

DEVELOPMENT AND VALIDATION OF WORKTEXT IN BASIC CALCULUS

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ABSTRACT:

Teaching mathematics entails the use of instructional materials which lead to independent learning. The study evaluated the content validity of a developed worktext in Basic Calculus. The worktext was evaluated/validated by the professor/mathematics teachers in the University and in the Department of Education, and by the students who are currently enrolled in the course Basic Calculus. The study utilized the descriptive-evaluative method in determining the validity of the developed worktext. The respondents were asked to evaluate the worktext using a checklist in terms of its different parts. Moreover, the researchers personally visited some schools for pilot testing of the questionnaire checklist to be used in validating the developed worktext. The reviews led to the refinement of the instrument and minor wording changes.

The content validity is very much valid as evaluated by 40 teachers and 40 students and it covers a one whole year in order to finish the worktext and the conduct of the study during the academic year 2020-2021. This indicates that the respondents strongly agreed that its different parts as to the lesson objectives; lesson inputs, lesson application, and lesson enrichment are useful, appropriate, and very much related to the different topics included in the course Basic Calculus. This further indicates that the validity measures done by the evaluators determine the students' knowledge, skills, and other attributes. The worktext should be considered as an instructional material and be used in the teaching-learning process of the course. The worktext should be tried out in other school to further improve its effectiveness and practicability.

Keywords: *content validity, developed worktext, instructional materials, Basic Calculus*

INTRODUCTION

It is a universal belief that the success of a society is determined not only by the quality of teachers but also by the quality of instructional materials and facilities used to attain quality, functional and relevant education. For a given instructional procedure to achieve desired objectives, it must be properly harnessed through adequate and proper use of instructional materials and facilities. Hence, it is the role of a teacher to prepare instructional materials that would enhance the effectiveness of the learning process. Utilization of instructional materials in teaching associated with the function of the teacher as manager of the instructional processes is important for the teacher to arrange the mechanics of the presentation and plan to make the materials meaningful to the audience. Furthermore, teachers must keep themselves abreast with the continuous changes and innovations in classroom teaching and one way to realize this is through exposure of the students to new or innovative instructional materials to further enhance their knowledge and skills and, thus, delivering an education that is of quality and relevance.

Section 3, Chapter 3 of the Education 1982 expressed the aim to develop curricular designs, prepare instructional materials, prepare, and evaluate programs to upgrade the quality of learning. Likewise, Presidential Decree 6-A, Section 5 dated 1972 stated that one of the educational objectives is to design, utilize instructional technology and

develop or produce textbooks and other instructional materials leading to quality education.

The researcher, having the thought of how he can contribute to the academic community in facilitating the teaching-learning process and how they can give their share in significantly developing independent learning among the students, are prompted to undertake this study that aims to develop and validate a worktext in BASIC CALCULUS. Wanting to serve as an agent of change towards improved teaching of Mathematics and with their research-oriented output, a validated worktext in BASIC CALCULUS, it is the conviction of the researcher that the use of it will speed-up the learning process, and therefore, helps strengthen students' mathematical skills and competencies. Furthermore, the researcher is hopeful that the tangible output of this study will be both copyrightable and marketable, hence, may contribute to generate income for the university.

OBJECTIVES

The main objective of the study was to develop and find out the level of validity of the worktext in basic calculus in terms of lesson objectives, lesson inputs, lesson application, and lesson enrichment and to determine the different comments suggested for the revision of the worktext

REVIEW OF RELATED LITERATURE AND STUDIES

The study of Torre Franca (2017) developed and validated instructional modules on two content areas of Algebra taught to second year high school students. Her findings revealed that all the evaluators strongly agreed that the instructional modules satisfied the criteria for evaluating the modules. She, likewise, found out that module, as a self-instructional material, can be used as a supplementary material to help the student improve his/her mastery and as means to help the student catch up with the missed lessons.

The result of the study of Ballado, R and Espinar, MJ (2017) showed that the level of acceptability of her developed worktext in Basic Mathematics 2 is very much acceptable and she concluded that the worktext is effective for use in teaching the course.

Manshelli (2017), she pointed out the positive effect of the utilization of instructional materials was indispensable in the teaching of Modern Algebra. That's why she recommended that use of varied instructional materials in teaching shall be observed by the teachers and monitored by the administrations plus there must be a provision of more and varied instructional materials in collegiate schools should be given priority by the concerned individual.

Terano (2015) developed a CHED compliant instructional material in Differential equations for engineering programs for the purpose of giving the students quality material for their learning processes. Based on the 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.

