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Applied of Visualization Technology in Representation Levels on Vocational High Education

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Abstract: Integration of dynamic visualization technologies in the representation of chemical concepts can help students who are struggling to study and improve student performance. The purpose of this study is to ascertain how dynamic visualization affects the representation of electrochemical subjects. The experimental approach utilized in this work has a matching pretest-posttest control group design and a quasi-experimental design. The research sample consisted of 102 mechanical engineering students who were divided into two groups, namely the control group and the treatment group. While the control group was taught identical chemical ideas using text modules, the experimental group was taught electrochemical principles using text modules coupled with visualization technology. To ensure students' initial performance, a pretest was given to both the control group and the experimental group prior to therapy. A post-test was given to the experimental group and the control group after therapy. Test for differences between the control group and the treatment group using statistical analysis and an independent t test with a significance level of 95%. The analysis's findings revealed a significant difference ($p<0.005$) between the experimental group and the control group. The experimental group scored higher (82.04) than the control group (73.71) based on the post-test average value. It may be possible to address students' learning challenges and improve student accomplishment by using dynamic visualization technologies in the representation of chemical ideas.

Keywords: Representation, Visualization, Technology, Dynamic, Chemistry Concept

1. Introduction

The use of chemistry is prevalent in many facets of daily life, as is the growth of numerous applied scientific fields. It has arguably the most connections to other academic disciplines. Despite the fact that chemistry is used in many other industries, it is still thought of as a challenging topic for students. Both the fundamental character of the subject and human learning may be the source of the challenges [1]. Since learning chemistry is largely about understanding an abstract concept, many educators have found that students have trouble grasping this concept. When students are learning complicated new concepts, the presentation of concepts with numerous representations can be beneficial to the whole class [2]. The basis for higher-level thinking in learners' cognitive structures is conceptual understanding. The three stages of chemical representation of matter that are outlined by Kuhlthau et al [3] are the macroscopic level, the sub-microscopic level, and the symbolic level.

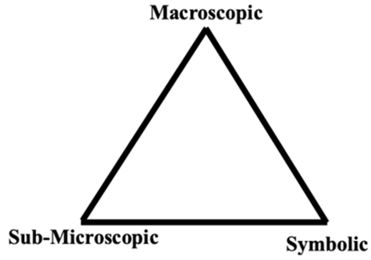

Figure 1. *Three Levels of Representation in Chemistry [1].*

The macroscopic level of representation can be thought of as a chemical representation that is derived from the direct observation of chemical occurrences like rust on metals and variations in matte condition. While symbolic representation refers to chemical equations that can explain the relationship between macroscopic and sub-microscopic representations, the sub-microscopic level is a chemical phenomenon that takes place at the particle level and cannot be directly or abstractly viewed [1, 4, 5]. The majority of students struggle to comprehend abstract chemical ideas and connect disparate representations to explain how chemicals behave. In order to help students explain the phenomena that take place, representation is required in science learning activities [6]. Learning to integrate different representations allows students to develop conceptual knowledge that links and unifies the numerous forms of information they are exposed to [7]. Because it is abstract, the representational realm of chemical cognition at the sub-microscopic level cannot be immediately and realistically understood, necessitating a model or tool to aid students in understanding the occurrences that take place [8]. Modeling and providing tools as media during the learning process might benefit teachers by helping students perform better and be more capable of handling given challenges [4].

Because submicroscopic chemical events cannot be seen with the naked eye and must instead be imagined, many students find it challenging to comprehend chemical representations at this level. To discover the visual and spatial links between atoms and molecules in learning activities, sub-microscopic representations are frequently used [9]. Using tangible models can help students identify the spatial information provided in molecular diagrams, connect one diagram to another, and translate between diagrams [10].

Electrochemical learning at vocational colleges is not easy for students majoring in mechanical engineering to absorb. there needs to be a combination of reference books, lecturer explanations, and visualization in representing the electrochemical concept. The integration of dynamic visualization technology in the representation of chemical concepts can help students with learning difficulties and improve student achievement.

The purpose of this research is to ascertain how dynamic visualization affects the representation of electrochemistry subjects so that there is an increase in students' understanding and increases their academic value. For this reason, it is deemed necessary to carry out this research.

