Students' Conceptual Understanding and Confidence on Balancing Chemical Equations Using Particulate Drawings

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Abstract For decades of experience in teaching Chemistry, a chemical equation is usually balanced by writing a coefficient before the formula of atoms, ions, or molecules. In this study, the effect of a pedagogical intervention on the understanding and confidence of students was investigated by combining the guided-inquiry approach and the process of drawing of particles on balancing a chemical equation in a Philippine science classroom context. This action research gathered both qualitative and quantitative data in two phases. Initially, a three-tiered concept test determined the students' initial understanding and perceived confidence in balancing chemical equations using particulate drawings. The inquiry-based worksheets were implemented and investigated for its effectiveness. Specific cases from reflection responses and interviews were presented. The use of three-tiered tests and inquiry-based particulate worksheets exhibited significant change and a moderate positive correlation between conceptual understanding and confidence. This study was able to help Grade 11-STEM students improve their understanding and became

more confident in learning the unseen particulate level of Chemistry concepts.

Keywords: *Conceptual understanding; guided inquiry; particulate drawing; perceived confidence; three-tiered*

Introduction

Balancing chemical equations, a lesson in Stoichiometry, is one of the most fundamental topics in Chemistry. Not only do students find stoichiometry difficult to learn, but also many teachers find it difficult to teach (Bridges, 2015). Three decades ago, Johnstone (1991) distinguished the three levels or domains of chemical representations as a triangle with the points labeled as macroscopic (tangible), submicroscopic (particulate), and symbolic (mathematical). He suggested that this 'multi-level thought requirement is what makes all sciences difficult for students to understand. As such, every concept in Chemistry can be expressed as a combination of these three domains. For students to develop a deep understanding of chemical concepts, they need to be able to translate concepts using the three levels of representations and transit across levels (Sunyono, Yuanita, & Ibrahim, 2015). Traditional lecture courses in chemistry have tended to emphasize the symbolic domain, while laboratory courses have highlighted the macroscopic level. Among the three levels of representation of chemical phenomena, the particulate domain earns insufficient emphasis because many students fail to learn it. This domain's invisible and theoretical aspect made students struggle to understand it. The challenge then is to find ways to help the students develop a conceptual understanding of the particulate domain and the ability to use and generate their representations. Descriptions of this level must include models in the form of drawings or diagrams. A study

revealed that although students can correctly use a balanced chemical equation in a stoichiometric algorithm, they do not understand the chemistry concepts that a balanced equation represents (Nyachwaya et al., 2014). This issue can be addressed through the use of inquiry learning. In 1930 the American philosopher John Dewey wrote about learning in relation to reflection and experience and promoted 'learning by doing'. This 'active learning' strategy evolved towards so-called 'inquiry-based' learning approaches throughout many disciplines. Guided-inquiry, as one of the domains of inquiry approach, is a planned, targeted, supervised intervention throughout the inquiry process. It is the way to meet the many requirements of the curriculum through engaging, motivating, and challenging learning. The principles and foundation of guided inquiry was based on solid research findings grounded on a constructivist approach to learning. Guided-inquiry also indicated its effectiveness in several developing Asian countries. In the study of Bunterm et al. (2014), the effects of guided versus structured inquiry showed greater improvements for students in the guided inquiry condition in both science content knowledge and science process skills measures. Another research in Indonesia describes the effectiveness of the guided inquiry learning model to improve the critical thinking skills of senior high school students on static fluid material (Nisa et al., 2018). In the Philippines, a study on the effectiveness of the Process Oriented Guided Inquiry Approach (POGIL) was conducted by Villagonzalo in 2014 among high school students in Chemistry specifically on the particulate nature of matter. Similarly, the study of Cascolan and Prudente (2018) showed an increase in conceptual understanding when students were exposed to POGIL activities. It was revealed that POGIL is effective in enhancing students' academic performance compared with the traditional method. Fortunately, ample evidence exists in support of both the use of particulate level representations in instruction (Davidowitz et al., 2010)

