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# Student Activity Worksheet Using Scaffolded Handwritten Constructed-Response Tasks to Support Slow Learners' Conceptual Understanding

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**ABSTRACT**

**Purpose –** This study aimed to describe changes in conceptual understanding of slow learners regarding chemical reaction equations through the implementation of a Student Activity Worksheet using the Scaffolded Handwritten Constructed-Response Tasks (SHCRT) strategy.

**Methodology –** A qualitative approach was employed, involving four participants from SMAN 10 Surabaya. Data were collected through pre-tests, SHCRT-based Student Activity Worksheet responses, post-tests, and interviews. The research instruments were validated by three validators: a chemistry lecturer, a special education lecturer, and a chemistry teacher. Data were analyzed descriptively by comparing student responses and reasoning across the learning stages.

**Findings –** The results showed that conceptual understanding developed gradually and varied across learners and levels of cognitive demand. The most apparent development occurred in identifying reactants and products and relating their roles to their positions in chemical reaction equations. Learners also demonstrated development in interpreting states of matter and evaluating chemical reaction equations. However, these abilities were less consistent, particularly when tasks required integration of multiple symbolic representations and higher-order reasoning.

**Contribution –** The SHCRT-based Student Activity Worksheet provided gradual support through phenomena, visual representations, conceptual explanations, examples, instructions, exercises, and evaluation tasks. It supported the progressive development and reinforcement of student conceptual understanding of chemical reaction equations, including among slow learners.

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## INTRODUCTION

Learning chemistry is one context that requires particular attention due to the abstract nature of its concepts and the involvement of macroscopic, microscopic, and symbolic representations (Musa et al., 2023). This level of abstraction may cause learners to have difficulty interpreting and connecting different levels of chemical representations to the meaning of the concepts being studied (Gkitzia et al., 2020). Problems with conceptual understanding in chemistry learning have also been demonstrated by Nurdin and Fitri (2025), who found that learners' conceptual understanding of chemical formulas, nomenclature, and chemical equations remained relatively low and was accompanied by misconceptions. These findings indicate that chemistry learning should not merely be oriented toward obtaining final answers but should provide learning experiences that help learners gradually construct conceptual understanding (Marbun et al., 2025).

One chemistry topic closely related to the use of symbolic representations is chemical equations. Chemical equations require learners not only to recognize the chemical formulas of substances but also to understand their roles as reactants or products and the transformation of reactants into products in a chemical reaction (Seliwati, 2023). Difficulties in understanding chemical equations are evident in the persistent conceptual errors in topics such as chemical formulas, compound nomenclature, and chemical equations (Nurdin & Fitri, 2025). Suhari et al. (2023) reported that many learners experience difficulties in understanding chemical equations, particularly when learning materials are dominated by text and chemical formulas. Such conditions may make chemical concepts difficult for learners to understand and less engaging.

These difficulties stem from learning materials dominated by text and chemical formulas, which are hard to understand and less engaging for learners. These issues become increasingly important in learning involving slow learners in inclusive education. Inclusive education is an educational approach that provides equal opportunities for all learners, including those with special needs, to learn together in a supportive, non-discriminatory educational environment (Budianto, 2023). Its implementation also emphasizes adapting instruction to learners' diverse abilities and individual needs (Regina & Rusmawaty, 2025). One group requiring particular attention in inclusive learning is slow learners, who may experience delays in processing and understanding instructional information and therefore require more time, repetition, and teacher assistance (Mansyur & Bunyamin, 2022). Consequently, uniform instruction may create difficulties for slow learners, indicating the need for adaptive and structured learning strategies that are adjusted to their abilities and learning needs (Regina & Rusmawaty, 2025). Teachers, therefore, need to adapt instructional methods, materials, media, and learning environments to facilitate slow learners' participation and learning development alongside other learners (Almala, 2025).

One instructional material that can be used to provide more structured learning is the Learner Activity Worksheet, which contains instructions, learning materials, tasks, and exercises systematically arranged to guide learners' learning activities (Aprilia & Mitarlis, 2025). The use of the Student Activity Worksheet in chemistry learning has demonstrated positive outcomes, including increased learner engagement and improved understanding of learning materials. Recent research has also explored the use of E-LAPD for learners with special educational needs. Farhani et al. (2025), for example, implemented an E-LAPD based on Liveworksheets to support students with intellectual disabilities in learning to write and balance chemical reaction equations. The E-LAPD incorporated visual support, step-by-step guidance, and interactive exercises, and the students demonstrated improved post-test performance after the learning intervention. These findings indicate that structured learning materials, supported by visual and sequential guidance, can help learners who have difficulty understanding abstract chemistry concepts.

Kurniawan et al. (2025) further investigated the use of E-LAPD-based Liveworksheets for students with intellectual disabilities to learn chemical compound nomenclature using the Universal Design for Learning (UDL) approach. Their learning design incorporated multiple means of engagement, representation, action, and expression, including images, videos, material summaries, practice questions, and opportunities for students to demonstrate their understanding. The study reported that the UDL-based E-LAPD was practical

to implement and that students demonstrated improved learning outcomes, as evidenced by pre- and post-test results. These findings strengthen the evidence that E-LAPD can provide accessible representations and structured learning experiences for learners with learning difficulties. However, the study primarily examined the implementation of UDL principles and students' learning outcomes rather than tracing how conceptual understanding develops through sequential written responses during scaffolded learning activities.

Although these studies demonstrate the potential of E-LAPD to support learners with special educational needs, their instructional focus differs from the focus of the present study. Farhani et al. (2025) emphasized the use of visual support, step-by-step guidance, and interactive exercises to facilitate students' understanding of chemical equations. In contrast, Kurniawan et al. (2025) emphasized the application of UDL principles through multiple means of engagement, representation, and action and expression. Both studies provide important evidence regarding the accessibility and usefulness of E-LAPD; however, they do not specifically examine the progressive development of conceptual understanding through a sequence of handwritten constructed-response tasks embedded within scaffolding. Furthermore, Farhani et al. (2025) identified a need for further development in content refinement and learning-assistance strategies, indicating that the design of instructional support remains an area for further investigation.

