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Beyond the Blackboard: A Deeper Look into Chemistry Teaching Experiences

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Abstract In this era of rapid technological advancement and complex global challenges, it is imperative that education adapts to foster the skills and competencies that are essential for success in the 21st century. Employing a phenomenological approach, this study focuses on the experiences of Senior High School Teachers in teaching and learning chemistry beyond the blackboard. This study sought to (1) investigate the challenges they are facing in teaching chemistry; (2) know the methods they do to ensure that their students are engaged while learning; and (3) know the topics in Chemistry they find challenging to teach. This study utilized a qualitative research study employing the descriptive phenomenology design, specifically, Colaizzi's method of descriptive phenomenological approach. Results revealed that teachers are challenged when it comes to instruction, resource, and curriculum management. To ensure that their students are engaged while learning chemistry, there should have interactive and engaging teaching strategies, as well as student participation and involvement. The topics in Chemistry which they find challenging to teach are chemical kinetics, thermochemistry, electrochemistry, and stoichiometry. It is recommended that training programs, workshops and/or seminars be provided to incapacitate teachers not only for the 21st century skills but for the 4.0 industrial revolution.

Keywords: *chemistry, teaching experiences, challenges, student engagement*

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1. Introduction

Education stands as the cornerstone of societal advancement, shaping the minds of future generations, and propelling innovation and growth. While the importance of effective education has been recognized for centuries, the methodologies and approaches employed in teaching continue to evolve, adapting to meet the changing needs of both students and society. In this era of rapid technological advancement and complex global challenges, it is imperative that education adapts to foster the skills and competencies that are essential for success in the 21st century.

Science education plays a pivotal role in preparing students to understand and address the pressing scientific and technological challenges of our time. Within the realm of science education, chemistry, often referred to as the "central science," [1] holds a key position in helping students develop critical thinking, problem-solving, and analytical skills. Grade 11, a crucial stage in the educational journey, represents a critical juncture where students make decisions about their educational and career paths. It is essential that they master not only the foundational principles of chemistry but also learn to apply them in a way that is relevant to their lives and the world around them.

According to the Philippine Program for International Student Assessment (PISA), science literacy where chemistry is a subcomponent, shows a relatively low number [2]. In comparison to the average score of 489, the Philippines only obtained 357 [3]. One of the major problems mentioned is the lack of innovative and engaging instructional approaches in the classroom that may stimulate students' interests in STEM (Science, Technology, Engineering, and Mathematics) education [4], [5]. Students find it challenging to relate abstract chemical concepts to concrete situations [6]. The study of learning experiences that include students in solving real, thought-provoking problems while collaborating with others and using their expertise, skills, and creativity to do so is also lacking. The fact that there are so few guidelines or models for creatively teaching chemistry in the classroom poses one of the most significant challenges for the field of chemistry education [7].

Literature review has yielded some topics in chemistry found to be difficult to teach and engage students and the possible approaches that can be used to address the challenge. Here are the examples:

1. Chemical bonding has been identified as one of the most challenging concepts for high school students to

grasp due to its complexity and the need to use abstract models to represent chemical bonds [8]. To address this difficulty, teachers can implement pedagogical strategies that focus on visual aids, hands-on activities, and real-life examples to help students better understand the underlying theory of chemical bonding.

2. Nuclear Chemistry poses significant challenges for high school students, requiring an understanding of radioactive decay, nuclear reactions, and isotopes [9]. Teachers may incorporate computer animations and simulations can provide interactive learning experiences that enhance students' comprehension of nuclear chemistry concepts.

3. The concept of hybridization is often considered one of the most difficult topics for chemistry students to grasp at all levels of learning [10]. To overcome this challenge, science teachers can employ visual aids, analogies, and hands-on activities to help students visualize and understand the concept of hybridization in chemical bonding.

4. Stoichiometry is a challenging topic for students as it involves complex calculations and understanding the relationships between reactants and products in chemical reactions [11]. Educators can utilize digital escape rooms, problem-solving activities, and formative assessments to engage students and reinforce their understanding of stoichiometry principles.

