# THE USE OF DYNAMIC AND STATIC VISUALIZATION IN TEACHING CHEMISTRY: ITS EFFECT ON STUDENTS' CONCEPTUAL UNDERSTANDING AND ACADEMIC ATTITUDE

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***ABSTRACT:*** *The study aimed to determine the effect of using static and dynamic visualization in the teaching of selected topics in chemistry on students' conceptual understanding and academic attitude. The study utilized a quasi-experimental design involving two groups of high school students enrolled at St. Michael's College Basic Education Department in Tibanga, Iligan City, Philippines. A total of 93 Grade 9 students in intact classes participated in the study and were randomly assigned to two treatments, namely Dynamic Visualization and Static Visualization. Both classes were given pretest and posttest and were exposed to different teaching methods according to schedule. Mean and Standard Deviation were used to describe the scores in the pretest and posttest for conceptual understanding and academic attitude. Results of the analysis indicated that the student's overall academic attitude is positive. The students also showed higher scores in the posttest when exposed to dynamic visualization. The Analysis of Covariance (ANCOVA) was employed to determine the significant difference in conceptual understanding with pretest as a covariate. This difference in the conceptual understanding between the two groups was statistically significant. Dynamic visualization using interactive simulation or animations may help learners improve their conceptual understanding of the selected chemistry topics. The teacher may consider using dynamic visualization in the form of simulation or animations in 3D models, structural images, and molecular models to help students improve their conceptual understanding in chemistry.*

**Keywords:** Dynamic Visualization, Static Visualization, Conceptual Understanding, chemistry achievement, and Academic Attitude

## 1. INTRODUCTION

Chemistry was often regarded as a difficult course that leads the students to dislike chemistry [1]. One of the reasons for the perceived difficulty is how to understand the level of representations and the linking of the macroscopic and microscopic levels of chemistry. Many junior high school students found these representations difficult to grasp. Chemistry could be described at three distinct levels of representations namely the macroscopic (sensory) level, the submicroscopic level (atomic/molecular particles), and the symbolic level (representing matter in terms of formulae and equations) [2, 3]. Chemistry instruction should navigate the level of connections between visuals and conceptual entities that include multiple representations for a specific concept [4, 5].

An understanding of how students learn could help teachers devise effective teaching strategies. Thus, researches on the learning process are made accessible as references [6]. In addition, to facilitate the development of students' views of knowledge, students need to be supported at the appropriate level. The conceptual understanding in chemistry could be achieved if the students can perform higher levels of mind processing using an internal representation or a mental model which has been constructed using all three levels of representations of macroscopic, submicroscopic, and symbolic representations [7, 8, 9].

For the students to have a better conceptual understanding, it is important to expose them to the relationship between the three levels of chemical representation [10]. One way to enhance the students' ability to learn is to use the different levels of representation when explaining the range of chemical phenomena. Several researchers affirmed that visualizations have been shown to help students develop scientific conceptions. Visualizations are thought to have great potential to enhance learning, they often require learners to invest the substantial mental effort to process them, and their educational effectiveness depends on a multitude of design considerations that are involved in the development of effective visual materials for learning [11]. Others [12] designed animations that illustrated chemical processes of dissolving salt in water with combined symbolic and molecular representations. They found that students who used animations outperformed those who were only lectured without viewing any animation.

In this study, dynamic visualization refers to the use of a simulation to teach chemistry topics such as ionic and covalent compounds, for example. Available interactive materials from the PhET website were also utilized. Animations on the Mole concept, Avogadro's number, Number of particles relationship, Molecular Mass, Mole to Mass, and Mass to Mole relationship were also used in the classroom. Dynamic visualizations could improve chemistry learning by presenting the unseen and submicroscopic levels to students while supporting students to make connections among levels in chemistry. It further encourages students to recognize and refine conflicting ideas. As such, the use of simulations or animations with images or models in science instruction is becoming central to scientific research. The instruction with visualizations of the molecular level could help students to construct more scientifically correct conceptions [13].

The positive effect of dynamic visualizations could be increased when the students have to create their drawings based on them [14, 15]. In addition, the development of students' positive attitudes towards visualization could benefit science teaching and learning.

The use of visualizations in science education has the role of not only making invisible concepts/ideas visible but also illustrating abstract concepts and making it concrete.

