

# Beyond the Formula: Student Perceptions and Difficulties in Chemistry

Christina Mae B. Fontanilla<sup>1</sup>

<sup>1</sup>Student  
Graduate Studies  
Ilocos Sur Polytechnic State College

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**Abstract:** Chemistry is widely regarded as one of the most challenging subjects in science education due to its abstract nature and reliance on multiple representational levels. While traditional instruction often emphasizes formulas and equations, students' lived experiences reveal deeper struggles in transitioning toward conceptual understanding. This literature review synthesizes global and local studies on cognitive difficulties, representational challenges, affective factors, and phenomenological perspectives in Chemistry learning. Anchored on constructivist learning theory, Johnstone's Triangle, and phenomenology, the review highlights gaps in research, particularly in the Philippine context, where qualitative explorations of student experiences remain scarce. The study justifies the need to explore students' perceptions and difficulties to inform learner-centered strategies that move beyond rote memorization toward meaningful conceptual engagement.

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## I. INTRODUCTION

Chemistry is widely regarded as one of the most intellectually demanding subjects in the science curriculum due to its abstract nature and reliance on multiple levels of representation. According to the framework proposed by Johnstone, effective understanding of Chemistry requires learners to integrate three levels: macroscopic (observable phenomena), submicroscopic (particle interactions), and symbolic (chemical equations and formulas). However, classroom instruction often emphasizes the symbolic level, encouraging students to focus on solving equations and applying formulas rather than understanding the underlying concepts.

Recent studies (Taber, 2019; Talanquer, 2020) highlight that this imbalance leads to a phenomenon known as algorithmic learning, where students can correctly solve problems without conceptual understanding. While this may result in acceptable academic performance, it often creates a fragile knowledge structure that collapses when students encounter unfamiliar problems.

Furthermore, research indicates that students experience significant cognitive and emotional challenges in Chemistry. For instance, Villafaña et al. (2021) found that students frequently report confusion when transitioning from concrete observations to abstract symbolic representations. Similarly, studies by Galloway and Bretz (2020) reveal that affective

factors such as anxiety, frustration, and low self-efficacy significantly influence students' engagement and persistence in Chemistry.

In the Philippine educational context, most studies have focused on quantitative measures such as achievement scores and performance levels, with limited attention given to students' lived experiences. This creates a gap in understanding how students personally perceive and navigate the complexities of Chemistry learning.

Thus, this study, titled "Beyond the Formula: Student Perceptions and Difficulties in Chemistry," aims to explore the lived experiences of students as they move beyond memorization toward conceptual understanding. By focusing on students' narratives, this research seeks to uncover the essence of their struggles and learning processes.

## II. LITERATURE REVIEW

### ➤ *Cognitive Difficulties in Chemistry Learning*

Chemistry's abstract and multi-layered nature makes it cognitively demanding. Students often develop misconceptions when interpreting invisible processes through everyday reasoning (Taber, 2019). Reliance on algorithmic problem-solving leads to fragile knowledge structures (Talanquer, 2020). Cooper et al. (2019) and Bretz (2020) found that learners can solve numerical problems but fail to explain chemical processes, highlighting surface-level

learning. In the Philippines, Orleans (2007) and Magwilang (2016) observed that rote memorization dominates, resulting in poor retention and application. Recent reports (Balagtas et al., 2019; DepEd, 2022) confirm persistent weaknesses in conceptual understanding.

#### ➤ *Challenges in Multiple Representations*

Johnstone's Triangle (1991) emphasizes the integration of macroscopic, submicroscopic, and symbolic levels. However, students often fail to connect these representations, leading to fragmented understanding (Gilbert & Treagust, 2020). Sevan and Talanquer (2021) noted difficulties in translating symbolic equations into molecular-level explanations. Garcia (2020) found that Filipino students particularly struggle with submicroscopic representations, rarely emphasized in instruction. While interventions using simulations show promise (Ambarwati et al., 2021), their use remains limited in local classrooms.

