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Effects of Inquiry-Oriented Modular Instruction on Grade 10 Students' Science Inquiry Processes Understandings, Scientific Explanation Construction, and Conceptual Understanding in Selected Biological Concepts

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Abstract

This study examined the effects of Inquiry-Oriented Modular Instruction on Students' Science Inquiry Processes Understandings, Scientific Explanation Construction, and Conceptual Understanding in Selected Biological Concepts. Using quasi-experimental design, 210 students from four intact sections enrolled at the Marawi City National High School in the school year 2021-2022 constituted the control and experimental groups of research participants. Six validated researcher-made instruments namely, scientific inquiry-oriented processes understanding test (SIPUT), scientific explanation construction test (SECT) and conceptual understanding test (CUT), and interview guide questions were used to generate the data. T-test for paired samples, Chi-square and Pearson r were employed to establish significant differences between scores obtained by the two groups on the variables at 0.05 level of significance. Findings showed that there were no significant differences between the mean scores of the control and experimental groups on the levels of understanding of the scientific inquiry-oriented processes test, scientific explanation construction test and conceptual understanding test before the intervention. The null hypotheses then were accepted at p=0.05. After the intervention the mean scores obtained by the two groups on the three tests were found to be significantly different from each other, with the experimental group obtaining higher means scores, thus the null hypotheses were rejected at p=0.05. In conclusion, science inquiry-oriented modular instruction was effective in raising the levels of understanding of the learners in the scientific inquiry processes, scientific explanation construction and concept understanding of the biology concepts. Given these findings, the teaching approach should be used more often to facilitate learning science.

Keywords: inquiry oriented-modular instruction, science inquiry processes, scientific explanation, conceptual understanding, scientific investigation

1. Introduction

Education in the Philippines today is facing great challenges. One such challenge lies in science instructions. It is perceived that a great number have hardly developed their analytical skills in science. Hence, academic institutions are now experiencing dilemmas on the alarming examination performance of students in science (Dela Cruz, 2012).

Poor math and science scores on the 2005 National Achievement Test (NAT) and the Trends in International Mathematics and Science Study (TIMSS) confirm public concerns about declining basic education quality (Brawner and Andara, 2005). The Autonomous Region in Muslim Mindanao (ARMM) consistently under performed, in 2006-2007 NAT, only 5.3% of ARMM's Grade 6 students reached the 75% mastery level in math (Basilan 0.8%, Lanao del Sur 10.9%, Marawi City 3.6%. ARMM's science scores were also considerably weaker than the national average (37% of national Grade 6 students reached 60% near mastery level).

Mindanao State University System-Wide Admission and Scholarship Examination (MSU-SASE) results reveal consistently poor in science and mathematics performance among high school students, disappointing parents and teachers. MSU-Lanao College of Arts and Trade (MSU-LNCAT) feeder high school students scored significantly lower than MSU-IIT students on the MSU-SASE from 2009-2013 averaging between 9.56% and 11.67% compared to MSU-IIT's 16.67% in 2013. The necessitates innovative teaching methods to improve student engagement and interest in science and mathematics, requiring teachers to creatively present material in an appealing and stimulating manner.

Despite the great deal of studies conducted abroad in favor of using inquiry-oriented approach in teaching science, there have not been enough studies locally to address the issue, especially in the use modules in teaching the concepts through inquiry-oriented approach. This study then aims to find out the effect(s) of inquiry-oriented modular instruction in relation to the learner's conceptual understanding and scientific investigation skills. The researcher believes that the results of this study would provide insights and awareness among education stakeholders in enhancing students' understanding on science inquiry process, scientific explanation construction and conceptual understanding. Which may in one way or the other contribute to the betterment of classroom instruction.

2. Objectives of the Study

This study focused on the strategy in teaching Science of Grade 10 Students of Marawi City National High School, Marawi City, it sought to answer the following questions:

1. What are the control and experimental groups of students' science inquiry processes understanding before and after intervention?
2. Is there a significant difference in SIPU test mean score between the control and experimental group of students before and after intervention and the mean gain score?
3. Is there a significant relationship association between students' scientific inquiry processes understanding and their conduct of scientific inquiry?
4. What are the control and experimental groups of students understanding of Scientific Explanation before and after intervention.
5. Is there a significant difference in the Scientific explanation construction test mean score between the control and experimental groups of Students before and after intervention and the mean gain score?
6. Is there a significant relationship/association between students' understanding of scientific explanation and their scientific explanation construction.