and inquiry-based instruction (Bunterm et al., 2014; Nisa et al., 2018) as means of improving students' conceptual understandings in Chemistry. However, few studies revealed the effectiveness of blending the two approaches (Bridle & Yezierski, 2012; Kimberlin & Yezierski, 2016). Likewise, no evidence exists for the effectiveness of an instructional approach that involves the combination of these two methods in the Philippine science classroom context. As specified in the performance standard of the topic on Stoichiometry on page 4 of the Department of Education K to 12 Basic Education Curriculum for Senior High School (SHS) - Science, Technology, Engineering, Mathemetics (STEM) specialized subjects, the learners must design using models or a representation of atomic structure. On the contrary, the assessment of the content in the teaching guide provided by the Department focuses only on the symbolic algorithmic stoichiometry.

To address this gap, this study explored the implementation and effectiveness of a guided-inquiry pedagogical intervention and the use of particulate drawings on balancing chemical equations in improving the understanding and increasing the learning confidence of students. This study entailed great challenge and enthusiasm for the lead author for she has not taught stoichiometry using this approach in more than two decades of teaching Chemistry.

This study is guided by the principle that inquiry-based learning is fundamental for the development of higher order thinking skills. Inquiry-based learning is believed to occur if students are given tasks to perform in class. Similarly, the theory of Johnson (1991) requires that every concept in Chemistry should be translated in three levels before it will be understood by students. Taken as a whole, these theories directed this study by allowing the

students to actively engage in the activities and construct their own new understanding on balancing chemical equations by drawing particles through the use of learning materials with collaboration among group mates. These learning frameworks developed their higher order thinking skills because participants were engaged with scientific scaffolding questions and were required to justify their explanation for every choice they made. A teacher in an inquiry classroom only facilitates learning by guiding the students in creating their current conceptions. Finally, the theories involved in the study enhanced students' ability to self-monitor and evaluate their own performance as they acquire reasoning skills and new ways of learning.

Purposes of the Research

The study intended to examine the effectiveness of guided-inquiry pedagogical intervention using particulate drawings in improving students' understanding and learning confidence in conceptual stoichiometry. Specifically, this action research was conducted for the following purposes:

1. determine the initial conceptual understanding of students towards balancing chemical equations using a three-tiered concept test with drawings;
2. determine the perceived confidence of students on balancing particulate chemical equations; and
3. investigate the effect of the intervention on the conceptual understanding and confidence of students in balancing chemical equations.

Methodology

Research Design

This study investigated the effectiveness of a pedagogical intervention in improving students' conception and confidence in balancing chemical equations through drawings using the PDSA (Plan, Do, Study, Act) action research design (Figure 1). Action research's primary aim is to use systematic methods to make improvements within the educational settings by solving specific classroom problems (De Galle & Boiselle, 2015). This iterative cyclical process includes: (1) Plan – selecting a focus and describing the current process for addressing the identified area of needs, (2) Do – implementing the plan, and collecting data, (3) Study - analyzing and interpreting the data gathered, and (4) Act - reflecting on the results and acting by implementing the next step of research procedure which can be used by teachers in the classroom.

Figure 1

PDSA Action Research Model
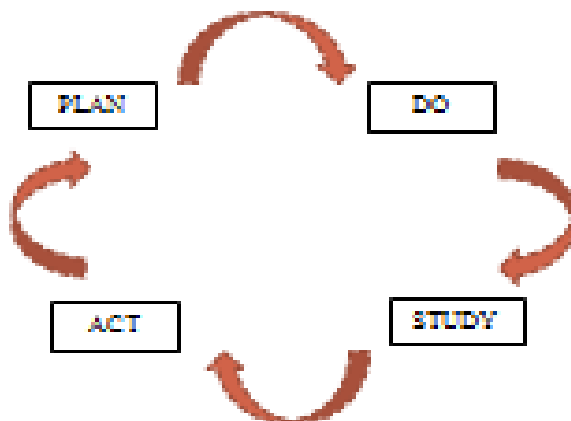
The study consisted of two phases: Phase I – pilot-testing of research instruments, and Phase II - implementation of the improved research instruments. Phase I was conducted in one intact class at a State University in the Visayas. Phase II was done in the laboratory high school of the same university with 36 students belonging to Grade 11-science, technology, engineering, and mathematics STEM intact class.

