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Learning Materials Based On 7E Model in Teaching Systematics for Grade 12 STEM Learners

Diosyjeanne D. Simyunn[1], Monera A. Salic-Hairulla[2], Angeline D. Dinoro[3], Douglas A. Salazar[4], and Munting Michael E. Manting[5]

[1]Student, Mindanao State University – Iligan Institute of Technology, College of Education, Department of Science and Mathematics Education

[2,3,4,5]Faculty, Mindanao State University – Iligan Institute of Technology, College of Education, Department of Science and Mathematics Education

***Abstract*—** The study aimed to develop and seek the effectiveness of the learning materials based on 7E model on students' conceptual understanding in learning systematics. The research utilized Analysis-Design-Development-Implementation-Evaluation (ADDIE) design and a mixed quasi-experimental pretest-post test design. The actual implementation was conducted in a public senior high school in the Division of Misamis Oriental, specifically in Alubijid National Comprehensive High School located in the municipality of Alubijid. The participants of the study include sixty (60) Grade 12 STEM senior high school students. Purposive sampling was used in selecting the participants. During the actual implementation phase the grade 12 learners utilized the Learning Materials based on 7E model as instructional material in their lesson in systematics in face to face learning. The developed Learning Materials was validated using the Department of Education standardized rubrics. It was evaluated by the STEM experts with a mean score of 26.2 in Content, Format with a mean score of 66, 18.6 mean score for Presentation and Organization and 24 mean score for Accuracy and Up - to - datedness of Information and all mean factors resulted with Passing remarks. For the pretest-post test results, the differences between the means of the test scores are 7.38 (G12 Australia) and 3.06 (G12 Switzerland). It yielded a t-value of 9.06 (G12 Australia) and 4.79 (G12 Switzerland) with a computed probability value of <0.0001, which is less than 0.05 significance level for both sections. Hence, there is, in fact, a significant difference between the pre-test and post-test of grade 12 STEM students in ANCHS who underwent the developed Learning Materials based on the 7E model STEM lesson.

***Keywords*—** Inquiry-based learning, systematics, taxonomy, 7Es model, evolution

1. INTRODUCTION

One of the most crucial areas of study in biology is studying the diversity of life on Earth and the intricate web of relationships between species and their surroundings which is known as biodiversity and ecosystems (Adler, 1968). With biodiversity it is where evolutionary biology and systematics come in. In connection, systematics and taxonomy as part of evolutionary biology are the least mastered and perceived as the most difficult topics taught in General Biology 2.

This is supported by the survey conducted by the Department of Education Misamis Oriental last August 2021 on the most difficult learning competencies taught in Science and Mathematics subjects. The fact that there are few studies using 7E model inquiry-based learning resources to teach systematics based on evolutionary relationships in the learning modules in senior high school is also noteworthy.

One of the solutions to this problem is a development of a learning material that best suited to 21st century learners where students want to find solutions to problems on their own by exploration. The rationale behind this study is rooted from the need to explore teaching materials based on 7E model inquiry-based learning that is align for STEM learners in science education to improve student learning outcomes and motivation.

Several related studies have shown that inquiry-based learning approaches are effective to traditional teaching methods and have improved students' academic performance, critical thinking, problem-solving abilities, motivation, and laboratory skills (Haury 1993; Smith 1996; Shymansky, Hedges, and Woodworth 1990; Rubin 1996; Crawford, 2000; Holbrook and Kolodner, 2000; Marx et al., 2004; Oliver-Hoyo et al. 2004; Oliver-Hoyo and Allen 2005; Tuan et al., 2005; McReary, Golde, and Koeske 2006; Madden, 2011). This has encouraged the researcher to design this study,

which will create learning resources based on the 7E model of inquiry-based learning and assess its impact on the conceptual learning of Grade 12 STEM students on systematics based on evolutionary relationships.

2. OBJECTIVES

This study aimed to develop learning materials based on 7E model inquiry-based learning and its effects on Grade 12 STEM learners in understanding the concept of systematics. Specifically, this study sought to address the following objectives:

1. Develop and validate the learning material based on 7E model in teaching systematics.
2. Determine the significant difference in the performance of the STEM 12 learners in the pretest - post test before and after exposure to the developed learning materials to the grade 12 STEM learners.