2. Research Method

This study used a quasi-experimental approach with group pre-test and post-test designs. The research sample was 102 students majoring in mechanical engineering who were divided into two groups, namely the control group and the treatment group. statistical analysis using independent t test with a significance level of 95% (alpha = 5%). When statistical controls are employed rather than the random assignment of subjects to groups, a design is considered quasi-experimental. A comparison or control group could still exist. This study's methodology is quantitative, which means that every piece of information or piece of data is realized as numerical data. Tests and questionnaires have been utilized as instruments for data collection. The data were statistically examined, and the outcome was then explained. The t-test was then used to statistically examine the data.

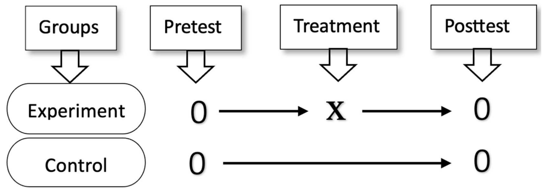

Figure 2. *The Experimental Design.*

While the control group was taught identical chemistry ideas using a text module, the experimental group was taught electrochemistry principles using a text module augmented by visualization technology. To ascertain the students' initial performance, a pretest was administered to both the control group and the experimental group before the therapy. The post-test was given to both the experimental group and the control group following the therapy.

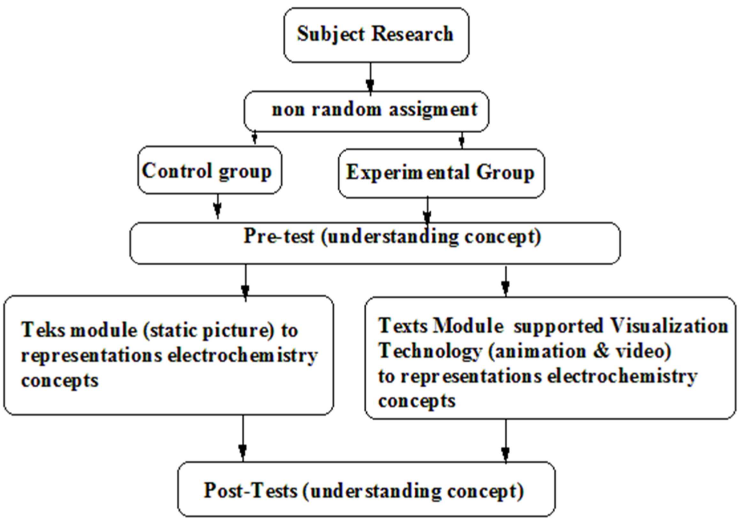

Figure 3. *Outline of Research Design.*

3. Results and Discussion

3.1. Visualization in Representation

According to Evagorou [11], visual representations in science can relate to both pure mental, conceptual, and abstract creations as well as objects with a physical or material reality. To aid students in developing conceptual knowledge, chemistry education has placed a strong emphasis on providing pupils with visual representations of chemical processes. discussing the many visual representations while addressing the visualization technology for each project. According to certain research findings, using visualization to describe chemistry learning can greatly motivate students to comprehend chemical events at the molecular level.

Students can better envision and comprehend the complicated, dynamic chemical processes that take place thanks to these visuals. Visualization technology can support active learning and integrate the knowledge acquired to comprehend challenging concepts and principles that can be applied to address chemical challenges. Students can alter a number of visual representations of abstract topics and investigate these notions through molecular modeling and visualization. With the help of visuals, it is now feasible to follow students' reactions, deeds, and interactions as they learn. Visualizations can provide better direction to enhance learning since they mediate the learning trajectory and cognitive processes [12]. Students are strongly motivated to grasp chemical events at the molecular level when learning chemistry through visualization. In chemistry education programs, information and communication technologies offer major prospects. They can also be a useful and effective instrument for creating new methods and procedures and deepening students' comprehension.

With dynamic pictures, such as animation, the characteristics of abstract chemical concepts can be depicted. Students should be shown abstract concepts in a variety of ways, especially to help them understand them. Students' comprehension of chemical topics has benefited from the use of models, modeling, and animations in representations of chemistry [13]. Multiple representations are frequently used in visualizations, which help students understand concepts cohesively in a variety of ways. Students get the chance to analyze a tangible phenomenon using an abstract idea that is understandable at the sub-microscopic level thanks to the use of animation. Because the sub-microscopic level cannot be readily observed firsthand, students have trouble understanding it. Since students cannot directly experience these phenomena, scientific models are crucial for representing these tiny things. Students could learn to describe and explain a chemical process using microscopic and symbolic representations with the aid of dynamic animations produced by technological instruments [14].