Data Collection and Analysis

The PDSA (Plan, Do, Study, Act) action research design followed a four-step cyclical process.

Plan

Action Research is a method of choice where the investigators systemically review practices using the research process for teaching improvement (Brydon-Miller et al., 2017). This particular study was intended to investigate the effect on the conceptual understanding and confidence of the Chemistry students when balancing chemical equations by drawing atoms, ions, and molecules. It also postulated the need to first assess the student's prior understanding of the concept of balancing chemical equations. Varied literature was reviewed on particulate drawings and other constructs that could enhance the study. After thorough discussions, a decision was made to facilitate a multiple-choice concept test that incorporated the particulate drawings as well as students' confidence level in making the choices in the test. After which, an intervention was conducted using a worksheet and a post-test was administered.

Four research instruments were used in this study, two of which were adapted and the rest were researcher-made. The instruments were modified to fit the Philippine K to 12 curriculum science education contexts. Quantitative data were gathered using the Visual Conceptual Questionnaire in

Stoichiometry plus Confidence (VCQS+C) concept test and Balancing in a Particulate Way (BPW) student worksheets. Figure 2 presents an example of a test question.

Figure 2

An excerpt from VCQS+C Concept Test

__1.1 Which particulate drawing BEST represents the balanced equation for reaction of iron with bromine?

$$\_\_ Fe + \_\_ Br_2 \rightarrow \_\_ FeBr_3$$
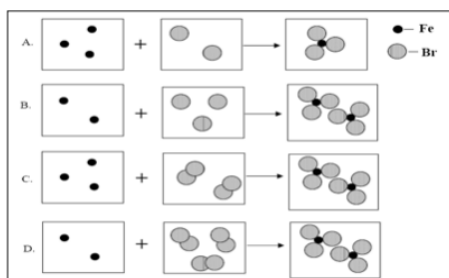
1.2   Please explain your answer _____

1.3   How confident/sure are you that the answer you have chosen is correct? Please put a check (√) inside the box.

0% sure	10	20	30	40	5 0 % sure	60	70	80	90	1 0 0 % sure

VCQS+C is a 10-item multiple-choice concept test intended to gather the numeric scores and percentage of students' understanding and perceived confidence in balancing chemical equations, respectively. The test was designed with particulate drawings to represent chemical equations. The VCQS+C is merely VCQS with an additional third-tier confidence rating question. The third tier is a Likert scale from 0% to 100% with 10% intervals, in which participants were asked to indicate their confidence in the accuracy of the chosen response in the first tier. VCQS has a reliability coefficient of .66 using KR-20 (Jaranilla et al., 2017).

BPW is a worksheet that was used an intervention learning material in the study (Figure 3). The worksheet was adapted from the online resources of Target Inquiry at Miami University (TIMU) professional development program for secondary Chemistry teachers (TIMU, 2015). TIMU was created to design and develop instructional materials to improve the frequency and quality of guided-inquiry instruction in high school Chemistry. Modifications were made in the worksheet by enhancing the color and shape of the particles in drawings using Photoshop applications. The worksheet has 10 activities or sample reactions with particulate drawings for students to work on. Each activity in the worksheet has scaffolding questions that vary in number. Every correct answer to each question was given one (1) point. The perfect score is 65 points for the entire worksheet.

