Development and Acceptability of the Simplified Text with Workbook in Differential Equations as an Instructional Material for Engineering

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Abstract *– Instructional material is a very important tool in the teaching-learning process in a classroom situation. This is in a form of textbooks, reference texts, the chalk and blackboard, computer aided presentations and other materials that are important and useful during discussions and teachings. This study focused on the development and evaluation of an instructional material in Differential Equations for engineering programs. The simplified text with workbook in differential equations for engineering was developed for the purpose of giving the students quality material for their learning processes. The developed material was based in accordance with the minimum requirements of the Philippine Commission on Higher Education (CHED) for engineering programs in the course Differential Equations. The acceptability of the material was evaluated in terms of its contents and structure and format. It was evaluated by two categories of evaluators namely, engineering professors and engineering students. The average weighted means are 4.85 in terms of the contents and 4.83 in terms of the structure and format. Based on these results, the researcher found out that the developed material is highly acceptable for use in engineering programs and responsive of the high requirement for engineering curriculum.*

Keywords *– Simplified Text with Workbook, Differential Equations, Instructional Material*

INTRODUCTION

Education plays the most important part in the society. This is the most important aspect that an individual needs to develop him towards achieving a better future. The improvement of knowledge, skills and competency of an individual are the important concern that should be taken up in every educational institution for an improved outcome of every individual.

Engineering education has to perform its major responsibilities in molding engineering students toward a more responsible and more knowledgeable individual who should possess basic skills and competencies in his chosen field of engineering studies. Several national trends are driving the advancement of engineering education within the United States. These trends include a declining interest of U.S.-born students in engineering [1]; a decrease in national achievement in mathematics and sciences at pre-college levels [2]; and a lack of technological literacy for all Americans [3]. This situation gives the concern in improving the mathematical and scientific knowledge of the students for them to be prepared in the engineering world.

In order to pose alternatives to improve situations facing science, technology, engineering, and mathematics (STEM) education, several authors have identified the necessity of focusing on the education of pre-college populations [4]. For example, the National Science Board, via the companion to the 2006 Science and Engineering Indicators, identifies the following priorities for developing high quality STEM education: strong public support of STEM education for all students and citizens, a high quality teaching workforce, appropriate learning opportunities for all students, effective guidance counseling on STEM education and careers and assessment tools that reinforce learning in STEM fields [5].

In the Philippines, engineering education also has such concerns on how to improve the skills and knowledge of students taking up engineering programs. In the implementation of the K-12 program in the Philippines, the present quality of education is reflected

in the inadequate preparation of high school graduates for the world of work or entrepreneurship or higher education. High school graduates also do not possess the basic competencies or emotional maturity essential for them to go into the higher education, thus it is very much important to consider the maturity for the total development of the students in his chosen field in his higher education level [6].

With these concerns, the design of the educational curriculum in the tertiary level should focus not only on the theoretical aspects but also on the skills which involves activities that will enhance the critical thinking skills of the students. This is where the role of educators comes in as they are tasked to develop and improve the needed skills of their students.

In the present engineering educational system, a large majority of engineering students fail to reach proficiency in mathematics as the foundation courses of engineering programs. Higher mathematics is very important in engineering that serves as the foundation of applications in this field. Differential equations is a higher field of engineering mathematics course that is taken mostly during the first semester of the third year engineering programs. Differential equations introduced students the ideas of higher mathematics in applications, not just purely theories but most important is its applications in the field of engineering.

Instructional materials are a prime concern in teaching. This is in a form of textbooks, reference text, the chalk and blackboard, computer aided presentations and other materials that are important and useful in the discussion and teaching. The most effective and important instructional materials are the textbooks and reference texts. These instructional materials contain all the topics that should be discussed in a particular course. These instructional materials should be curriculum based and substantial for the purpose of teaching and the learning of the students.

As stated, instructional programs to be valid, it must achieve a purpose; students must attain the goals of instruction to which the program is directed. Such validity imposes two requirements: (1) the broad goals of instruction must be defined so that their attainment is measurable. The question that confronts all educators is: What must each student be able to do as a result of instruction? Instructional programmers should be as explicit as possible, employing modern techniques of task and content analysis in order to specify the broadest, most worthwhile educational goals. This analysis will also indicate how the attainment of goals can be measured – either by direct observation of student capability or by evaluating student performance on a broad set of tasks; (2) the requirement for consistent attainment by students means that programmed instruction must be available in a format that is sufficiently reusable to assure such consistency. Early programs appeared in textual form or were presented with the help of mechanical devices called teaching machines. This term was unfortunate because the program, not its method of instruction accomplished the instruction. Current programs are available in a variety of additional formats, involving computers, special training simulators, multimedia devices and even sophisticated instructional systems that include elaborate instructor manuals to specify the precise role recommended for teachers and other support personnel [7].

