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Reconstructing Conceptual Understanding of Slow and Regular Learners through LAPD SHCRT on Volume Comparison Law

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Abstract

Background: Understanding concepts is important in learning chemistry, but students differ in how they build their understanding. This study aims to analyze and compare the processes of reconstructing the concept understanding of slow learners and regular students, and to relate these processes to changes in pretest and posttest scores through a *Lembar Aktivitas Peserta Didik* (LAPD) based on Universal Design for Learning (UDL) and Scaffolded Handwritten Constructed-Response Tasks (SHCRT) on the Volume Comparative Law material. **Methods:** The study used a qualitative descriptive design with four students at SMAN 10 Surabaya: two slow learners and two regular students. Data were obtained through video recordings of learning, interviews, and pretest-posttest. We analyzed qualitative data using NVivo 12 through thematic analysis and matrix coding, while pretest-posttest score changes served as supporting data. **Results:** Both groups went through the same stages of reconstruction, connecting, examining and revising, and reusing concepts, but showed different characteristics. Slow-learning students tended to require teacher support and gradual scaffolding, especially in connecting information to concepts and verifying understanding. In contrast, regular students were more independent in checking and reinforcing understanding through examples, visual representations, and comparisons of answers. Changes in pretest and posttest scores indicated improved understanding in both groups. **Conclusion:** These findings show that differences in reconstruction are more evident in students' independence and use of information resources than in the stages of reconstruction completed, so learning support needs to be adjusted to students' characteristics.

INTRODUCTION

Chemistry is a conceptual and abstract science, so understanding concepts is an important aspect of learning (Rahmawati et al., 2022). Because chemistry is a conceptual and abstract science, understanding concepts is an important part of learning (Moloi et al., 2026). Conceptual understanding is demonstrated not only by recalling information or using chemical equations, but also by connecting various representations to explain chemical phenomena. Dewi & Mulyani (2024) show that the interconnectedness of the three representations plays an important role in building conceptual understanding, while limitations in their integration can cause difficulties in understanding concepts. Therefore, chemistry learning should give students opportunities to build a meaningful conceptual understanding, not just master facts or procedures.

In gas laws material, students can perform calculations correctly but may not be able to explain the relationships among gas quantities conceptually (Leslie & Bearden, 2023). Similar difficulties arise in the Law of Volume Comparison, which requires an understanding of the relationship between gas volumes and reaction coefficients (Sihaloho et al., 2024). Gas-volume comparisons depend on the coefficients in the equation for the equivalent reaction, so students need to connect symbolic representations to quantitative volume relationships. In practice, students may struggle to distinguish coefficients from indices, balance reaction equations, determine volume ratios, and apply these to solve quantitative problems (Salame et al., 2026; Sihaloho et al., 2024). Nur et al. (2024) show that students still struggle to apply the Law of Volume Comparison, especially when determining relationships between gas volumes from reaction equations. The findings align with observations during the School Field Introduction activity, which showed that students struggled to determine gas volumes from reaction equations, especially when one gas volume was known. The difficulty arose because students could not relate the reaction coefficient to comparisons of gas volumes. This shows that students' constraints lie not only in the calculation procedure but also in their conceptual understanding of the relationship between the reaction equation and gas volumes. Therefore, it is necessary to examine how students build and develop conceptual understanding during learning. It is also necessary to explore how conceptual understanding forms and changes during learning.

Difficulty in understanding chemical concepts also needs to be considered in slow learners. Slow learners may struggle to understand abstract concepts, maintain concentration, and follow instructions, so they need additional support (Virani et al., 2026). The findings also align with Nabillah & Yoenanto (2025), who found that teaching slow learners can be supported through gradual material delivery, adjusted teaching methods, appropriate media, and additional time. These characteristics suggest possible differences in how slow learners build and develop their understanding compared to regular learners. Therefore, regular learners can serve as a comparison group to identify differences in how the two groups build and develop conceptual understanding. These differences matter not only for learning outcomes but also for how learners connect information, examine and refine their understanding, and reuse concepts during learning.

Conceptual understanding develops as learners acquire new information and connect it to prior knowledge (Alreshidi, 2023). In chemistry learning, this process involves associating concepts with multiple representations, which can help build cognitive structure, mental models, and conceptual understanding (Permatasari et al., 2022).

Connecting representations to concepts is important for conceptual understanding, although learners may struggle to integrate the two (Phajan et al., 2025). When there is a discrepancy between initial understanding and scientific concepts, learners need to evaluate their understanding to allow conceptual change. Assessment and feedback can support this process by giving learners opportunities to examine, reflect on, and revise their understanding (Carter & Prevost, 2023). Learners then need to reuse the reconstructed understanding in different problems or contexts as a form of knowledge transfer (Jere & Mpeta, 2024). Based on this synthesis, this study understands the reconstruction of conceptual understanding as a process of changing and developing understanding by associating new information with prior knowledge, examining and revising understanding, and reusing concepts in the next problem. Thus, changes in conceptual understanding are evident not only in differences between pretest and posttest scores but also in the processes of connecting, checking, correcting, and reusing understanding during learning.

The LAPD can provide structured learning information and activities to support learners in building conceptual understanding (Anggraini & Susilowati, 2022). Integrating Scaffolded Handwritten Constructed Response Tasks (SHCRT) supports learners through assignments, questions, or cues that guide them to develop reasoning and articulate their understanding in writing (Crowder et al., 2024). Tasks that encourage students to explain and elaborate their reasoning in writing also support knowledge construction in chemistry learning (Zaimi et al., 2023). Meanwhile, *Universal Design for Learning* (UDL) provides multiple ways to represent information and alternatives for demonstrating their learning, thereby supporting students with diverse learning characteristics and needs (Reyes et al., 2021). The application of UDL in chemistry learning allows for a flexible and inclusive learning environment through a variety of representations, expressions, and engagements. Integrating SHCRT-based LAPD with UDL can help learners with different learning characteristics connect concepts, examine and revise their understanding, and reuse concepts (King-Sears et al., 2023; Appiah-Twumasi, 2024; Hendri et al., 2025). However, how slow learners and regular students reconstruct understanding through UDL-based LAPD SHCRT still needs exploration.

Previous research shows that Universal Design for Learning (UDL) can support learning outcomes for students with diverse characteristics. A meta-analysis by King-Sears et al. (2023) of 20 studies found that implementing UDL positively affected academic achievement. In a systematic review, Zhang et al. (2024) also showed that UDL supports various learning outcomes through learning designs that accommodate student diversity. However, the study focuses more on UDL implementation and learning outcomes, while it does not explore in depth how conceptual understanding changes during learning. Research that specifically compares how slow learners and regular students reconstruct their conceptual understanding remains limited. These limitations are increasingly seen in chemistry learning using LAPD with UDL-based SHCRT scaffolding, especially in the Volume Comparative Law material. Therefore, this study aims to analyze and compare how slow learners and regular learners reconstruct their conceptual understanding through UDL-based LAPD SHCRT on the Volume Comparative Law material, and to relate these processes to changes in pretest and posttest scores.