The use of the Student Activity Worksheet can be further strengthened through scaffolding, which involves providing gradual learning support tailored to learners' initial abilities and needs, enabling them to learn more independently (Susilo & Prihatnani, 2022). For slow learners, effective scaffolding should be provided in a contextual, concrete, and logical manner, using concise instructions to facilitate understanding (Susilo & Prihatnani, 2022). Scaffolding can also be implemented through work-step instructions, worked examples, guiding questions, and directions that are gradually withdrawn as learners become capable of completing tasks independently (Aghata et al., 2026). In chemistry learning, scaffolding can be directed toward the processes of understanding problems, analyzing information, planning solutions, applying strategies, and evaluating answers, thereby making learners' thinking processes more structured (Vo et al., 2024). To examine the process of understanding, the Student Activity Worksheet can incorporate constructed-response tasks that provide learners with opportunities to formulate their own answers and explain their reasoning based on their understanding (Yik et al., 2021). Such open-ended responses can provide deeper insight into learners' conceptual understanding because learners are not merely required to select an answer but are also encouraged to articulate their reasoning in writing (Yik et al., 2021). Therefore, constructed-response tasks can make learners' developing understanding more visible and provide information about the types of conceptual difficulties that remain during learning.

Previous studies provide evidence that scaffolding can support slow learners through gradual assistance, while constructed-response tasks can reveal learners' conceptual reasoning through written responses. Aghata et al. (2026), for example, demonstrated the use of work-step instructions, worked examples, and guiding questions as forms of scaffolding in chemistry learning. However, the study did not specifically focus on slow learners. Meanwhile, Susilo and Prihatnani (2022) demonstrated that scaffolding can assist slow learners in understanding learning materials through gradually provided support. In chemistry learning, Yik et al. (2021) showed that constructed-response tasks can reveal learners' reasoning and conceptual understanding through written responses. However, these approaches have generally been examined separately, and limited evidence explains how conceptual understanding develops across sequentially scaffolded written tasks, particularly in learning chemical reaction equations among slow learners.

Therefore, the novelty of the present study is not simply the combination of scaffolding and constructed-response tasks. Rather, the novelty lies in using the Scaffolded Handwritten Constructed-Response Tasks (SHCRT) strategy as a structured learning sequence in which learners receive gradual support as they construct written responses to increasingly demanding conceptual tasks. The learners' written responses are examined across the learning stages to trace how their conceptual understanding develops, is reinforced, or remains inconsistent. This process-oriented perspective distinguishes the present study from previous E-Student Activity Worksheet research that primarily emphasized accessible representations, UDL principles,

visual support, step-by-step guidance, or overall learning outcomes.

The SHCRT-based Student Activity Worksheet is particularly relevant to chemical reaction equations because learners need to coordinate chemical formulas, reaction arrows, the positions of reactants and products, and states of matter. The learning sequence, therefore, begins with more explicit conceptual support and examples, then progresses to exercises and evaluation tasks that require learners to construct responses with greater independence. This progression enables the development of conceptual understanding to be examined not only from whether an answer is correct, but also from how learners' written responses change across the learning stages. Such an approach is important because a learner may correctly identify reactants and products yet still have difficulty interpreting states of matter, connecting multiple symbolic representations, or evaluating an incorrect chemical equation.

Accordingly, this study aims to describe the development of students' conceptual understanding of chemical reaction equations through the implementation of a Learner Activity Worksheet using the Scaffolded Handwritten Constructed-Response Tasks (SHCRT) strategy, with particular attention to slow learners in an inclusive chemistry learning context. The development of conceptual understanding is examined through students' pre-test and post-test responses, written responses during the SHCRT-based Student Activity Worksheet, and interview data. Through this process-oriented analysis, the study seeks to identify how learners' understanding changes across different learning stages, which aspects of chemical reaction equations show clearer development, and which conceptual demands remain inconsistent despite scaffolding.

## METHODOLOGY

### Research Design

This study employed a qualitative, descriptive design to examine changes in students' conceptual understanding of chemical reaction equations during the implementation of the Student Activity Worksheet, which used the Scaffolded Handwritten Constructed-Response Tasks (SHCRT) strategy. A descriptive qualitative design was selected because the study focused on describing students' responses, reasoning, difficulties, and changes in conceptual understanding throughout the learning process, rather than statistically measuring the effectiveness of the intervention. The research process involved examining student initial understanding through a pre-test, tracing the development of their understanding through responses to the SHCRT-based Student Activity Worksheet, identifying changes through a post-test, and clarifying their understanding and difficulties through interviews. The data from these stages were subsequently analyzed descriptively to provide a comprehensive account of students' development of conceptual understanding. Descriptive qualitative analysis was used to describe the research data in relation to the problems examined (Sofwatillah et al., 2024), while a qualitative approach was used to understand and describe the phenomenon based on data obtained from research participants (Muliawanti et al., 2022).

### Participant

The participants in this study consisted of four students from SMAN 10 Surabaya, comprising two slow learner students and two regular students. Participants were selected based on their characteristics and the study's objectives to obtain information relevant to the research focus. Participant selection based on the research objectives aligns with purposive sampling in qualitative research, which aims to obtain information relevant to the research focus.

**Table 1**. Student profile

| Name | Gender | Condition |
|---|---|---|
| Kr | Male | Slow learner |
| Ys | Male | Slow learner |
| Ar | Male | Regular |
| Mz | Female | Regular |

**Data Collection**

Data collection was conducted through several stages: (1) administration of a pre-test, (2) implementation of the Student Activity Worksheet using the SHCRT strategy, (3) administration of a post-test, and (4) interviews. At the initial stage, the participants completed a pre-test to assess their conceptual understanding of chemical reaction equations. Subsequently, the participants completed the Student Activity Worksheet in a series of stages, with scaffolding assistance adjusted to the difficulty of the tasks. The participants' written responses at each stage of the Student Activity Worksheet were documented as data reflecting the development of their conceptual understanding. After the learning process, the participants completed the post-test to identify changes in their responses following the learning intervention. Finally, interviews were conducted to gather information about the participants' understanding, difficulties, and experiences during task completion.