3. METHODS

As an analytical framework, this study utilized the Analysis-Design-Development-Implementation-Evaluation (ADDIE) paradigm. The ADDIE model is a general and simplified instructional systems-design approach utilized by technology-based education designers (Molenda, 2003).

The ADDIE paradigm was used in this study, which utilized a one-group pretest-post test quasi-experimental design in the implementation and assessment stages, the pretest was administered before exposure of the learners to the developed Learning Materials. Following the introduction of the approach, the post test was being administered.

This study was conducted in a selected public school in the Division of Misamis Oriental. The actual implementation of the study was conducted in a public secondary high school in the municipality of Alubijid, Misamis Oriental, Philippines.

Moreover, the school has its senior high school that offers Science, Technology, Engineering and Mathematics (STEM) strand.

The participants of this study included Grade 12 senior high school learners who are currently enrolled in the second semester during the academic year 2023-2024. In determining the effectiveness of the developed Learning Material on the conceptual understanding and perception of the students, two (2) sections of Grade 12 students were selected. The schedule of the study was conducted on the 3rd Quarter. This study utilized the purposive sampling technique in choosing the participants of the study.

3.1. Development of the Learning Materials based on 7E Model in Teaching Systematics

Based on the result from the survey on the least and most difficult competency done by Dr. Rafunzel D. Epanis, Division's Education Program Supervisor for Senior High School, there is one (1) learning competency for General Biology 2 which is perceived as the most difficult and the least mastered and this is learning competency STEM_BIO11/12IIIh-j-16, "describe species diversity and cladistics, including types of evidence and procedures that can be used to establish evolutionary relationships."

The content of this learning competency is systematics based on evolutionary relationships wherein students' performance tasks is to make a phylogenetic tree or cladogram that shows relationships of taxa based on shared derived characteristics which is stipulated in the existing Learning Module provided by the Department of Education. Thus, an additional Learning Material is needed to be developed in order to hasten and develop learners' conceptual understanding.

3.1.2 Expert Validation

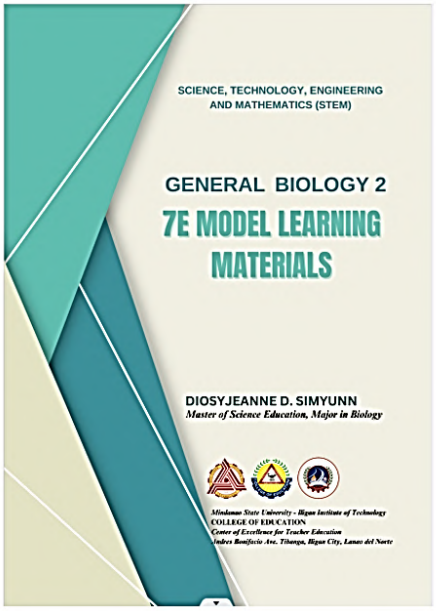
The developed Learning Materials was evaluated and rated by the STEM experts. It utilized the rubrics set by the Department of Education.

3.1.3. Revision: Following the procedure of validation

Comments and suggestions of the experts were considered in improving the Learning Materials based on 7E Model.

3.1.4. Developed Learning Materials based on 7E model in teaching Systematics

The developed Learning Materials based on 7E model in teaching systematics was utilized throughout the entire duration of the study.



LESSON DESCRIPTION

The 7E Model Learning Materials investigate the conceptual knowledge of cladistics, phylogeny, and classification in systematics based on evolutionary relationships. This lesson plan's main goal is to apply the material to well-known objects so that students can fully understand it.

(a) (b)

Figure 1. *Learning Materials based on 7E Model (a) Cover page (b) Lesson Description*

3.2. Research Instruments and Data Analysis

To obtain sufficient data to meaningfully support the goals of this investigation, the following tools were used:

1. Instructional Material Evaluation Tool

The researcher utilized the DepEd (2015) Standardized Rubric to assess and improve the STEM lesson based on the 7Es model inquiry approach. Evaluation criteria for the researcher's 7Es model learning materials include (a) content, (b) format, (c) presentation and organization, and (d) accuracy and timeliness of the information. Additionally, it offers a space for the evaluators to record their thoughts and recommendations for improving the 7Es iSTEM lesson prior to its use.