METHODS

This study uses a qualitative descriptive approach with a comparative case study design to describe and compare the process of reconstructing the conceptual understanding of slow learners and regular learners in the material of the Law of Comparative Volume (Gay-Lussac), with data analysis referring to the Miles, Huberman, and Saldaña (2014) model. The study involved four students at SMAN 10 Surabaya, comprising two slow learners and two regular students. The researchers selected subjects using purposive sampling based on student characteristics aligned with the research objectives. Slow learners are categorized as students with special needs in inclusive education (Nurfadhillah et al., 2022). The limited number of participants reflects school policy limiting the admission of students with special needs to no more than 5% of the student body per school year. This number is considered adequate for in-depth analysis because the study emphasizes individual-level data and compares the characteristics of slow-learner and regular groups. Based on information from the accompanying teacher, Table 1 presents the students' characteristics.

Table 1. Student Identity

Name	Gender	Category
YS	Male	Slow Learner
KR	Male	Slow Learner
AR	Male	Regular
SB	Female	Regular

The identity of this student serves as a reference for the development of the research instruments. In addition, this identity helps researchers understand how concept understanding differs between slow learners and regular students. Data collection begins with a pretest to identify students' initial understanding. Researchers use instruments with slow learners and regular students. Learning uses LAPD, with four Chemistry Education students assisting, one per student. The observer records students' behavior and provides additional scaffolding as needed. After learning, students complete posttests, interviews, and response questionnaires. Pretest-posttest data support descriptions of changes in conceptual understanding, while the main analysis qualitatively reconstructs conceptual understanding. The study does not use N-Gain because it does not aim to measure intervention effectiveness quantitatively. The study analyzes and codes qualitative data based on predetermined categories.

The study integrates LAPD-based learning with Scaffolded Handwritten Constructed Response Tasks (SHCRT), tailored to students' needs based on observation data during learning. YS (slow learner) receives intensive guidance through gradual instruction, repeated explanations, and briefings to connect concepts. KR (slow learner) receives guidance when experiencing difficulties and then continues working. In AR and SB (regular), the teacher provides assistance through clarification, confirmation, and explanation when doubt arises. Scaffolding is provided during learning, while students take pretests and posttests independently, without teacher assistance.

The research instruments include LAPD, observation sheets, interviews, response questionnaires, and pretests and posttests. The printed LAPD is arranged according to the characteristics and needs of slow learners and regular learners by integrating SHCRT strategies. Observation sheets document activities that show the process of connecting

concepts, examining and revising them, and reusing them. Pretests and posttests are used to assess understanding of concepts before and after learning. Before use, all instruments were validated by three validators: experts in extraordinary education, chemical materials experts, and practicing teachers at SMAN 10 Surabaya. Validation included material suitability, construction, presentation, and language. The validation results are based on the three validators' score distributions and converted to a validity percentage using the maximum scale score. All instruments fell into the valid or highly valid categories and were deemed suitable for use. Table A summarizes the validation results.

Table 2. Instrument Validation Results

Instruments	Validation Components	Validation Results (%)	Criteria
LAPD	Content, presentation, SHCRT, UDL, constructs, and language.	75%	Valid
Observation Sheet	Content, construction, language.	75%	Valid
Pretest – Posttest	Material, construction, language.	75%	Valid
Response Questionnaire	Content, construction, language.	100%	Highly Valid
Interview Sheet	Content, construction, language.	100%	Highly Valid

Data analysis refers to the Miles, Huberman, & Saldaña (2014) model, which includes data condensation, data display, and conclusion drawing/verification. The analysis focused on two areas. First, it analyzed changes in concept understanding by comparing pretest and posttest scores and responses to each question; second, it traced how students reconstructed concept understanding through their activities and responses during learning using LAPD. At the data condensation stage, qualitative data is transcribed, encoded, and grouped using NVivo 12. The reconstruction process is analyzed based on three aspects: (1) connecting concepts, i.e., relating new information with previous knowledge or information; (2) examining and revising, i.e., comparing, verifying, and improving understanding or answers; and (3) reusing concepts, i.e., applying concepts that have been understood to the next problem. These three aspects become parent nodes, which develop into child nodes based on activities in the data. Case classification is used to group students into slow learner and regular categories. In the data display stage, Matrix Coding Queries and comparison diagrams are used to identify patterns in the reconstruction process and compare the two groups. Furthermore, in the conclusion-drawing/verification stage, the findings are interpreted and verified, along with changes in pretest and posttest scores, to identify the relationship between the reconstruction process and changes in concept understanding.

The credibility of the data was ensured by cross-checking multiple data sources. The reconstruction of concept understanding identified from the learning video recordings was matched with students' written responses to the LAPD to ensure compatibility between the activities and the understanding shown during learning. The qualitative findings were also compared with changes in pretest and posttest scores as supporting data. In addition, the coding and interpretation results were re-examined to ensure their compatibility with the research data.

RESULT AND DISCUSSION

The improvement in conceptual understanding was analyzed by comparing pretest and posttest scores and by examining responses to each question after learning, using a UDL-based LAPD SHCRT on the Volume Comparative Law material. The analysis was carried out individually on slow learners and regular students to identify the characteristics of the development of the ability to understand and apply concepts. The comparison results of each student's pretest and posttest are presented as follows.

Table 3. Pretest and Posttest Comparison Results

Groups	Name	Score Pretest	Score Posttest
Slow Learner	YS	45	95
Slow Learner	KR	63	90
Regular	AR	67	90
Regular	SB	70	100

Based on the table, pretest and posttest scores indicate changes in students' abilities after learning, with distinct patterns of comprehension development in each group and among individual students. These findings are supported by Pratiwi et al. (2020), who state that regular students understand concepts better than slow-learning students. Furthermore, responses to each question are analyzed by comparing pretest and posttest answers to obtain a more in-depth picture of the development of understanding.

YS (Slow Learner)

The pretest results showed that YS scored 45, the lowest among students. Response analysis showed that YS had a basic initial understanding but still struggled with some aspects of the concept. After learning, the score increased to 95 on the posttest, indicating developed conceptual understanding, as shown by comparisons across items.

