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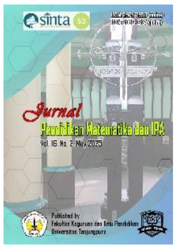

PROFILE OF HIGH SCHOOL STUDENTS' UNDERSTANDING IN SOLVING STOICHIOMETRY PROBLEMS IN TERMS OF MULTIPLE INTELLIGENCES

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Abstract

Understanding the concept of mole in chemistry learning is an important aspect in supporting student learning success, especially in stoichiometry material which is abstract and complex. This research aims to explore the profile of students' conceptual understanding of stoichiometry based on the dominance of multiple intelligences. The study employed a descriptive qualitative approach with 36 students of class XI-F4 at SMAN 1 Darul Imarah. Data were collected through a multiple intelligence questionnaire, concept understanding test, and semi-structured interview. Data analysis consisted of data presentation and data verification, conducted by comparing students' test results with interview responses to ensure consistency of understanding indicators. The results showed that students with linguistic, intrapersonal, and interpersonal intelligence understood all indicators of understanding, such as defining concepts, interpreting meanings, identifying concept features, and comparing relevant concepts. Students with logical-mathematical and musical intelligences were able to understand most indicators but had difficulty in differentiating concepts. Students with spatial, naturalistic, and existential intelligences excelled in concept identification and comparison but lacked in verbal definition. Students with kinesthetic intelligence mastered only basic indicators. This finding confirms that intelligence variation plays an important role in understanding chemical concepts. Teachers are expected to design learning that is adaptive to students' intelligence profiles to improve learning quality.

Keywords: Chemistry, Multiple Intelligences, Stoichiometry

INTRODUCTION

Stoichiometry is one of the central concepts in chemistry learning that explains the quantitative relationships between substances in chemical reactions. Mastery of this material requires both conceptual and procedural understanding, particularly

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in molar mass calculations, the law of conservation of mass, and mole relationships among substances. However, many students face difficulties in solving stoichiometric problems due to weak mathematical reasoning and limited ability to interpret chemical symbols quantitatively. According to students' errors often arise from their inability to connect symbolic representations with numerical meaning, affecting the accuracy of their calculations [1]. These challenges are closely related to low mathematical literacy, indicating that students' conceptual and computational struggles in chemistry cannot be separated from their mathematical abilities [2]. Therefore, research that integrates mathematical reasoning into chemistry learning is needed to help students bridge symbolic, quantitative, and conceptual understanding. In the context of 21st-century learning and the implementation of the independent curriculum, differentiated instruction has become increasingly essential. Teachers are required not only to master subject content but also to understand students' individual characteristics and learning preferences to create adaptive learning experiences.

This approach aligns with the four essential competencies of 21st-century education—critical thinking, creativity, collaboration, and communication [3]. Visual and technology-based strategies, such as STEM approaches using GeoGebra, have been proven to enhance mathematical representation skills and can also support visualization of abstract chemistry concepts like moles and reactions [4].

The theory of Multiple Intelligences developed provides a framework for recognizing diverse types of student intelligence—linguistic, logical-mathematical, visual-spatial, kinesthetic, musical, intrapersonal, interpersonal, naturalistic, and existential—which influence how students process information and solve problems [5]. Studies show that students with visual-spatial and logical-mathematical intelligence demonstrate stronger conceptual understanding when learning materials are presented through diagrams and problem-based contexts ([6]; [7]). However, most stoichiometry research still focuses on general cognitive skills without considering the diversity of intelligence profiles [8]. By exploring the role of multiple intelligences, this study addresses the mathematical and conceptual barriers students face, offering a more adaptive learning perspective for chemistry education.

This study aims to identify students' profiles of conceptual understanding in solving stoichiometry problems based on their dominant intelligence types. Understanding how different intelligences contribute to learning will provide practical insights for designing more inclusive chemistry instruction.

The expected impact of this research is to enhance the quality of chemistry learning by encouraging teachers to develop strategies that accommodate variations in students' intelligences and improve their ability to connect mathematical reasoning with chemical understanding.

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METHOD

This research uses a descriptive qualitative approach that aims to describe in depth the profile of high school students' understanding in solving stoichiometry problems. This approach was chosen because it aligns with the exploratory nature of the study, which seeks to understand the phenomenon contextually from the point of view of the research subjects.

The subjects in this study were class XI students of SMAN 1 Darul Imarah in the even semester. The subject selection technique used in this research followed the purposive sampling method based on consideration [9]. The selection of class XI-F4 was based on recommendations from the chemistry teacher at the school, considering that this class has a heterogeneous academic composition, demonstrates active participation in chemistry learning, and had completed the stoichiometry material during the even semester, making it the most suitable representation for the study.

The instruments used in this research were: (1) a multiple intelligences questionnaire, (2) stoichiometry comprehension test items focusing on the mole concept, and (3) a semi-structured interview guide. The multiple intelligences questionnaire was used to identify the dominant types of intelligences possessed by students. It consisted of 54 statements covering indicators for each type of intelligence, using a 4-point Likert scale ranging from 1 to 4.