Modern chemistry was characterized by interdependent, networked thinking in different representational domains. This consideration was in the core of [16] famous contribution: 'Why is science difficult to learn?' The author explained that learning and thinking in modern chemistry always take place in a constant shift between three different representational domains: the macroscopic, submicroscopic, and symbolic domain.

To aid the learning process on the submicroscopic level, scientific models are used and illustrated using static [17] or animated visualizations [18]. Such visualizations in a stable format are available in every chemistry textbook for the secondary level. With advanced improvements in modern ICT, animated visualizations have also become readily available for teaching and learning. The use of visualization can foster students' learning of model-based explanations of the submicroscopic world [19]. Pictures, animations, and simulations are powerful tools for teaching and learning chemistry. There was great potential in the use of these visualizations because they helped foster students' understanding of three-dimensional structures [20], it can aid in developing learners' spatial abilities [21], it provides a resource for reducing students' misconceptions about basic chemical principles [22, 23, 24], and increased students' motivation when learning about chemistry [25].

Visualization tools that support students in constructing and revising models to represent science concepts or phenomena could help students learn about science [26] and learn to do science [27, 28]. Thus, exposure to visualization may help students understand chemistry better.

The behavioral attitudinal responses are not behaviors per se but are the person's action tendencies toward the attitude object [29]. An attitude was a relatively enduring organization of beliefs, feelings, and behavioral tendencies towards socially significant objects, groups, events, or symbols [30]. Attitude's structure is described in terms of three components: affective component involves a person's feelings/emotions about an attitude object, behavioral component the attitude has influenced how a person act or behave and cognitive component involves a person's belief/knowledge about an attitude object. In essence, effective chemistry instruction calls for the improvement of students' academic achievement and attitude. For these reasons, this study sought to determine the effect of science instruction using dynamic visualization and static visualization on the students' academic attitude and academic achievement.

## 2. METHODOLOGY

### 2.1 Research Design

The study utilized a quasi-experimental research design. This design involved the two intact sections of Grade 9 students randomly assigned to two treatments.

### 2.2 The Instruments

A 40-item multiple-choice teacher-made test was validated (KR 20 is 0.72) and used to determine the student's conceptual understanding of selected topics in chemistry. To measure academic attitude, a questionnaire was adopted and validated (Cronbach's Alpha is 0.88) for use. The academic attitude questionnaire contains 23 items with 3 constructs, namely cognitive, affective and behavioral.

### 2.3 The Participants of the Study

The participants of this study were the two sections of Grade 9 students enrolled in St. Michael's College Basic Education Department, Iligan City. A total of 93 Grade 9 students participated in this study.

### 2.4 Data-Gathering Procedure

Both classes were given the same set of prepared questionnaires for pretest and posttest to measure academic achievement. An adapted questionnaire to measure academic attitude (Affective, Behavioral, and Cognitive) was also provided to the students in dynamic and static visualization. In dynamic visualization, the students were exposed to hands-on online activities in the Computer Laboratory. On the other hand, students in the static visualization were exposed to the usual teacher-led classroom set-up and discussion. The students in the static visualization group either worked individually, by a peer, or by a group for the opportunities to share ideas with their classmates in the concept learning in chemistry.

Both groups of students were provided with video and PowerPoint presentations of the lessons. Weekly quizzes were given to the students. The allotted time in conducting the dynamic activity was 1 hour and 15 minutes per session. Both groups of students were exposed to their treatments for the same duration, session time, and topics under the same tea

## RESULTS AND DISCUSSIONS

Table 1 showed that both groups of students manifested positive attitudes in the three constructs of academic attitude before and after the treatment. However, the students in the dynamic visualization group showed higher means in all constructs. To determine if the difference in the mean scores for academic attitude is significant, an Analysis of Covariance was conducted.