Rubin, et al, (2014) on their study, analyzed the effect of various activities using models of integers like the Target integer, Integer chips, the use of Damath and an online game Number Cruncher. They found that these activities led to a greater increase in students' performance and conceptual understanding on integers. The study concluded that students' conceptual understanding and procedural skills are enhanced when activity-based teaching is used.

The teacher-respondents in the study of Adora (2014) perceived and agreed that her developed workbook in Elementary Mathematics VI is very much valid instructional material possessing clarity, usefulness, language and style, illustrations, presentation, and suitability.

Laroza (2015), Cruz, (2014), Constantino (2010), Robles (2004), Maranan (2004) and Abarro (2004) found on their studies that developed worktext and modules are very useful in enhancing the learning of the students as evaluated by students and instructors.

Mariani (2015), the concept of module is strictly linked to the idea of a flexible language curriculum, which should provide all those concerned with education (primarily learners and teachers, but also parents and administrators, as well as society at large) with a framework to establish clear and realistic language learning objectives. This keynotes the relevance of developing instructional materials that are catered primarily to the needs of the learners. Learning objectives to be attainable must focus on what is essential and attainable. To realize this, there should be careful planning of the lessons to be included in the module.

Penamora (2013) stated that instructional materials in teaching and learning makes the students learn more and retain better what they have been taught and that it also promotes and sustains the students' interest. It also allows the learners to discover themselves and their abilities. Instructional materials enrich learners' knowledge and reinforce verbal instruction. Research reports have shown that availability of instructional and ability of the Mathematics teachers to use them are vital determinant of teaching methods to be used by the Mathematics teachers and consequently, Mathematics achievements. He stressed that a good instructional material might be a substitute for real life objects in the classroom as against the use of exploratory method.

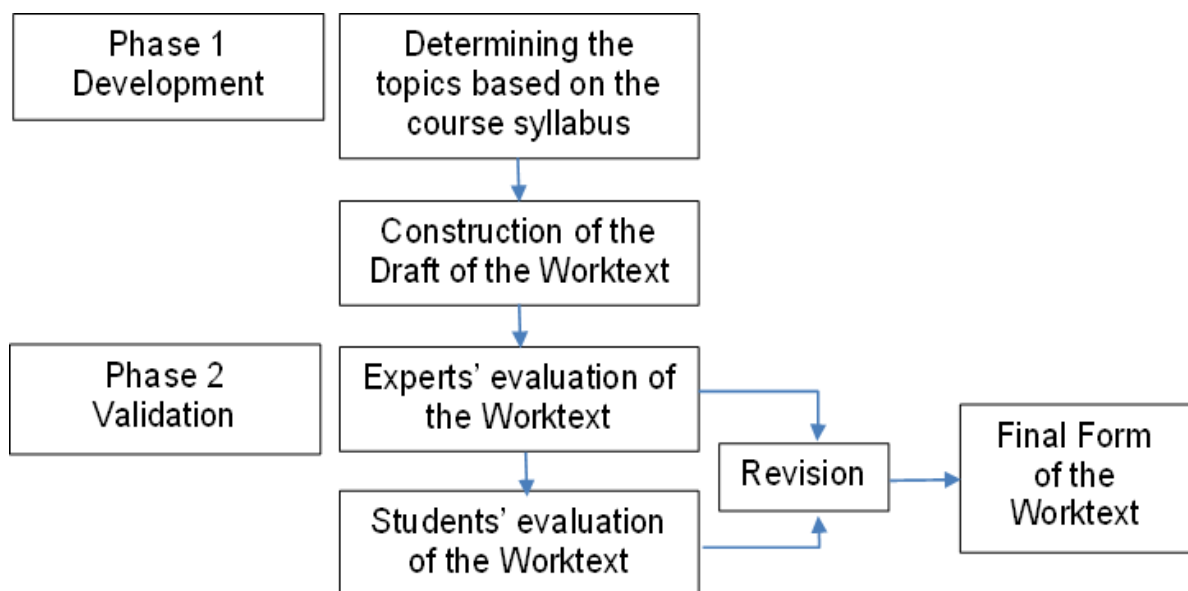
Ibay (2012), developed and validated instructional materials in Advanced Algebra and found that the Filipino-based instructional materials increased the mathematical performance of the students. Respondents who are exposed to the developed Filipino-based instructional materials performed better than the students who utilized the traditional way of teaching with respect to the learning areas as revealed by the posttest.

To be effective, teachers need to understand and be committed to their students as learners of mathematics. They need to be skillful in choosing and using a variety of pedagogical strategies and learning materials. Instructional materials provide ideas and practices which frame classroom activity via text and diagrammatic representations and help teachers in achieving goals that they presumably could not or would not accomplish of their own (Brown, 2019).

