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The Effectiveness of YouTube Channel-Based Learning in Improving Engineering Students' Understanding of Stoichiometry in General Chemistry at Batangas State University

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I. THE PROBLEM AND ITS BACKGROUND

A. Introduction

The rapid growth of digital media in the last decade has transformed traditional education, offering students new ways to access and understand academic content. One widely used platform is YouTube**,** which provides accessible instructional videos that help simplify complex scientific concepts. According to Johnson (2014), online videos enhance students' comprehension by presenting lessons through visual and auditory formats that support different learning styles. As education continues to modernize, YouTube has become an effective supplementary learning tool, especially for subjects that require step-by-step demonstrations and clear visualization.

In the field of engineering, where academic programs demand strong foundations in mathematics and science, effective learning strategies play an essential role. AtBatangas State University – The National Engineering University, students must develop analytical skills, discipline, and mastery of courses such as General Chemistry. Chemistry is fundamental in engineering because it explains the behavior of matter, chemical reactions, and energy transformations used in laboratory work and innovation. However, many students find Chemistry difficult due to its abstract nature and symbolic representations. Mayer (2014) emphasized that learners struggle when concepts are not visually represented, making Chemistry challenging for many.

One of the most difficult topics in General Chemistry is Stoichiometry, which requires conceptual understanding of mole ratios, chemical equations, and mathematical operations. Students often struggle with mole conversions, equation balancing, and applying chemical relationships to quantitative problems. Devkota et al. (2014) noted that Chemistry becomes more difficult when ideas cannot be easily visualized, resulting in misconceptions and poor performance.

Traditional teaching methods such as lectures and laboratory activities provide important foundational knowledge. However, many students continue to experience difficulty connecting theoretical concepts with actual computational tasks in Stoichiometry. This gap suggests the need for alternative learning strategies that provide clearer visualization and more accessible explanations.

One effective approach is the use of YouTube channel–based learning, where students can access videos that visually explain Stoichiometry concepts. Sumanik et al. (2015) found that technology-based learning increases student engagement by offering interactive and visually appealing instructional materials. YouTube videos break down Stoichiometry problems into simpler steps, demonstrate calculations, and present chemical models that improve students' conceptual understanding. Similarly, Ayuna et al. (2015) emphasized that YouTube helps reduce monotony in the classroom by providing interactive and motivating content that enhances the learning experience.

YouTube also encourages active learning by allowing students to replay difficult lessons, take notes at their own pace, and visualize chemical relationships more clearly. Hadibarata (2015) highlighted that digital tools, including simulations and video lectures, strengthen blended learning by increasing student participation and comprehension. Through these online resources, students can develop confidence, improve their problem-solving skills, and better apply Stoichiometry concepts.

Furthermore, YouTube-based learning positively influences students' attitudes. Engaging video lessons increase motivation, sustain interest, and provide support beyond classroom instruction. Sulaiman et al. (2014) explained that YouTube becomes effective when the videos are relevant, understandable, and aligned with the lesson objectives.

Given these findings, it is important to investigate how YouTube channel–based learning affects the Stoichiometry performance of engineering students at Batangas State University. Since Chemistry is essential in engineering, improving students' understanding contributes to their academic success and future professional readiness. Additionally, the integration of multimedia instruction promotes innovative teaching strategies and supports students who struggle with abstract and computational concepts.

In summary, this study aims to examine the effectiveness of YouTube-based instruction in enhancing students' understanding of Stoichiometry in General Chemistry. By evaluating how instructional videos support conceptual learning, critical thinking, and problem-solving skills, this study seeks to offer insights that will benefit both educators and engineering students at Batangas State University.

B. Theoretical Framework

Cognitive Load Theory (Sweller, 1988) is one of the primary premises of this paper according to which learning is most effective when the information is provided in a manner that minimizes leakage in the mental process. Simulation resources and visual learning can be utilized in order to simplify the complex concepts in chemistry - molecules, reactions, and equations by giving the students visual representations of the concepts in a clear manner. This assists in avoiding cognitive overload and enhances greater understanding.

A second reinforcing theory is Dual Coding Theory (Palvio, 1971) which provides that individuals learn more when they are presented with information in verbal and pictorial modes. The visualizations combined with text or lecture descriptions of information, when shown to engineering students, allow their brains to process information on two channels (verbal and visual) which enhance the memory and understanding.

Constructivist Learning Theory (Piaget, 1972; Vygotsky, 1978) also informs this study since it states that learners develop their own knowledge by means of experience and interaction. The simulation tools can offer students the interactive experience of manipulating variables, watching results, and applying the chemistry concepts in their practical form - can help students construct the knowledge, not passively memorize it.

Finally, Multimedia Learning Theory (Mayer, 2001) is in support of using text, images and animations in teaching. This theory suggests that the best way to learn is through the multiple media that are well-organized and in line with the learning objectives. Visual and simulation-based instruction in the teaching of chemistry, therefore, can lead to a better understanding, motivation and Long term retention.

In short, this theoretical framework argues that the visual learning and math simulation tools can be useful in understanding general chemistry by reducing the cognitive load, involving both visual and verbal processing, active knowledge construction, and multimedia learning. The combination of these theories assists in stating that abstract chemistry concepts can be brought to life by means of digital and visual tools helping engineering students better understand the material.

C. Conceptual Framework

This study illustrates how a specific intervention transforms initial conditions into measurable learning outcomes. As explained by Marquez (2014), the IPO model allows researchers to clearly organize the flow of educational activities by identifying what goes into the system, how it is processed, and what results are produced. In the context of this study, the inputincludes the selected YouTube instructional videos on Stoichiometry, the participating first-year engineering students enrolled in General Chemistry, and the pretest that establishes their baseline level of understanding. These inputs serve as the foundational elements necessary for the effective delivery of the intervention. Buzzetto-More (2015) emphasized that digital instructional materials, such as YouTube videos, enhance learning by providing accessible, reusable, and visually rich resources that accommodate varying learning paces.