5. Understanding energy transformations in chemistry, including concepts like enthalpy, entropy, and Gibbs free energy, can be challenging for students transitioning from general chemistry to biochemistry [12]. To address this challenge, educators can focus on real-world applications, hands-on experiments, and case studies to help students relate energy concepts to practical scenarios and improve their comprehension.

Knowing that science teachers in the global scale faced difficulties in engaging students, it would be interesting to know about the chemistry teaching experiences of local teachers. Employing a phenomenological approach, this study focuses on the experiences of Senior High School Teachers in teaching and learning of chemistry beyond the blackboard. Highlighting their stories and capturing their perceptions would be a way of assessing the appropriate program, which may lead to sound interventions and improvement of the implementation. Hence, this research undertaking.

1.2. Research Question

This study sought to answer the following research questions:

(1). What are the challenges that teachers are facing in teaching chemistry?
(2). How do teachers ensure that their students are engaged while learning chemistry?
(3). What topics in Chemistry 2 do teachers find challenging to teach?

2. Research Methodology

2.1. Research Design

This study utilized a qualitative research study employing the descriptive phenomenology design, specifically, Colaizzi's method of descriptive phenomenological approach. This design is frequently used in social science research as a method for examining and describing experiences of individuals [13]. The qualitative data were collected through a semi-structured interview and focus-group discussion to conduct a needs assessment based on the experiences and perceptions of the teachers in chemistry classroom.

2.2. Research Instrument

This study used semi-structured interview questions validated by an expert. A semi-structured interview, according to Edwards and Holland [14], is a type of qualitative research approach that includes a predetermined list of open questions. As a result, new ideas might be expressed, and the interviewer can explore certain themes or responses deeper. Semi-structured interviews were used by this researcher to examine a framework of themes and provide participants the freedom to express themselves completely without being pressured to come to a particular understanding or conclusion about the notable experiences of teachers in chemistry learning in the classroom.

2.3. Data Gathering Procedure

In the conduct of this study, a written letter of permission was addressed to each qualified participant. They were then invited to participate in a focus group discussion through email with attached informed consent and interview protocol. Focus group are distinct kind of conferences that are designed to collect data from a saturation of five participants in a well-defined target population. A focus group's main objective was to encourage self-disclosure among its participants [15].

The researcher captured the participants' experiences in chemistry teaching and learning. Each discussion session lasted approximately 1 hour. It was then recorded and transcribed following the Colaizzi's method of descriptive phenomenological approach to generate themes.

2.4. Analysis of Data

After gathering the data, the transcriptions were analyzed based on the statements given by the participants in the recorded interview and focus group discussion. This study patterned the modified Colaizzi's phenomenological descriptive method [16], as shown in Figure 1.

To ensure that no aspect of the phenomena was overlooked, the process of refining was iterative [17]. The interviews were first transcribed and translated, and thoroughly read. The words, phrases, sentences, and meaningful units that exhibit patterns were then compared using a traditional content analysis method. Concepts were chosen, and subthemes were created and defined during open coding. To identify conceptual patterns, relationships between subthemes were also evaluated utilizing tables and diagrams. Line-by-line coding were used to formulate themes, which were then combined with sub-themes through constant concept comparison analysis. To ensure sufficient analysis and interpretation of the data, findings were discussed with a group of experts [18].