To define, clarify, and predict the characteristics of chemical substances and processes, chemists use a number of matter models. Some scholars have thought it vital to distinguish between various modeling levels since these models reflect matter at various scales [15]. Discrete particles, atoms, or molecular structures at the model-based level. Most chemical theories and explanations of chemical phenomena depend on an understanding of the microscopic world, which is linked to the phenomenological world, and both are expressed through symbols [16]. Chemistry exists in a visible (macroscopic) form where its properties and reactions can be observed. To explain macroscopic behavior, a sub-microscopic method developed in terms of atoms, molecules, and structure, as well as representative approaches, are all provided to the learners simultaneously in multimedia presentations. The world of atoms and their derivatives, ions, and molecules is what is considered at the sub-microscopic level. This is an invisible realm that can only be seen in one's imagination. It is impossible to undervalue the importance of imagination in chemistry research or in the depth of student understanding. As such, we would do well to make our students aware of it so that they can work on improving their visualization skills. Building linkages between macroscopic and sub-microscopic level representations and the symbolic level by using various representations is essential for learners to successfully solve chemical challenges. Scientific models are utilized in the learning process at the sub-microscopic level, and they are illustrated via static or animated visuals.

For pupils, the envisioned world of sub-microscopic chemistry poses significant difficulties. Technology for visualizing information has been created to assist students in their efforts to comprehend chemical principles and procedures. Animations have been shown to improve knowledge of abstract processes in numerous studies. Animations can be thought of as a visualization approach in the context of teaching. Animations add details that can enhance comprehension of the sub-microscopic environment in ways that static images alone cannot. While simulations allow students to explore phenomena and their representations, animations are frequently used to help students understand and explain abstract chemistry ideas [17]. In addition to providing new opportunities to raise student achievement in chemistry, the creation and increased use of these tools give us a chance to learn more about how students use external representations to solve problems in real-world situations [18].

Chemistry studies benefit from visualizations because they may help explain intricate, sub-molecular interactions and dynamics that are challenging to communicate verbally and because visualizations might appear to be incredibly simple. According to Cook et al [19], some representations of dynamic information are so simplistically presented that learners may only pay attention to surface futures while ignoring conceptually important characteristics. More efficiently than static images and words, animations and simulations may convey the dynamic chemical world [10]. When compared to static graphics, dynamic representations offer a much greater potential to support the learning of chemistry [17, 20]. They are able to present fully developed models of the processes as well as dynamic, previously unknown processes [12]. Students require assistance integrating fresh concepts from a visualization with their prior learning.

The significance of giving visual representations of chemical processes has been recognized in chemistry instruction as a means of assisting students in building conceptual knowledge. The effects of computer animations on students' learning have been the subject of numerous studies. Scientific events are commonly visualized via computer animations. The physical and chemical processes involved in producing light from flashlights were illustrated via computer animation. The illustrations explicitly demonstrated how the battery moves and how electrons migrate in conductors [21]. Since students cannot directly experience these events, scientific models are essential for illustrating submicroscopic realities. Modeling tools have the potential to have a big impact on how molecular-level concepts are learnt and comprehended because they are now available for use in the classroom. Chemistry research benefits from visualizations because they can be used to portray subtle, complicated chemical interactions and dynamics that are difficult to communicate verbally [22].

Conceptual visualizations, such as molecular structure and dynamics, and data visualizations, including graphs and structural renderings, are the two main types of visualization utilized in chemistry [23]. The most important characteristics and functions of key scientific concepts have been conveyed visually through diagrams, animations, and other visual representations. The use of visualization in science, including the benefits of various visualization techniques for representing scientific content, the environments and circumstances that encourage the most effective application of particular visualization techniques in science, the traits of students who benefit most from particular visualization techniques, and the impact of visualization on student performance [24].

Chemistry is widely used in many facets of daily life and in the advancement of many applied sciences, particularly in the disciplines of technology and engineering. the idea that productive lessons supporting skills and competencies are prioritized over adaptive learning in vocational education. For students majoring in mechanical engineering, chemistry is less desirable as an adaptable course. One subject that helps mechanical engineering students be competent is electrochemistry. Examples of expertise in this area include understanding corrosion, batteries, metal coatings, and materials. Many students or student teachers have trouble grasping electrochemical principles and have misconceptions about them. When teaching about electrochemistry, teachers hardly ever employ effective visualization techniques.