The process stage involves students' active engagement with the YouTube-based instructional materials. During this phase, students watch curated videos that explain Stoichiometry concepts step-by-step, allowing them to visualize chemical relationships and review lessons repeatedly at their own pace. This process also includes guided viewing, practice problem-solving activities, and the administration of a posttest to determine learning progress. The process is grounded in Mayer's Cognitive Theory of Multimedia Learning (2014), which states that students learn more effectively when information is presented through both visual and auditory channels, reducing cognitive overload and promoting better comprehension. This is supported by Green et al. (2015), who noted that self-paced online learning increases engagement, supports students with different learning needs, and fosters deeper conceptual understanding.

The output of the model represents the measurable results of the intervention. In this study, the outputs include the improvement in students' understanding of Stoichiometry— reflected through higher posttest scores—as well as their perceptions of YouTube as a supplementary learning tool and the identification of specific areas where improvement has occurred. Johnson (2014) highlighted that digital media and online video-based resources significantly enhance learning outcomes by offering explanations that are clear, relatable, and easy to revisit. Thus, the IPO framework effectively demonstrates how YouTube channel– based learning contributes to improved comprehension in Stoichiometry among engineering students at Batangas State University.

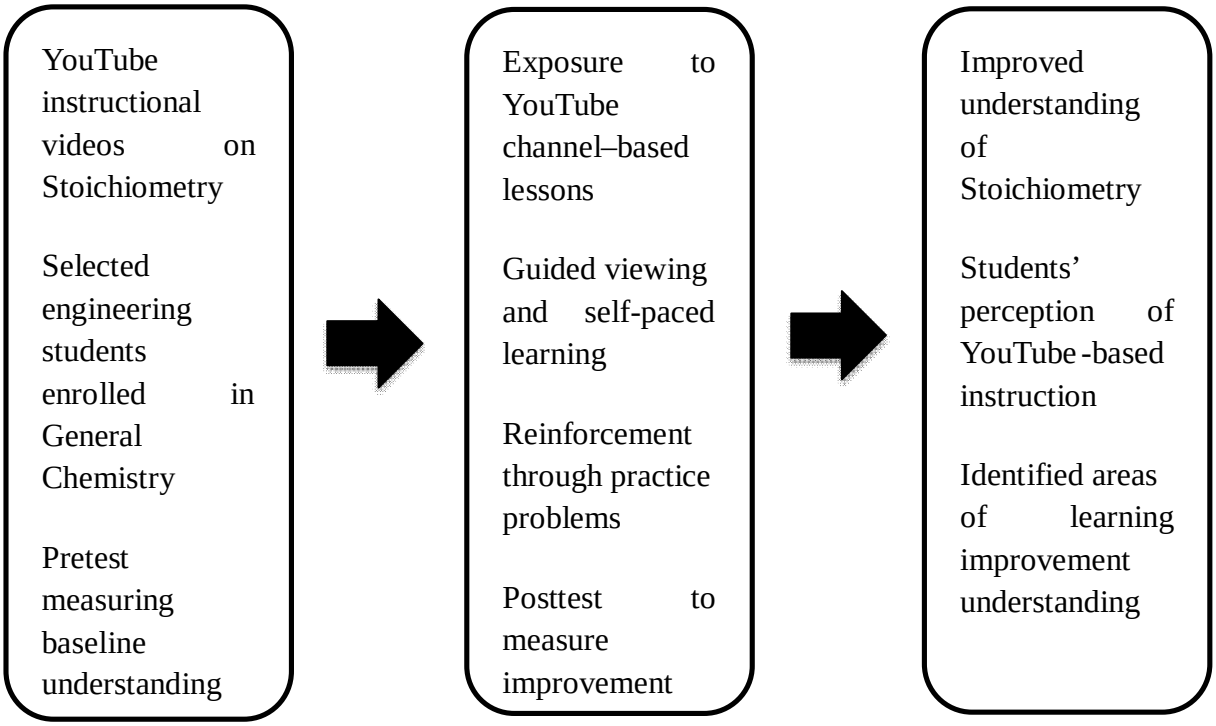

Figure 1
Research Paradigm

D. Statement of the Problem

This study aims to determine the efficacy of visual learning in enhancing the understanding of stoichiometry among engineering students in General Chemistry at Batangas State University. It focuses on improving students' comprehension through visual aids such as video presentation. Specifically, this study seeks to answer the following questions:

1) To what extent does visual learning affect students' understanding of stoichiometry?
2) Is there a significant difference in students' understanding of stoichiometry before and after visual learning?
3) How do students perceive the usefulness of visual learning in learning stoichiometry?

E. Hypotheses of the Study

To further determine this topic, researchers propose the following hypotheses:

1) There is no significant difference in students' understanding of stoichiometry before and after visual learning.
2) There is a significant difference in students' understanding of stoichiometry after visual learning.

F. Significance of the Study

The results of this study would be of great help to students, educators, and future researchers, especially to those who find Stoichiometry in General Chemistry difficult to understand. It would serve as a basis for proposing the use of visual learning strategies to enhance students' understanding of stoichiometry.

To the students, this study will help students enhance their understanding of Stoichiometry in General Chemistry through visual learning. Such improvement in comprehension could lead to better academic performance and a deeper appreciation of the subject.

To the educators, this study will help educators identify effective visual learning strategies that can improve students' understanding of stoichiometric concepts and make teaching more engaging and efficient.
To the future researchers, this study will serve as a basis of future researchers in conducting similar or related studies.

G. Objectives of the Study

The main objective of this study is to determine the Effectiveness of YouTube ChannelBased Learning in Improving Engineering Students' Understanding of Stoichiometry in General Chemistry at Batangas State University. Specifically:

1) To assess the level of understanding of engineering students in stoichiometry before and after the application of visual learning strategies.
2) To examine the impact of visual learning tools on students' conceptual understanding and problem-solving skills in stoichiometry.
3) To evaluate how visual learning influences students' engagement and interest in learning stoichiometry.
4) To identify possible differences in students' performance based on their year level.
5) To explore students' interaction with visual learning tools in learning General Chemistry.

