance. The disparities in LPS values among students indicate variations in their responsiveness to mediation, which can be understood as differences in the accessibility and extent of each learner's ZPD. In this

sense, LPS functioned as an operational indicator of developmental change rather than a simple measure of score improvement.

A notable pattern emerged among moderate-performing students, who demonstrated the largest proportional gains following mediation. This finding suggests that these learners possessed sufficient prior knowledge to engage meaningfully with mediated support while still experiencing conceptual gaps within their ZPD. Consequently, mediation was able to facilitate substantial restructuring of understanding. In contrast, high-performing students exhibited smaller gains, likely due to limited remaining developmental space, whereas some low-performing students may have lacked the foundational knowledge necessary to fully benefit from mediation within the limited intervention period.

Importantly, the findings demonstrate that gain scores alone were insufficient to capture students' learning potential. Discrepancies between gain scores and LPS values highlight the influence of initial performance levels on proportional developmental change. For example, students with relatively low initial scores could demonstrate large raw gains without achieving high LPS values, whereas students with higher initial performance could achieve high LPS values with smaller gains. This pattern underscores the value of LPS in differentiating learners' developmental responsiveness within and across performance categories.

The results also indicate that dynamic assessment was sensitive in identifying latent learning potential among students classified within the same performance group. In the moderate- and low-performing categories, certain students exhibited greater learning potential than what their initial achievement would have suggested. These findings support previous research (Kamrood et al., 2019; Ghaemi & Houshangi, 2021; Zare et al., 2021) that suggests conventional assessments may mask learners' developmental capacity, revealing it only through mediated learning experiences.

Despite these positive outcomes, the findings should be interpreted with caution. Some enhancement in post-test performance may be partially ascribed to familiarity with the assessment format rather than solely to mediation effects. Even though parallel test forms were used and the analysis focused on LPS instead of raw score gains, practice effects can't be completely ruled out. Future research could incorporate delayed post-tests or alternative task formats to further disentangle mediation effects from test familiarity.

The findings collectively furnish empirical validation for the implementation of dynamic assessment as a method to operationalize the Zone of Proximal Development (ZPD) in chemistry education. Dynamic assessment incorporates mediation into evaluation, providing a more nuanced comprehension of students' learning potential, especially in conceptually challenging subjects like thermochemistry.

CONCLUSION

This study examined the effects of interventionist dynamic assessment on students' learning potential in the thermochemistry topic using an LPS framework. The findings indicate that dynamic assessment supported developmental progress across all performance categories, as evidenced by higher mediated scores and differentiated LPS values. These findings indicate that static achievement measures alone are insufficient to comprehensively assess students' learning potential.

Importantly, the use of LPS revealed developmental distinctions that were not apparent from gain scores or performance categories. High-performing students consistently exhibited significant learning potential, whereas the variability within moderate- and low-performing groups underscored the existence of latent developmental capacity among certain learners. This finding underscores the sensitivity of dynamic assessment in operationalizing the Zone of Proximal Development by identifying both inter- and intra-group differences in responsiveness to mediation.

From a pedagogical perspective, the findings suggest that dynamic assessment offers a viable approach for supporting learning in conceptually demanding STEM topics such as thermochemistry. By integrating assessment with mediation, dynamic assessment enables instructors to move beyond outcome-based evaluation toward a more diagnostic and development-oriented understanding of

student learning. This approach aligns with current assessment reform initiatives that emphasize formative, learner-centered practices.

In conclusion, this study contributes empirical evidence supporting the application of dynamic assessment in STEM education by demonstrating its capacity to reveal students' learning potential through mediated interaction. The findings extend existing dynamic assessment research beyond its predominant focus on language education and highlight the value of LPS as a theoretically grounded indicator of developmental change in chemistry learning.

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DATA AVAILABILITY STATEMENT

Data will be made available on request.

CONFLICT OF INTEREST

There is no conflict of interests.

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