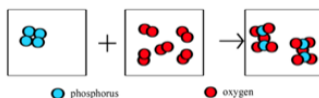**Figure 3**

An excerpt from BPW worksheet

Reaction #5

phosphorus   oxygen

Diagram 5a: Particulate representation of phosphorous and oxygen reacting
(balanced particle drawing)
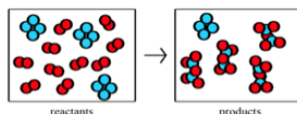

reactants   products

Diagram 5b: Particulate representation with excess reactant

4. Write a balanced symbolic equation of the reaction of phosphorus and oxygen, using diagram 5a. _____

5. How does the particulate drawing assist in deriving a balanced symbolic chemical equation?
_____
_____

6. Refer to diagram 5b. A student wrote the following chemical equation to represent the particulate representation in diagram 5b:
$$3\,P_4 + 10\,O_2 \rightarrow 4\,P_2O_5 + P_4$$
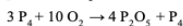
Explain in as much detail as possible why the student's chemical equation is *inaccurate*._____

On the other hand, Reflection on Learning (ROL) is a set of researcher-made questions intended to gather qualitative data from students at the end of every learning session. The interview protocol was also developed to solicit responses among students who earned extreme scores (3 highest scorers and 3 lowest scorers) after administering VCQS+C. Three chemistry education teachers reviewed the aforementioned instruments for face and content validity of the ROL instrument and interview protocol. All instruments used in the study did undergo pilot testing.

Do

Appropriate communications to conduct the study were accomplished by following the guidelines set by the Research Ethics Committee. The participants of the study were conveniently selected. Phase I was done to pilot-test all research instruments. In Phase II, 32 Grade 11-STEM students were subjected to pre-testing, which was followed by teaching intervention, and post-testing to measure any changes in their understanding and confidence in balancing chemical equations using particulate drawings. Twenty-eight of them were female and the majority (64%) was 16 years old. The learning intervention was conducted in three 2-hour sessions. This excluded two hours of pre-and post-testing. Throughout the intervention process, teacher-observers were present to witness the conduct of the class. Researchers performed a one-on-one interview with students that have extreme scores on the tests given.

Study

Descriptive statistics were taken from the data of concept test and drawing worksheets in determining the initial understanding of the students on conceptual stoichiometry using particulate representations or drawings. The study determined the significant change in the conceptual

understanding of the students after the intervention. Paired sampled test was computed to determine if the change is significant or not. The normality of small data samples was verified through the Anderson-Darling test. The confidence level of students before and after the learning intervention was calculated using descriptive statistics taken from the data of the third tier of the concept test. The average confidence scores served as the confidence rating. Finally, Pearson's correlation ($p < .05$) was employed to determine the relationship between students' conceptual understanding and confidence level before and after learning intervention. Qualitative data from reflection writing and one-on-one interview were encoded and transcribed verbatim using Microsoft Excel. These were analyzed thematically to further validate the obtained scores from VCQS+C and BPW.

Act

After analyzing the data gathered during the pilot-testing phase, the needed changes were realized and incorporated into Phase II. If the pedagogical intervention that was performed did not bring any increase in the scores of the students, then the researchers will go over the cycle to incorporate a better plan. But if it is successful, then the new way of balancing particulate equations will be included in classroom practices and will be recommended to other chemistry teachers. Similarly, the learnings in the previous cycle brought new and better plans for the next phase in achieving the research objectives.

Results and Discussion

Students' Initial Conceptual Understanding on Balancing Chemical Equation

The students' numeric score in the 10-item, multiple-choice VCQS+C concept test was gathered to generate the initial

understanding on the particulate balancing of chemical equations. The first tier of the instrument presents four options in particulate representations/drawings. Descriptive statistics were taken from the data. The sum of all correctly answered items in the first tier of VCQS+C was used; with correct answers coded as one (1) and incorrect answers zero (0). The individual total score was converted to percentage and transmuted using to the grading system of the Department of Education (DO #8 s. 2015) to identify if students' initial understanding of particulate balancing of the equation is rated as passed or failed. In this paper, only the responses on the first tier and third tier were utilized.

