EVALUATING THE EFFECTIVENESS OF VARIOUS TEACHING STRATEGIES IN CHEMICAL BONDING

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ABSTRACT

In the rapidly evolving educational landscape of the 21st century, integrating multimedia-assisted instruction to teaching and learning procedures has become a pivotal strategy for enhancing learning outcomes.This study aimed to investigate the effectiveness of four different instructional approaches in teaching chemical bonding in Grade 9 chemistry, a subject traditionally perceived as challenging due to its abstract concepts and complex problem-solving requirements. The research employed a quasi-experimental design involving a sample of 163 high school students randomly assigned to four groups. Each group was exposed to a different instructional method: multimedia-assisted instruction, PowerPoint presentation lecture, traditional chalk and board discussion, and hand-on learning method. Pre-tests and post-tests were administered to assess students' knowledge acquisition. Additionally, students' perception in learning chemistry was measured through survey where challenges were foregrounded due to complex textbook language, fast-paced lectures, difficulty applying mathematical concepts, lack of visual aids, and low student confidence in problem-solving abilities. Furthermore, results indicated significant increase in the pre-test and post test results all four groups, but has no statistical difference when four post test scores were compared. These implies that diverse instructional techniques may be equally effective in terms of student learning outcomes. This suggests that either individually or in combination of varied approaches has a great potential for effectively learning chemical bonding. Thus, it is imperative for teachers to be innovative and proactive in their instructional strategies to optimize student learning outcomes in chemistry by in enhancing students' learning experiences.

Keywords: *multimedia-assisted instruction, learner's performance, chemical bonding*

1. INTRODUCTION

In response to the demands and challenges of the twenty-first century, the Philippines has recently undertaken significant educational reforms. These changes have transitioned the country's 10-year basic education system into a K-12 curriculum, aiming to expand students' learning programs, improve access to quality education, and prepare individuals for global competitiveness [1]. Building upon these reforms, the Department of Education has recently introduced the MATATAG K-10 curriculum. This latest initiative seeks to further streamline and enhance the basic education program by focusing on essential competencies and reducing the academic load on students [2]. These consecutive reforms demonstrate the Philippines' ongoing commitment to adapting its educational system to meet evolving global standards and student needs.

Research has shown that Filipino students struggle with certain chemistry concepts, particularly chemical bonding, stoichiometry, and the mole concept, which are identified as some of the most challenging areas in the Philippine basic education science curriculum [3]. This difficulty is not unique to the Philippines, as studies have highlighted the persistence of student misconceptions in chemical bonding even with existing instructional tools [4]. Recognizing these challenges, educators and researchers emphasize the need for more effective instructional approaches. It was also suggested that to enhance the learning of chemical bonding, teaching methods should move beyond simply cataloging basic misconceptions prevalent in introductory chemistry courses and focus on advanced bonding models[5]. This recommendation aligns with earlier findings by Özmen, who highlighted the critical need to explore and implement research-based science teaching approaches that can effectively bridge the learning gap and enhance students' comprehension of this fundamental chemistry topic[6]. Given the ongoing difficulties high school students face in grasping chemical bonding concepts, it is clear that developing and implementing innovative, research-based teaching strategies is crucial. These approaches should aim not only to address common misconceptions but also to provide students with a deeper, more nuanced understanding of chemical bonding, thereby improving their overall comprehension of this essential chemistry topic.

Integrating multimedia and conventional teaching approaches can both be effective in educational settings. However, the multimedia approach has been found to be more favorable in terms of student achievement, particularly in senior high school [7]. Furthering this finding, recent studies have further explored the impact of technology in education. For instance, it discovered that integrating Information and Communication Technology (ICT), specifically through PowerPoint presentations, not only promotes student motivation but also leads to increased achievement compared to conventional instruction methods [8]. This trend is not limited to well-resourced educational environments.

It was also examined the effects of PowerPoint integration and conventional instruction on students' motivation and achievement in less endowed senior high schools, further emphasizing the potential of educational technologies across diverse settings [9]. While these technological approaches show promise across various subjects, their application in specific challenging areas, such as chemical bonding, requires careful consideration. Similarly, the crucial need for effective instructional approaches in teaching chemical bonding to address common misconceptions, emphasize electrostatic interactions, and enhance understanding of bond formation energetics [10]. This underscores the importance of not only adopting new technologies but also tailoring instructional methods to the specific needs of complex scientific concepts.