Table 1. *Scaling Evaluators Ratings on 7Es Model Inquiry-Based STEM Questionnaires*

Mean Interval	Description
3.25-4.00	Very Satisfactory
2.50-3.24	Satisfactory
1.75-2.49	Poor
1.00-1.74	Not Satisfactory

The ratings on the Learning Materials questionnaires by the evaluator were analyzed using the adapted scale from Jumawan et al. (2022). There is a corresponding description for each mean interval. The fact that the first two descriptions are very satisfactory and satisfactory means that the Learning Materials can be used in the study. Before being implemented, the developed Learning Materials must be revised if the descriptions are poor or not satisfactory.

2. Pretest-Posttest Instrument

One research instrument that was utilized in this study which was a 30-item Pretest/ Post adapted and modified from Campbell Biology, 10th edition (Reece, 2019) test bank. This questionnaire was administered to the same student-respondents as the post test. To measure the students' academic performance, the following scale is adapted from the Department of Education Order No. 8, series of 2015.

Table 2. *Academic Performance Scale*

Percentage Equivalent	Transmuted Grade	Descriptive Interpretation
84.00 to 100	90 to 100	Outstanding
76.00 to 83.99	85 to 89	Very Satisfactory

68.00 to 75.99	80 to 84	Satisfactory
61.60 to 67.99	75 to 79	Fairly Satisfactory
0.00 to 61.59	Below 75	Did Not Meet Expectations

The researcher employed statistical tools to analyze and interpret the collected data. The pretest and post-test results was computed using the scale (Table 2) adapted from the Department of Education Order No. 8, series of 2015 and analyzed using paired t-test.

4. RESULTS AND DISCUSSION

The development of the Learning Materials were based from the survey conducted by the Division of Misamis Oriental Department of Education. It was evaluated by the STEM experts and was improved following the comments and suggestions of the evaluators. The following subsections were the results and discussions of the development of the Learning Materials.

4.1 Evaluation of the Learning Materials

The researcher utilized the DepEd (2015) Standardized Rubric to assess and improve the STEM lesson based on the 7Es model inquiry approach. Evaluation criteria for the researcher's 7Es model learning materials include (a) content, (b) format, (c) presentation and organization, and (d) accuracy and timeliness of the information.

Table 3. *Summary of the Evaluation Results of the Learning Materials*

Criteria/ Factor	Mean	Remarks
Content	26.2	Passed
Format	66	Passed
Presentation and Organization	18.6	Passed
Accuracy and Up-to-datedness of Information	24	Passed

After designing the Learning Materials, it was critiqued by five (5) evaluators. Table 3 summarizes the mean and corresponding remarks. The Learning Materials passed the four (4) criteria in the adopted evaluation tool.

Table 4. *Evaluation Results of the Learning Materials*

CRITERIA	Mean	Remarks
Factor 1: Content		
1. Content is suitable to the student's level of development.	3.8	Very Satisfactory
2. Material contributes to the achievement of specific objectives of the subject area and grade/year level for which it is intended.	3.6	Very Satisfactory
3. Material provides for the development of higher cognitive skills such as critical thinking, creativity, learning by doing, inquiry, problem solving, etc.	3.8	Very Satisfactory
4. Material is free of ideological, cultural, religious, racial, and gender biases and prejudices.	3.8	Very Satisfactory
5. Material enhances the development of desirable values and traits such as: (Put a check (√) mark only to the applicable values and traits)	3.8	Very Satisfactory
6. Material has the potential to arouse interest of target reader.	3.6	Very Satisfactory
7. Adequate warning/cautionary notes are provided in topics and activities where safety and health are of concern.	3.8	Very Satisfactory
Note: Resource must score at least 21 points out of a maximum 28 points to pass this criterion. Please put a check mark (√) on the appropriate box.	26.2	Passed
Factor 2: Format		
1. Prints		
1.1 Size of letters is appropriate to the intended user.	3.8	Very Satisfactory
1.2 Spaces between letters and words facilitate reading.	3.8	Very Satisfactory
1.3 Font is easy to read.	3.8	Very Satisfactory