The quality of learning material is enhanced if the material is designed to take into account learners' individual learning styles that mean a consistent or habitual mode of acquiring or imparting knowledge through study, experience or teaching [8].

A systematic instructional design processes include the core elements of analysis, design, development, implementation and evaluation (ADDIE) to ensure congruence among goals, strategies and evaluation and the effectiveness of the resulting instruction [9].

Developers need to design materials for flexibility, diversity and balance for higher education requires students to comprehend, and not merely to reproduce ideas and that acknowledging different approaches to learning enables authentic tasks to be created which are responsive to learner needs [10].

Instructional designs need to be based not only on desired learning outcomes, but also on motivational, cognitive and volitional views of learning from the learners' perspective. This view of the learning process takes into account contextual and learner variables and leads to a constructivist, learner-responsive view of materials design [11].

Merely providing content and information and showing learners structural relationships is not sufficient for higher cognitive performance. They concluded that "what matters most is the construction of personally relevant knowledge structures". This means that learners must be able to engage with the learning materials at varying levels and depths and be capable of accessing resources, which match or accommodate their learning preferences [12].

With these, the researcher was inspired to develop a simplified text with workbook in differential equations for engineering as a supplement for classroom teaching to facilitate student-learning process. The development of an instructional material based on the needs of curriculum and designed according to the needs of the student was the main goal of this study.

OBJECTIVES OF THE STUDY

Generally, this study was aimed to develop and design a simplified text with workbook in differential equations as an instructional material for engineering in terms of its contents and structure and format. This study also considers the acceptability of the developed material in terms of its compliance with various CHED CMOs and the acceptability of the design of the proposed instructional material in terms of its contents and structure and format.

MATERIALS AND METHODS

The researcher made use of a descriptive-developmental research. The researcher had undergone different processes for this research; planning, designing, development and evaluation.

The researcher started with data gathering on what should be done in order to come up with an instructional material that will enhance the teaching-learning process. This includes the review of the related studies and literatures that serves as a guide on what to develop based on the needs of the students and the engineering education. This process also involved planning the design along the contents and the structure and format of the simplified text with workbook. Also, making of the preliminary drafts and layout based on the gathered data from the previous studies reviewed was also considered in this process.

In the designing process, this involved the preparation of the contents and format and structure of the simplified text with workbook. The design of the material along contents was guided by the course description and outline as provided by the CHED CMOs and the classifications of the learning objectives as provided by the Bloom's Taxonomy. Along the format and structure, the material was carefully made to enhance the interests of the students that are appropriate to their needs.

For the development of the simplified text with workbook, after the researcher made the outline based on the different references, the task of developing the instructional materials by undertaking careful analysis as to what content the researcher will put in each chapter followed. The discussions in each chapter were kept simple and short as possible considering the level of the students' understanding and interest. Encoding the discussions take a lot of time, since the researcher should be very careful not to make any mistakes in putting terms and equations in the discussions of each topic. Grammar editing was the next procedure in the development of the simplified text with workbook. This involved checking the right terms and checking the accuracy of each equation. The researcher ensured that the discussions are sequential in accordance with the course outline.

After the development of the material, the researcher formulated and validated the evaluation form as the instrument used to assess the acceptability of the developed instructional material. The instrument consist of two parts namely contents and structure and format. For the contents, it contains (1) objectives, (2) topics included, (3) terms used, (4) discussions presented, (5) examples given, and (6) exercise problems given. For the structure and format, it contains (1) simplicity of the structure, (2) organized format, (3) over-all structure, and (4) over-all design.

The researcher made use of the evaluation form as the data gathering tool and weighted mean as statistical treatment. A 5-point Likert scale was used to determine the level of acceptability of the material as shown in table 1.

Table 1. Five-point Likert Rating Scale Interpretation of Weighted Mean

Scale	Range-Value	Verbal Interpretation
5	4.50-5.00	Highly Acceptable
4	3.50-4.49	Acceptable
3	2.50-3.49	Moderately Acceptable
2	1.50-2.49	Fairly Acceptable
1	1.00-1.49	Not Acceptable

After the proposed instructional material and the evaluation form had developed, the researcher attached a sample copy to the evaluation form in order for the evaluators to assess the acceptability of the proposed instructional material. The evaluators of the study were subdivided into two groups of categories, namely, 1) engineering professors and 2) engineering students.