7. What are the control and experimental groups of students conceptual understanding on the Biology Topics Domain of the study before and after intervention?
8. What are the control and experimental groups of students' conceptual understanding levels in the biology topic domains of the study before and after intervention?
9. Is there a significant difference in the level of conceptual understanding between students in the experimental and control groups before and after intervention?
10. Is there a significant difference in the conceptual understanding test (CUT) mean score and mean gain score between students in experimental and control groups before and after the intervention?

3. Hypothesis

Given the stated research problem, the following hypotheses were tested on 0.05 level of significance.

H1: There is no significant difference between the science inquiry processes understanding test (SIPUT) mean scores and the mean gain scores of the control and experimental group of students before and after intervention.

Decision: The null hypothesis is rejected at p=0.05 after the intervention

H2: There is no significant difference between the scientific explanation construction test (SECT) mean scores and the mean gain scores of the control and experimental groups of students before and after the intervention.

Decision: The null hypothesis is rejected at p=0.05 after the intervention.

H3: There is no significant difference in the levels of conceptual understanding between students in experimental and control groups before and after intervention.

Decision: The null hypothesis is rejected at p=0.05 after the intervention

H4: There is no significant difference between the conceptual understanding test (CUT) mean scores and the mean gain scores of the students in experimental and control groups before and after the intervention.

Decision: The null hypothesis is rejected at p=0.05 after the intervention

4. Methods

4.1 Research Design

This study employed both quantitative and qualitative approach of research to investigate the effect of inquiry-oriented modular instruction on students' scientific inquiry processes understanding, scientific explanation construction, and conceptual understanding on selected topics in Biology. The quantitative part used quasi-experimental design using two intact groups. Specifically, the matching-only pretest-posttest control group design used as illustrated in the diagram below:

Experimental Group	M	O	X	O
Control Group	M	O	C	O

The experimental group refers to the group of students who were exposed to scientific inquiry-oriented modular instruction while the control group of students has been taught using conventional modular instruction. The symbol M in this design means that the two groups were matched based on their respective average grades in Grade 9 of the school year 2020-2021. The symbol O corresponds to the observation in the first administration (pretest) and second administration (posttest) of test instruments to both experimental and control groups respectively. The symbol X represents the use of the scientific inquiry-oriented modular instruction in teaching the experimental group on the selected topic domain in Biology. While symbol C represents the use of conventional modular instruction in the control group.

The qualitative aspect relied on the interviews and observation so that the views of the participants were not restricted. Class observations, journal entries, interviews and responses through video and audio recordings were done to verify the result of students' impression, feelings and experience towards inquiry-oriented instruction.

4.2 Population and Sampling

The subject participants were four sections of intact classes of Grade 10 high school students who were enrolled in school year 2019-2020 at the Marawi City National High School. The four sections were grouped into two. Two intact sections were used as experimental group and another two intact sections served as the control group. Grouping was determined by drawing lots to minimize bias. The total number of participants included in the study were 210 students in all with 60 males and 150 females. Classes sectioning was heterogeneous thus matching the study participants was employed to increase the likelihood that in the groups, the student participants were equivalent. The matching of subject participants was based on their average in Grade 9 during the school year 2020-2021. Their ages ranged between 15-18 years old. The students from the experimental group used the symbol SE with an accompanying subscript number to hide their identity. This holds true with those in the control group. For example: Students from the experimental group were coded SE. For Student number 1 in the experimental group. The student is coded SE 1. This is followed by SE 2, SE 3 … SE n until all the students in the group were coded. On the one hand, the students from control group are coded with SC. Subscript numbers were also used in the coding. For example, SC 1 means "Students number 1 from the control group. This is followed by SC 2, SC 3 … SC n until all the students that composed the control group were coded.

4.3 Instruments

The following instrument used in gathering data; these are Conceptual Understanding Test (CUT), Scientific Explanation Construction Test (SECT), Science Inquiry Processes Understanding Test (SIPUT), Interview Guide and Journal Notes.

1) Conceptual Understanding Test (CUT). This was researcher-constructed test to elicit students' conceptual understanding on the Biology topics covered in this study. This test assesses the students' ability to recognize facts and ideas into a meaningful concept rather than plain memory recall and at the same time identify the students' possible misconceptions.

In preparation of CUT, initially 60-items open-end questions drawn from cases or situations for analyses were constructed. Originally 60 cases, trimmed down to 20. The were constructed with an accompanying table of specification (TOS) of objectives categorized based on Bloom's taxonomy. Items included the following topics: Evolution and Environment/Biodiversity. (Appendix I) The said test instrument was validated using researcher made rubrics. The scoring distribution is reflected on the scoring rubrics (See Appendices D and E).