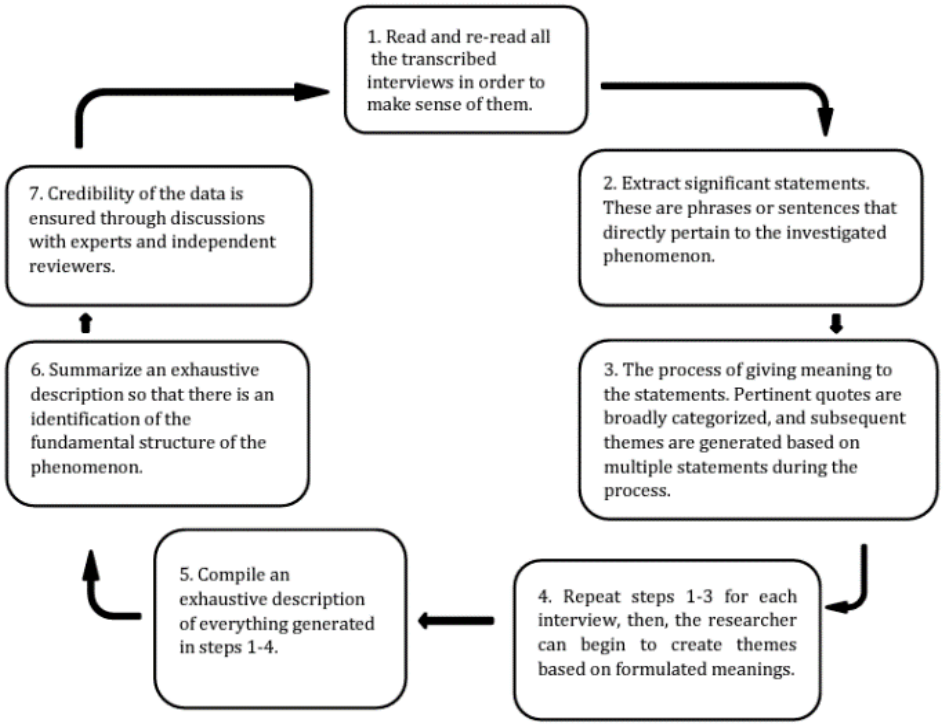

Figure 1. A modified Colaizzi's seven-step method

2.5. Ethical Considerations

The researcher adhered to the necessary regulations for issues like human rights, legal compliance, conflict of interest, safety and health standards, and others. Letters of permission and invitations were sent to the participants with attached informed consent. The researcher made sure that they had read the said form and signed their consent. To make sure the transcriptions' material is accurate, the participants were individually sent with a copy of transcriptions from the interviews that were recorded. The participants were informed that their answers and individuality remained anonymous, and the researcher acknowledged all authors who participated in this study.

3. Results and Discussion

This section presents the themes extracted from the transcript of the interviews. The transcripts were subjected to reduction, coding, and extraction of theme clusters before developing the emergent themes using the Colaizzi's method of analysis. The said emergent themes were associated with the experiences of teachers in chemistry learning.

Challenges of Teachers in teaching chemistry

There are two emergent themes that arose from the analysis of the significant statements generated from the transcribed interviews. The teachers were challenged when it comes to (a) instruction; and (b) resource and curriculum management.

Theme 1 (Instructional Challenges) had two clusters: time constraints, and prior knowledge and retention. Theme 2 (Resource and Curriculum Management), on the other hand, had four clusters: curriculum challenges, laboratory limitations, assessment pressure, and student engagement.

Theme 1. Instructional Challenges

The study participants shared the challenges they experienced during their chemistry classes. It was emphasized that one of the biggest challenges in teaching chemistry is the need to cover all the topics provided in the DepEd curriculum guide within the given time frame. They find it very hard to fit all the objectives and competencies into the limited semester time. These findings are drawn from the following extracts:

"……. there is really a problem in squeezing all the topics for just the span of time that is given to us. Because even if the expectation of teachers in senior high school was just to teach the objective by objective, if we review with my students about the basic concepts of chemistry, they really tend to forget about the basic concepts." (P1)

" But then I have no choice but to go back because we cannot proceed with the writing and naming unless I discuss again the basics. And the fact that the competency in chemistry 1 and 2, the number of competencies is greater than the number of times you meet with your students." (P5)

According to Musengimana et al. [3], 71.2% of the students claimed that the chemistry syllabus was too broad. Also, the study of Nsanzimana et. al. [19], considered the length of chemistry lessons as another constraint faced by the teachers where in most cases, some chapters remain uncovered in a semester. This became a challenge for the teachers because when the materials to be discussed are too vast, they tend to only focus on completing the coverage without guiding the students to acquire relevant skills.