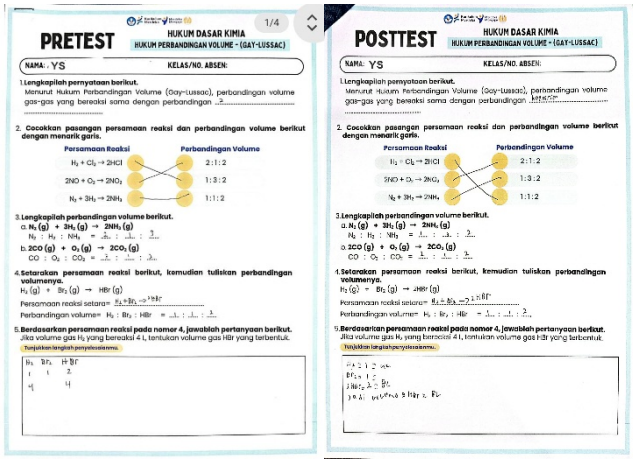


Figure 1. YS's Pretest and Posttest Responses

In question number 1, YS was asked to complete a statement about the relationship between gas volume and reaction coefficient. On the pretest, YS answered "2," indicating he did not remember the concept. In the posttest, YS answered "coefficient," indicating progress in identifying the concept, though it was not complete, as it was supposed to be a "reaction coefficient." In question 2, YS matched the reaction equation to the volume

comparison based on the coefficients. In the pretest, only 1 in 3 pairs answered correctly, indicating that the relationship between the reaction coefficient and the gas volume comparison had not been mastered. In the posttest, all pairs answered correctly, indicating they understood the relationship.

In question 3, YS determined the volume ratio using the coefficient in the equivalent reaction equation. In the pretest, both answers were incorrect (2:1:3 and 3:1:3). In the posttest, both were correct (1:3:2 and 2:1:2), indicating a more precise understanding of the relationship between reaction coefficients and volume ratios. In question 4, YS was able to equalize the two reaction equations and correctly determine the volume ratio in both the pretest and posttest. Thus, this ability has been mastered from the beginning and remains consistent after learning.

In question 5, YS identified the information and used the comparison table in the pretest but did not complete the volume calculation. In the posttest, YS completed the calculation, obtained the final volume of HBr gas, and wrote a concluding statement. This comparison indicates a change from an incomplete solution to a more complete quantitative response, suggesting improved application of the relationship between reaction coefficients and gas volume ratios. Overall, YS shows progress mainly in remembering concepts, relating reaction coefficients to volume comparisons, determining volume ratios, and applying concepts to quantitative problems. In contrast, the ability to equalize reaction equations and determine volume comparisons has been mastered from the beginning and remains consistent. These developments are further traced through video analysis of learning to identify the process of reconstructing YS's understanding and activity in using the LAPD.

KR (Slow Learner)

The pretest results showed that KR scored 63. Response analysis showed that KR had prior knowledge of reaction equations and volume comparisons, but was inconsistent in relating the reaction coefficient to the volume comparison and in applying it to new problems. After learning, the score increased to 90 on the posttest, indicating the development of conceptual understanding, which was further explored by comparing responses to each item.

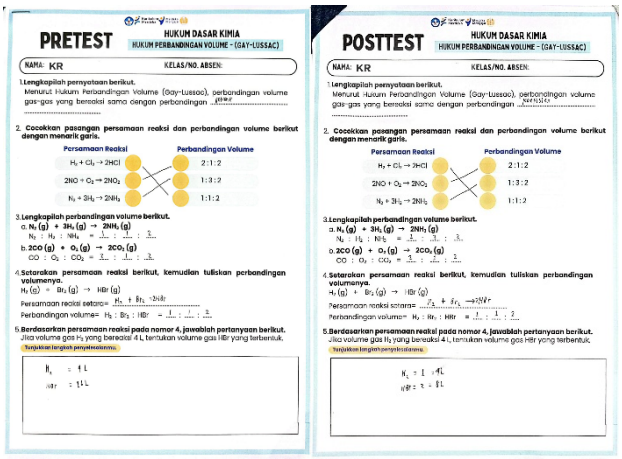


Figure 2. KR's Pretest and Posttest Responses

In question 1, KR answered "volume" on the pretest, indicating that KR recognized the terms related to the material but did not fully understand the concept. In the posttest,

KR answered "coefficient," indicating progress in identifying concepts, even though their response was incomplete; they were supposed to be "reaction coefficients." In question 2, KR correctly matched all pairs of reaction equations and volume comparisons on both the pretest and posttest. This shows that KR mastered the ability to determine volume comparisons based on reaction coefficients from the beginning, and it remained consistent.

In question 3, KR gave one correct and one incorrect answer on the pretest. KR initially wrote 1:1:2, while the correct answer was 1:3:2, indicating that KR had used reaction equation information but still misidentified the coefficient due to the distraction of the chemical formula without the coefficient. In the posttest, KR determined both ratios precisely, namely 1:3:2 and 2:1:2, showing an improved understanding of how to connect the reaction coefficients to the gas volume comparison.

In question 4, KR was able to balance the reaction equation and determine the correct volume ratio for both the pretest and posttest. KR mastered this ability from the beginning, and it remained consistent after learning. In question 5, KR obtained an answer of 16 L on the pretest by writing down information and performing calculations, even though the correct answer was 8 L. In the posttest, KR determined the HBr volume of 8 L with the correct completion step but had not yet reached a conclusion, so the answer was not perfect. This shows an increase in the ability to apply the relationship between reaction coefficients and volume comparison in quantitative problems.

Overall, KR shows progress mainly in identifying concepts, determining volume comparisons using reaction coefficients, and applying these to quantitative problems. The ability to match volume comparisons and equalize reaction equations has been mastered from the beginning and remains consistent. These developments are further traced through analysis of learning videos to identify how KR's understanding and activities in using LAPD are reconstructed.

AR (Regular)

Based on the pretest results, AR obtained a score of 67, indicating a basic understanding of the relationship between the reaction equation coefficient and gas volume comparisons. However, the application was inconsistent across all questions. After learning, the score increased to 90 on the posttest, indicating the development of conceptual understanding, which was further explored by comparing responses to each item.