**Table 1. Descriptive Statistics of Students' Academic Attitude**

| | Dynamic Visualization | | | Static Visualization | | |
|---|---|---|---|---|---|---|
| Academic Attitude Construct | Mean | SD | Interpretation | Mean | SD | Interpretation |
| Behavioral | 3.99 | 0.82 | Positive | 3.91 | 0.84 | Positive |
| Affective | 4.09 | 0.83 | Positive | 3.93 | 0.87 | Positive |
| Cognitive | 3.84 | 0.92 | Positive | 3.68 | 1.01 | Positive |
| Over-all | 3.97 | 0.86 | Positive | 3.84 | 0.91 | Positive |

Table 2 showed the ANCOVA results for the students' academic attitudes. A one-way ANCOVA was conducted to compare the effects of two treatments on students' conceptual understanding and academic attitude while controlling for the pretest. Levene's test and normality checks were carried out and the assumptions were met. There was a significant difference in mean academic attitude [F (1.90) =27.111, p=0.020] between the groups of students exposed to dynamic and static visualization. This indicates that students exposed to dynamic visualization have a better academic attitude when compared to the students exposed to static visualization. However, the treatment can only explain 23% of the variance in the academic attitude. This might be because attitude has different components which include cognitive (knowledge, beliefs, and ideas), affective (feeling, like, and dislike), and behavioral (tendency towards an action [31, 32].

**Table 2. ANCOVA Results on Students' Academic Attitude**

| Source | Type III Sum of Squares | df | Mean Square | F | Sig |
|---|---|---|---|---|---|
| Corrected Model | 2698.042[a] | 2 | 1349.021 | 14.761 | .000 |
| Intercept | 540.387 | 1 | 540.387 | 5.649 | .017 |
| Group | 516.292 | 1 | 516.292 | 27.111 | .020 |
| Pretest | 2477.705 | 1 | 2477.705 | 277.083 | .000 |
| Error | 8225.141 | 90 | 91.390 | | |
| Total | 761885.000 | 93 | | | |
| Corrected Total | 10923.183 | 92 | | | |

a. R Squared = .247 (Adjusted R Squared = .230)

Table 3 showed the students' pretest and posttest performance in the academic achievement test. Both of the student groups have a comparable background or prior knowledge as evident in their pretest scores. However, the students exposed to dynamic visualization have a higher mean score than the students in the static visualization group. The standard deviation also indicated that the scores are more dispersed. This could be due to the variability of students' capacity to learn and thrive in the learning environment provided for them. To determine whether this difference is significant or not, ANCOVA was employed.

**Table 3. Descriptive Statistics of Dynamic and Static Visualization Academic Achievements of the Students**

| Teaching Approach | N | Pretest Mean | Standard Deviation | Posttest Mean | Standard Deviation |
|---|---|---|---|---|---|
| Dynamic | 46 | 18.22 | 3.025 | 31.30 | 5.133 |
| Static | 47 | 17.43 | 2.725 | 30.64 | 4.954 |

Table 4 indicated that the students exposed to dynamic visualization performed better than the students provided with static visualization exposure [F (1.90) =27.797, p=0.000]. It also indicated that 75% of the variance in academic achievement can be explained by the treatment. The positive effect of using simulations on conceptual understanding may be attributed to its ability to provide the students with a concrete presentation of an otherwise very abstract chemistry concept. It is said that simulations promote cognitive enjoyment and provide students with an enjoyable learning process that strengthens conceptual understanding [33]. It is affirmed that the use of simulations in teaching work to improve understanding of the concept of science [34]

Table 4. **ANCOVA Results on Students' Conceptual Understanding**

| Source | Type III Sum of Squares | df | Mean Square | F | Sig | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 1584.803[a] | 2 | 792.402 | 138.842 | .000 | .755 |
| Intercept | 63.148 | 1 | 63.148 | 11.065 | .001 | .109 |
| Group | 158.645 | 1 | 158.645 | 27.797 | .000 | .236 |
| Pretest | 1581.369 | 1 | 1581.369 | 277.083 | .000 | .755 |
| Error | 513.649 | 90 | 5.707 | | | |
| Total | 92217.000 | 93 | | | | |
| Corrected Total | 2098.452 | 92 | | | | |

a. R Squared = .755 (Adjusted R Squared = .750)

## CONCLUSIONS AND RECOMMENDATIONS

Attitude is a complex construct that may be improved by providing an engaging learning experience to students. Chemistry learning can be made enjoyable and productive for students through the use of technology especially in this new normal. Dynamic visualization using interactive simulation or animations may help learners improve their conceptual understanding of the selected chemistry topics. The teacher may consider using dynamic visualization in the form of simulation or animations in 3D models, structural images, and molecular models to help students improve their conceptual understanding of chemistry.

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