After the construction of the test, it was presented to the researcher's adviser and the experts of the discipline for corrections, suggestions, and content validity. After incorporating all their comments and suggestions on the research instrument, it was presented back to the experts of the field for final evaluation before it was pilot tested. This test was pilot tested to Grade 10 Students of Lake Lanao National High School having similar science cognitive level with the subject participants. The result was item-analyzed and was tested for its reliability using Cronbach's alpha. When the result of Cronbach;s alpha reliability of *.872* was accepted, the test instrument was administered as pretest to both experimental and control groups prior to the proper intervention phase, The posttest administered consisted of parallel question with the pretest to avoid students from recalling the exact questions of the pretest. Students' level of conceptual understanding was measured in terms raw scores obtained. Their raw scores in the pretest and post test conceptual understanding test were categorized into different levels of categorization as follows.

Table 1. Categorization of Students' Levels of Conceptual Understanding

Raw Scores	Conceptual understanding Level
46 to 100% of score (46-60)	Advanced (2.3-3.00)
41 to 45% of score (41-45)	Proficient (2.05-2.25)
31 to 40% of score (31-40)	Approaching (1.35-2.00)
26 t0 30% of score (26-30)	Developing (1.3-1.5)
0 to 25% of score (0-25)	Beginning (0-1.25)

Note. adapted from DepEd Order 31,s 2012

Other than the DepEd adapted categorization of the students' level of conceptual understanding to show the data gathered was reliable, a researcher-developed rubric has also been used in categorizing the students' scores to the CUT. Some related studies have used DepEd Order 31,s. 2012 to measure the level of conceptual understanding.

2) Scientific Explanation Construction Test (SECT). The Scientific Explanation Construction Test was an instrument used to evaluate student understanding on scientific explanation construction. This instrument consisted of five elements or components of scientific explanation construction such as question, evidence, science concept, scientific reasoning and claim that need to answer. The instrument and scoring rubrics was researcher made. The validity of the instrument was made complete by incorporating the suggestions and comments made by the experts in the field of Biology who had reviewed the said instrument. The said survey questionnaire had followed an iterative and consultative process from the subject specialist for validation. After undergoing comprehensive validation and pilot testing, the process rendered the final questionnaire. The instrument was re-validated by experts of biology and was pilot tested to Grade 10 Students of Lake Lanao National High School having comparable science abilities with the respondents to evaluate its quality and reliability. when the result of Cronbach;s alpha reliability of *.334* it was administered before and after the intervention.

Understanding Scientific Explanation Construction was scored from 0 (No Mastery) to 3 (Exceptional). Each element of SEC scored a maximum of 3 points. This questionnaire, together with the other instruments, was simultaneously given as pretest and posttest to both experimental and control groups. Students' level of understanding scientific explanation construction was measured in terms of their obtained scores and was analyzed and interpreted using the categorization, No Mastery (0), Partial Mastery (1), Mastery (2) and Exceptional (3) as shown in the table below.

Table 2. Categorization of Students levels of understanding Scientific Explanation Construction

Range	Levels of Scientific Explanation Construction
12-15	Exceptional (2.4-3)
8-11	Mastery (1.6-2.2)
4-7	Partial Mastery (0.8-1.4)
0-3	No Mastery (0-0.6)

For construction of scientific explanation, this was a descriptive type of test that was composed of five elements of scientific explanation construction which requires scientific explanation answers. Students constructed phenomenal problems embedded biology concepts and principles that will be explained the cause of the phenomenon to occur. The questions require the students to explain the causes of the occurrence of the phenomenon and construct their answer in at least three sentences in a paragraph form. The rubrics base on the content of the answer of students are: Three (3) points every correct answer and categorized according to the following scores, No Mastery (0), Partial Mastery (1), Mastery (2) and Exceptional (3). As shown in the table below.

Table 3. Categorization of Students levels of Scientific Explanation Construction

Raw Scores	Levels of Scientific Explanation Construction
3	Exceptional
2	Mastery
1	Partial Mastery
0	No Mastery

This questionnaire, together with the other instruments was simultaneously given as pretest and posttest to both experimental and control groups. Students' level of scientific explanation construction was measured in terms of their obtained scores and was analyzed and interpreted using the categorization below, this was a descriptive type of test that composed of five elements of scientific explanation construction which requires scientific explanation answers.

Science Inquiry Processes Understanding Test (SIPUT). It was a self-made research instrument; it was an important tool for research in many scientific disciplines. This is used to measure the understanding of students in the science process. This instrument had 10 open ended questions. The said instrument was validated and reviewed by experts in Biology and science education. The initial draft was pilot tested to grade 10 students at Lake Lanao National High School. As the instrument was described validated and reliable, when the result of Cronbach;s alpha reliability of *.756* was accepted it was administered before and after intervention to the grade 10 Students' of Marawi City National High School. Students' answers in SIPUT were graded using self-made rubrics and categorized according to the following scores, beginning (0), developing (1), accomplished (2) and exemplary (3).