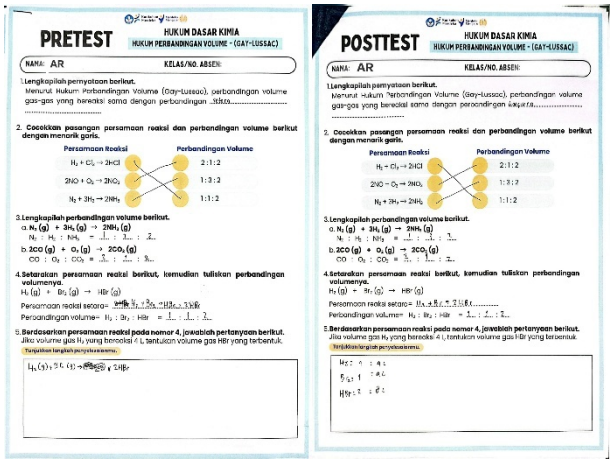


Figure 3. AR's Pretest and Posttest Responses

In question 1, AR answered "equivalent" on the pretest, indicating that AR had recognized the terms related to matter but had not fully understood the concept. In the posttest, AR answered "coefficient", showing progress in understanding the relationship between the reaction coefficient and gas volume comparison. However, it was incomplete because it was supposed to be a "reaction coefficient". In question 2, AR correctly matched all reaction equations to their volume ratios on both the pretest and posttest. This shows that AR mastered the ability to relate reaction coefficients to volume comparisons from the beginning, and it remained consistent.

In question 3, AR also determined both volume ratios correctly on the pretest and posttest, 1:3:2 and 2:1:2. Thus, the ability to determine volume comparisons based on reaction coefficients was mastered from the beginning and remained consistent. In question 4, AR balanced the reaction equation and determined the volume ratio on the pretest, although errors remained in writing the balanced equation. In the posttest, AR wrote $H_2 + Br_2 \rightarrow 2HBr$ and correctly determined the 1:1:2 volume ratio, indicating increased accuracy in balancing the equation and in determining the volume ratio.

In question 5, AR identified information from the reaction equation in the pretest but had not yet continued the calculation of the HBr volume. In the posttest, AR determined the HBr volume to be 8 L using the correct completion step, although it had not yet provided a conclusion. This shows the development of the ability to apply volume comparison in quantitative problems. Overall, AR shows progress, especially in identifying the concept of the Law of Volume Comparison, improving the accuracy of equalizing reaction equations, and applying the relationship between reaction coefficients and volume comparisons in quantitative problems. The ability to determine volume comparisons in questions 2 and 3 was mastered from the beginning and remains consistent. This development is further traced through the analysis of learning videos to identify the process of reconstructing AR's understanding and activity in using LAPD.

SB (Regular)

Based on the pretest results, SB obtained a score of 70, the highest among the four students, indicating a basic understanding of the relationship between the coefficients in the reaction equation and the comparison of gas volumes. However, the application was inconsistent across all questions. After learning, the score increased to 100 on the posttest, indicating the development of conceptual understanding, which was further explored by comparing responses to each item.

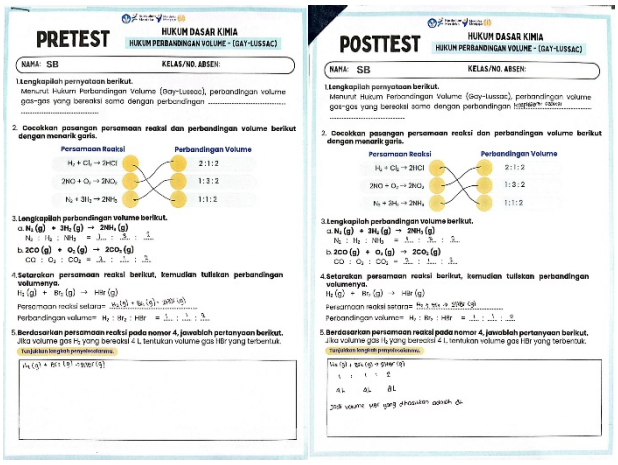


Figure 4. SB's Pretest and Posttest Responses

In question 1, SB did not answer the pretest, so he did not demonstrate understanding of the concept being asked. In the posttest, SB answered "reaction coefficient", showing the ability to identify concepts correctly and the development of understanding. In question 2, SB correctly matched the reaction equation to the volume ratio in both the pretest and posttest. SB mastered the ability to relate the reaction coefficient to the volume comparison from the beginning, and it remained consistent.

In question number 3, SB was also able to determine both volume ratios correctly in the pretest and posttest, namely 1:3:2 and 2:1:2. This shows that the ability to determine volume ratios based on reaction coefficients has been mastered from the beginning. In question 4, SB balanced the reaction equation and determined the correct volume ratio in both the pretest and posttest. SB wrote $H_2 + Br_2 \rightarrow 2HBr$ with a volume ratio of 1:1:2, showing that the ability has been mastered and remains consistent after learning.

In question number 5, SB was able to identify information from reaction equations in the pretest but had not yet continued the calculation of the HBr volume. In the posttest, SB determined the HBr volume to be 8 L using a 1:1:2 volume ratio a completed the calculation. This shows SB's developing ability to apply volume comparison in quantitative problems. Overall, SB shows progress, especially in identifying the concept of the Law of Volume Comparison and applying it to quantitative problems. The ability to relate reaction coefficients to volume comparisons, as well as equalize equations and determine volume comparisons in questions 2–4, has been mastered from the beginning and remains consistent. These developments are further traced by analyzing learning videos to identify how SB's understanding and activity are reconstructed during use of the LAPD.

Reconstruction of Concept Understanding

The reconstruction of concept comprehension was analyzed using students' activities and responses during learning, based on a UDL-based LAPD SHCRT on the Volume Law material, to identify changes in understanding as they encountered information or problems. The analysis includes three aspects, namely (1) connecting concepts through visual representations, previous information, and previous examples or problems; (2) examining and revising through comparison of answers, information verification, and revision based on feedback; and (3) reusing concepts through application to new and posttest questions and the use of information in LAPD. These three aspects describe the development of conceptual understanding in slow learners and regular students during learning.

YS (Slow Learner)

In YS students, conceptual understanding is reconstructed through three main processes: connecting concepts, examining and revising, and reusing concepts. These three processes show YS's development of understanding, from initially needing help connecting concepts to reusing them more independently. In connecting concepts, YS used information and visual representations available in the LAPD to support understanding. This interpretation was based on qualitative data from learning video recordings and their transcripts, cross-checked against YS's written responses in the LAPD. The data were coded and analyzed using NVivo to identify patterns in YS's conceptual reconstruction. This pattern indicates that YS builds relationships between concepts by using prior information and visual representations, as evidenced by the NVivo coding results.