**Instrument**

The instruments used to collect data for analysis consisted of pre-test and post-test questions, the Student Activity Worksheet using the SHCRT strategy, and student interviews. The pre-test and post-test were used to obtain an overview of changes in the participants' conceptual understanding before and after the implementation of the Student Activity Worksheet using the SHCRT strategy. The Student Activity Worksheet was used as an instructional instrument to provide learning activities progressively through scaffolding and constructed-response tasks. Interview data were obtained through audio recordings, which were subsequently transcribed and analyzed based on participants' responses and explanations of their understanding after using the Student Activity Worksheet during the learning process**.**

Before being used in the research, the instruments were validated by three validators: a chemistry lecturer, a special education lecturer, and a chemistry teacher. The validation was conducted to assess the instrument's suitability and quality for examining students' conceptual understanding and supporting the learning process. The validation results yielded a mode score of 3 out of 4, indicating that the instrument met the criteria for good validity and was suitable for use in the research.

**Data Analysis**

The research data were analyzed using descriptive qualitative analysis to describe changes in the participants' conceptual understanding of chemical reaction equations. The data analyzed consisted of the pre-test and post-test results, participants' responses to the Student Activity Worksheet at each stage of the learning process, and interview transcripts. The pre-test and post-test results were analyzed by comparing the participants' responses to each item to identify changes in conceptual understanding before and after the learning process. The Student Activity Worksheet responses were analyzed based on the participants' responses at each stage of the activity to identify the development of their understanding and their responses to the assistance provided through scaffolding. The interview transcripts were analyzed descriptively by identifying participants' statements related to conceptual understanding, difficulties encountered, and responses to the scaffolding process. Furthermore, the pre-test results, Student Activity Worksheet responses, interview transcripts, and post-test results were compared and integrated to obtain an overall description of the development of the participants' conceptual understanding. The results of the analysis were then presented descriptively for each participant and according to the conceptual understanding indicators examined.

## FINDINGS

**Changes in Conceptual Understanding of Chemical Reaction Equations**

Changes in students' conceptual understanding of chemical reaction equations were analyzed by integrating pre-test results, students' work on the Student Activity Worksheet using the Scaffolded

Handwritten Constructed-Response Tasks (SHCRT) strategy, post-test results, and interviews. The research instruments were validated by three validators: a chemistry lecturer, a special education lecturer, and a chemistry teacher. The validation results showed a mode score of 3 out of a maximum score of 4, indicating that the instruments were valid and met the good criteria. The analysis involved four students: two slow learners, Kr and Ys, and two regular students, Mz and Ar. The analysis focused on changes in students' responses to each test item and the development of their responses during the scaffolding process. The Student Activity Worksheet responses were used to trace changes in conceptual understanding from the pre-test to the post-test. In contrast, the interview data were used to strengthen the interpretation of students' written responses. To investigate changes in students' understanding of chemical reaction equations, this study used pre- and post-tests developed from the learning objectives and targeted competency indicators.

**Table 2.** Indicators of competencies measured in the pre-test and post-test.

| Test Questions | Question Indicators | Cognitive Levels |
|---|---|---|
| 1 | Given the chemical reaction between magnesium and sulfur, students can identify the role of compounds as reactants or products in the chemical equation. | C2 (Comprehension) |
| 2 | Given the chemical equation for the formation of hydrochloric acid (HCl), students can identify the substances that act as reactants and products and correctly state the physical state of each substance. | C3 (Application) |
| 3 | Given data on several substances in a reaction, students can analyze the roles of those substances and then correctly match the pairs of substances based on their roles as products or reactants. | $C_4$ (Analysis) |
| 4 | When presented with an incorrectly written reaction equation for the formation of carbon dioxide ($CO_2$), students can evaluate it and write the reaction equation correctly according to the rules. | $C_5$ (Evaluation) |

The four indicators were used to examine the development of students' understanding not only in recognizing basic concepts but also in applying and evaluating them when representing chemical reaction equations. Therefore, changes in students' understanding showed different patterns across the conceptual demands. The most apparent development occurred in the ability to identify reactants and products, whereas the ability to integrate symbolic information and use concepts to evaluate and construct chemical reaction equations showed varying levels of stability across individuals. Therefore, changes in conceptual understanding were examined not only by changes in the number of correct responses between the pre-test and post-test, but also by how students used the concepts during the scaffolding process.

**Students' Initial Conceptual Understanding Based on the Pre-test**

The students' initial conceptual understanding was identified through the pre-test. The results showed different levels of understanding among the four students. In the first item, students were required to identify the roles of Mg and S in the equation Mg + S → MgS. Ar correctly identifies Mg and S as reactants from the beginning. In contrast, Kr identified Mg as magnesium metal and S as sulfur, indicating that he referred to the substances' identities rather than their roles in the chemical equation. Ys identified Mg as "reaction" and S as "sulfide," indicating that the terms reactant and product had not yet been appropriately understood. Mz identified Mg as a product and S as a reactant, indicating a partial but inaccurate understanding.

**Table 3.** Students' responses on the pre-test in identifying reactants and products in the equation Mg + S → MgS.

| Name of student | Result of pre-test |
|---|---|
| Ar | a. Mg is a reactant<br>b. S is a reactant |
| Kr | a. Mg is Magnesium metal<br>b. S is Sulfur |

| | |
|---|---|
| Ys | a. Mg is a reaction.<br>b. S is sulfide |
| Mz | a. Mg is a product<br>b. S is a reactant |

These responses indicate that students entered the learning process with different levels of conceptual understanding. Ar had already demonstrated the target concept, whereas Kr, Ys, and Mz had difficulty relating the position of substances in a chemical equation to their roles as reactants or products.

The second item required students to identify reactants, products, and states of matter in the equation $H_2(g) + Cl_2(g) \rightarrow HCl(g)$. Kr identified H and Cl as parts of the reactants, whereas Ys identified only $H_2$ and incorrectly identified $Cl_2$ as the product. Mz correctly identified $H_2$ and $Cl_2$ as reactants and HCl as the product, but did not provide the state of matter. Ar correctly identified the reactants and product and stated that the substances were gases. These responses indicate that the fundamental relationship between the positions of substances and their roles was not equally well understood by all students. In addition, the presence of subscripts and state symbols introduced additional symbolic information that had to be interpreted simultaneously.