Extrapolating on the importance of effective instructional approaches in teaching complex scientific concepts like chemical bonding, this study takes a comprehensive approach to addressing the challenges in chemistry education. Specifically, it evaluates the effectiveness of four instructional approaches: chalk and board lecture, PowerPoint slide presentation, hands on laboratory and multimedia-assisted instruction, in enhancing students' achievement scores in chemical bonding, with the primary goal of promoting meaningful learning and highlighting the potential of these methods for effective chemistry teaching. Hence, by examining different teaching strategies, this research not only aims to improve student outcomes but also to inspire educators, encouraging teachers to be more innovative and proactive in their approach to teaching chemistry, particularly when dealing with challenging topics. Furthermore, this study seeks to provide concrete recommendations for effective teaching methodologies, addressing gaps in current educational practices and contributing operative instructional strategies to the field. Through this multifaceted approach, the study aims to bridge the gap between theoretical understanding and practical application in chemistry education, potentially transforming how chemical bonding and other complex chemistry concepts are taught in classrooms.

2. METHODOLOGY

2.1 Research Design

An experimental pretest-post test design was utilized to investigate the effectiveness of 4 instructional approach on student achievement in learning chemical bonds. Four heterogeneous groups were used and have been exposed to four different instructional approaches: (1) multimedia assisted instruction, (2) PowerPoint presentation lecture, (3) hands-on learning activity, and (4) chalk and board lecture.

2.2. Sampling and Participants

The participants of this study were Grade 9 students from Misamis Oriental General Comprehensive High School in the Division of Misamis Oriental. A simple random sampling method was employed to select participants from the total Grade 9 population of 163 students, who were distributed across four sections. All selected students were invited to complete a 15-question survey administered via Google Forms, which aimed to identify the challenges they faced in learning chemistry. Additionally, a test instrument was administered as both a pretest and posttest to assess the students' performance before and after the intervention. This test was designed to evaluate their responses to various types of instructional approaches and to measure any changes in their understanding of chemistry concepts.

2.3 Data Analysis

The table categorizes student proficiency based on percentage scores, aligned with educational standards. The categories are as follows: developing (75-79%), approaching proficiency (80-84%), proficient (85-89%), and advanced (90% and above). Students in the developing category are approaching competency but have room for improvement. Those approaching proficiency demonstrate a solid understanding and are nearing mastery. The proficient category indicates students who have achieved a satisfactory level of content mastery. Advanced students exhibit exceptional mastery in the subject. This framework provides educators with a tool to assess student achievement and implement targeted strategies and interventions tailored to each proficiency level [11].

Table-1: Interpretation of Test Scores [12]

Level of Proficiency	Equivalent Percentage Score
Developing	75-79%
Approaching Proficiency	80-84%
Proficient	85-89%
Advanced	90% and above

To investigate the effectiveness of different teaching approaches, a one-way Analysis of Variance (ANOVA) was conducted. This statistical method was used to assess significant differences in pre-test and post-test scores across the various instructional methods [13]. Additionally, paired t-tests were employed to explore differences within each approach, providing more detailed insights into their specific instructional impacts [14]. These analyses allowed for a comprehensive evaluation of the relative effectiveness of each teaching strategy and the magnitude of improvement within each approach.

3. RESULTS AND DISCUSSION

3.1 Perceived Difficulties in Learning Chemistry

Students face several common challenges in learning chemistry. These include difficulty understanding complex language in chemistry textbooks, lectures that are often too fast-paced to comprehend fully, struggles with applying mathematical concepts to solve chemistry problems, a lack of visual and interactive elements in traditional lectures, and a lack of confidence in solving chemistry problems independently. It was also noted that difficulties in chemistry may also stem from the abstract nature of many topics and students' lack of a solid background in fundamental chemistry concepts [15, 16]. Furthermore, students' perception of a topic's difficulty significantly influences their ability and willingness to learn chemistry [17, 18].