Students' level of understanding in science inquiry processes was measured in terms of their obtained average scores from the questionnaire and was interpreted using the categorization below.

Table 4. Categorization of Students' Level of understanding on Science Inquiry Processes

Range	Level of Understanding on Science Inquiry Processes
2.3-3.0	Exemplary
1.6-2.2	Approaching
0.8-1.5	Developing
0.7 Below	Beginning

Interview Guide. The researcher was constructed interview guide questions that were serving as compass for the researcher to direct the conversation toward the topics and issues. (Appendix J) The interview was done through focus group discussion (FGD) interview and written modality. The prompt question was primarily intended to assess students' feedback on Way/s Students' Science Inquiry Processes Understanding Translated with their Conduct of Scientific Inquiry, Way/s Students' Scientific Explanation Understanding translated into (the ways they) their Scientific Explanation construction, and the traces of Influenced of Students' Scientific Explanation Understanding and their Scientific Explanation Construction. All the questions are open-ended. The data from the interview was used for triangulation purposes of the quantitative data collected.

Journal Notes. This served as field notes of researcher where she wrote the problems encountered, the class observation, and the impact of inquiry-oriented modular instruction in their learning. This helped in the qualitative data collection to cross-validate the results obtained in the study and it helped the researcher to realize and know if there are mistakes in conducting the study.

4.4 Data Collection

Students' response from the instruments was gathered, scored, and obtained the necessary data. Scoring of the questionnaires were evaluated and observed by the three inter-rater professionals in educational field to avoid biases, the result data was analyzed and interpreted. Group discussion interviews as well as written interview from randomly selected students was obtained for triangulation purposes of quantitative data collected. Statistical analysis of quantitative data and thematic analysis of qualitative data was followed next.

4.5 Treatment of the Data

The data that includes are the scores and responses of the two groups. These data are compiled, sorted out, organized and tabulated. Collected quantitative data was analyzed and interpreted using SPSS software for MS windows. In analyzing data, the following statistical tools were used in this study: the Frequency Counts, Percentage Analysis, Chi-square Test and T-test for independent samples and Person Product Moment Correlation Coefficient (r).

Frequency Counts. This used to determine the number of students in each level of conceptual understanding and science process skills level. Statistical treatment will all be tested at $\alpha = 0.05$ level of significance.

Percentage Analysis. This used to create a contingency table from the frequency distribution and represent the collected data for better understanding.

Chi-square Test. This used to determine the significant difference between the level of conceptual understanding of control group and experimental groups before and after intervention.

T-test for independent samples. This tool used to determine the significance difference between experimental and the control groups in terms of their pretest and posttest mean and mean gain score set at 0.05 level of significance.

Person Product Moment Correlation Coefficient (r). This tool is used to determine the relationship of student's scientific inquiry processes understanding and their conduct of scientific inquiry. This tool was used to determine if the two dependent variables such as understanding on scientific explanation construction and constructing scientific explanation had relationship.

As for the qualitative data, it is statistics free. But data was organized and presented thematically in narrative and descriptive forms.

4.6 Ethical Consideration

Before the intervention the researcher considered that no ethical consideration would be violated; the participants would not be subjected to any harm and health protocols would be strictly implemented. Parents' consent for the voluntary participation of Students in the study during Covid 19 pandemic has been sought prior to the conduct of the study. Protection of the privacy of the research participants by using pseudo name and the adequate level of confidentiality of the research data were ensured.

5. Results and Discussion

Control and Experimental Groups of Students' Science Inquiry Processes Understanding Before and After Intervention

Students understanding science inquiry processes were measured before and after intervention using researchers created science inquiry processes understanding test (SIPUT) questionnaire. It consisted of ten (10) open ended questions. Embedded in the questionnaire are the different science processes that are applied in scientific inquiry. Based on this, the science processes were identified, and the students' answers were graded using self-made rubrics and categorized according to the following scores, beginning (0-0.7), developing (1.6-2.2), accomplished (1.6-2.2) and exemplary (2.3-3.0). Table 5 shows the frequency and percentage distribution of science inquiry processes understanding the level of the students.