The third item examined students' ability to apply the concepts of reactants and products in a structured task. The pre-test responses indicated that students demonstrated different levels of initial understanding. Importantly, students who answered correctly at this stage were considered to have demonstrated existing understanding rather than improvement resulting from the Student Activity Worksheet.

The fourth item required students to evaluate and reconstruct an incorrectly written chemical reaction equation. The equation $O_2(g) \rightarrow C(s) + CO_2(g)$ had to be reconstructed into $C(s) + O_2(g) \rightarrow CO_2(g)$. Kr and Ys still placed substances in incorrect positions. Mz considered the incorrect equation to be correct because it represented a combination of substances, while Ar also did not correctly reconstruct the equation. These responses indicate that recognizing individual substances or their identities did not necessarily mean that students could use the reactant-product relationship to evaluate and reconstruct a chemical equation.

Overall, the pre-test showed that students' initial understanding was heterogeneous. The concept of reactants and products was not yet consistently connected to the structural representation of a chemical equation, particularly when students were required to interpret multiple symbolic elements or evaluate an incorrect equation. These initial conditions provided the basis for examining the changes that occurred during and after the SHCRT-based Student Activity Worksheet.

**Students' Final Conceptual Understanding After the SHCRT-Based Student Activity Worksheet**

After completing the SHCRT-based Student Activity Worksheet, students completed the post-test to examine their conceptual understanding following the learning process. The post-test assessed the same four conceptual demands as the pre-test, allowing the students' responses after the implementation of the Student Activity Worksheet to be examined. In the first item, students demonstrated a clearer understanding of the roles of substances in chemical reaction equations. Kr and Ys were able to determine that substances located on the left side of the reaction arrow were reactants, whereas substances located on the right side were products. Kr was able to apply this understanding to equations such as $Fe + S \rightarrow FeS$ and $2Mg + O_2 \rightarrow 2MgO$. Ys was also able to provide $H_2$ and $O_2$ as reactants and $H_2O$ as the product. Compared with their pre-test responses, Kr and Ys shifted from responses that did not appropriately represent the reactant-product concept to responses that correctly identified the roles of substances. Mz also changed from identifying Mg as a product to correctly identifying it as a reactant.

In the second item, students showed development in identifying reactants and products, although the interpretation of states of matter was less consistent. Kr correctly identified $H_2$ and $Cl_2$ as reactants, HCl as the product, and the substances as gases. Ys also correctly identified $H_2$ and $Cl_2$ as reactants and HCl as the product. However, his response concerning the state of matter was represented by the reaction equation rather than explicitly stating "gas." Mz correctly identified the reactants, the product, and the state of matter, while

Ar maintained his understanding. These findings indicate that students were generally better at identifying reactants and products than at integrating all the symbolic information contained in a chemical equation.

In the third item, students demonstrated the ability to apply the concepts introduced through the Student Activity Worksheet. However, the interpretation of the results took into account the students' initial conditions. Students who answered correctly in both the pre-test and post-test were interpreted as maintaining or reinforcing their understanding. In contrast, students who changed from incorrect to correct responses were interpreted as demonstrating development.

In the fourth item, the post-test showed that some students were able to transfer their understanding of reactants and products to evaluating and reconstructing a chemical reaction equation. Kr was able to use the relationship between the positions of substances and their roles to correct the equation into $C(s) + O_2(g) \rightarrow CO_2(g)$, although the response was partly expressed in written words. Ar was also able to complete the evaluation task after the learning process. However, Ys and Mz continued to have difficulty transferring their basic understanding to the more complex evaluation task.

Overall, the post-test indicated that students' final understanding was stronger in identifying reactants and products than in integrating several symbolic representations or evaluating an incorrect chemical equation. The findings also suggest that the development of conceptual understanding was not uniform across students or across levels of cognitive demand.

**Change in Students' Conceptual Understanding During the SHCRT-Based Student Activity Worksheet**

Changes in students' conceptual understanding were examined by comparing their pre- and post-test responses and by tracing their responses during implementation of the SHCRT-based Student Activity Worksheet. The comparison showed that the development of understanding varied according to the conceptual demands of the tasks.

The first item examined students' ability to identify the roles of substances as reactants and products in a chemical reaction equation. The pre-test results showed that the students entered the learning process with different levels of understanding. As shown in Table 3, Ar had already correctly identified Mg and S as reactants, whereas Kr identified the substances by name as magnesium metal and sulfur. Ys provided responses that did not appropriately represent the concepts of reactants and products, while Mz identified Mg as a product and S as a reactant. After completing the SHCRT-based Student Activity Worksheet, all four students correctly identified Mg and S as reactants in the post-test. The comparison between the pre-test and post-test responses is presented in Table 4.

**Table 4.** Comparison of students' responses on the pre-test in identifying reactants and products in the equation $Mg + S \rightarrow MgS$.

| Name of student | Result of Pre-test | Result of Post-test |
|---|---|---|
| Ar | a. Mg is a reactant<br>b. S is Reactant | a. Mg is a reactant<br>b. S is Reactant |
| Kr | a. Mg is Magnesium metal<br>b. S is Sulfur | a. Mg is a reactant<br>b. S is Reactant |
| Ys | a. Mg is a reaction.<br>b. S is sulfide | a. Mg is a reactant<br>b. S is Reactant |
| Mz | a. Mg is Product<br>b. S is Reactant | a. Mg is a reactant<br>b. S is Reactant |

The development observed in the pre-test and post-test responses was also supported by students' responses during the SHCRT-based Student Activity Worksheet. At the concept presentation stage, students received explanations of reactants and products through examples of chemical reaction equations, pictures, symbols, and reaction arrows. The equation $H_2(g) + O_2(g) \rightarrow H_2O(l)$ was used to introduce the relationship between substances before and after a reaction and to connect these positions with the terms reactants and products.