Table 1 presents the students' understanding in the pre-test. The mean score was 4.2 out of 10 points. Initially, the performance of the students did not meet expectations or is rated as failed, as the equivalent transmuted grade was only 70% using the Department of Education transmutation table.

Table 1

Students' Pre-test Performance

	Performance (test scores, %) Max score=10, N=36
Mean Score	4.2 (1.81)[a]
Minimum	1(3%)
Maximum	9(3%)

[a] standard deviation

This observation is expected by the study since the participants admitted to have not yet experienced this type of science instruction particularly in chemistry. A study on Grade 10 chemistry students in Thailand exhibited lack of understanding in stoichiometry concepts which posed concern because it is found as a significant predictor of their performance in college (Lausin & Kijai, 2020).

Perceived Confidence of Students on Balancing Particulate Chemical Equation

The results on the perceived confidence of students on balancing chemical equations before the intervention show a 50% confidence self-rating. This is interpreted as average level of confidence as a class. Table 2 presents the confidence levels of students using descriptive statistics. Data shows a 25.2 standard deviation which implies a dispersed distribution of perceptions among participants.

Table 2

Students' Perceived Confidence Levels

	Perceived Confidence, %N=36
Mean	50 (25.2)[a]
Minimum	8
Maximum	90

[a] standard deviation

The high standard deviation is evidenced by the wide gaps in the confidence levels which they confirmed in the interview and data gathering processes. Students were grouped into four quartiles according to their actual performance in the test, from the bottom 25% to top 25%. Surprisingly, students in the bottom and second quartile had overestimated their abilities while the top performers gave lower confidence ratings of oneself during the pretest.

Most of those who scored high were hesitant to admit that they were confident with their answers. This scenario can be likened to what Lemoine (2021) described as rationally misplaced confidence. Using the Bayesian learning framework that is premised on the assumption that when effort and ability are complementary and payoffs are affected by a general class of shocks, feedback given should not be

unconditionally vague. Lemoine (2021) characterized this scenario on the management of outcomes under confidence or overconfidence. Classroom teachers can sometimes indeed be vagne with rewarding under performing and overperforming learners. When ability and efforts are not complementary, underconfidence and overconfidence can persist in the environment even when the participant understands his/herr environment (Hestermann & Yaouanq, 2021). It was in this light that methodologies such as guided inquiry are useful approaches to teaching in order to reduce learner and learning anxiety and create a more encouraging classroom atmosphere. The data on learners' confidence levels at the end of the sessions revealed how the guided inquiry approach have been instrumental in raising their level of confidence in what they have learned and what they are able to do with what they have learned.

Effect of the Intervention on the Conceptual Understanding and Confidence of Students on Balancing Chemical Equations

To determine the change in understanding of students on the particulate matter of balancing chemical equations, descriptive statistics was determined as presented in Table 3.

Table 3

Students' Post-test Performance

	Performance (test scores, %) Max score=10, N=36,
Mean Score	6.4 (1.99)[a]
Minimum	3(11%)
Maximum	10(6%)

[a] standard deviation

The post-test mean score was 6.4 which translated into a transmuted grade of 77% or fairly satisfactory. The understanding of the concept of students about the particulate balancing of equations had increased from failed to passed indicating a substantial increase after using the BPW worksheet as intervention learning material. This information affirms the effectiveness of guided inquiry BPW worksheets in developing learner's competence in balancing chemical equations using particulate drawings.

The study gathered and analyzed the six activities in the worksheet which required the students to draw the atoms and molecules of chemical equations. An example of the information on the effect of BPW worksheet on conceptual understanding of balancing particulate equations is depicted in Table 4. The drawings in the aforementioned table were deduced from the second activity which revealed the particulate drawings of students and their corresponding percentage performance. The result showed that students got a 100% increase in the group performance with correct particulate drawing (Drawing A). The students' error was rooted in writing the incorrect number of particulate reactant molecules as stipulated in Drawing B. Some students still made a wrong interpretation of the coefficient in 4HCl (Drawing C). A consistent increase in performance was noticed after the students discussed their individual responses and agreed with the final answer in each activity among themselves.