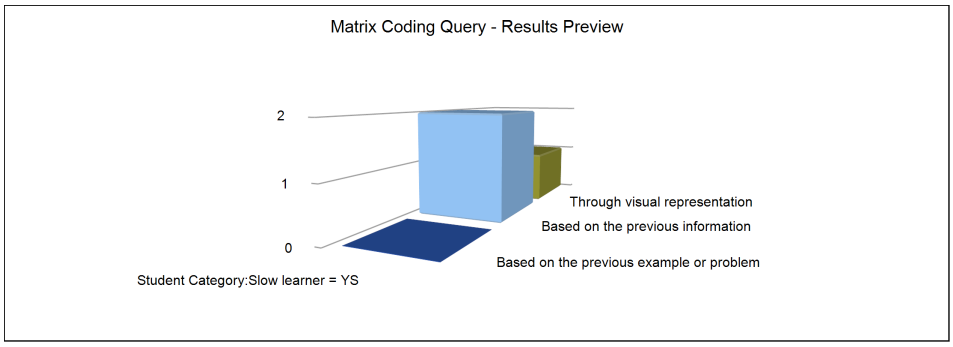


Figure 5. The Process of Connecting Concepts by YS

The process then moves to the checking and revising stage. YS does not always receive the answers immediately but returns to review the information on the previous page to verify his understanding. When he is confused, YS also asks the teacher for an explanation before continuing. After obtaining an explanation, YS adjusts the answers provided. Thus, YS's examination process is evident not only in questioning activities but also in changes in answers after receiving information or feedback. This pattern aligns with the appearance of a revised child node in response to feedback on the NVivo coding results.

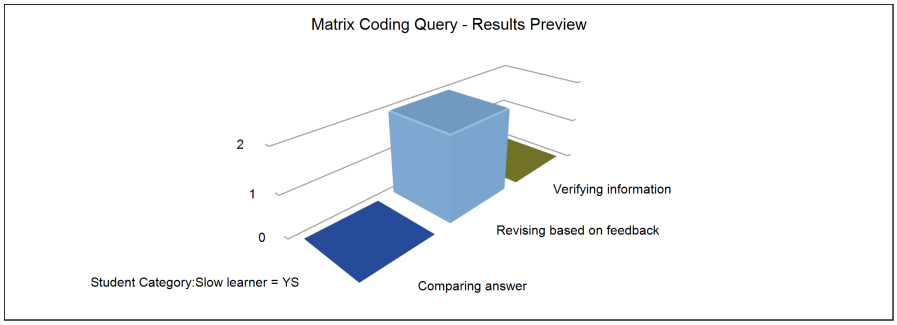


Figure 6. Checking & Revising Process by YS

Next, YS showed the process of reusing the concept. After obtaining an explanation and checking his understanding, YS again used LAPD information to analyze the evaluation problem and determine the relationship between gas volume and the reaction coefficient. YS also mentioned the concept being studied again, namely the law of volume comparison. In the final stage, YS completed the posttest independently, without the teacher's help. The coding results showed that YS reused LAPD information and applied the concepts to the posttest.

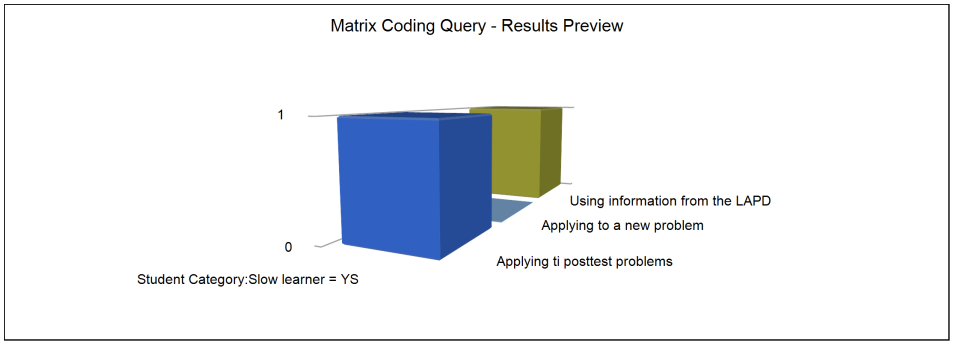


Figure 7. The Process of Reusing the Concept by YS

Based on the overall process, the reconstruction of understanding of YS's concept shows a progression from reliance on assistance and information sources to more independent reuse of concepts. At the beginning of the process, teacher assistance still plays a role in helping YS build a relationship between volume and reaction equations. This condition aligns with Susilo & Prihatnani (2022), who show that slow learners need scaffolding to overcome difficulties in understanding concepts. Next, YS began to re-examine the information, refine the answers in response to the teacher's feedback, and apply what was learned to solve the next problem. This change shows a shift from dependence on external help to more independent use of concepts, consistent with Aliyah et al. (2024) on the development of slow learners from special assistance to learning independence.

KR (Slow Learner)

In KR students, conceptual understanding is reconstructed through three main processes: connecting concepts, examining and revising, and reusing concepts. At the stage of connecting concepts, KR uses more previous information as a basis for understanding the problems faced. This can be seen from the tendency of KR to re-open or read information on the previous page when experiencing difficulties in answering questions. This aligns with the emergence of NVivo child nodes from prior information and visual representations. These findings show that KR is more effective at building concept relationships by re-accessing previously learned information. At the same time, visual representation also serves as a supporting source in the process.

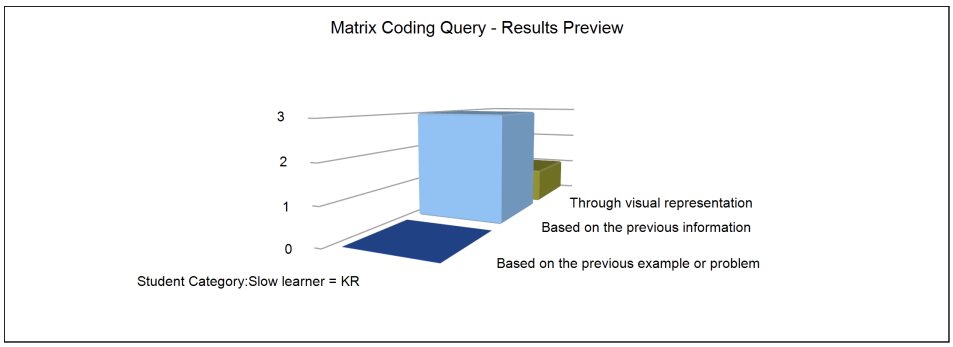


Figure 8. The Process of Connecting Concepts by KR

In the checking and revising stage, KR confirms and receives feedback to check his understanding. When the answer is not yet believed, or the concept is not understood, KR asks the teacher for an explanation and then adjusts the answer after obtaining it. This shows that the teacher's feedback not only helps KR arrive at the answer but also improves the understanding that has already been formed. The coding results indicate the emergence of a revised child node in response to feedback.