Another challenge they experienced is the lack of prior knowledge of the students particularly in fundamental concepts in chemistry. Because of this, they have difficulty in retaining such knowledge which was

supposedly taught and learned during their junior high school, thus resulted to the need to constantly review the basic concepts when being taught again in senior high school before they proceed to the intended topics to be discussed. The following statements capture this perception:

"……students really lack the prior knowledge on the basics or basic concepts of chemistry. Maybe I do not know what the reasons behind this were….but maybe we could connect this one to, you know, online classes, no actual face to face or actual experimentation." (P2)

"…. challenging in the sense that we need to deliver the topics wherein students can easily understand that even grade 1 can understand……..…the fundamentals were forgotten. Even the significant figures they forgot." (P3)

"In the 1st day of my class, I ask them to enumerate the elements in the periodic table but considering that its already in STEM class, but I was kind of frustrated, because there is just only one student who was able to name almost 30 elements." (P5)

This accords with the study of Idah and Eyan [20] where students lack knowledge due to sudden loss of interest when they had their chemistry lessons because they lack mathematical proficiency in practical chemistry calculations, then perceived chemistry as a difficult subject. As stated by Timilsena et al. [21], students have a negative view of learning chemistry, making it hard for them to learn. Maybe because of the limitation of time and facilities as mentioned by the participants, where they are forced to discuss the chemistry lessons through chalk-and-talk and with less practical activities. These practical activities should involve a leaner-centered learning environment which will engage students critical thinking skills opposite from that of teacher-centered environment which only involves absorption of information [6]

Theme 2. Resource and Curriculum Management

Based on the gathered interview, resource and curriculum management also became a challenge for teachers teaching chemistry subject. They mentioned that the competencies in the curriculum are too broad that teachers find hard to integrate all the essential concepts which may supposedly allow for a deeper understanding and application of concepts. They also observed that there is somewhat a mismatch between the curriculum guide's suggested duration for topics and the actual time available for teaching. As stated by one of the participants,

"……the curriculum in the general chemistry 1 and general chemistry 2 curriculum guide of the DepED is actually very broad. The challenge is how to integrate the lesson to actual application. More or less the time has been consumed for the lecture or the discussion of the topic." (P2)

"So, aside from the curriculum guide, we followed the most essential learning competencies. And even if we have followed the MELCS, there is really a problem in squeezing all the topics for just the span of time that is given to us." (P1)

This is possible because when the learning competencies to be discussed are too broad, and teachers have no choice but to complete the coverage as a requirement of the curriculum, then the guidance would be lacking, thus students could not acquire the expected skills learned. This is in line with the study of Eilks and Marks [22]. The authors argue that the chemistry content is lacking importance due to the lack of relevance of teaching chemistry, thus leading to lack of interest among students and results in low level of motivation.

Aside from the constraints in curriculum, the participants also shared challenges related to the lack of laboratory facilities. According to them, they are experiencing difficulties in conducting hands-on laboratory activities due to constraints in time and resources. And since they are teaching senior high school, participants express frustration with the lacking detailed step-by-step procedures in the curriculum guide for laboratory activities. As stated,

"…. sad to note that here in our school, we don't have what we call functional science laboratory." (P4)

"Also, in terms of laboratory, we also don't have a functional laboratory, although we have classroom that can be converted into laboratory. But I think most of the laboratory activities that are included in the curriculum guide are somewhat hand out that you give to your students. No step-by-step procedure provided by our curriculum. Aside from that, it's so hard to conduct activity given the limited time." (P5)

"…… less time for the application of the concept for laboratory experimentation." (P2)

The availability of laboratory facilities and other teaching resources positively affect the attitude and engagement of students toward chemistry [23]. One of the possible reasons is that laboratory experiments help students to understand the chemistry lessons by relating concepts of chemistry to everyday life. Thus, failure to use adequate teaching resources to both students and teachers negatively affects students' engagement and attitude [3].