Table 5. Numbers and Percentage Distribution of Students' Science Inquiry Processes Understanding Level Before and After Intervention

Range	Level of Science Inquiry Processes Understanding	Control Group n=105		Experimental group n=105	
		Before	After	Before	After
		Number (%)	Number (%)	Number (%)	Number (%)
2.3-3.0	Exemplary	0 (0%)	2 (2%)	0 (0%)	13 (12%)
1.6-2.2	Accomplished	8 (17%)	32 (30%)	19 (18%)	58 (55%)
0.8-1.5	Developing	43 (41%)	41 (39%)	39 (37%)	34 32%)
0-0.7	Beginning	44 (42%)	26 (25%)	47 (45%)	0 (0%)
Total		105 (100%)	105(100%)	105(100%)	105(100%)

As shown in Table 5, in the science inquiry processes understanding (SIPU), all the students from both groups were not in the exemplary level category of SIPU before the intervention. In the experimental group, 19 (18%) of them were in the accomplished level, 39 (37%) in the developing level and 47 (45%)in the beginning level of SIPU before the intervention. After the intervention 13 (12%) of the students in the experimental group attained an exemplary level of understanding; 58 (55%) were found to be in the accomplished level, 34 (32%) developing level and 0 (0%). beginning level. In the control group, before the intervention, 8 (17%) were in the accomplished level, 43 (41%) in the developing level and 44 (42%) in the beginning level of the SIPU. After the intervention in the control group, 33 (30%) were found to be at the accomplished level, 41 (39%) in the developing level and 26 (25%) in the beginning level of the SIPU.

In line with this finding, Andrini (2016) stated that science inquiry processes understanding does not only develop intellectual abilities but all potential the students possess including emotional and other development skills. Paglinawan (2002) in the findings of his study emphasized that through developed science process skills, the students' abilities are strengthened. He further stated that the science process improves learner's performance not only in science but in other fields of study like reading, language, arts, and mathematics. The result of the study suggests that inquiry-oriented instruction significantly improved science inquiry processes understanding of the students.

Comparison of Control and Experimental Groups of Students' SIPU test mean score and mean gain score between the control and experimental group of students

To determine whether there is a significant difference in the test mean scores and mean gain scores in Science Inquiry Processes Understanding Test (SIPUT) in Biology topic domains between the control and experimental groups of students, t-test paired samples was used.

Table 6. Results of T-test Analysis Examining the Science Inquiry Process Test Means Before and After the Intervention.

		PAIRED DIFFERENCE						
Period	Group	Mean Scores	Mean Gain Scores	Mean Difference	Standard Deviation	t-value	p-value	Remarks
Pretest	Control Group	.9267			.37654			
	Experimental Group	.9181		.00857	.40544	.159	.874	(ns)
Posttest	Control Group	1.1838			.55541			
	Experimental group	1.7438		-.56000	.45360	-8.002	.00	(s)
	Control and Experimental		.2571 .8257		.61642 .64674	-6.521	.00	(s)

Note. s=significant at 0.05 level of significance, ns=not significant

As shown in Table 6 before the intervention the t-test value is .159 with a p-value of .874 that is greater than 0.05. This implies that there is no significant difference between the pretest score means of the two groups of research participants. The result of the t-test for independent sample test were in the mean scores and the standard deviation of control group (X=.9267, SD=.37654) and experimental group (X=.9181,SD=.40544) were almost the same before the intervention indicates that the two groups at the start of intervention are comparable in their understanding of science inquiry processes. Moreover, the students may have poor prior knowledge of the science processes.

However, after the intervention results showed that the t- value is -8.002 and p-value .000 which is less than 0.05, the level of significance. The mean scores obtained by the two groups were significantly different from one another, which indicates that their understanding of the science processes differs. It may be inferred that the inquiry-oriented modular activities given to the experimental group of students provided them opportunities to do the activity on their own, reconstruct their ideas based on their understanding of the process. Managing their own learning, the students are given the chance to explore and experience the scientific phenomenon being studied and their scientific investigative abilities can be up skilled. From the results, there is reason to believe that inquiry-oriented modular instruction has improved the students' understanding of the processes employed in a scientific investigation. Students' understanding of science inquiry process when fully displayed, practice and applied as they engaged in higher level of inquiry direct them to progressive manifestation of the basic and integrated science process skills (Leonor, 2015). Likewise, the quest for achieving a common goal, encouraging teachers to use scientific inquiry (science investigation) as a pedagogical approach led to a big commitment of resources for developing innovative curriculum, teachers and students (Minner, Levy & Century, 2010).