Engineering Professors. The professors who evaluated the proposed instructional material are the different engineering professors from the different universities and colleges in the Bicol Region. There were a total of thirty-three (33) engineering professors who had evaluated the material. They were ten (10)

professors from the Camarines Sur Polytechnic Colleges, Nabua, Camarines Sur (CSPC), five (5) professors from the Bicol University College of Engineering, Legazpi City (BUCENG), five (5) professors from the Bicol University Polangui Campus, Polangui Albay (BUPC), five (5) professors from the University of Northeastern Philippines, Iriga City (UNEP), three (3) professors from the Sorsogon State University, Sorsogon City (SSC), three (3) professors from the Camarines Norte State College (CNSC) and two (2) professors from Dr. Emilio B. Espinosa Sr. Memorial State College of Agriculture and Technology (DEBESMSCAT). Majority of the evaluators are engineering mathematics professors.

Engineering Students. The students who evaluated the material are those who had used the material. There were a total of ninety (90) engineering students who have recently taken up the course during the first semester of the academic year 2013-2014 who evaluated the material. They were specifically sixty-seven (67) third year civil engineering students and twenty-three (23) mechanical engineering students of Camarines Sur Polytechnic Colleges, Nabua, Camarines Sur.

RESULTS AND DISCUSSION

The difficulties encountered by the researcher in delivering the course to the students were the primary considerations in coming up with the design of the instructional material that caters to the level of understanding of the students and thus, aid in their learning process. A careful study and evaluation of the policies, standard and guidelines for engineering based on the CHED CMO was undertaken. Construction of the learning objectives was also considered by taking into consideration the Bloom's Taxonomy of learning in education. The course description, course outline as well as the textbooks and other reference materials used were also considered and evaluated.

Each chapter of the developed simplified text with workbook in differential equations has a format and sequence which is composed of: (1) Chapter Number and Title, (2) Learning Objectives, (3) Lesson Number and Topic, (4) Discussions, (5) Sample Problems and Solutions, (6) Exercises, and (7) Supplementary Problems.

The development of the proposed simplified text with workbook in differential equations for engineering was guided by the CHED minimum requirements for differential equations for all engineering programs.

Table 2. Acceptability in terms of its Compliance with the CHED CMOs

CHED Requirements	The Proposed Material
1. Definitions 1.1. Definition and Classifications of Differential Equations (D.E.) 1.2. Order Degree of a DE/Linearity 1.3. Solution of a DE (General and Particular)	Chapter 1: Introduction to Differential Equations
2. Solution of Some 1st Order, 1st Degree D.E. 2.1. Variable Separable 2.2. Homogeneous 2.3. Exact 2.4. Non Exact 2.5. First-Order Linear 2.6. Bernoulli's Equation	Chapter 2: Separable Differential Equations Chapter 3: Homogeneous Differential Equations Chapter 4: Exact Differential Equations Chapter 5: Non-Exact Differential Equations Chapter 6: First-Order Linear Differential Equations Chapter 7: Bernoulli's Differential Equations
3. Applications of 1st Order D.E. 3.1. Decomposition /Growth 3.2. Newton's Law of Cooling 3.3. Mixing (Non-Reacting Fluids) 3.4. Electric Circuits	Chapter 8: Applications: Exponential Growth and Decay Problems Chapter 9: Applications: Physical and Geometrical Problems
4. Linear D.E. of Order *n* 4.1. Standard Form of a Linear D.E. 4.2. Linear Independence of a Set of Functions 4.3. Differential Operators 4.4. Differential Operator Form of a Linear D.E.	Chapter 10: Linear Differential Equations of Higher Order
5. Homogeneous Linear D.E. with Constant Coefficients 5.1. General Solution 5.2. Auxiliary Equation	Chapter 11: Homogeneous Linear Differential Equations with Constant Coefficients
6. Non-Homogeneous D.E. with Constant-Coefficients 6.1. Form of the General Solution 6.2. Solution by Method of Undetermined Coefficients	Chapter 12: Non-Homogeneous Linear Differential Equations with Constant Coefficients
	Chapter 13: Laplace Transforms Solutions to Linear Differential Equations

Table 2 shows the acceptability of the proposed material in accordance with the compliance with the various CHED CMOs for engineering programs.

The acceptability of the simplified text with workbook in differential equations for engineering was done by tabulating the data gathered on the evaluation of the developed instructional material by the two (2) categories of evaluators.