Other challenges mentioned by the participants are related to centralized exams for the entire division which added pressure to ensure that all competencies are covered. They have struggles in designing assessments that will encourage critical thinking skills among the students. As what the participants added,

"All our exams in the Senior High School were departmentalized or was centralized. So, for example, I was the one who made the general chemistry exam. That would be the exam for the rest of the schools across the division. So added pressure to us." (P1)

"…if it is an assignment, they'll just research it and just use any information that we get from AI software or applications." (P2)

This phenomenon cannot be avoided especially if the said order comes from the administration. With this situation, what the teachers could do is to implement other teaching strategies that will involve problem-based and/or project-based learning. This could change the students' perception in chemistry through which they find its relevance in their daily life [24], [9].

How teachers ensure engagement of students while learning chemistry

The clusters for the emerging experiences of teachers on how they ensure that their students are engaged in learning chemistry as depicted in the statement gathered from the participants. These include encouraging questioning and reflective writing, and interactive

methods and varied strategies, for (1) Interactive and Engaging Teaching Strategies; and collaborative work, for (2) Student Participation and Involvement.

Theme 1. Interactive and Engaging Teaching Strategies

The participants highlighted the importance of active engagement through questioning and reflective practices. They mentioned that when they conduct post-discussion participation and reflective writing assignments, e.g., lab reports, and reflective writing, e.g., SLR (Summary, Learning, Reflections), they can help to enhance students' engagement. This is to ensure that the students understand and enhance their critical thinking skills in such a way that teaching strategies are integrated based on their experiences. As stated by the participants,

"I really ask them to prepare questions before the class ends, and then I'll be picking some questions, let them prepare 1/ 8 to write their questions. With that, if they can answer their questions, I can still somehow assure that they have learned." (P1)

"…..use index cards….. they will write their answers on the index card. and when I call their names, they will raise the index card. Then I sign the index cards as my way of acknowledging their correct answers." (P3)

This aligns with the findings of Smith [25], who noted the positive impact of reflective writing on student engagement, and Van Rensburg at al [26], who emphasized the adaptability in learning strategies when students are encouraged to reflect on their experiences.

Also, the participants are engaged in learning when they involve technology in teaching, e.g., games, interactive PowerPoints, and videos. This is one way of capturing their students' interest. Ullah and Anwar [27] support this by highlighting the benefits of diverse learning experiences that cater to different learning styles, indicating that such interactive methods can significantly improve student engagement in chemistry.

Theme 2. Student Participation and Involvement

Collaborative work, e.g., pair or group activities, and brainstorming sessions, provided a sense of involvement and active participation among students, according to most of the participants, where they

"…..let them do reflections and collaborate through doing group projects. And of course, oral recitation in the classroom, and fostering collaboration through doing group projects. " (P4)

"They have body system. Sometimes they can work with the worksheets. where they can answer by pair for them to do brainstorming. And other times, I do use of interactive PowerPoints and videos, mostly videos." (P5)

"I involved them, I categorized "those who are highly intelligent, average, and below average students". Then there was a peer tutoring or peer collaboration." (P2)

These methods are instrumental in encouraging students to actively contribute their ideas [4], which is important for a dynamic and engaging learning environment.

These themes collectively suggest a structured approach to ensure student engagement in chemistry learning through varied and interactive methods, which is essential for educational development.

Topics in Chemistry 2 where teachers find challenging to teach.

The emergent themes where teachers find challenging to teach in Chemistry 2 subject.

Theme 1. Chemical Kinetics and Thermochemistry

The teacher-participants face challenges in conveying the abstract concepts of reaction rates, energy changes, and thermodynamics since it needs mastery of analytical skills, mathematical understanding, and a clear teaching approach to ensure student comprehension.