Control and Experimental Groups of Students Understanding Scientific Explanation Before and After Intervention

Students' understandings of scientific explanation construction were identified using SECT questionnaires. Students answered the questions by creating and constructing scientific explanations in paragraph form. Students scientific explanation answers were analyzed based on five components: Question, Evidence, Science Concept, Scientific Reasoning and Claim. Students' answers in SECT were graded using self-made rubrics and categorized according to the following scores, *No Mastery (0)*,*Partial Mastery (1)*,*Mastery (2)*and E*xceptional (3).*

Table 7. Numbers and Percentage Distribution of Students' Level Understanding of Scientific Explanation Before and After the Intervention

Range	Level of Understanding of Scientific Explanation	Control Group n=105		Experimental group n=105	
		Before	After	Before	After
		Number (%)	Number (%)	Number (%)	Number (%)
2.4-3	Exceptional	0 (0%)	0 (0%)	0 (0%)	24 (23%)
1.6-2.2	Mastery	15 (14%)	41 (39%)	22 (21%)	45 (43%)
0.8-1.4	Partial Mastery	82 (78%)	64 (61%)	76 (72%)	36 (34%)
0-0.6	No Mastery	8 (8%)	0 (0%)	7 (7%)	0 (0%)
Total		105 (100%)	105 (100%)	105 (100%)	105 (100%)

As shown in Table 7 before the intervention, the almost the same number of students registered "no mastery" of scientific explanation construction in the control group and the experimental group. None of the groups were at the exceptional level.

After intervention, both groups improved in their levels of understanding scientific explanation with the experimental group showing greater improvement from lower category level to higher category level. For example, there was zero (0) % of the group who were at "exceptional" level before the intervention but at the same level, 23% of them were found to be at the "exceptional" level in understanding scientific explanation after the intervention. On the other hand, while the control group registered zero (0) %at the "exceptional" level before the intervention, this percentage of respondents remained the same or no one among the students reached the "exceptional" category after the intervention.

The results in this study find support in the works of Cheng (2004). Accordingly, students easily learn concepts when experiment/activities are performed outside of the school, where students participate actively. They can easily catch up lessons given by their teachers if they are active students. In his study, there was an increase in the numbers (%) of students both in the experimental and control groups from low to moderate level after the intervention. He alludes that regardless of the technique that the teacher use in dealing with the students how the students participate, learn and interact with each other inside and outside the school is deemed important. Moreover, having students write their scientific explanations help them to reflect on what they are learning in a way that is not usual in oral exchanges, such as in classroom discussions (Tishman& Perkins, 1997). Writing may help students to think critically and construct new knowledge by exploring the relationship between ideas and transforming rudimentary ideas into knowledge that is more coherent and structured (Bereiter & Scardamalia, 1987; Klein, 1999, 2004; Rivard& Straw, 2000). The construction of written scientific explanations should be considered, then, at the heart of scientific inquiry and should be emphasized in every science class in which scientific inquiry teaching is taking place. Scientific inquiry, then, is fundamentally about acquiring relevant data, transforming that data first into evidence and then into explanations that can be conceived as answers to particular scientifically oriented questions (Duschl, 2003; Sandoval &Reiser, 2004).

Control and Experimental Groups of Students' Conceptual Understanding Levels in the Biology Topic Domains Before and After Intervention

To assess the students' conceptual levels in the biology topic domains of the study before and after intervention, a validated 20 items open-ended situational case questions researcher-made Conceptual Understanding Test in Biology (CUT) was administered. The categorized conceptual understanding levels of students on the CUT in both groups before and after intervention are shown in the succeeding table.

Table 8. Numbers and Percentage Distribution of Students' Conceptual Understanding Levels in the Biology Topic Domains Before and After the Intervention

Period	Conceptual Understanding Level	Number (%) of Students	
		Control Group (n=105)	Experimental Group (n=105)
Control and Experimental Group (Before intervention)	Beginning	105 (100%)	105 (100%)
Control Group (After Intervention)	Beginning	105 (100%)	
Experimental Group (After Intervention)	Beginning		33 (31.4%)
	Developing		4(4.0%)
	Approaching Proficiency		45(43.0%)
	Proficient		12(11.4%)
	Advance		11(10.5%)
	Total	105	105

Note. Beginning- 0-1.25; Developing-1.3-1.5; Approaching Proficiency-1.55-2.00; Proficient-2.05-2.25; Advance-2.3-3.00

As shown in Table 8 before the intervention all student research participants, (100%) both control and experimental groups were at the beginning level of conceptual understanding. This indicates that all the students had little or no prior knowledge on the topic before the intervention. However, after the intervention the experimental group obtained scores under the different levels of conceptual understanding:31.4% beginning, 4.0% developing, 43.0% approaching proficiency, proficient 11.4% and advance 10.5% while Control group still remained on the beginning level. From the computed scores of the students in the open-ended situational case questionnaires (Appendix N16) show that the conceptual understanding levels of the students in the experimental group have improved. The fact that the test administered was far from the conventional CUT composed of multiple-choice items, the improvement of students' conceptual understanding may be attributed to the inquiry-oriented modular instruction used in the intervention. The CUT results of the students under study concurred with Adejo (2015) who indicated that the inquiry approach was effective on students' understanding of scientific knowledge. The results agree with Opara (2011) who revealed that students exposed to the inquiry approach scored higher on the test composed in the selected units of Biology than students exposed to the traditional method.