H. Scope and Delimitations

This study focuses on evaluating the effectiveness of YouTube channel–based learning as a supplementary instructional tool in improving the Stoichiometry performance of engineering students at Batangas State University. It specifically involves first-year engineering students enrolled in General Chemistry and covers only the topic of Stoichiometry, including balancing chemical equations, mole ratios, conversions, limiting reagents, and quantitative problem-solving. The intervention consists of selected YouTube instructional videos chosen for their clarity, accuracy, and relevance to Stoichiometry. A pretest–posttest design is used to measure the changes in students' understanding after exposure to these materials.
The study is delimited in several ways. It does not include other Chemistry topics such as thermochemistry, atomic structure, or gas laws, as it is limited solely to Stoichiometry. Only YouTube-based learning materials are utilized, excluding other digital platforms such as TikTok lessons, virtual laboratories, or online simulations. Additionally, the findings of the study are confined to engineering students from Batangas State University and may not represent the experiences of students from other institutions. Factors such as teacher influence, classroom environment, and students' prior knowledge obtained outside of YouTube exposure are also beyond the scope of this research and are not considered as variables.

I. Definition of Terms

This section clarifies key concepts and terminologies used throughout this study. The following definitions are provided to ensure a clear and consistent understanding of the variables and context of the research.
Understanding of Stoichiometry. The level of comprehension and ability to apply stoichiometric principles and calculations, as measured by pre and post-test.
Stoichiometry. the study of the quantitative relationship between reactants and products in a chemical reaction.
General Chemistry. The introductory chemistry course required for engineering students at Batangas State University, which includes the study of stoichiometry.
It covers fundamental chemical concepts, including atomic structure, chemical bonding, thermodynamics, and chemical kinetics, with a significant emphasis on Stoichiometry. The course aims to equip students with the essential chemical knowledge and problem-solving skills necessary for their future engineering studies and professional practice.

II. REVIEW OF RELATED LITERATURE AND STUDIES

In this chapter, the researchers explore the existing body of literatures and studies relevant to the effectiveness of YouTube- based learning in improving engineering students' understanding of Stoichiometry. By identifying gaps in the current knowledge, this chapter aims to highlight the necessity for further investigation and set the stage for the original contributions to the field.

A. Foreign Literature

Cognitive Theory of Multimedia Learning still serves as a primary guide in the analysis of multimedia instructional materials in the light of effective learning (Mayer, 2025).

The theory proves that there are two different ways to process information: one channel is for visual input and the other is for verbal input. Each channel has a defined limit when it comes to the amount of information that can be processed at once, which makes it crucial for multimedia content to be designed in such a way that it does not dominate the learners' cognitive resources. It also indicates that cognitive engagement is required and active, and the learners will have to select the important information, integrate it in the form of visual representations, and connect it with their previous knowledge. Studies have confirmed that visual learning developed in accordance with Cognitive Theory of Multimedia Learning to better retention, understanding, and application of knowledge by the learners, specifically in video-based learning environments (Mayer, 2025).

Multimedia instruction, especially when video is included, has been recognized as a valuable instructional approach for chemistry students, specifically for its effect on students' understanding of chemistry topics and their independence from laboratory instruction. Students who viewed a short, student-generated video instruction would be more confident and less reliant on teaching assistant's direction in the laboratory as compared to students who received instructions only through a teaching assistant and no video. Previous studies, before these student video instructions, indicated that video representation helps students score significantly higher on assessments and create experimental techniques precisely when compared to students who only received a teaching assistant's in-person briefing before conducting the laboratory section.

Using a short, student-generated video demonstrated effectively shortened students' completion time and reduce laboratory mistakes, all while also increasing students' perceived value of performing laboratory tasks, when compared to students receiving only written instructions. Additional literature supports the promise of interactive and multimedia elements outlining laboratory directions, both reducing completion time and errors than traditional instruction limiting to make use of paper or video instruction alone. These approaches guide students more effectively through "how-to" procedures, even if content concepts require demonstrated instruction through different active instructional methods (Jenkins & Fawcet, 2024).

Al Zboun et al. (2018) conducted a study on students' perceptions of using YouTube videos as supplementary material in a university course. The study found that students perceived YouTube videos as useful for enhancing their understanding of the subject matter and for increasing their engagement in the learning process. Moreover, students reported that using YouTube videos as supplementary material helped them to better prepare for examinations.

According to Sutirman, Imrona, and Sholikah (2025), research found that 84% of respondents agreed to use YouTube as a digital learning resource for Financial Management material, and 77% believed that watching subject-related videos on YouTube was more effective for learning than reading books. Additionally, students strongly supported the use of YouTube as a digital learning resource for financial management. The study indicated that YouTube helps store material in long-term memory, facilitating easier review and enhancing student understanding. The combination of visual and auditory elements in YouTube videos was found to improve engagement and retention. Furthermore, YouTube was recognized as an effective platform for developing financial skills. Teachers acknowledged that YouTube aids in making abstract financial concepts more concrete through visual explanations.

The conclusion highlighted YouTube's potential as an effective digital platform for learning, especially in enhancing students' financial skills. Its accessibility, diverse content, and user-friendly nature contribute to its value as a supplement to traditional learning resources in the digital era. Felanie, (2021) and Olasina, (2017) states that YouTube is very appropriate to apply in theoretical learning. This finding aligns with previous empirical evidence where 98% of students used YouTube as a source of information, and 86% of them stated that YouTube helped their learning.

B. Local Literature

The use of visual tools in Philippine education has gained recognition as one of the most crucial methods to improve student engagement, comprehension, and even academic performance. The Department of Education highly encouraged the use of visual tools in education through the procision of multimedia instructional materials matched with the K to 12 curricula and the nurturing of 21st century skills such as digital literacy, critical thinking, and creativity. Different schools in the Philippines have conducted research to prove that visual aids, such as videos, animations, and interactive simulations significantly increase students' motivation and help them easily grasp difficult concepts (Almacen et al., 2023).