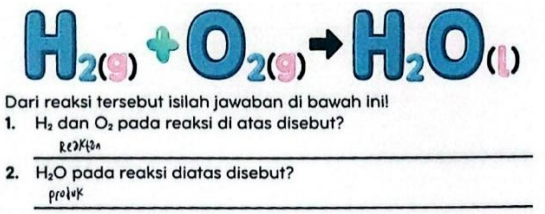



**Figure 1.** Form of scaffolding at the stage of introducing the concepts of reactants and products in the SHCRT-based Student Activity Worksheet for Kr.

The concept presentation was followed by exercises that guided students in connecting the terms reactants and products with the positions of substances in chemical reaction equations. Kr and Ys demonstrated the use of this relationship during the practice and evaluation stages (Figure 2). This pattern was consistent with their post-test responses, in which both correctly identified Mg and S as reactants.

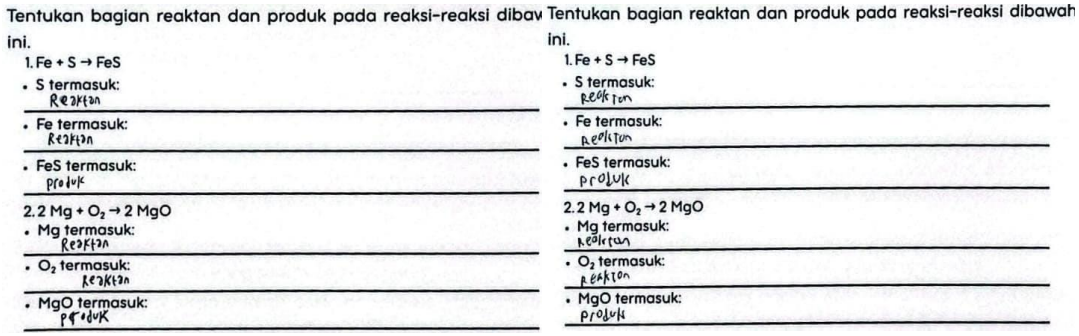



**Figure 2.** Responses of Kr (left) and Ys (right) at the practice and evaluation stages of the SHCRT-based Student Activity Worksheet in identifying reactants and products.

Kr's responses on the Student Activity Worksheet showed a shift from identifying substances by name to identifying their roles as reactants and products. This change was subsequently reflected in the post-test, where Kr correctly identified Mg and S as reactants. Ys also demonstrated development from an initial response that did not appropriately identify the roles of substances to a correct identification of reactants and products after the learning process. These changes suggest that the scaffolding provided by examples and guided practice may have helped students connect the structural positions of substances in an equation to the conceptual terms "reactant" and "product."

The provision of scaffolding in learning materials can help students practice using concepts gradually through problems arranged from simple to complex levels (Fajriani et al., 2021). At this stage, development did not occur uniformly. Some students were able to determine the positions of reactants and products, whereas others still demonstrated errors. This condition indicates that the presentation of concepts alone did not immediately lead to stable understanding and that students required opportunities to apply the concepts through practice. This finding is consistent with Minshall and Yezierski (2021), who showed that students may still experience difficulties in developing conceptual understanding after participating in learning activities, indicating the need for additional scaffolding through more targeted questions to help students establish relationships between concepts.

Changes in students' ability to interpret states of matter were examined using the second item. During the SHCRT-based Student Activity Worksheet activities, students were provided with examples combining chemical formulas, reaction arrows, and states of matter. These representations enabled students to observe that chemical reaction equations contain information not only about the substances involved in a reaction but also about their physical states.

**Table 5.** Comparison of students' responses on the pre-test and post-test in identifying reactants and products in the equation $H_2(g) + Cl_2(g) \rightarrow HCl(g)$.

| Name of student | Result of Pre-test | Result of Post-test |
|---|---|---|
| Ar | a. The reactants are $H_2$ and $Cl_2$ | a. The reactants are $H_2$ and $Cl_2$ |
| | b. The product is HCl | b. The product is HCl |
| | c. State of matter is Gas(g) | c. State of matter is Gas(g) |
| Kr | a. The reactants are H and Cl | a. The reactants are $H_2$ and $Cl_2$ |
| | b. The product is HCl | b. The product is HCl |
| | c. The state of matter is Gas(g) | c. State of matter is Gas(g) |
| Ys | a. The Reactants are $H_2$ | a. The reactants are $H_2$ and $Cl_2$ |
| | b. The product is $Cl_2$ | b. The product is HCl |
| | c. States of matter are not answered | c. State of matter is $H_2 + Cl_2 \rightarrow HCl$ |
| Mz | a. The reactants are $H_2$ and $Cl_2$ | a. The reactants are $H_2$ and $Cl_2$ |
| | b. The product is HCl | b. The product is HCl |
| | c. The state of matter is not answered | c. State of matter is Gas(g) |

The comparison in Table 5 shows differences in students' responses between the pre-test and post-test when identifying reactants, products, and states of matter. Kr changed from identifying H and Cl to correctly identifying $H_2$ and $Cl_2$. In contrast, Ys changed from identifying only $H_2$ as the reactant and $Cl_2$ as the product to correctly identifying $H_2$ and $Cl_2$ as reactants and HCl as the product. During the Student Activity Worksheet activities, the students were repeatedly exposed to examples that connected chemical formulas to their positions in equations and their state symbols. This representation allowed students to examine several types of information simultaneously while still receiving contextual support from the examples.

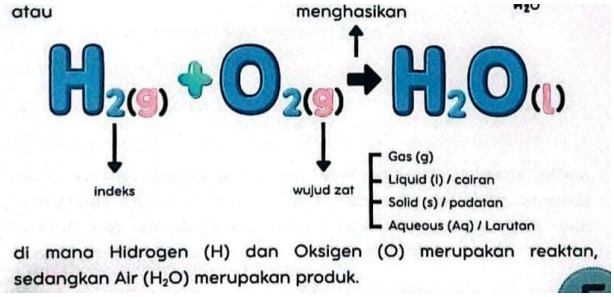
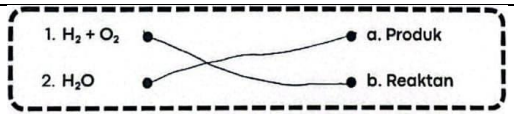
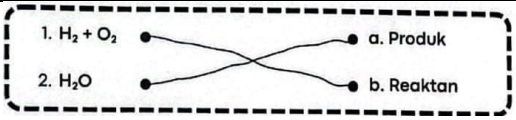
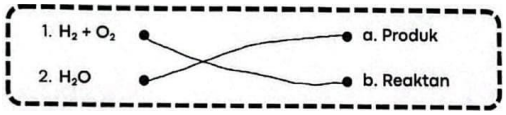
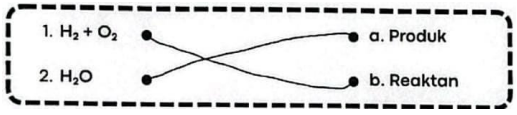



**Figure 3.** Scaffolding through examples of chemical reaction equations and representations of states of matter in the SHCRT-based Student Activity Worksheet.