Yuliati et.al. (2018) presented through their study results, Inquiry approach permits students to solve for viable solutions, organize conceptual knowledge, form deeper understandings of procedural and experimental knowledge, and formulate strategies to apply and implement problem-solving and critical-thinking skills, while activating memory recall and retention of content material. In related to other research studies (Baker & Robinson, 2018; Schmid & Bogner, 2015; Johnson & Cuevas, 2016) have shown the positive impacts of implementing inquiry approach into the science classroom. Research suggested that the incorporation of inquiry-instruction within the classroom can lead to strong increases in student engagement, student motivation, and student academic achievement with long-term knowledge retention.

Comparison of Control and Experimental Groups of Students' Conceptual Understanding Levels Before and After Intervention

Table 9. Results of Pearson's Chi-square and Fisher's Exact Test Examining Control and Experimental Groups of Students' Conceptual Understanding Levels Before and After Intervention

Period	Group	Level: Informed (46-60)	Level: intermediate (30-45)	Level: naïve(30 below)	Pearson Chi-square p-value	Fisher's Exact Sig. Test 2-sided 1 sided
Pretest	CG (n=105)	0	13	92	.55(ns)	.69.34
	EG (n=105)	0	16	89		
Post test	CG (n=105)	0	35	70	.01(s)	
	EG (n=105)	9	37	59		

*Note. ns= not significant at 0.05 level; s= significant at 0.05 levelX^2 (LCU-Before)= .360, p-value = .548>.05 (Not Significant)X^2 (LCU-After)= 9.994, p-value= .007<.05 (Significant)***t**

The CUT scores obtained by the students in both groups were descriptively classified as Informed for scores 46 -60, Intermediate for scores 30 – 45 and naïve for scores below 30. Comparing the scores obtained by the students in the control group with the scores obtained by the students in the experimental group, the analysis reveals that the scores obtained by both groups in the pretest were almost the same for all the score ranges. The Pearson X^2computed p-value is 0.55, Fisher's Sig. Test = 0.69(2-sided) and Exact Test = 0.34 (i-sided), all computed values are not significant at p= 0.05. Thus, the null hypothesis merits acceptance (not rejected).

On the other hand, the scores obtained by the two groups in the posttest show a marked difference in the score range 46-60 (Informed) with the experimental group posting 9 students to have obtained scores in this score range against zero (0) students (no student) whose scores fall in the range of 46-60 scores. Likewise in the score range 30-below, (naïve) there is also a noticeable difference in the number of students whose scores fall within this score range, with 70 in the control group and 59 in the experimental group.

It is noteworthy to mention that there were more students in the control group who remained in the naïve category of conceptual understanding on the biology concepts taught using DepEd modules during the duration of this study than those in the experimental group which may imply that the use of the inquiry-oriented modular instruction which used researcher-developed modules for the experimental group have impacted on the learning of the students. There may be slight difference in the number of students in both groups to have either improved in their conceptual understanding skills, but it did not affect the impact created by the intervention on the conceptual understanding skills of the experimental group. The result of the Pearson Chi-square analysis shows, Pearson X^2p value = 0.01 which is highly significant at 0.05, the level of significance set for the rejection or acceptance of the null hypothesis.

Anderson's (2002) study supported indicating that employing inquiry-based science teaching in science education has some positive effects on cognitive achievement, process skills and attitude towards science, but it is relative. Furthermore, Leonor (2015) stated that as the students engaged in Differentiated Science Inquiry (DSI) activities, they were able to exhibit their conceptual understanding characterized by integrating the different aspects of a concept into a coherent whole and extending it to making connections not only within the given subject area, but also beyond it. They were able to conceptualize at a higher level of abstraction and look at ideas in new and different ways. Similarly, Adorno & Pizzolato (2015) corroborated that as students were able to learn how to dialogue with each other, they became socially gathered, and shared information which is a powerful means toward building individual conceptual understanding.

Comparison of Control and Experimental Groups of Students' Conceptual Understanding Test CUT Mean S Scores and Mean Gain Before and After the Intervention

Students' Conceptual Understanding Test (CUT) mean scores and mean gain scores of the control and experimental groups before and after intervention were compared to find out any significant differences between the scores to guide one to make decisions as to rejection or acceptance of the null hypothesis. Table 10 shows the results of the analysis.

Table 10. Result of the T-test Analysis Examining the Conceptual Understanding Test (CUT) Means and Gain Score Means Before and After the Intervention.