Students consider these topics as complex and difficult [25]. This conforms with the study of Finkenstaedt-Quinn et al. [28] that students are struggling to make connections on the concepts between the relationship of thermodynamics and kinetics. They see them as two separate topics with no relationship and sometimes combining their meanings and explanations According to Marzabal et al. [29], the difficulties of learning the key concepts of chemical kinetics are maybe due to the fact that traditional teaching does not consider the learning of the students in the domain of chemistry, and also lacks research on proposing teaching strategy that empathize students and know their intuitive conceptions.

Theme 2. Electrochemistry

Electrochemistry on the other hand, focusing on redox reactions, is perceived as challenging, indicating potential difficulties in conveying the intricacies of this subject to students as it often involves intricate processes that are difficult to visualize. Schmidt and Harrison [21] emphasized that it is a topic difficult to understand because of its content, interdisciplinary nature, and dynamic structure. One example given by one of the participants is redox reactions. Redox reactions are one of the central concepts of chemistry which is commonly perceived to be one of the topics that are very difficult to teach and to learn [30] as cited by [28]. This has been proven by the study of Ali, Woldu, and Yohannes [31] that the main challenges that contribute to the students' learning difficulties in electrochemistry include their lack the ability to apply main ideas with structure-property relationships; absence of teaching resources; misinterpretations of terms used in chemistry contexts; frequent overloading working memory; inability to represent chemical concepts at the macroscopic, particulate, and symbolic levels; and teachers' and learning materials' made misconceptions.

Research studies point out that to improve the understanding of this subject and the scope of electrochemistry applications, students should be exposed to more diverse laboratory activities and real-life applications [15,20].

Theme 3. Stoichiometry

Chemical stoichiometry is a significant concept taught in general chemistry courses. Martin [32] describes stoichiometry as an aspect of Chemistry that calculates the masses or volume of reactants and products involved in a chemical reaction. The participants find it challenging to teach because its concept requires critical thinking and problem-solving skills. As stated by one of the participants,

"They find it hard to understand, especially if the problems given are not the same examples from the discussion. They no longer know how to apply the

concepts to another problem. More or less, they lack analysis." (P2)

"If the concept involves numbers and problem-solving, that is where the students are struggling." (P3)

This is supported by the study of Ogbeba and Ajayi [33], who found that the concept of stoichiometry in general chemistry was the most difficult for students because of the students' lack of problem-solving skills. Also, Gulacar et al. [34] added that though students could algorithmically solve problems, it was determined that this could have shown more conceptual understanding on the part of the students. A lack of conceptual understanding of the mole concept is closely related to students skipping crucial steps in stoichiometry problems, especially the sub-problems of stoichiometric ratio and mole concept.

Thus, complicated chemistry concepts such as chemical kinetics, thermochemistry, electrochemistry, and stoichiometry must be taught appropriately using innovative methods.

4. Conclusion

The challenges that teachers are facing in teaching chemistry were based on instruction, resource, and curriculum management.

To ensure that their students are engaged while learning chemistry, there should have interactive and engaging teaching strategies, as well as student participation and involvement.

The topics in Chemistry 2 which teachers find challenging to teach are chemical kinetics, thermochemistry, electrochemistry, and stoichiometry.

5. Recommendation

Based on the study's findings, the following recommendations are proposed:

Provide training programs, workshops and/or seminars that will focus on redesigning and upskilling chemistry teachers that will not only incapacitate them for the 21st century but for the 4.0 industrial revolution. Their experiences and struggles reflect their feelings and, when attended to, may lessen the impact on the succeeding teacher entrants.

Given the experiences of teachers on the efforts they gave to engage their students, more efforts are still needed to motivate them to use alternative strategies, such as the integration of design thinking in the curriculum, as it fosters student engagement not only on the usual constructivism and cognitive development but a combination of problem solving and project-based approach. Also, incorporate real-world applications of chemistry concepts to demonstrate their relevance and increase student interest.

Lastly, it is important that teachers know the potential of their students, especially the possible misconceptions on topics related to chemical kinetics, thermochemistry, electrochemistry, and stoichiometry. Future researchers may develop teaching resources that may help overcome such student difficulties.

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