Table-2: Items in the Questionnaire on Perceived Difficulties in Learning Chemistry

STATEMENT	MEAN	SD	REMARKS
Chemistry textbooks are often difficult to understand with their complex language.	2.395	0.870	Agree
The pace of lectures in chemistry class is often too fast for me to understand the material.	2.505	0.989	Agree
I struggle to apply the mathematical concepts used in chemistry to solve problems.	2.490	0.989	Agree
The lack of visuals and interactive elements in traditional lectures makes learning difficult.	2.329	0.964	Agree

I lack confidence in my ability to solve chemistry problems independently.	2.557	1.016	Agree

3.2 Comparison of Four Teaching Approaches for Chemical Bonding

In teaching chemical bonding, four distinct approaches were employed across different class groups. The plain PowerPoint presentation slide lecture utilized digital slides to present information visually, allowing for the incorporation of images, diagrams, and text to explain bonding concepts. This method is effective for presenting complex information in a structured manner. The traditional chalk and board lecture involved the teacher manually writing and drawing on a blackboard or whiteboard, offering a more dynamic and adaptable presentation style that can be paced according to student understanding. Laboratory hands-on teaching and learning provide students with practical experience, allowing them to observe and manipulate physical models and conduct experiments related to chemical bonding, enhancing their understanding through direct interaction with the concepts. Lastly, multimedia-assisted instruction incorporated various digital tools such as interactive simulations, videos, and online resources to engage students with the material. This approach can offer a more immersive and varied learning experience, catering to different learning styles and potentially increasing student engagement. Each of these methods has its own strengths and can be more or less effective depending on the specific content being taught, the resources available, and the learning preferences of the students in each class group.

Table-3: Paired T-test Results for Pre-test versus Post test of the Different Approaches Used

Teaching Approach	t-value	p-value	Remarks
Multimedia assisted instruction	22.87	< 0.01	Significantly higher
PowerPoint slide lecture	18.49	< 0.01	Significantly higher
Chalk and board lecture	20.02	< 0.01	Significantly higher
Hands-on laboratory activity	10.38	< 0.01	Significantly higher

The analysis of pre-test and post-test scores across four different teaching approaches for chemical bonding in Grade 9 learners reveals significant improvements in student performance for all methods. However, the degree of improvement varies among the approaches, as indicated by their respective t-values and p-values. The PowerPoint slide lecture approach demonstrated the highest level of improvement, with a t-value of 22.87 ($p<0.01$). This suggests that the visual presentation and structured format of PowerPoint slides were particularly effective in enhancing students' understanding of chemical bonding concepts. The clear organization and visual aids provided by this method likely contributed to its success.

Following closely, the laboratory hands-on activity approach showed substantial improvement with a t-value of 20.02 ($p<0.01$). This high t-value indicates that practical, experiential learning played a crucial role in solidifying students' grasp of chemical bonding. The opportunity to physically manipulate models or observe chemical reactions likely provided concrete experiences that reinforced abstract concepts. Furthermore, the traditional chalk and board lecture method also proved effective, with a t-value of 18.49 ($p<0.01$). While slightly lower than the PowerPoint and hands-on approaches, this method still demonstrated significant improvement in student understanding. The dynamic nature of this approach, allowing for real-time explanations and adaptations based on student responses, likely contributed to its effectiveness. Interestingly, the multimedia-assisted instruction showed the lowest t-value among the four approaches at 10.38, although still statistically significant ($p<0.01$). While this approach did lead to improvement, the lower t-value suggests that it may not have been as effective as the other methods for this particular topic or group of students.

Table-4: One Way ANOVA Table Comparing the Effectiveness of 4 Different Approaches

Source of Variation	SS	dF	MS	F-value	P-value
Between-treatments	233.98	3	77.99	2.25	0.08
Within-treatments	5513.16	159	34.67		
Total	5747.14	162			

The study evaluated the effectiveness of four instructional methods—Multimedia assisted instruction, PowerPoint slide lecture, Chalk and board lecture, and Hands-on laboratory activity—on students' post-test scores on chemical bonding. The one-way ANOVA results revealed a between-treatments sum of squares of 233.98 and a mean square of 77.99. While the F-value was calculated at 2.25, the p-value of 0.08 exceeding the threshold of 0.05 for significance. This indicates that there were no statistically significant differences in test scores between the different instructional methods, challenging the notion that any one method is distinctly superior in enhancing students' understanding of chemical bonding.