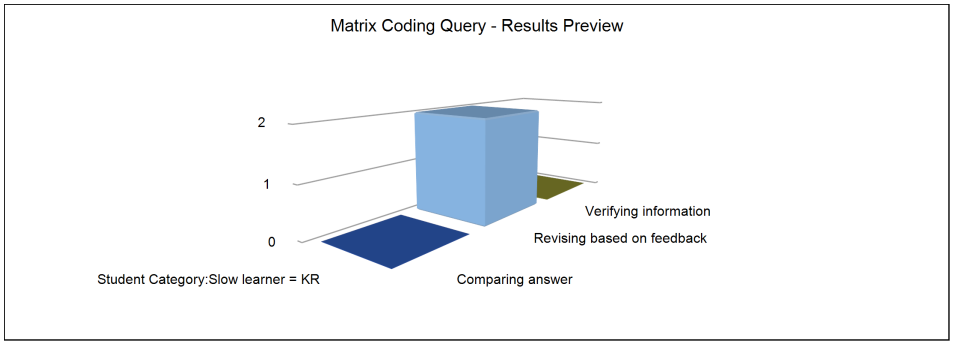


Figure 9. Checking & Revising Process by KR

At the concept-reuse stage, KR began to leverage the understanding built to solve the next problem. This is evident when KR again used information from the previous page to understand the evaluation questions and conclude the relationship between gas volume and the reaction coefficient. At the end of the lesson, KR also explained that the material studied related to the law of volume comparison and completed the posttest independently without the teacher's help.

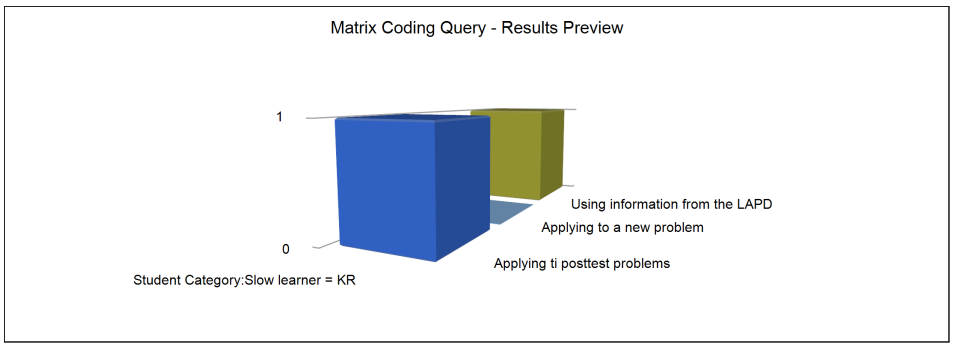


Figure 10. The Process of Reusing the Concept by KR

Thus, the KR reconstruction process shows that prior information is the primary source for connecting concepts, and that the teacher's feedback is used to check and improve understanding. The teacher's role as a feedback giver becomes dominant in the learning process; this aligns with Susilo & Prihatnani (2022), which show that slow learners need scaffolding to overcome difficulties in understanding concepts. Then the reconstructed information is reused in problem solving. This change reflects a shift from dependence on external help to more independent use of concepts, consistent with Aliyah et al. (2024), who found that slow learners progress from special assistance to learning independence.

AR (Regular)

The process of reconstructing concept understanding in AR shows a pattern that differs fairly from those of KR and YS. At the concept-connecting stage, AR tends to use previous examples or problems as a foothold for understanding the problem at hand. Child nodes in NVivo are detected through previous examples or problems. In addition, visual representations help build understanding, as shown by the emergence of child nodes. These findings show that AR builds conceptual relationships by referring to the forms of problems or examples encountered and utilizing the representations available in learning.

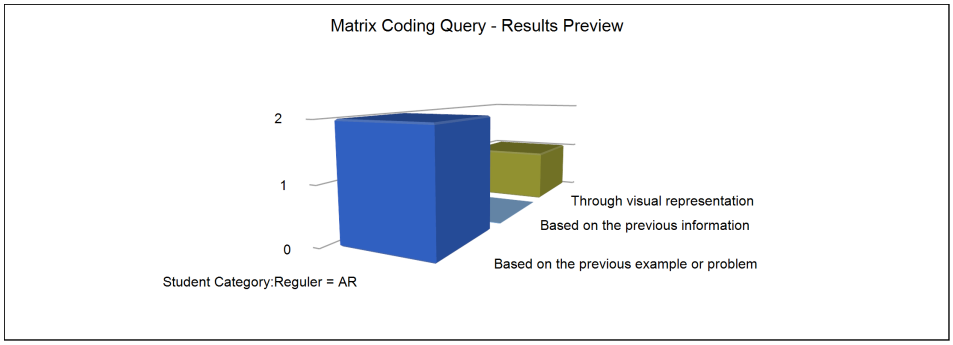


Figure 11. The Process of Connecting Concepts by AR

At the checking and revising stage, the AR pattern is more prominent in the activity of verifying and comparing answers. This aligns with the appearance of child nodes verifying information; when comparing answers, the most dominant child nodes, with the most appearances, are the most common. This shows that when faced with uncertainty, AR tends to verify information and compare results to ensure the answers are appropriate. Interestingly, the code does not reflect this process in the child node "revising based on feedback". Hence, the AR examination mechanism is more often seen as a process of checking and comparison than as a revision explicitly triggered by teacher feedback.

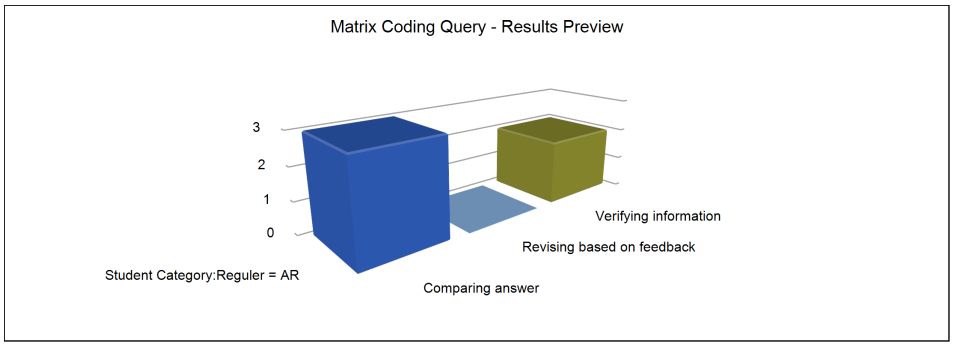


Figure 12. The Process of Checking & Revising by AR

Furthermore, at the stage of reusing concepts, AR demonstrates the ability to apply the understanding built to different problems, as shown by the emergence of child nodes that address new problems. It also successfully reuses concepts in posttest questions. This shows that concepts examined through examples, information, and comparisons of answers are beginning to be used to address new problem situations.