Additionally, the result of the perceived confidence of students during post-test revealed that top scorers were unsure of the responses they made even though it was found correct. Meaning, top performers had lower perceived confidence compared to their actual confidence in the test. The findings of the study conformed to the result of Mathabathe and Potgieter (2014) in investigating the relationship between accuracy of confidence on self-evaluation and learning gain in stoichiometry.

Table 4

Students' Percentage Performance of Particulate Drawing on Activity 2

Activity #2	Particulate Representation $CH_4 + 4Cl_2 \rightarrow CCl_4 + 4HCl$	Individual Performance, %	Group Performance, %
Drawing A*		39	78
Drawing B		33	11
Drawing C		28	11

* correct particulate representation

The gathered data were subjected to the AD-normality test and paired sample t-test to find out if the change in students' understanding of the concept is significant or otherwise. The result of paired sample t-test [t (35) = -7.381, p = .000/2 = .00] showed that the mean difference was significant because the p-value was < .05. These results mean that the understanding of Grade 11-STEM students was substantial after learning the concept of balancing chemical equations using worksheets.

Table 5

Statistical Correlation of Students' Conceptual Understanding and Confidence

		Conceptual Understanding Post-test	Confidence Post-test
	Pearson Correlation	1	.469**
	Sig. (2-tailed)		.004
	N	36	36
Confidence Post-test	Pearson Correlation	.469**	1
	Sig. (2-tailed)	.004	
	N	36	36

** Significant at the .01 level (2-tailed)

Pearson's test was also used to determine the relationship between students' conceptual understanding and confidence level after the learning intervention. Table 5 revealed the correlation result of the post-test data as .469. This result denoted that conceptual understanding and confidence of students after post-test have a moderate

positive relationship. The relationship was also found to be statistically significant at the .01 level. Positive correlation implies that as students' understanding of the concept increases, his/her confidence level also increases. This means that top scorers during post-test exuded greater confidence than bottom-performing students. The students' learning confidence were valid reflections of their actual knowledge on the concept .

Reflection On Learning (ROL) journal entries and responses to interviews made by the students validate the abovementioned findings. While many have had low levels of confidence in the beginning, the exposure helped them improve their performance . Student number (SN) 10 claimed that *"....the confidence level ...in the pretest is very low because .... I still don't know how to balance an equation but after the exposure, I think my confidence level became higher because I learned from our group discussion."* SN32 also admitted that *"I think my confidence level boosted because I was more sure with my answers."* These two are just some of the examples that illustrate how the exposure to genuine inquiry teaching has helped boost students' confidence in their own learning. These journal entries were confirmed by some of students' feedback during the interview. Below are some transcripts on the responses of the highest scorers (HS) and lowest scorers (LS) to how was the intervention able to help them understand and have confidence in balancing chemical equations:

> HS2: *"At first, it was quite confusing but as time went on, we were enlightened how we could use the particulate drawing in balancing equation, but at the end we learned that this process was convenient and easy."*

> LS3: *"I find it a lot easier balancing a chemical equation using a particulate drawing since it helps*

me visualize. At first it's a bit hard but as the time goes by I find it really helpful."

HS1: *"It helps me to answer the questions because of the drawing it is easy to understand and to balance an equation. Because of that, our critical thinking skills were practiced".*

LS2: *"It helps me visualize the reactants and the possible outcome".*

Conclusion and Recommendations

This study aimed to investigate the effectiveness of a new pedagogical approach in improving students' conceptual understanding and confidence on balancing chemical equations by drawing atoms and molecules. This action research employed Plan, Do, Study, Act (PDSA) research framework utilizing the quantitative and qualitative data of two intact groups of students.