The instructor makes use of electrochemical phenomenon models. Due to these phenomena' micro-scale, real-world studies are rarely conducted in regular classroom settings [25]. Figure 4 illustrates how a dynamic visualization display, which uses computer animations to depict how particles move in electrolytic and galvanic cells, is more effective at clearing up student confusion.

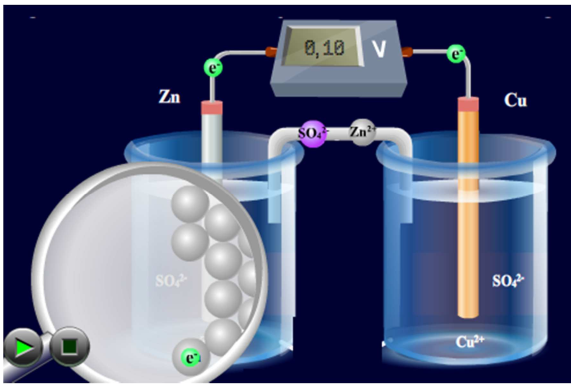

Figure 4. *Visualization in Galvanic Cell.*

3.2. Comparison of Experimental and Control Groups

To ascertain the students' initial performance, the pre-test was administered to both the control group and the experimental group. Table 1 contains the outcomes of the pre-test. According to Table 1, there was no significant difference between the experimental group and the control group's comprehension of chemistry concepts, with the pre-test retrieved significance (p) = 0.941, p > 0.05.

Table 1. *The Results of the t-Test on Mean Scores in the Pre-test.*

Group	N	Mean	SD	t	P
Control	24	52.21	7.96	0.075	0.941
Experimental	25	51.04	7.77		

After treatment, both the experimental group and the control group underwent the post-test. Table 2 contains the outcomes of the post-test. The information in Table 2 demonstrated a statistically significant difference in the experimental group's and control group's comprehension of chemical concepts (p = 0.004, p < 005).

Table 2. *The Results of T-Test on Mean Scores in the Post-test.*

Groups	N	Mean	SD	t	P
Control	24	73.71	9.89	-3.004	0.004
Experimental	25	82.04	9.52		

The comparison between the performance of the experimental and control groups before and after treatment is shown in Figure 5.

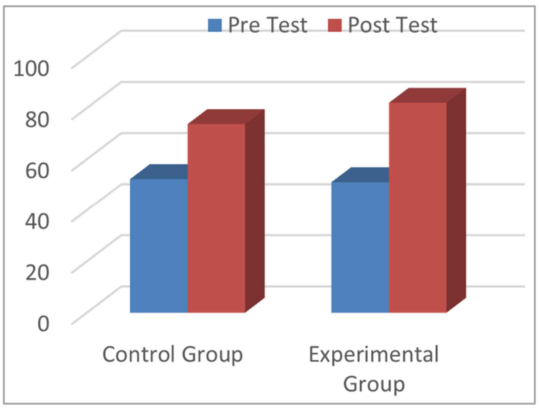

Figure 5. *The Comparison of Experimental and Control Groups.*

The experimental group scored higher (82.04) than the control group (73.71) based on the post-test average value. The experimental group's students provided clearer explanations of the electrochemical cell's electron displacement process, the battery's charge and discharge process, the fuel cell's operating mechanism, the coating process, and corrosion. Students are inspired to learn about electrochemical processes by using visualization technology, such as animation, when learning electrochemical principles. Some findings from studies on the use of visualization technologies in science teaching, particularly chemistry, were also found, such as research conducted by Yusuf and Arsani [26] and Arsani at al [27] there was an increase in achievement in the treatment group compared to the control group by means of visualization for problem based learning.

4. Conclusion and Recommendations

Students in the experimental group comprehend concepts more clearly than those in the control group. Visualization technology offers a lot of potential to help students learn about electrochemistry and improve chemistry education. The use of visualization technology in chemical representation is strongly advised to be utilized in chemistry learning in order to overcome the teacher's challenges in teaching chemical concepts and minimize the student's difficulties in understanding chemical concepts. The results of student learning can be enhanced by the use of visualization technology.

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