#### ➤ *Affective Factors: Attitudes, Anxiety, and Perceptions*

Emotions significantly influence Chemistry learning. Anxiety, frustration, and low self-efficacy reduce engagement and achievement (Galloway & Bretz, 2020). Villafañe et al. (2021) reported that students perceive Chemistry as intimidating, discouraging participation. Negative attitudes correlate with poor performance (Salta & Tzougraki, 2004; Kan'an, 2018). In the Philippines, Alcantara & Bacsa (2017) and Domingo (2021) found that fear of Chemistry stems from abstract content and teacher-centered methods. DepEd (2023) highlighted low confidence in science subjects as a barrier to academic engagement.

#### ➤ *Teaching Approaches and Constructivist Learning*

Constructivist theory posits that meaningful learning occurs when students actively construct knowledge through interaction and prior knowledge (Piaget, 1970; Vygotsky, 1978). Student-centered approaches such as inquiry-based learning and simulations improve conceptual understanding (Redhana, 2019; Ambarwati et al., 2021). Lemke (2002) emphasized the role of discourse in science learning. In the Philippines, despite frameworks like Understanding by Design (DepEd, 2019), classrooms remain largely teacher-centered (Tan, 2020), perpetuating rote learning.

#### ➤ *Lived Experiences in Chemistry Learning*

Phenomenological studies reveal that students often describe Chemistry as a struggle between "following procedures" and "understanding concepts" (Bowen, 2020; Duda & Garrett, 2022). Learners report disconnection from abstract ideas, confusion in transitions, and reliance on memorization as coping strategies. In the Philippine context, qualitative research remains scarce. Reyes (2019) and Santos (2022) explored science learning experiences but did not focus specifically on Chemistry, underscoring the need for contextualized phenomenological inquiry.

### III. METHODOLOGY

The study employs a transcendental phenomenological design (Husserl, 1931), using bracketing to set aside researcher biases. Data will be collected through semi-

structured interviews with purposively selected students enrolled in Chemistry. The Stevick–Colaizzi–Keen method will guide analysis, involving horizontalization, clustering of themes, and synthesis of essence to capture the lived experiences of learners.

### IV. FINDINGS/RESULTS

Based on the literature, students' lived experiences in learning Chemistry are expected to reveal a strong reliance on memorization as a coping mechanism, particularly when faced with complex and abstract concepts. Learners often experience cognitive difficulties in connecting multiple representations, such as linking symbolic equations to macroscopic observations and submicroscopic processes, resulting in fragmented understanding. Alongside these challenges, students frequently encounter emotional barriers, including anxiety and frustration, which can hinder their engagement and persistence in the subject. Despite these struggles, students engage in meaning-making processes that shape how they interpret their experiences viewing them either as obstacles that discourage learning or as opportunities for growth and deeper understanding. Collectively, these insights underscore a persistent gap between theoretical frameworks and actual classroom practices, especially in the Philippine context, where instruction often remains focused on rote memorization rather than conceptual development.

### V. DISCUSSION

The literature confirms that Chemistry learning is shaped by cognitive, representational, and affective challenges. While global studies provide insights into these dimensions, local research remains limited and largely quantitative. This study addresses these gaps by exploring Filipino students' lived experiences, situating findings within constructivist learning theory, Johnstone's Triangle, and phenomenology. The results are expected to inform learner-centered strategies that move beyond formula-based instruction toward meaningful conceptual engagement.

### VI. CONCLUSION

Chemistry education faces persistent challenges rooted in cognitive demands, representational difficulties, and affective factors. While existing literature identifies these issues, few studies capture the subjective experiences of learners, particularly in the Philippine context. This study contributes to filling that gap by exploring how students perceive and make meaning of their struggles. By doing so, it supports the development of contextualized, learner-centered teaching strategies that foster deeper conceptual understanding and resilience in Chemistry learning.

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