	PAIRED DIFFERENCE							
Period	Group	Mean Scores	Mean Gain Scores	Mean Difference	Standard Deviation	t-value	p-value	Remarks
Pretest	Control Group	.6405		-.07905	.42585	-1.304	.194	(ns)
	Experimental Group	.7195			.45242			
Posttest	Control Group	1.1881	.5476	-.49667	.41041 .50911	-7.783	.00	(s)
	Experimental group	1.6848	.9652	-.41762	.61486 .70684	-4.568	.00	(s)

Note. s=significant at 0.05 level of significance, ns=not significant

Table 10 presents the results of the analyses performed on the mean scores obtained by the two groups under study. The results reveal that the CUT pretest means of the two groups did not differ significantly before the intervention as shown in the computed t-test value -1.304and a p-value of 0.194. The computed p-value is greater than 0.05, the level of significance set for the rejection or acceptance of the null hypothesis. After the intervention, the mean scores of the two groups significantly differed. The computed t-value was -7.783 and a p-value of 0.00, highly significant at p=0.05. Likewise, the mean gain scores of the two groups also significantly differ from each other, the experimental group posting a higher mean gain score of .9652 as compared to the mean gain score of the control group of .5476. The computed t-value was -4,568 and a p-value of 0.00, highly significant at p=0.05.

On the basis of the analysis results, it could be inferred that science inquiry-oriented modular learning was effective in developing conceptual understanding skills among the students. While improvement in conceptual understanding was more apparent among the students in the experimental group, it cannot be ignored that there was also improvement in the development of conceptual understanding skills among the control group learners as manifested by their increased scores in the CUT. This suggests that the teaching method employed in instructional transactions for any group is valuable and successful in improving student learning. Inquiry methods instruction engages students in the processes of scientific discovery and can make science relevant towards their real-world concerns (Darling-Hammond et al., 2020).

Teaching through an inquiry approach has improved engagement in science learning and has resulted in a deeper conceptual understanding of scientific concepts. In addition, inquiry approaches have developed students' higher order thinking skills and positive attitudes toward learning Science. (Alameddine & Ahwal, 2016; Wang, Guo & Jou, 2015).

This study was undertaken to investigate the effect(s) of science inquiry-oriented modular instruction in teaching selected Biology concepts on students' understanding of science inquiry process, scientific explanation construction and conceptual understanding among Grade 10Students. Quantitative and qualitative research methods were adopted in this study. The study was conducted at Marawi City National High School, with two hundred ten 210 respondents selected from intact classes of four sections using matched sampling, divided into two groups, the experimental and control groups. The experimental group was composed of one hundred five 105 students and likewise the control group also consisted of one hundred five 105 students. The experimental group was exposed to scientific inquiry modular teaching approach, whereas the control group received conventional modular learning approach. The following findings emerged from the data gathered and data analysis.

6. Conclusion and Recommendations

Based on the findings this study concludes that:

Scientific Inquiry-Oriented Modular Instruction is more effective in improving students' understanding of the science inquiry processes, scientific explanation construction and the conceptual understanding of the students than the traditional blended modular learning approach. The use of the researcher-developed science inquiry modules developed better learning abilities of the students exposed to the scientific inquiry-oriented modular approach in understanding the science processes, gain knowledge and skills in constructing explanations for better understanding of the science processes involved in the performance of the activities in their learning of the biology concepts.

In line with the findings the following recommendations are given:

The teachers are encouraged to develop investigative modules for science subjects to encourage student's inquiry-based learning and scientific investigation. They may develop learning materials which are activity-oriented along the line of environmental concepts applied to mitigation of environmental degradation, protection and related issues and concerns. It is recommended that curriculum makers and developers take cognizance on the inquiry processes comprehension, scientific explanation, creation, and conceptual understanding, explicit instructional exposure, and engagement and emphasize their inclusion in the development of teaching resource materials in science. Science teachers are encouraged to use more innovative teaching methods/strategies or approaches and assessment strategies during pandemic and beyond, embracing more facilitative teaching rather than being a director of learning as used in the traditional teaching modality to cater to students' needs, skills, and abilities, and promote better performance-based learning , as required by the K–12 curriculum and the 21st Century life skills development. Test construction of non-conventional type, out-of-the-box types of assessment tools for student learning and analysis of such is recommended as part of the school's INSET program. School administrators are endeavored to create and implement a training program on scientific inquiry integration with emphasis on strategies to develop scientific explanation construction which has been observed to be wanting among learners. It is recommended that administrators and other stakeholders join hands to find ways to source out enough learning materials to schools in order to improve teaching and learning processes. Similar studies using other disciplines to include other variables be conducted to a wider number of participants/schools is encouraged for more valid and reliable outcomes.

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