The students' responses suggest that the scaffolding was more effective in supporting recognition of reactants and products than in supporting the integration of multiple symbolic representations. For example, Kr was able to explain the relationship between a substance's position and its role as a reactant or product, and could mention several states of matter that had been learned. Ys was also able to identify $H_2$ and $O_2$ as examples of reactants and $H_2O$ as a product. However, Ys did not explicitly state "gas" when asked about the state of matter; instead, they reproduced the chemical equation. This response suggests that although he had developed the ability to identify the substances involved in the reaction, his interpretation of the additional symbolic information was not yet fully stable. Therefore, the findings suggest that the SHCRT-based scaffolding may have helped students establish the basic relationships among chemical formulas, reaction positions, and reactant-product roles. At the same time, interpreting multiple symbolic representations simultaneously remained challenging for some students.

The third item examined the application of reactant and product concepts. The Student Activity Worksheet activities provided opportunities for students to apply the concepts introduced through examples and guided practice.

**Table 6.** Examples of the responses of slow learner student Ys (left) and regular student Mz (right) on the pre-test and post-test for the application of reactant and product concepts

| Name of student | Result of pre-test | Result of post-test |
|---|---|---|
| Ys |  |  |
| Mz |  |  |

The comparison of the responses needs to take into account the students' initial conditions. When students provided a correct response on both the pre-test and post-test, the change was interpreted as reinforcement or maintenance of understanding. Therefore, the contribution of the Student Activity Worksheet was not necessarily reflected by a change from an incorrect response to a correct response, but could also be reflected in the reinforcement and consolidation of previously acquired understanding.

The fourth item involved a higher cognitive demand because students were required to evaluate and reconstruct an incorrectly written chemical reaction equation. The task required students to use the relationship between reactants and products to evaluate the chemical representation.

**Table 7.** Comparison of students' responses on the pre-test and post-test in evaluating and constructing chemical reaction equations.

| Name of student | Result of pre-test | Result of post-test |
|---|---|---|
| Ar | $C(s) + CO_2(g) \rightarrow O_2(g)$ | $C(s) + O_2(g) \rightarrow CO_2(g)$ |
| Kr | When C reacts with O, it produces a compound CO | $C(s) + O_2(g) \rightarrow CO_2(g)$ |
| Ys | $C(s) \rightarrow O_2(g) + CO_2(g)$ | $C(s) \rightarrow O_2(g) + CO_2(g)$ |
| Mz | That is right, because it is a combination of two compounds | That is right, because it corresponds to the compound |

The comparison showed that the transfer of conceptual understanding to the evaluation task was less consistent than the identification of reactants and products. The clearest change was observed in Kr, who was able to use the relationship between the positions of substances and their roles to correct the equation into $C(s) + O_2(g) \rightarrow CO_2(g)$. Ar also correctly completed the evaluation task in the post-test. Because his initial response did not correctly reconstruct the equation, this change can be interpreted as a development in his ability to apply the reactant-product relationship to an evaluation task. In contrast, Ys and Mz continued to demonstrate difficulties. Ys maintained the incorrect arrangement of the substances, while Mz continued to judge the incorrect equation as acceptable. These responses indicate that the ability to recognize reactants and products did not automatically transfer to the evaluation and reconstruction of a complete chemical equation.

Overall, the findings indicate that the SHCRT-based Student Activity Worksheet may have supported students' conceptual understanding, particularly in identifying reactants and products. However, the transfer of this understanding to tasks involving multiple symbolic representations and higher-order evaluation was less consistent.

**Students Responses and Interview Findings**

The interview findings provided additional information regarding students' experiences during the implementation of the SHCRT-based Student Activity Worksheet and helped clarify the changes observed in their written responses. Kr stated that the material became easier to remember after the learning process and

that the examples of reactants and products helped his understanding. This response was consistent with his development from initially having difficulty using the concepts of reactants and products to subsequently identifying their roles in several chemical equations.

Ys stated that the examples of reactants and products were very helpful in understanding the material. After the learning process, he was able to provide $H_2$ and $O_2$ as reactants and $H_2O$ as the product. However, he also stated that he somewhat forgot the material when asked to summarize the overall learning. This suggests that his ability to apply the concept to examples had developed, although his ability to independently articulate the concept was not yet fully stable.

Ar stated that the instructions in the Student Activity Worksheet helped him complete the tasks and that his initial difficulties decreased after using it. Mz also considered the instructions clear and the Student Activity Worksheet presentation easy to read and interesting. These responses indicate that the structured instructions and presentation of the Student Activity Worksheet supported students in completing the learning activities.

The interview findings also showed that correct written answers did not always indicate fully internalized conceptual understanding. Ys was able to provide examples of reactants and products, but still had difficulty summarizing the overall learning. Similarly, Mz demonstrated improvement in written responses but remained inconsistent when explaining the positions of reactants and products verbally. Therefore, the interview data complemented the written responses by providing information about students' reasoning and the stability of their conceptual understanding.

## DISCUSSION

When the four items are analyzed as a whole, the development of students' conceptual understanding of chemical reaction equations appears to be gradual and non-uniform across individuals. The ability to identify reactants and products was the aspect that developed most readily. After receiving examples, instructions, and practice, students demonstrated a more consistent ability to determine substances before and after the arrow. In contrast, when the task demands increased to integrating symbolic information or evaluating and reconstructing chemical reaction equations, the level of success became more varied. This condition indicates that increasing task demands from information recognition to the integration of chemical representations can create greater difficulties for students. This finding is consistent with Moju et al. (2025), who reported that students still experienced difficulties in connecting macroscopic, symbolic, and submicroscopic representations when understanding chemical concepts, including chemical equations.