1.4 Printing is of good quality (i.e., no broken letters, even density, correct alignment, properly placed screen registration).	3.8	Very Satisfactory
2. Illustrations		
2.1 Simple and easily recognizable.	3.8	Very Satisfactory
2.2 Clarify and supplement the text.	3.6	Very Satisfactory
2.3 Properly labeled or captioned (if applicable).	3.4	Very Satisfactory
2.4 Realistic / appropriate colors.	3.8	Very Satisfactory
2.5 Attractive and appealing.	3.6	Very Satisfactory
2.6 Culturally relevant.	3.2	Satisfactory
3. Design and Layout		
3.1 Attractive and pleasing to look at.	3.8	Very Satisfactory
3.2 Simple (i.e., does not distract the attention of the reader).	3.8	Very Satisfactory
3.3 Adequate illustration in relation to text.	3.6	Very Satisfactory
3.4 Harmonious blending of elements (e.g., illustrations and text).	3.6	Very Satisfactory
4. Paper and Binding		
4.1 Paper used contributes to easy reading.	3.6	Very Satisfactory
4.2 Durable binding to withstand frequent use.	3.4	Very Satisfactory
5. Size and Weight of Resource		
5.1 Easy to handle.	3.8	Very Satisfactory
5.2 Relatively light.	3.8	Very Satisfactory
Note: Resource must score at least 54 points out of a maximum 72 points to pass this criterion. Please put a check mark on the appropriate box.	66	Passed
Factor 3: Presentation and Organization		
1. Presentation is engaging, interesting, and understandable.	3.8	Very Satisfactory
2. There is logical and smooth flow of ideas.	3.8	Very Satisfactory
3. Vocabulary level is adapted to target reader's likely experience and level of understanding.	3.8	Very Satisfactory
4. Length of sentences is suited to the comprehension level of the target reader.	3.6	Very Satisfactory
5. Sentences and paragraph structures are varied and interesting to the target reader.	3.6	Very Satisfactory
Note: Resource must score at least 15 points out of a maximum 20 points to pass this criterion. Please put a check mark on the appropriate box	18.6	Passed
Factor 4: Accuracy and Up-to-datedness of Information		
1. Conceptual errors.	4	Very Satisfactory
2. Factual errors.	4	Very Satisfactory
3. Grammatical errors.	4	Very Satisfactory
4. Computational errors.	4	Very Satisfactory
5. Obsolete information.	4	Very Satisfactory
6. Typographical and other minor errors (e.g., inappropriate or unclear illustrations, missing labels, wrong captions, etc.).	4	Very Satisfactory
Note: Resource must score 24 out of a maximum 24 points to pass this criterion. Please put a check mark on the appropriate box.	24	Passed

Table 4 provides specific details on the evaluation results of the Learning Materials showing that in Criterion Content there is a very satisfactory rating and having a mean of 26.2 which indicates a Passing remarks, while Criterion Format with very satisfactory on most of its ratings and one (1) with a satisfactory rating. Criteria 3 and 4 having very satisfactory rating with a passing mean of 18.6 and 24, respectively. Although the LM satisfied most of the criteria for approval, the evaluators noted some significant comments for the improvement of the learning material before it could be pilot-tested.

4.2 Pretest and Post Test Results of the Learning Materials

Table 5. *Summary of Pre-test and Post-test from Final Implementation with 29 student participants from ANCHS section AUSTRALIA*

Grading Scale	Descriptor	Pre-test		Post-test	
		Frequency	Percent	Frequency	Percent
90-100	Outstanding	1	3.44	20	68.97
85-89	Very Satisfactory	1	3.44	1	3.44
80-84	Satisfactory	3	10.34	4	13.79
75-79	Fairly Satisfactory	4	13.79	1	3.44
Below 75	Did not meet expectations	20	68.97	3	10.34
Total		29	100	29	100
Mean		65		90	
Standard Deviation		4.63		2.81	

Table 5 shows the summary of the pre-test and post-test results of grade 12 STEM students from section AUSTRALIA during the final implementation of the 7E model Learning Materials at ANCHS. Pre-test data showed that only two students scored 85 or higher, 10.34% of students received a satisfactory score, and 13.79% received a fairly satisfactory score. Pre-test data also showed that 68.97% of the remaining group did not meet expectations. But in the post-test following their exposure to the 7E model learning materials, 68.97% of the students received an outstanding score; in contrast, 3.44% received very satisfactory scores, 13.79% received satisfactory scores, and 3.44%—or just one student—had a fairly satisfactory score. Ultimately, fewer students did not meet expectations compared to the pre-test results (i.e., from 20 students to 3 students), suggesting that the developed material may have improved students' conceptual grasp of systematics. Prior to the full-scale implementation, the 7E model learning materials were refined, and the findings were more favorable and similar to the initial results of the pilot testing, which also indicated that the material was effective.