David et al. (2024) investigated the impact of video tutorials on the learning outcomes of STEM students in the Philippines. Their findings indicated that students perceived video tutorials as effective tools for enhancing their comprehension and practical application of chemistry concepts, including stoichiometry. The study concluded that video-based instructional materials significantly support chemistry education in the Philippines.

Reyes and Cruz (2025) explored the use of social media, particularly YouTube, to enhance project-based learning in chemical engineering education. They emphasized that integrating YouTube videos into the curriculum improved student engagement and deepened their understanding of fundamental topics like stoichiometry. Their research supports the integration of social media platforms as valuable educational resources for engineering students.

Johnson et al. (2025) developed a research-informed framework for designing and assessing conceptual chemistry instructional videos, including those hosted on YouTube. Their work focused on creating high-quality multimedia content that facilitates the teaching of stoichiometry and related engineering principles, ensuring that videos effectively aid student learning through well-structured visual explanations.

Ortencio et al. (2025) also performed a phenomenological analysis of academic difficulties and adaptive methods employed by STEM and non-STEM learners in the BSEdScience program at Sultan Kudarat State University. Students encountered obstacles with abstract topics such as stoichiometry, yet they relied on video materials and group study sessions to enhance their grasp of general chemistry principles.

C. Foreign Studies

A study done by Akintokun (2025), examined an active flipped classroom teaching strategy for stoichiometry in General Chemistry course. In this approach, learners content purposely designed outside of class such as video lectures, and engage in active learning activities during class meetings. The findings indicated the learners' academic performance was significantly better and that they were more eager to learn in a flipped classroom than a typical lecture approach. According to the learners, there was emotional, social, and cognitive engagement increased on-task behavior and evidence of success using stock knowledge. The video lectures of both near and at a distance, and increased engagement with teachers and peers led to productive learning experiences and understanding of stoichiometry concepts.

Segala (2023) tackles the widely-documented challenge of students learning stoichiometry by making a YouTube channel that provides a series of step-by-step video demonstrations for stoichiometry problems with complexity. Created by smartphones and uncomplicated production methods to allow for reproducubility, the study implemented a onegroup pre-test and post-test design, including a student survey to measure the educational effectiveness. The results indicate significance in the eductsional improvement toward students' understanding of concepts and problem-solving skills of stoichiometry, before and after the video materials. Students also expressed positive impressions of the multimodal instructional materials, recognizing them to be useful for learning at your own pace and for reviewing the concepts. This study contributes to the evidence of the usefulness of digitally available video supports, especially for conditions were engaging, accessible and flexible instructional materials are desirable for stoichiometry education.

One study by Asogwa (2020) indicates that YouTube tutorials boost problem-solving abilities in stoichiometry through detailed, sequential breakdowns and visual demonstrations. Engineering students exhibited stronger analytical skills and viewed video-guided problems as less challenging than those from textbooks, leading to marked gains in grasp and results.

A separate analysis by Mecida et al. (2024) revealed that incorporating video tutorials into chemistry courses strengthens comprehension of stoichiometry by delivering lively, userfriendly materials. Such videos promote group work and individualized pacing, vital for handling intricate computations in engineering programs.

Other evidence from Evans et al. (2008) video instruction cultivates teamwork abilities and favorable views of stoichiometry, based on student feedback highlighting the appeal and utility of video-enhanced activities for tackling tough subjects. This matches teaching practices in engineering programs at places like Batangas State University, where online supplements bolster conventional approaches.

Overall, studies by Asogwa (2020), Mecida et al. (2024), and Evans et al. (2008) affirm YouTube channel learning markedly advances engineering students' stoichiometry mastery via approachable content augmenting standard instruction.

D. Local Studies

An appropriate study shows that problem-based learning modules embedded with video tutorials result in greater sucess in solving stoichiometry problems when compared to students engaging in traditional approach. The video component allows for flexible, self-paced learning; students can pause, rewind, and repeat difficult stoichiometry concepts and problem-solving steps, which creates opportunities for mastery. Researchers found significant result increases in students' post-test scores and positive feedback on improving understanding and engagement.

The studies conclude that video-based instructional materials improve conceptual clarity and application skills in stoichiometry classes (Minguito& Valencia, 2025).

The research conducted by Reyes and Silang (2021) primarily focused on the role of technology in chemistry teaching and its influence on pupils' performance. A close examination of the results pointed to a strong positive correlation between the degree of technology incorporation and the transfer of knowledge among the chemistry students. Even though the technology was incorporated only in occasional teaching sessions, students reached very good performance levels in chemistry. The use of technological tools and applications aroused student interest and participation, which in turn, resulted in effective knowledge transfer.

The researchers acknowledged the mixed effects of technology, but they mostly talked about it as a factor that contributed to the improvement of the learning process in chemistry classrooms in the Philippines.

The implications are that pro-technological changes in the chemistry classroom help students with their academic performance and knowledge retention. In fact, the research is amongst the numerous arguments put forward in favor of the use of multimedia and virtual learning tools for better chemistry instructions, which is in line with the contemporary educational reforms aiming at technology-enhanced learning environments worldwide (Reyes & Silang, 2021).

Arcega and Valdez (2025) studied the Technology Enhanced Learning Approach (TELA) using virtual labs on Grade 10 students' stoichiometry performance in the Philippines.

Their results from pre- and post-tests showed significant improvement and high ratings of TELA's effectiveness, leading to recommendations for integrating technology to enhance learning outcomes.

Nolasco (2025) evaluated supplementary modular materials designed for Grade 12 STEM engineering students, focusing specifically on gaining mastery in stoichiometry. The intervention showed improvement in students' understanding, supporting the use of blended digital resources in general chemistry education in the Philippines.