The second instrument, the mole concept comprehension test, consisted of 10 multiple-choice questions assessing various aspects of conceptual understanding, including mole ratio, the law of conservation of mass, and mol-gram unit conversions. These questions were validated by two Chemistry Education lecturers from Syiah Kuala University to assess content and construct validity. The validation ensured that the questions met the required standards and were appropriate for measuring students' conceptual understanding.

Reliability testing was conducted using the Inter-Rater Agreement (IRA) method by calculating the Kappa coefficient, which yielded a value of 72.7%**,** categorized as strong reliability. This result indicates a high level of agreement between expert validators, confirming that the instrument is both reliable and valid for consistent measurement.

The third instrument, the interview guide, consisted of six main questions, with each interview lasting approximately 5–10 minutes per student. The questions were semi-structured and allowed flexibility to explore students' responses in depth. Interview subjects were selected based on the highest scores on the mole concept comprehension test among representatives of the nine multiple intelligences categories.

The data analysis techniques used were data presentation and data verification. In the data presentation stage, student groupings were displayed based on dominant multiple intelligences, followed by the presentation of results from the mole concept comprehension test and interviews. The data verification stage involved comparing the results of the comprehension test with interview responses and questionnaire results to ensure consistency and accuracy of

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students' conceptual understanding according to the measured indicators.

RESULT AND DISCUSSION

Based on the data analysis of students' responses to the comprehension test and the results of interviews with nine research subjects, a detailed recapitulation of students' understanding in solving stoichiometry comprehension problems on the concept of mole is presented in Table 1. The interpretation of the data was verified for consistency between the written test and interview results. The four indicators of chemical understanding analyzed in this study include:

(1) the ability to define concepts verbally,
(2) the ability to recognize the meaning and interpretation of concepts, (3) the ability to identify the properties and conditions of a concept, and (4) the ability to compare and contrast related concepts.

Table 1. Recapitulation of Student

MI	Subject	Understanding Indicators			
		1	2	3	4
M1	S15	✓	✓	✓	✓
M2	S11	✓	×	✓	×
M3	S18	✓	✓	✓	×
M4	S13	✓	✓	✓	✓
M5	S9	✓	✓	×	×
M6	S3	✓	✓	✓	✓
M7	S14	✓	✓	✓	✓
M8	S8	✓	✓	✓	✓
M9	S4	×	✓	✓	✓

.

In general, students with linguistic (M1), spatial (M4), intrapersonal (M6), interpersonal (M7), and naturalistic (M8) intelligences demonstrated mastery of all four comprehension indicators, reflecting an integrated understanding between conceptual definition, interpretation, and application. On the other hand, students with musical (M2), kinesthetic (M5), and logical–mathematical (M3) intelligences only fulfilled two to three indicators, particularly showing limitations in comparing or differentiating chemical concepts.

Meanwhile, the student with existential intelligence (M9) displayed adequate understanding of interpretation and comparison but was less able to define the concept of mole verbally. This global pattern indicates that the type of dominant intelligence significantly influences students' approaches to conceptual understanding. The consistency between written and oral responses during interviews reinforces the accuracy of these categorizations, showing that interpretation of data aligns with both comprehension test outcomes and interview transcripts.

1. Linguistic Intelligence (S15)
The linguistic intelligence subject demonstrated full mastery of all four indicators. During interviews, the student was able to verbally define the mole concept, describe its relationship with mass, particle number, and gas volume at STP, and differentiate

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between the mole in theoretical and practical contexts. The student also expressed the relationships between concepts in a coherent scientific narrative, indicating strong verbal reasoning. This finding aligns with who stated that linguistic intelligence supports the ability to reformulate scientific ideas effectively through words [10]. The student's detailed verbal explanations further indicate high metalinguistic awareness, allowing efficient transfer of conceptual knowledge into scientific language.

2. Musical Intelligence (S11). The student with musical intelligence fulfilled only two indicators defining concepts verbally and identifying conceptual properties but struggled with deeper interpretation and differentiation. During interviews, the student tended to associate chemical reactions with patterns or rhythms, reflecting a rhythmic cognitive style rather than analytical reasoning. According to rhythm-based learning aids in memorization but requires contextual support for deeper conceptualization [11]. The subject's understanding of the mole was limited to procedural recall, suggesting that musical intelligence must be supplemented by pattern-based visualization or mnemonic learning to enhance abstract comprehension.

3. Logical–Mathematical Intelligence (S18). This subject performed strongly in the first three indicators but had difficulty distinguishing between related chemical laws, such as conservation of mass and mole ratio. The student could calculate and interpret data accurately but lacked explanation beyond the numerical level. This supports who found that logical–mathematical intelligence enhances computational accuracy but not necessarily conceptual generalization [12]. The student's reasoning emphasized quantitative precision, showing a strong ability to apply formulas but limited capacity to articulate theoretical distinctions, a pattern typical of learners favoring deductive over reflective thinking.