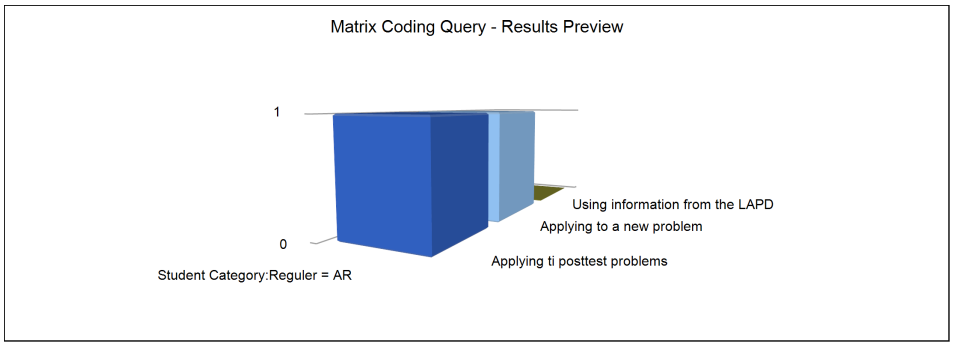


Figure 13. The Process of Reusing Concepts by AR

Thus, AR tends to reconstruct understanding through previous examples/questions and visual representations, then strengthen that understanding through information verification and, especially, comparison of answers, before applying the concept to new and posttest questions. These findings are in line with Vo et al. (2024) regarding the development of slow learners from special assistance to learning independence.

SB (Regular)

The process of reconstructing concept understanding in SB follows a pattern similar to that of AR. At the stage of connecting concepts, SB establishes a relationship between the concepts under study and the available learning resources. Based on the coding results, this process is illustrated using previous examples or problems and visual representations as references to understand and connect information. This shows that SB not only receives information directly but also uses available examples and representations to build relationships between concepts, as shown in the NVivo coding results below.

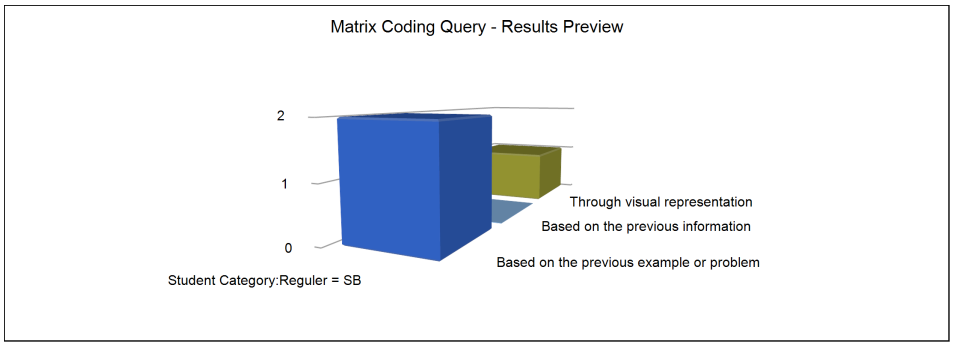


Figure 14. The Process of Connecting Concepts by SB

At the checking and revising stage, SB tends to reconfirm his understanding before continuing the work. This process is seen through the activity of comparing answers and verifying information. SB uses previously obtained answers or information as a basis to ascertain whether the answers provided are appropriate. Thus, SB's examination process seems more like checking and confirming understanding than simply accepting the answers given, as shown by the following NVivo coding results.

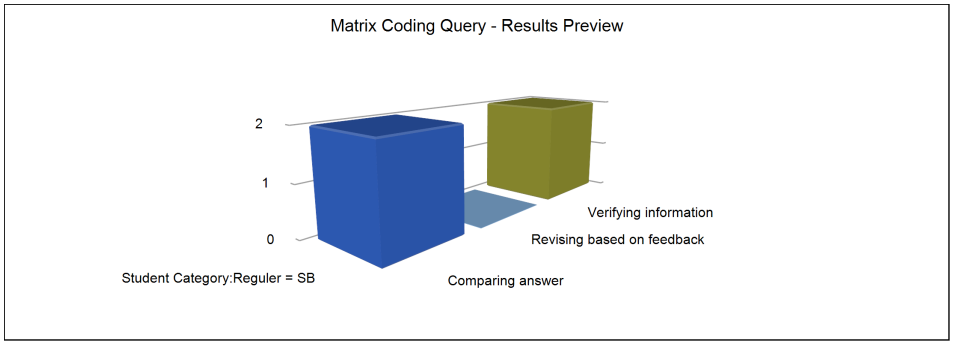


Figure 15. The Process of Checking & Revising by SB

Furthermore, at the stage of reusing concepts, SB applies the concepts built to new questions and then to posttests. This shows that the concepts acquired during the learning

process do not remain limited to understanding previous examples but are reused when SB faces other problems, as evidenced by the following NVivo coding results.

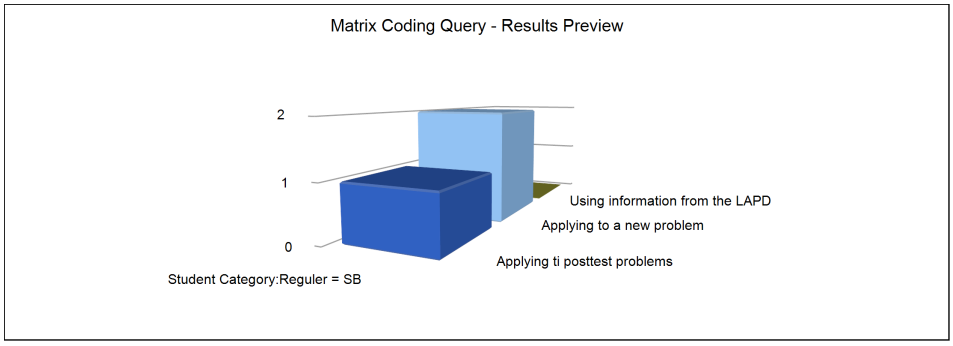


Figure 16. The Process of Reusing Concepts by SB

Overall, the SB reconstruction process showed a pattern of connecting concepts through previous examples and questions, using visual representations to check understanding by comparing answers and verifying information, and then reusing concepts in new and posttest questions. These findings align with Vo et al. (2024), who show that comparing the solution with the reference solution and reflecting help students identify mistakes and determine improvement strategies.