Guiamalon et al. (2024) tested instructional videos about mole concepts and stoichiometry on senior high school students in Makilala public schools. Findings from pre- and post-assessments revealed greater learning gains over traditional teaching, endorsing videos to aid learning gaps.

These studies proved that visual learning such as utilizing YouTube for visual representations greatly improve students' learning.

III. RESEARCH METHODOLOGY

A. Research Design

This study will use a quasi-experimental one-group pretest–posttest design to evaluate the effectiveness of YouTube channel–based learning on the Stoichiometry performance of first-year engineering students at Batangas State University. Participants will take a pretest to measure baseline understanding of Stoichiometry, be exposed to a structured set of selected YouTube instructional videos and guided practice activities over a fixed intervention period, and then take a parallel posttest that measures the same learning outcomes. The pretest–posttest design allows measurement of learning gains attributable to the intervention while keeping the study feasible within the course context.

B. Research Respondents

The target population of this study consists of first-year engineering students enrolled in General Chemistry at Batangas State University during the semester in which the research will be conducted. These students represent an appropriate population because Stoichiometry is a major component of their foundational chemistry coursework. A purposive or convenience sampling technique will be utilized, since participants will be drawn from the researcher's accessible General Chemistry sections and must voluntarily agree to participate. This sampling approach is practical in an actual classroom setting and ensures that respondents have direct exposure to the instructional intervention being evaluated. The intended sample size of approximately 30 students is considered adequate for educational research using a pretest–posttest design, as it provides sufficient statistical power for detecting meaningful changes in performance through paired-sample analyses. A sample of this size also allows for reliable interpretation of learning gains while remaining manageable for test administration, scoring, and analysis within the constraints of an academic semester.

C. Research Instruments

The Researcher made a Stoichiometry Test, which will serve as both the pretest and posttest, is specifically designed to measure students' understanding and mastery of Stoichiometry concepts in General Chemistry.

Both tests are aligned with a carefully constructed test blueprint to ensure that all essential content areas—such as balancing chemical equations, mole concept, mass-mole-molecule conversions, limiting reagents, and stoichiometric calculations—are adequately covered.

To maintain the validity and reliability of the measurements, the pretest and posttest will be designed as parallel forms, meaning that while the items differ in specific details, they adhere to the same blueprint, cognitive levels, and difficulty distribution. This approach minimizes potential practice or memory effects, ensuring that improvements in posttest performance reflect actual learning from the intervention rather than familiarity with the test items. Additionally, the tests will undergo review by content experts to establish content validity and a pilot administration to evaluate item clarity, difficulty, and discrimination indices.

In addition to the achievement tests, a perception survey will be administered to gather qualitative and quantitative information regarding students' experiences with YouTube channel–based learning. The survey will include Likert-scale items (5-point scale: Strongly Disagree to Strongly Agree) assessing students' perceptions of the usefulness, clarity, and engagement of the YouTube videos, as well as their motivation and confidence in solving Stoichiometry problems. Open-ended questions will also be included to capture students' personal reflections and suggestions for improvement. The survey is intended to complement the achievement tests by providing insight into how students interact with the videos, how they perceive the learning process, and which aspects of YouTube-based instruction they find most helpful.

Together, these instruments will provide a comprehensive understanding of both the objective learning outcomes and the subjective experiences of students. This combination allows the study to evaluate not only the effectiveness of YouTube channel–based learning in improving Stoichiometry performance but also the students' attitudes, engagement, and receptiveness toward this instructional strategy.

D. Data Gathering Procedure

The data collection procedure for this study will follow a systematic sequence to ensure the accuracy, reliability, and ethical conduct of the research. First, informed consent will be secured from all participants to guarantee voluntary participation and adherence to ethical research standards. Following this, the pretest (Form A) will be administered in a controlled environment, ensuring that all students complete the assessment under similar conditions to maintain consistency and reduce external influences on their performance. The scores from the pretest will be recorded and stored securely for subsequent analysis.

After the pretest, the intervention phase will be implemented. Students will engage in a series of YouTube instructional videos focusing on Stoichiometry, complemented by guided practice activities to reinforce learning. The intervention will take place over a defined period, with multiple viewing sessions scheduled to allow students to absorb and apply the concepts at their own pace..

Upon completion , the posttest (Form B) will be administered under conditions similar to the pretest to measure any changes in students' understanding and performance. In addition, participants will be asked to complete a perception survey and provide qualitative comments regarding the usefulness, clarity, and engagement of the YouTube-based learning experience.

Finally, all test results will be carefully scored and this procedure ensures that the study systematically captures both quantitative improvements in Stoichiometry performance and qualitative insights into students' experiences with YouTube channel–based learning.

E. Data Analysis

The collected data will first undergo preliminary checks to ensure completeness and accuracy. Any missing data will be addressed using listwise deletion if the number of missing responses is small, and excluded cases will be noted accordingly. To determine whether the data meet the assumptions for parametric testing, the normality of the differences between pretest and posttest scores will be evaluated using the Shapiro–Wilk test, supplemented by visual inspections of histograms and Q–Q plots. If multiple-choice and rubric-scored items are combined, raw scores will be converted to percentage or scale scores to allow comparability across different item types.

Descriptive statistics will be calculated to summarize the students' performance. This includes reporting the mean, median, standard deviation, minimum, and maximum scores for both pretest and posttest results. Frequency distributions and percentiles will also be presented to provide a clearer view of the overall score patterns. Additionally, gain scores will be computed by subtracting pretest scores from posttest scores, and percent gain will be calculated using the formula [(posttest − pretest)/pretest × 100] where meaningful, to quantify improvement attributable to the intervention.

For inferential analysis, a paired-samples t-test (dependent t-test) will be conducted to determine whether the mean posttest scores are significantly higher than the pretest scores, using a significance level of $\alpha = 0.05$. The t-value, degrees of freedom, p-value, and 95% confidence interval for the mean difference will be reported. If the assumption of normality is violated, the nonparametric Wilcoxon signed-rank test will be used instead, and the corresponding rank statistics and p-value will be presented. Effect sizes will be calculated using Cohen's d for paired samples to quantify practical significance, with small, medium, and large effects corresponding to approximately 0.2, 0.5, and 0.8, respectively. For nonparametric tests, the effect size r will be reported.