The high within-treatments sum of squares (5513.16) and mean square (34.67) suggest significant variability within each group, implying that student performance varied considerably regardless of the instructional approach used. These findings highlight the importance of individual student factors, such as engagement and prior knowledge, in influencing learning outcomes.

Chart-1: Average Distribution of Post-test Scores

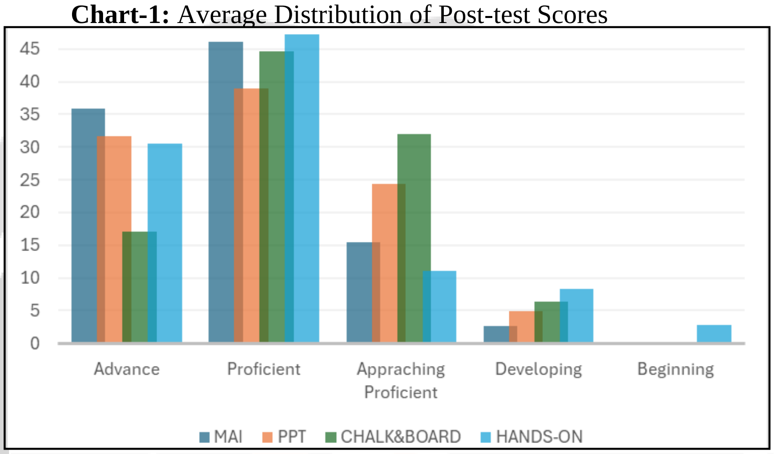

Chart 1 illustrates the distribution in post-test scores across the four teaching approaches. In the multimedia assisted instruction (MAI) group, the majority of students (46.15%) reached the proficient level, with a significant number advancing to the advanced level (35.90%). Only a small percentage remained at the developing (2.56%) and approaching proficient (15.38%) levels, indicating that this teaching method was highly effective, and no students were at the beginning level. Meanwhile, in the PowerPoint presentation group, a considerable proportion of students (39.02%) achieved proficiency, but fewer reached the advanced level (31.71%), suggesting room for improvement. A considerable number (24.39%) were still approaching proficient, with a small percentage at the developing level (4.88%).

Furthermore, the Chalk and Board method resulted in most students (44.68%) achieving proficiency, with some students (17.02%) advancing to the highest level. However, a noticeable fraction (31.91%) was still at the approaching proficient stage, while a smaller percentage (6.38%) was at the developing level. The hands-on method demonstrates the highest number of Proficient students (47.22%), with a substantial percentage (30.56%) reaching the advanced level. Fewer students were at the approaching proficient (11.11%) and developing (8.33%) levels, with a very small number at the Beginning stage (2.78%). The post-test findings underscore the effectiveness of diverse instructional methods, with the majority of students across all methods achieving proficiency. Particularly, the success of the Multimedia-assisted Instruction approach, evidenced by significant advancement to the proficient and advanced levels, aligned with other research findings endorsing multimedia-assisted instruction in science education due to its potential to enhance student understanding, engagement, and performance [19].

4. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the study highlights that students' learning of chemistry is significantly influenced by personal challenges such as difficulties in grasping chemistry concepts, the rapid pace of lectures, and the challenges of applying mathematical principles in the subject, which in turn diminishes their confidence in independent problem-solving. These obstacles can lead to a reluctance to engage in the learning process, including asking questions and taking risks. However, the research identified that diverse instructional approaches—specifically Multimedia-assisted instruction (MAI), PowerPoint presentations, traditional chalkboard methods, and hands-on activities—were effective in enhancing students' posttest scores, indicating that they experienced meaningful learning. Therefore, incorporating these varied instructional methods, or a combination thereof, within the classroom has a high potential to improve the delivery of chemistry lessons. It is imperative for educators to adopt innovative and effective strategies to enhance students' learning experiences. Hence, this research underscores the importance of diverse instructional approaches as a potent pedagogical tool in 21st-century classrooms, fostering an interactive and immersive learning environment that leads to improved educational outcomes in the study of chemistry. Furthermore, future research is encouraged to explore these factors more deeply and to examine additional instructional strategies or variations in implementation that might affect student learning in chemistry more positively, given the marginal results obtained in this analysis.

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