4. Spatial Intelligence (S13). The spatial intelligence subject demonstrated a clear ability to visualize chemical quantities through diagrams and concept maps. When solving problems, the student translated verbal information into symbolic and graphical representations before computing answers.
This visual translation aids comprehension and confirm who found that three-dimensional visualization and augmented reality enhance learning of abstract chemistry concepts [13]. Such learners tend to construct mental imagery to connect microscopic and macroscopic chemical representations, leading to stronger holistic understanding.

5. Kinesthetic Intelligence (S9). The student with kinesthetic intelligence succeeded in defining and recognizing concepts but failed to identify and compare them. Interview responses revealed a preference for learning through action or physical analogy (e.g., "imagining moving atoms") rather than symbolic reasoning. According to kinesthetic learners grasp concepts better through movement or hands-on tasks but struggle with purely abstract representations [14]. This subject's answers were concise and procedural, reflecting reliance on intuition and

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motion-based imagery rather than formal reasoning.

6. Intrapersonal Intelligence (S3). The intrapersonal intelligence subject achieved full mastery across all indicators. This student showed strong self-reflection during problem-solving, regularly checking answers and identifying calculation errors independently.

Such behavior demonstrates high metacognitive awareness**,** enabling the student to regulate thought processes effectively. Emphasize that intrapersonal intelligence supports self-monitoring, emotional regulation, and analytical persistence, all of which were visible during interviews [15].

7. Interpersonal Intelligence (S14). The student with interpersonal intelligence displayed mastery of all indicators and showed high engagement in discussing alternative solutions during interviews. The subject often articulated reasoning in dialogue form, showing conceptual understanding reinforced through social explanation. This support who found that collaborative discussion enhances comprehension for interpersonal learners because sharing ideas and feedback strengthens conceptual retention and correction of misconceptions [16].

8. Naturalistic Intelligence (S8). The naturalistic intelligence subject exhibited comprehensive understanding and mastery of all indicators. The student related the mole concept to natural phenomena such as the conservation of matter in biological cycles, indicating contextual integration between chemistry and environment. This finding agrees with who highlighted that naturalistic learners prefer learning grounded in real contexts [17]. Their cognitive strength lies in identifying relationships between observable phenomena, which enhances interpretive and comparative reasoning.

9. Existential Intelligence (S4). The student with existential intelligence performed well in interpretation, identification, and comparison but struggled with verbal definition. Interview transcripts show that the student focused on the underlying meaning of chemical laws and their philosophical implications, rather than memorizing formal definitions. This finding resonates with who noted that existential learners possess a strong ability to conceptualize essence and meaning but often neglect terminological accuracy [11]. In this case, the subject's abstract reasoning aids comprehension but limits precise verbal articulation.

Overall, data triangulation between tests and interviews confirmed that interpretation of data was consistent and credible. The results indicate that each type of intelligence contributes uniquely to the understanding of the mole concept. (1) Verbal intelligences (linguistic and interpersonal) excel in explanation and articulation. (2) Analytical intelligences (logical–mathematical and intrapersonal) dominate in interpretation and evaluation. (3) Visual and contextual intelligences (spatial and naturalistic) facilitate concept linking and application. (4) Meanwhile, rhythmic (musical), physical (kinesthetic), and philosophical (existential) intelligences need targeted pedagogical adaptation to reach balanced conceptual mastery.

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These findings suggest that chemistry instruction should integrate differentiated learning strategies to accommodate students' dominant intelligences using visual aids, collaborative problem-solving, reflective exercises, and contextual experiments to promote more holistic conceptual understanding.

CONCLUSIONS

Based on the results of data analysis and discussion, it can be concluded that the profile of students' concept understanding in solving stoichiometry problems on the material of the mole concept is different depending on the type of multiple intelligences that dominate each individual. Students with linguistic, intrapersonal, and interpersonal intelligence show a thorough understanding, characterized by mastery of the four indicators, namely defining concepts verbally, recognizing the meaning and interpretation of concepts, identifying properties and conditions of a concept, and comparing and contrasting concepts. Students with musical and logical-mathematical intelligence are able to understand the first three indicators, but are not yet optimal in distinguishing concepts.

Meanwhile, students with spatial, naturalistic, and existential intelligence show mastery of the last three indicators, but are not yet fully able to define concepts verbally. In contrast, students with kinesthetic intelligence only mastered the first two indicators, and still had difficulty in identifying and comparing concepts in depth.

This finding reinforces that students' understanding of chemistry concepts varies greatly, and is directly influenced by the dominance of the type of multiple intelligences they have. Therefore, a learning approach that takes into account the learning styles and intelligence potential of individual students is needed.
This study only analyzes and describes the ability to understand students' chemical concepts in terms of multiple intelligence on a small scale. Suggestions for future researchers are expected to be able to carry out on a larger scale with the type of case study research to find out more deeply about the understanding of chemical concepts in terms of multiple intelligence of students.

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