Item analysis will be performed on multiple-choice items by calculating item difficulty, defined as the proportion of students who answered each item correctly, and item discrimination, determined using point-biserial correlations or a discrimination index. Items with very low discrimination or extreme difficulty may be revised or removed to improve the quality of the test.

Perception survey data will be analyzed separately. For Likert-scale items, the mean and standard deviation will be computed for each item, and the overall scale reliability will be assessed using Cronbach's alpha. Open-ended responses will be analyzed using thematic analysis to identify recurring themes, such as enhanced visualization, increased motivation, or technical issues encountered by students while using YouTube channel–based learning. This combined approach ensures that both quantitative performance outcomes and qualitative student experiences are thoroughly examined.

IV. PRESENTATION, ANALYSIS AND INTERPRETATION ODF DATA

This chapter dealt with the results and discussion of the study. The discussion consisted of paragraphs, which solved the results of the survey conducted to answer the problem in this study.

Table 1
Normality Test Results (Pre and Pre Test)

Test	Statistic	p-value	Verbal Interpretation
Pre - Test	0.8265	0.0022	Not Normal
Post - Test	0.4467	0.00000001	Not Normal

Legend, (1.00 -1.50) Strongly Disagree (1.51-2.50) Disagree (2.51-3.50) Agree (3.51-4.00) Strongly Agree

Based on the result of the normality test for both pre-test and post-test scores indicate that the data do not follow a normal distribution. The pre-test recorded a test statistic of 0.8265 with a p-value of 0.0022, which is below the 0.05 significance level. This demonstrates that students initial performance scores significantly depart from a normal distribution. Similarly, the post-test yielded a test statistic of 0.4467 and a p-value of 0.00000001, further confirming a strong deviation from normality. This implies that the distribution of the pre-test and posttest data does not follow a standard normal distribution.

Anaesth (2019) stated that the continuous data, test of the normality is an important step for deci ding the measures of central tendency and statistical methods for data analysis. When the data follow normal distribution, parametric tests otherwise nonparametric methods are used to compare. There are different methods used to test the normality of data, including numerical and visual methods, and each method has its own advantages and disadvantages. Since the results showed that both datasets were not normally distributed, this confirms the need to use non-parametric statistical methods rather than parametric tests for further analysis, in line with standard practices for handling non-normal data.

Table 2
Wilcoxon Signed-Rank Test

Test	Statistics	p-value
Wilcoxon Signed- Rank Test Results	0.0	0.001349

Legend, (1.00 -1.50) Strongly Disagree (1.51-2.50) Disagree (2.51-3.50) Agree (3.51-4.00) Strongly Agree

The Wilcoxon Signed-Rank Test was employed to determine whether there was a significant change in students' performance between the pre-test and post-test. The analysis produced a test statistic of 0.0 with a p-value of 0.001349, which is well below the 0.05 level of significance. This result indicates a statistically significant difference between the pre-test and post-test scores. The students demonstrated measurable improvement following the intervention or instructional strategy used in the study. The finding supports the effectiveness of the learning intervention, showing that it led to meaningful changes in students' understanding and per formance.

According to teachers.institue (2024) Non-parametric tests are a vital tool for researchers in the field of education, providing a way to analyze data when parametric assumptions do not hold. These tests offer flexibility, robustness, and ease of use, making them ideal for analyzing a wide variety of educational data. By understanding when and how to use non-parametric tests, researchers can ensure that their findings are both reliable and meaningful, contributing to the advancement of education science. By this, the non-parametric Wilcoxon test directly addresses the non-normality of the data while allowing you to assess the effectiveness of the intervention.

Table 3
Knowledge on Stoichiometry and Chemistry Concepts

Statement	Mean	Verbal Interpretation
I understand the concept of moles	3.25	Agree
I know how to balance chemical equations	3.20	Agree
I know how to calculate limiting reactants	3.05	Agree
I understand steps in solving stoichiometry problems	3.10	Agree
I can apply mole ratios properly	3.25	Agree
I am aware of common mistakes in stoichiometry	3.00	Agree
Weighted Mean	3.14	Agree

Legend, (1.00 -1.50) Strongly Disagree (1.51-2.50) Disagree (2.51-3.50) Agree (3.51-4.00) Strongly Agree

Students have a moderate understanding of stoichiometry and chemistry concepts, with a (WM = 3.14). They grasp concepts like moles (3.25) and balancing equations (3.20), but struggle with calculating limiting reactants (3.05) and recognizing common mistakes (3.00).

Overall, they have a good foundation, but could improve with practice

According to Niaz, M.(2016) Stoichiometry is considered a difficult topic for students as understanding depends on various other topics, such as the particulate nature of matter, the concept of mole, Avogadro's number, conservation of matter, balancing chemical equations, and the laws of definite and multiple proportions. Furthermore, according to A. Rocke, from the historical perspective, laws of definite and multiple proportions are nothing more than special cases of the law of equivalent proportions.