The study found that the prevalent understanding of balancing of chemical equations of Grade 11 STEM students in the aforementioned laboratory high school in the concept test did not meet the expectations of the grading system of the Department of Education, but has greatly improved to fairly satisfactory after the teaching interventiony. The change in the level of students' conceptual understanding was found significant before and after the learning intervention. The mean percentage of the perceived confidence of students during pretest and post-test also increased. A moderate positive correlation and significant relationship were found between conceptual understanding and confidence of students. The changes in students' conception and confidence as validated and corroborated by data from interview, self-reflection and observation reinforce the effectiveness of guided inquiry

approach. At the end of the intervention, the study was able to accomplish its performative goal of redirecting and reconstructing learners' concept to fully embrace the implementation of balancing a chemical equation through particulate drawing. Likewise, the self-referentiality goals were also accomplished as evidenced by the changes in the conception and confidence level of students. The hesitation that was clearly present before the intervention was greatly reduced in the process. The willingness of both the teacher and the learners to try a new approach was also a key factor to be considered in the apparent success of the intervention. Both the quantitative and qualitative data affirmed the effectiveness of guided inquiry approach in general and balancing chemical equation through particulate drawing method in particular.

Furthermore, the findings of the study can be of help in developing a standardized three-tiered test in balancing chemical equations for use in Philippine science classes. The available data provided by this study as well as those from existing literature reinforced the idea that guided inquiry approach is a useful and productive approach especially that this study was able to prove how it was able to transform the abstract nature of stoichiometry into a more concrete one through particulate diagrams/drawings.

The study recommends the adoption of the strategy of using particulate diagrams and drawings in teaching stoichiometry. The decades of teaching experience that researchers have had attests to the novelty of this approach as they have no knowledge of it being used before which the participants similarly claimed. Thus, retooling chemistry teachers for this strategy is a necessary step to ensure that the success seen in this study can be replicated. It is highly recommended that particulate level of representation be included in the course content, assessment and teaching guide of the DepEd's K-12 Curriculum in order to address

and integrate the standards set by the curriculum. Further, study replication of this kind is encouraged to explore how learner type affect the effectiveness of guided inquiry. There is a need to determine first the learning style of the students involved in this kind of research. It is believed that different types of learners have special ways in adapting to every teaching-learning approach.

Reflection

The effectiveness of teaching and learning depends on many factors. Some of which are the content knowledge and teaching skills of the teacher as well as the learning styles of students. A teacher needs to continuously search and develop new approaches to determine what works best with students, especially when dealing with topics that they find very challenging. As chemistry teachers for more than two decades, the researchers have an idea of what lessons in chemistry the students find very puzzling. One of which is balancing chemical equations. The researchers were interested in the students drawing particles and balancing chemical equations, and also determining the changes in their confidence levels. This teaching approach was not used before by the researchers or come across this manner of learning even as students. This study excites the researchers because they wanted to present this lesson by just guiding the students learning process and not doing the usual lecture. The initial literature reviews helped the researchers decide to use action research design to bridge the gap between theory and teaching practices. More so, this design can be performed in a series of phases to continuously improve students' performance.

The conduct of phase one which was the pilot testing of all research instruments brought a lot of changes in the second phase of this study. An improvement in students' post-test scores was noticed after engaging with worksheets which served as learning intervention material. The researchers

saw in students' eyes the eagerness to come up with correct answers though it was also obvious that their minds were stirred up because they encountered this manner of balancing for the first time. Students even clapped their hands and were joyful after finding out that they managed to draw the correct equation. There was a feeling of accomplishment in discovering that the students not only gained a better understanding of the topic and became more confident but also acquired intangible positive values or characteristics like cooperation, respect, patience, teamwork, and unity to name a few. These reactions were evident in students' responses to reflection and interview questions after three intervention sessions.

It gave the researchers a feeling of fulfillment to develop a strategy to teach balancing chemical equations through drawing which eventually increased students' understanding of the concept and boosted their learning confidence. This teaching approach will be readministered and studies will be performed to further validate and improve the existing results. Truly, the conduct of action research is an authentic academic learning experience.

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Acknowledgment

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