Table 6. *Summary of Pre-test and Post-test from Final Implementation with 31 student participants from ANCHS section SWITZERLAND*

Grading Scale	Descriptor	Pre-test		Post-test	
		Frequency	Percent	Frequency	Percent
90-100	Outstanding	3	9.68	11	35.48
85-89	Very Satisfactory	3	9.68	6	19.35
80-84	Satisfactory	4	12.90	7	22.58
75-79	Fairly Satisfactory	7	22.58	1	3.23
Below 75	Did not meet expectations	14	45.16	6	19.35
Total		31	100	31	100
Mean		75		85	
Standard Deviation		3.35		2.67	

Table 6 shows the summary of the pre-test and post-test results of grade 12 STEM students from section SWITZERLAND during the final implementation of the 7E model Learning Materials at ANCHS. As can be seen from the Pre-test results, only 10 students scored 80 or more, and 7 students had a fairly satisfactory result. Based on the outcomes also of their pre-test, the remaining 14 pupils did not meet expectations. But in the post-test following their exposure to the 7E model learning materials, 35.48% of the students received an outstanding score; in contrast, 19.35% received very satisfactory scores, 22.58% received satisfactory scores, and 3.23%, or just one student, received a fairly satisfactory score. The content again could improve students' conceptual understanding of Systematics for this section, as evidenced by the reduction in the number of students who did not meet expectations from pre-test results to post-test results, from 14 students to 6

students. After the 7E model Learning Material was adjusted based on the initial findings of the Pilot Testing phase, when the educational content was shown to be effective, even better results were again obtained during the full-scale implementation.

Table 7. *Significant Difference Between Pretest and Posttest Scores from Final Implementation with 31 student participants from ANCHS section AUSTRALIA.*

Test	Mean Difference	t-statistics	p-value	Interpretation
Pretest	7.38	9.06	<0.0001	Significant
Posttest				

H0: There is no significant difference between the pre-test and post-test of grade 12 STEM students at ANCHS who undergo the developed learning material based on the 7E model inquiry-based STEM lesson.
**Significant at p<0.05 alpha level.*

Table 8. *Significant Difference Between Pretest and Posttest Scores from Final Implementation with 45 student participants from ANCHS section SWITZERLAND.*

Test	Mean Difference	t-statistics	p-value	Interpretation
Pretest	3.06	4.79	<0.0001	Significant
Posttest				

H0: There is no significant difference between the pre-test and post-test of grade 12 STEM students at ANCHS who undergo the developed learning material based on the 7E model inquiry-based STEM lesson.
**Significant at p<0.05 alpha level.*

Table 6 and Table 7 above present the analysis using paired samples t-test between the pretest and post test scores of Grade 12 STEM students from Sections AUSTRALIA and SWITZERLAND, respectively. Based on the results, the differences between the means of the test scores are 7.38 and 3.06, respectively. It yielded a t-value of 9.06 and 4.79, respectively with a computed probability value of <0.0001, which is less than 0.05 significance level for both sections.

Hence, the researcher concluded that there is, in fact, a significant difference between the pre-test and post-test of grade 12 STEM students in ANCHS who underwent the developed learning material based on the 7E model inquiry-based STEM lesson, rejecting the null hypothesis completely in the process. This suggests that after being exposed to the learning material, the students' conceptual understanding of Systematics was improved. Several related studies have shown that inquiry-based learning approaches are effective to traditional teaching methods and have improved students' academic performance, critical thinking, problem-solving abilities, motivation, and laboratory skills (Haury, 1993; Smith, 1996; Shymansky et al., 1990; Rubin 1996; Crawford, 2000; Holbrook and Kolodner, 2000; Marx et al., 2004; Oliver-Hoyo et al. 2004; Oliver-Hoyo and Allen, 2005; Tuan et al., 2005; Golde et al., 2006; Madden, 2011).

5. Conclusion

In conlusion, the study showed that the developed Learning Materials satisfied the validation test utilizing the standardized rubrics from the Department of Education having a rating of passed in each criterion. It became evident that after exposure to 7E LM it produced significantly better acquisition level of students' achievements, thus, showed a statistically significant increase in conceptual understanding.

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