Table 4
Attitude Toward YouTube-Based Learning

Statement	Mean	Verbal Interpretation
YouTube videos are helpful.	3.50	Agree
Videos increase my confidence	3.35	Agree

I feel motivated using visual aids.	3.40	Agree
YouTube makes stoichiometry less stressful.	3.30	Agree
I prefer videos over traditional lectures.	3.35	Agree
Weighted Mean	3.36	Agree

Legend, (1.00 -1.50) Strongly Disagree (1.51-2.50) Disagree (2.51-3.50) Agree (3.51-4.00) Strongly Agree

Table 4 shows , shows students' attitudes towards YouTube-based learning. All five students achieved an average score between 3.30 and 3.50 that is in the "Agree" range showing clear agreement about the benefits of YouTube videos. The highest mean score of 3.50 was given to "Useful YouTube videos" confirming that they are an effective tool for improving understanding and learning outcomes in the field of stoichiometry. The overall mean of 3.36 also corresponds to "Agree" indicating an overall positive perception of YouTube-based learning that increases engagement and reduces stress in difficult topics such as stoichiometry.
Al Zboun et al. (2018) conducted a study on students' perceptions of the use of YouTube videos as supplemental material in a university course. The study found that the students found , found YouTube videos , videos useful to improve their understanding of the subject matter and increase their , their engagement in the learning process. Additionally students reported that using YouTube videos as supplemental materials helped them better prepare for exams. These , These suggestions are based on the positive attitudes shown in the survey data such as the average overall score of 3.36 that reflects agreement on the learning benefits of YouTube , YouTube stoichiometry. Recommendations focus on maximizing YouTube's educational potential while addressing challenges such as maintaining quality content and aligning with academic goals.

Table 5
Practices in Learning Stoichiometry

Statement	Mean	Verbal Interpretation
I watch and take notes.	3.25	Agree
I pause and replay difficult parts.	3.35	Agree
I attempt practice problems after watching.	3.10	Agree
I review previous videos.	3.05	Agree
I ask questions or clarify doubts.	2.65	Agree
Weighted Mean	3.08	Agree

Legend, (1.00 -1.50) Strongly Disagree (1.51-2.50) Disagree (2.51-3.50) Agree (3.51-4.00) Strongly Agree

According to the outcomes, the students are sure as to the effectiveness of learning about Stoichiometry through the use of YouTube. They stated that YouTube assisted them in comprehending the lessons better (M = 3.50) and made the subject more exciting (M = 3.40). The students were also more confident having used the video lessons (M = 3.30) and felt that they were able to solve more Stoichiometry problems (M = 3.35). The best rating was based on recommending YouTube resources (M = 3.55), where positive attitudes are very strong in using YouTube as a means to learn. All in all, YouTube is regarded as an effective learning tool with a weighted mean of 3.42 (Agree).These results are consistent with existing literature on video-based learning.
According to Mayer's Cognitive Theory of Multimedia Learning (2009), students learn better when information is presented both visually and verbally, which explains why YouTube makes Stoichiometry easier to understand. Similarly, Kay (2012) found that educational videos improve comprehension and support problem-solving skills by allowing students to learn at their own pace.

A study by Clifton and Mann (2011) also highlighted that YouTube increases student engagement because videos provide more relatable and accessible explanations compared to traditional classroom instruction. These studies support the positive perception of students in this research, showing that YouTube is an effective supplementary tool for improving understanding and motivation in learning complex scientific topics.

Table 6
Perceived Effectiveness of YouTube- Based Learning

Statement	Mean	Verbal Interpretation
YouTube	3.50	Agree
I can now solve more Stoichiometry problems.	3.35	Agree
YouTube made Stoichiometry	3.40	Agree
I feel more confident after using videos.	3.30	Agree
I would recommend YouTube resources.	3.55	Agree
Weighted Mean	3.42	Agree

Legend, (1.00 -1.50) Strongly Disagree (1.51-2.50) Disagree (2.51-3.50) Agree (3.51-4.00) Strongly Agree

The findings show a tendency among learners that the use of YouTube videos in studying stoichiometry helps them understand the concept better and encourages them to learn more about the topic and it lies between the responses of 3.30 to 3.55. The strongest agreement was in suggesting YouTube links and there was a great deal of supporting these learning means. Respondents showed more confidence toward the learning of the topic and problem-solving skills which showed a positive effect on the learners motivationally and cognitively. With a mean of 3.42 supporting the effectiveness of the learning videos, the participants considered Youtube videos to act as an educational aid resource in learning of stoichiometry as Youtube tutorials served as a means of learning.
Khan et al. (2023) also stated that learning tutorials from yourube boost students' learning rate, comprehension of the lesson, as well as the flexibility in learning, since they can be used as a resource for repetitive review. Most of the study's participants responded to the study with strong positive responses and they showed motivation to learn and improved their academic performance and cited YouTube as a valuable resource and an educational tool.

V. SUMMARY, CONCLUSION AND RECOMMENDATION

This chapter presents the summary of the findings, the conclusion based on the results of the survey conducted as well as the recommendation that could be helpful for the other researchers.

A. Summary of Findings

This summary synthesizes the key findings of the analyses, which examined the normality of the data, the effectiveness of youtube channel-based learning in improving engineering students' understanding of stoichiometry in general chemistry at Batangas State University. The results of the normality test showed that both pre-test and post-test scores did not follow a normal distribution, indicating the need for non-parametric statistical methods. Using the Wilcoxon Signed-Rank Test, the study found a significant difference between the pre-test and post-test scores, showing that students' performance improved after the use of YouTube-based lessons.
For students' attitudes, the overall weighted mean of 3.36 revealed that learners positively viewed YouTube videos as helpful in understanding Stoichiometry, increasing confidence, and reducing stress in learning difficult topics. Similarly, students strongly agreed on the effectiveness of YouTube as a learning tool, with an overall mean of 3.42, noting that the videos enhanced comprehension, made lessons more engaging, improved problem-solving skills, and motivated them to learn.

Overall, the findings indicate that YouTube-based instruction is an effective aid in improving performance and fostering positive learning attitudes in Stoichiometry.

B. Conclusion

This study at Batangas State University addressed all the objectives by proving that YouTube-based learning has significantly improved engineering students' comprehension and understanding towards Stoichiometry. The positive results were supported and aligned with the existing studies about multimedia learning in YouTube.

Based on these findings, the findings further indicated that the students were more involved and more confident in their ability to solve stoichiometric problems when they used YouTube tutorials as the learning supplements. The availability of the visual demonstrations, step wise solutions to problems, and real time explanation helped in getting a better picture of the complex concepts that are not easy to understand as a result of the traditional lectures. In addition, the article also noted that the adaptable learning platform of YouTube enabled the students to learn at a pace that suited them- go stopping, rewinding, or playing lessons whenever they needed them, which also led to a better understanding of the subject.