Table 3. Acceptability of the Contents

Item	Weighted Mean		Total WM	VI
	Profes-sors	Students		
Objectives	4.81	4.83	4.82	HA
Topics Included	4.90	4.91	4.91	HA
Terms Used	4.76	4.88	4.82	HA
Discussions Presented	4.73	4.86	4.80	HA
Examples Given	4.88	4.89	4.89	HA
Exercise Problems Given	4.81	4.87	4.84	HA
Over-all Weighted Mean	**4.82**	**4.87**	**4.85**	**HA**

WM: Weighted Mean; VI: Verbal Interpretation;
HA: Highly Acceptable

Table 3 shows the acceptability of the simplified text with workbook in terms of the contents. The first indicator is the objectives and was rated by the professors and the students and has a mean rating of 4.82 which are verbally interpreted as highly acceptable. The result only implies that the objectives are clearly stated and jibe with the objectives as cited in the CHED CMOs. The second indicator is the topics included. The mean rating is 4.91 which are verbally interpreted as highly acceptable. This only implies that the topics included in the text comply with the minimum requirement as provided in the CHED CMO for the course. The third indicator is the terms used. The mean rating is 4.82 which are verbally interpreted as highly acceptable. This implies that the terms used in the text are appropriate and suit to the students' level of understanding. The fourth indicator is the discussions presented. The mean rating is 4.80 which are verbally interpreted as highly acceptable. This only implies that the discussions of the subject matter are simplified, clear and understandable. The fifth indicator is the examples given. The mean rating is 4.89 which are verbally interpreted as highly acceptable. This only implies that the examples given in every topic are clearly presented and sufficient to understand the concepts. And the sixth indicator is the exercise problems given. The mean rating is 4.84 which are verbally interpreted as highly acceptable. This only implies that the exercise problems given at the end of each topics/subtopics are sufficient.

Further, the average weighted mean of 4.85 along the contents which are verbally interpreted as highly acceptable implies that the content of the proposed material is responsive of the high requirement for engineering curriculum.

Shown in Table 4 are the results of the acceptability of the simplified text with workbook in terms of its structure and format. The first indicator is the simplicity of the structure. The mean rating is 4.78 which are verbally interpreted as highly acceptable. This only implies that the structure of the text is in simple and concise form. The second indicator is the organized format. The mean rating is 4.87 which are verbally interpreted as highly acceptable. This only implies that the format was organized in a sequential manner. The third indicator is the over-all structure. The mean rating is 4.86 which are verbally interpreted as highly acceptable. This only implies that the over-all structure is complete and self-contain for the purpose of a simplified text. And the fourth indicator is the over-all design. The mean rating is 4.81 which are verbally interpreted as highly acceptable. This only implies that simplified text was carefully designed to encourage the interest of students on the subject matter.

Further, the average weighted mean rating in terms of structure and format was 4.83 which are interpreted as highly acceptable. The results imply that the evaluators highly accepted the proposed material in terms of structure and format.

Table 4. Acceptability of the Structure and Format

Item	Weighted Mean		WM	VI
	Profes-sors	Students		
Simplicity of the structure.	4.73	4.82	4.78	HA
Organized format.	4.85	4.88	4.87	HA
Over-all structure.	4.85	4.87	4.86	HA
Over-all design.	4.76	4.86	4.81	HA
Over-all WM	**4.80**	**4.86**	**4.83**	HA

WM: Weighted Mean; VI: Verbal Interpretation;
HA: Highly Acceptable

Generally, the developed material is highly acceptable in terms of its contents and structure and format and is suitable for use in engineering programs. From the tables presented, it is noticed that the mean ratings of the students are much higher than those of the

professors which only implies that the material is highly acceptable for the students and find it much comprehensive that are suitable to the level of their understanding.

CONCLUSION AND RECOMMENDATION

The following conclusions are taken from the findings of the study. The design of the Simplified Text with Workbook in Differential Equations for Engineering in terms of content follows the minimum requirement in accordance with CHED CMOs for engineering programs and incorporated various aspects of learning: cognitive, psychomotor and affective. Along the design in terms of structure and format, it utilized common format as utilized in the previous studies reviewed. The material is acceptable in terms of its compliance with the various CHED CMOs for engineering. The material is highly acceptable to various evaluators in terms of its contents and structure and format.

Based from the summary, findings and conclusions of the study, recommendations were drawn. Further evaluation can be done to improve the design. The material should be revised periodically to accommodate changes or updates in the CMOs. Item analysis may be conducted in order to improve the acceptability. The professors and students in Differential Equations should use the material for more effective teaching-learning process. The format of the material can serve as guide for other professors to develop their own instructional materials related to their field of specialization.

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