The pattern of development suggests that the scaffolding provided through the Student Activity Worksheet was more readily utilized for relatively explicit conceptual relationships than for tasks requiring the integration and transfer of several representations. The assistance was provided through phenomena, pictures, conceptual explanations, examples, instructions, exercises, and evaluations. These components provided students with a sequence from concrete or familiar representations toward more symbolic tasks. However, the findings also indicate that the presence of scaffolding did not automatically result in consistent understanding across all levels of conceptual demand. Students could use the provided examples and instructions to complete less complex tasks. At the same time, greater difficulty emerged when they were required to interpret relationships independently or evaluate a chemical reaction equation. Thus, the scaffolding served as a bridge between students' initial abilities and the task demands, but its contribution was not equally effective across all types of conceptual processing.

This pattern is also reflected in the students' interview responses. Ys reported that the images of burning wood and rusting iron helped him recall the concept of chemical reactions. In contrast, the examples of reactants and products "*membantu banget*" ("helped a lot") in understanding the material. Similarly, Kr stated that the images and phenomena helped him remember the previously learned material and that the examples of reactants and products helped him understand the topic. These responses suggest that the visual

phenomena and examples served as accessible entry points to connect familiar or previously learned information with the symbolic concepts of reactants and products.

The interview findings provide more nuanced evidence of how the SHCRT-based Student Activity Worksheet supported students' learning. Rather than merely indicating that students perceived the Student Activity Worksheet as easy or interesting, their responses suggest that different components served distinct supportive functions. Ys reported that the instructions were clear and easy to understand, and that the images and presentation were interesting. These responses indicate that the instructions provided procedural support for navigating the learning activities, whereas the visual representations provided representational support for accessing previously learned concepts.

Similar patterns were observed among the other students. Mz described the Student Activity Worksheet as very helpful, reported that the instructions were very clear, and considered the writing and visual design easy to read and interesting. Ar also stated that the instructions helped him complete the tasks and that the images helped him recall previously learned material. The consistency of these responses among the four students suggests that the Student Activity Worksheet's accessibility was attributable not to a single component but to the combination of concise instructions, visual representations, and structured activities.

The examples provided in the Student Activity Worksheet also appeared to play an important role in supporting students' initial conceptual construction. Ys explicitly stated that the examples of reactants and products were very helpful, while Kr reported that the examples supported his understanding of the material. This indicates that worked examples may have reduced the initial conceptual demands by providing students with an observable model of how substances are classified as reactants or products. Such support is consistent with the SHCRT sequence, in which students are not immediately required to construct responses independently but are first provided with conceptual explanations and examples before progressing to exercises and evaluation.

Nevertheless, the findings indicate that a correct answer does not always correspond to a fully internalized understanding. Ys provides a clear example of this distinction. Although he reported that the material was easy to understand and the examples were very helpful, he had difficulty summarizing what he learned when asked. He stated that he had "*agak-agak lupa*" ("somewhat forgotten") the material. When the question was narrowed to a specific conceptual relationship, however, he was able to identify $H_2$ and $O_2$ as reactants and $H_2O$ as the product. This contrast suggests that the scaffolding was sufficient to support the retrieval of specific conceptual relationships within a familiar context, but was less sufficient for independent summarization and broader organization of the concept. In other words, Ys ability to identify specific examples did not necessarily indicate that the concept had been fully organized into a stable and independently retrievable conceptual structure.

A similar pattern was observed, Mz. Although he perceived the Student Activity Worksheet as very helpful and the instructions as very clear, his verbal explanation of the positions of reactants and products initially showed inconsistency before he corrected the position of the product. This discrepancy is important because it shows that perceived clarity of instructional materials and successful engagement with the tasks do not necessarily indicate that the underlying conceptual relationship has become fully stable. Kr also demonstrated a more basic level of conceptual explanation. He was able to state that reactants were positioned on the left and products on the right, and could mention states of matter. However, his final response indicated that there were still "*beberapa hal*" ("several things") that needed to be understood. This suggests that his understanding had developed at the level of identifying key components of a chemical reaction equation but had not necessarily extended to a comprehensive explanation of the concept.

These findings demonstrate the importance of integrating process data and interview data when assessing the development of conceptual understanding. They indicate that assessing conceptual understanding should not rely solely on answer accuracy but should also consider students' reasoning and ability to explain relationships between concepts. This finding is consistent with Sidauruk et al. (2026), who showed that correct answers in chemistry assessments do not always reflect adequate conceptual

understanding, as students may obtain them without appropriate conceptual reasoning. Therefore, the assessment of conceptual understanding needs to consider not only the final answer but also the reasoning process underlying the response.

Although the SHCRT-based Student Activity Worksheet provided gradual assistance, the findings also reveal limitations in its capacity to resolve all forms of conceptual inconsistency. The main limitation was not the absence of scaffolding, but the fact that the provided scaffolding did not always result in a stable understanding that could be independently explained or transferred to a different task context.

First, the scaffolding appeared more supportive when students were required to recognize explicit conceptual relationships, such as distinguishing reactants from products. However, its contribution was less sufficient when students were required to summarize concepts, integrate symbolic information, explain relationships verbally, or evaluate and reconstruct chemical reaction equations. Ys difficulty in summarizing despite being able to identify specific reactants and products illustrates this limitation. Thus, the progression from recognition toward conceptual integration was not equally successful for all students.

Second, the findings suggest that scaffolding can support performance within the learning sequence without necessarily guaranteeing retention or independent transfer. Ys reported that he had previously learned the material but had forgotten some of it, and that the Student Activity Worksheet helped him understand it again. This indicates that the Student Activity Worksheet may have supported the reconstruction or retrieval of prior knowledge. However, the interview evidence does not demonstrate that the knowledge had become fully stable after the learning activity.