Besides this, the research indicates that YouTube incorporation in the learning process may assist the instructor in meeting the different needs of the students in terms of learning. A large number of the students said that the platform served to fill the gaps in the understanding as it offered alternative explanations and visual examples that supplemented the discussion in the classroom. It means that multimedia materials may be used as the effective reinforcing agents to enhance understanding and memorization and make complex engineering courses more accessible.

In summary, this study shows that learning with YouTube videos can greatly improve stoichiometry knowledge for Sanitary Engineering students at Batangas State University, with strong results and positive feedback supporting its effectiveness. Teachers are encouraged to use reliable YouTube videos in their chemistry classes and pair them with guided activities to boost student engagement and learning. Future research should look at long-term effects, compare YouTube with other platforms, and test these methods in other engineering fields to keep improving multimedia teaching in higher education.

C. Recommendation

The researchers will implement the activity to give engineering students at Batangas State University an insight into the importance of creative learning and problem solving. Students can benefit from this study by actively engaging in online activities that develop their critical thinking and problem-solving skills, particularly through YouTube-based learning. By participating in guided problem-solving exercises, interactive video tutorials, and self-paced review sessions, students can strengthen their understanding of Stoichiometry, improve their ability to solve chemical equations, and gain confidence in applying concepts in different scenarios.

Educators play a crucial role in supporting this process by integrating carefully selected YouTube videos into their classroom instruction. Teachers can use these videos as visual aids during discussions, as supplemental materials for assignments, or as part of blended learning strategies to make lessons more engaging, accessible, and effective in enhancing students' comprehension.

Future researchers are encouraged to expand upon this study by using larger and more diverse groups of participants and exploring additional topics in General Chemistry. Further research may examine whether multimedia-based learning remains effective across different areas of the subject, assess long-term retention, and investigate innovative ways to integrate visual learning tools with traditional teaching methods to maximize student engagement and performance. By this, students, educators and future researchers can improve the academic performance rates.

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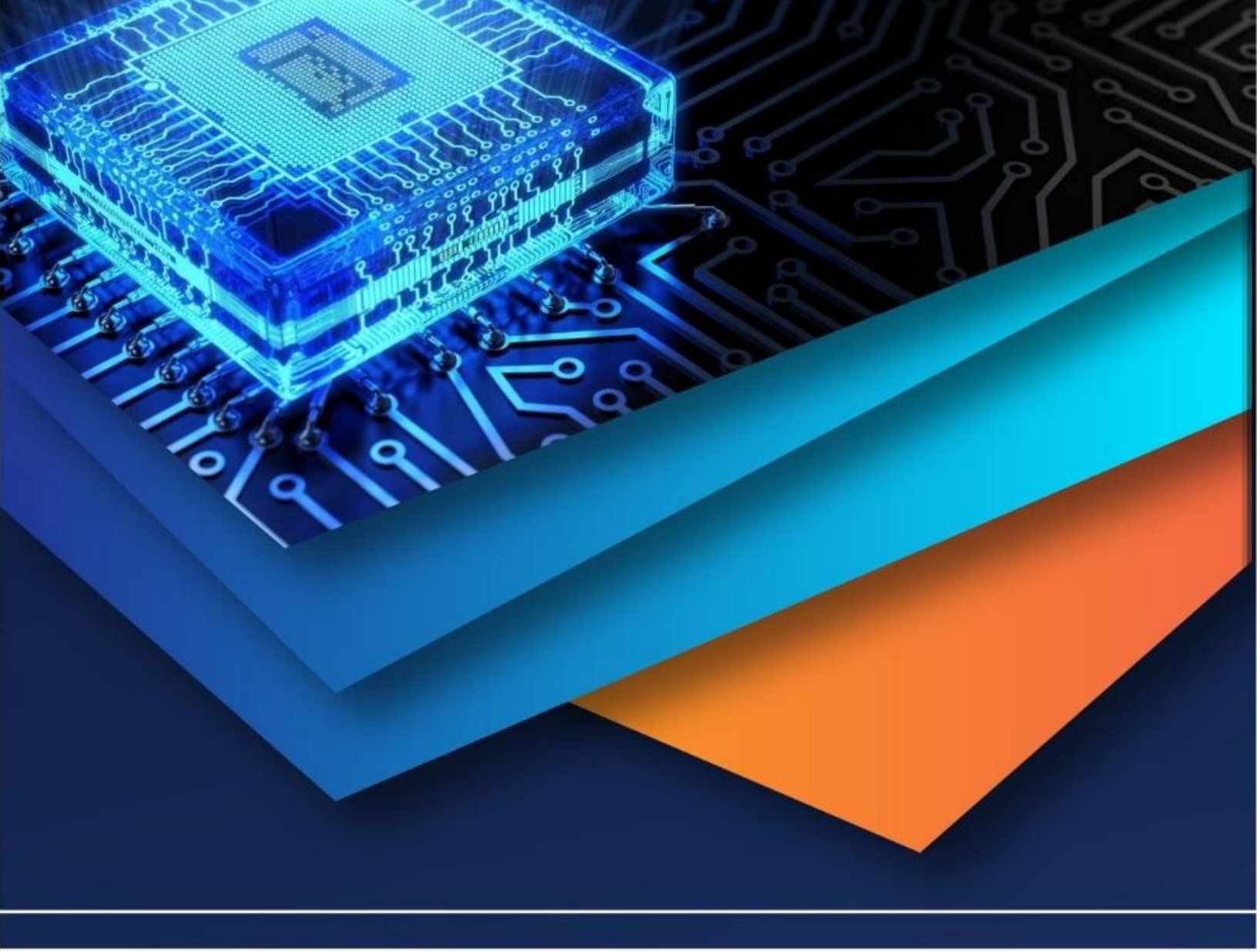

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