Comparison of Reconstruction of Slow Learner Students with Regular

Based on NVivo coding results, slow learners and regular learners alike demonstrate the process of reconstructing understanding through connecting concepts, examining and revising, and reusing concepts. Although they follow similar stages, the reconstruction process differs in the sources of information they use and the support they receive during learning.In the slow learner group (YS and KR), reconstruction tends to begin by reactivating previously learned information and using it in the LAPD. When experiencing difficulties, students return to the information in the LAPD or need the teacher's explanation and guidance to connect the information to the concept. KR shows a conceptual connection through prior information, which is reinforced by the teacher's feedback. At the same time, YS uses the available information to rebuild their understanding but still needs feedback when facing difficulties. However, the slow learner group reconstructs concepts primarily through information reactivation and scaffolding before using them in problem-solving. This aligns with Susilo & Prihatnani (2022), who state that slow learners need scaffolding to overcome difficulties in understanding concepts, and is supported by Aliyah et al. (2024) regarding the development of slow learners from special assistance to learning independence.

In contrast, the regular group (AR and SB) showed a stronger tendency to examine and strengthen their understanding. AR verified information and compared answers before applying concepts to new questions or posttests. At the same time, SB used previous examples or questions to verify and compare answers before applying concepts to new problems. The regular group's reconstruction process was more visible, as they checked the suitability of the information, compared results, and used the examination results to solve the next problem. These findings are in line with Vo et al. (2024), who found that comparing the solution with the reference solution and reflecting on it helps students identify mistakes and determine improvement strategies.

These differences do not reflect absolute differences in the reconstruction stages, because both groups continue to connect, examine, revise, and reuse concepts. The difference is seen in the characteristics of the child nodes connected to each group. The regular group is characterized by using previous examples or questions, verifying information, comparing answers, and applying concepts to new problems. Meanwhile, the slow learner group draws on more prior knowledge and LAPD information to build understanding and revises based on feedback. Both groups use visual representations and apply concepts on the posttest. Thus, the main difference lies in how students progress through each stage of reconstruction, particularly in the use of information sources, verification, and support during learning. Figure 17 summarizes these comparative findings and illustrates the coded patterns of conceptual reconstruction across slow learners and regular students. The diagram was generated from the NVivo 12 Matrix Coding Query results, based on coding learning video recordings and students' written LAPD responses, and provides a visual overview of similarities and differences in the reconstruction processes between the two groups.

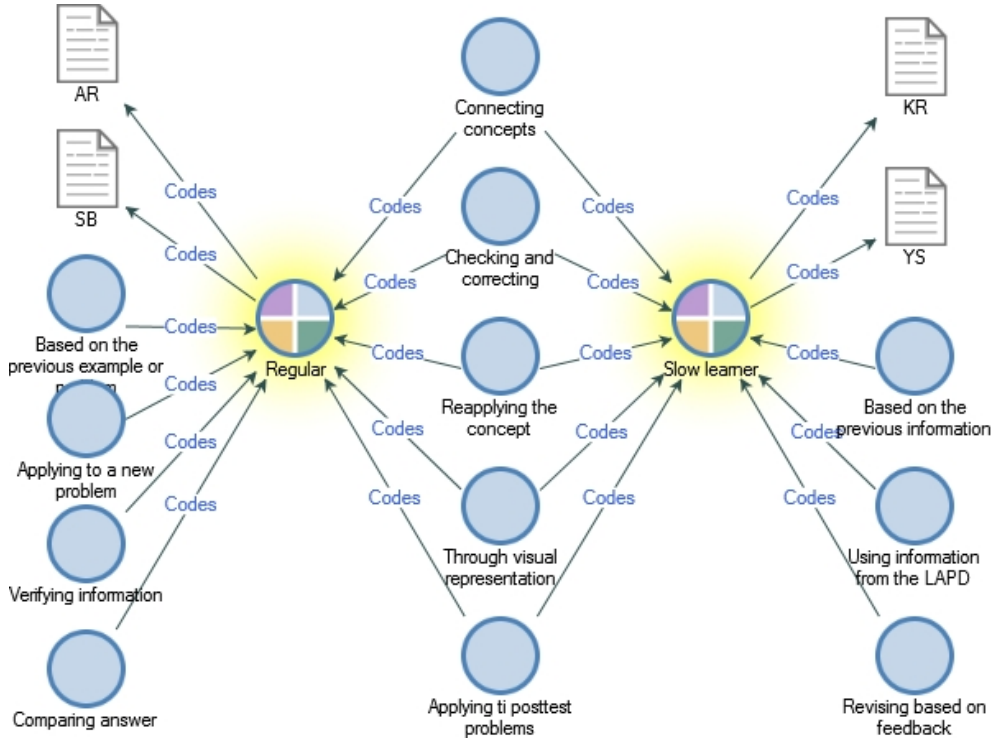


Figure 17. Results of Comparison of Reconstruction Process in Slow and Regular Learners

The pre-test results showed that all students' scores increased after learning using LAPD: YS by 50 points, KR by 27 points, AR by 23 points, and SB by 30 points. The score changes aligned with the process of reconstructing concept understanding identified for each student. However, the magnitude of the increase cannot be directly attributed to the characteristics of any particular process, as each student exhibited a different combination of activities, information sources, and levels of support. Thus, quantitative data strengthen the interpretation of concept development based on qualitative data.

CONCLUSION

Based on the analysis, both slow and regular learners engaged in reconstructing conceptual understanding through the stages of connecting concepts, examining and revising, and reusing concepts. Although they followed the same stages, the two groups showed different process characteristics. Slow learners tended to use more available information and teacher support or scaffolding to connect and check their understanding. In contrast, regular learners tended to be more independent in using examples, visual representations, verification, and comparison of answers. Thus, the difference in the reconstruction process between the two groups lay not in the stages they passed through, but in how students used information sources and reprocessed their understanding during learning. Changes in the pretest and posttest results also indicated development in both groups, but the process analysis showed that these developments occurred through different reconstruction characteristics. This research addresses an existing gap: most studies review only effectiveness or learning outcomes, without an in-depth analysis of how students reconstruct their conceptual understanding for both slow learners and regular students. This finding implies the need for learning support tailored to students' characteristics as they reconstruct their conceptual understanding.

DECLARATION OF GENERATIVE AI

During the preparation of this manuscript, the author used ChatGPT to assist with paraphrasing, grammar checking, and improving sentence clarity. Grammarly was also used to support grammar correction and language editing. Following the use of these tools, the author carefully reviewed and revised the content as necessary and takes full responsibility for the accuracy, integrity, and final content of this publication.

CONFLICTING INTEREST STATEMENT

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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