Third, the same structured scaffolding did not produce identical patterns of understanding among students. Mz, for example, still showed a momentary inconsistency when verbally identifying the positions of reactants and products, even though he considered the instructions very clear. Ar, in contrast, reported that his initial difficulty decreased after reading and following the Student Activity Worksheet. These differences indicate that students may require different levels or forms of support even when they receive the same structured learning sequence. Therefore, SHCRT should be understood as a structured scaffolding framework rather than as an automatically individualized mechanism that can resolve every student's conceptual difficulty.

Fourth, the findings suggest that higher-demand conceptual tasks may require additional forms of scaffolding beyond examples and procedural instructions. Students may need more explicit prompts that require them to explain relationships, justify their answers, summarize concepts, compare representations, and apply concepts to unfamiliar chemical reaction equations. Such additional support may be necessary to facilitate the transition from supported performance toward independent conceptual reasoning.

These limitations do not negate SHCRT's contribution. Rather, they clarify the conditions under which its contribution should be interpreted. The strategy appears useful for structuring students' progression from supported recognition to more independent responses. However, the transition to stable conceptual understanding, explanation, and transfer may require repeated practice and differentiated scaffolding. Therefore, the findings support a process-oriented interpretation of SHCRT: scaffolding can initiate and strengthen conceptual development, but it does not automatically produce conceptual mastery across all levels of task demand.

The comparison between slow learners and regular students also indicates that differences in development cannot be explained solely by these categories. Kr and Ys, as slow-learning students, demonstrated development after receiving scaffolding, although the levels of consistency and the ability to transfer concepts differed between them. Among the regular students, Mz also showed signs of misconceptions at the initial stage, whereas Ar had relatively good initial ability but still required assistance with higher-demand tasks. The interview findings reinforce this interpretation. Ys, despite reporting that the Student Activity Worksheet was easy to understand, they still experienced difficulty summarizing the learning independently. Meanwhile, Mz, who also perceived the Student Activity Worksheet as clear and helpful,

showed a momentary inconsistency when explaining the positions of reactants and products. These patterns demonstrate that conceptual inconsistency was not exclusive to slow learners.

Thus, the more apparent differences were not merely between slow learners and regular students but also involved initial ability, types of errors, task complexity, and the level of assistance required by each student. When provided with appropriate scaffolding, students who are slow learners were able to demonstrate development and produce responses comparable to those of regular students on certain tasks. This finding suggests that instructional support should be determined not solely by learner classification but also by students' demonstrated conceptual needs during learning.

Overall, this study shows that the Student Activity Worksheet using the SHCRT strategy supported the development of conceptual understanding of chemical reaction equations through a gradual process. The changes were observed beginning with recognizing reactants and products, followed by connecting the positions of substances to their roles, interpreting symbolic information, and using concepts to evaluate chemical reaction equations. However, the level of development varied among students. The combined evidence from students' written responses and interviews provides a more detailed interpretation of this development. The interviews indicate that phenomena and images helped students recall or access chemical reaction concepts, examples supported the identification of reactants and products, and instructions facilitated students' engagement with the learning tasks. At the same time, the interviews revealed that these supports did not always lead to stable conceptual organization, as evidenced by difficulties with summarizing and occasional inconsistencies in explaining conceptual relationships. Therefore, the success of scaffolding is more appropriately understood as a process of progressively constructing and strengthening understanding rather than as an intervention that directly produces conceptual mastery across all aspects. The contribution of SHCRT lies in providing a structured pathway through which students can move from supported recognition toward increasingly independent conceptual responses. Nevertheless, the findings demonstrate that this progression is neither linear nor uniform, and that higher-level conceptual integration, retention, verbal explanation, and transfer may require additional, differentiated scaffolding.

This interpretation is particularly important for inclusive chemistry learning because students who receive the same instructional material may not respond to scaffolding in the same way. The findings, therefore, suggest that the SHCRT-based Student Activity Worksheet should be implemented flexibly, with opportunities for additional explanation, repeated practice, and more explicit prompts when students demonstrate persistent conceptual inconsistency.

## CONCLUSION

The findings indicate that the use of the Learner Activity Worksheet incorporating the Scaffolded Handwritten Constructed-Response Tasks (SHCRT) strategy supported the gradual development of students' conceptual understanding of chemical reaction equations. The most apparent development occurred in identifying reactants and products and relating their positions to their roles in chemical equations. Students also demonstrated progress in interpreting symbolic information and applying conceptual understanding to evaluate and reconstruct chemical reaction equations, although these higher-level abilities were less consistent across individuals. These higher-level abilities were particularly inconsistent when tasks required integrating multiple symbolic representations and higher-order reasoning. The findings further demonstrate that the contribution of SHCRT-based scaffolding was not limited to correcting students' answers but also involved reinforcing prior knowledge, guiding students to establish conceptual relationships, and supporting the gradual development of more independent conceptual responses. However, conceptual development varied according to students' initial understanding, types of errors, and task demands. Therefore, scaffolding should be provided progressively and adjusted to individual needs, particularly when students demonstrate persistent difficulties in integrating multiple symbolic representations or performing higher-order conceptual tasks. Theoretically, these findings highlight the importance of viewing scaffolding as a process-oriented mechanism in which conceptual development is examined through students' responses, reasoning, and

progression across learning stages rather than through answer accuracy alone. Practically, chemistry teachers in inclusive classrooms can use the SHCRT-based Student Activity Worksheet to provide structured support while adjusting prompts, explanations, and opportunities for repeated practice according to students' demonstrated conceptual difficulties. A teacher can also provide progressive prompts, connect students' prior knowledge with symbolic representations, and gradually reduce assistance as students demonstrate greater conceptual independence. Overall, the SHCRT-based Student Activity Worksheet can serve as an alternative instructional support for facilitating conceptual understanding of chemical reaction equations in inclusive chemistry learning, including for slow learners. Nevertheless, the findings from this small-scale qualitative study should be interpreted as evidence of the learning process rather than as a generalized measure of intervention effectiveness. Further research involving more participants and longer implementation is needed to examine the consistency of conceptual development and the effectiveness of the SHCRT-based Student Activity Worksheet across diverse learner characteristics and chemistry topics.

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