CONCEPTUAL FRAMEWORK

This study made use of the research and development (R and D) design, which involves the process of developing and validating educational products. The following procedure was performed in the development and validation of the worktext: First Phase, Development Phase (determining the topics based on the course syllabus, deciding on the components/sections, writing the draft of the worktext and revising the draft), and the second phase, Validation Phase (experts' evaluation and students' evaluation)

Figure 1 shows the procedure in conducting the study.



A checklist which was patterned from the study of (Gayagay, G. (2018). "Development and Validation of a Learning Package for Grade Seven Mathematics" Conference Proceedings, International Research Conference on Higher Education, Bacolod City) was used to evaluate the worktext in terms of its parts namely: Lesson Objectives, Lesson Inputs, Lesson Application, Lesson Enrichment.

METHODOLOGY

Based on the syllabus of the course Basic Calculus, the worktext was developed. Various textbooks on Calculus, some existing supplementary materials and internet sources were used in developing the worktext. The worktext was evaluated/validated by 50 experts (Mathematics Book writers and teachers teaching the subject) and by 30 students who are currently enrolled in the course Basic Calculus. The study utilized the descriptive-evaluative method in determining the validity of the developed worktext, furthermore, in the preparation of the chapter test, table of specification was prepared to ensure the proper placement of the test items and distribution of knowledge and skill to be developed. The respondents were asked to evaluate the worktext using a checklist in terms of its different parts.

Moreover, the researchers personally visited some schools for pilot testing of the questionnaire checklist to be used in validating the developed worktext. The reviews led to the refinement of the instrument and minor wording changes. The reliability based on the pilot testing was high as reflected in the result of the Cronbach alpha of 0.91 and because of the results of the pilot test, it was considered reliable to start data collection for the study.

RESULTS AND DISCUSSIONS

Development of the Worktext in Basic Calculus

The developed worktext in Basic Calculus consists of three main topics as shown in Table 1 with the lessons per topics include limit and continuity of functions, derivatives of algebraic functions and antidifferentiation. Each lesson starts with objectives followed by discussion and illustrative examples in increasing level of difficulty and complexity and ends with exercises. Multiple and meaningful representations are given to facilitate understanding of the lessons. Sufficient examples and practice sets are provided to develop mastery and skill on mathematical concepts. Routine and non-routine problems are also included to enhance students' higher order thinking skills (HOTS) such as critical, creative, and metacognitive thinking.

Table 1. Topics and Lessons in Basic Calculus

Topics	Lessons
Limits Continuity Functions	And of <ul style="list-style-type: none"> • Limit of a Function • Left-Hand Limit of a Function • Right-Hand Limit of a Function • Two-Sided Limit of a Function • Difference between $\lim_{x \rightarrow a} f(x)$ and Function Value $f(a)$ • Theorems on Limit of a Function • Limit of a Function Involving Infinity • Theorems on Limit of a Function Involving Infinity • Limits of Exponential, Logarithmic and Trigonometric Functions • Continuity of a Function at a Number • Continuity of a Function on an Interval • Intermediate Value Theorem • Types of Discontinuity

Derivatives Of Algebraic Functions	<ul style="list-style-type: none"> • Increment • Derivative • Increment Method/Four-Step Rule of Differentiation • Slope of the Tangent Line and the Derivative • Derivatives of Algebraic Functions • Derivatives of Higher Order • Implicit Differentiation • Chain Rule of Differentiation • Maximum and Minimum Value of a Function • Concavity Test • Optimization Problems • Time – Rates • Derivatives of Transcendental Functions
Antidifferentiation	<ul style="list-style-type: none"> • Antidifferentiation • Antidifferentiation of Powers • Standard Antidifferentiation Formulas • Antidifferentiation Using Substitution Rule • Integrals Involving Inverse • Trigonometric Functions and Logarithms • Differential Equations • Exponential Growth and Decay, Bounded Growth and Logistic Growth • Riemann Sum • Fundamental Theorem of Calculus • Definite Integral as Area under a Curve

Validation of the Worktext in Basic Calculus

Table 2. Respondent's Evaluation on the Validity of the Worktext's Lesson Objectives

Lesson Objectives	Experts		Students		Overall	
	Mean	VI	Mean	VI	Mean	VI
The lesson objectives of the worktext are....						
1. relevant to the objectives/ topics of Basic Calculus	4.78	VMV	4.56	VMV	4.73	VMV
2. specific and clearly stated	4.88	VMV	4.52	VMV	4.7	VMV
3. measurable	4.88	VMV	4.24	VMV	4.56	VMV
4. attainable	4.88	VMV	4.51	VMV	4.7	VMV
5. result oriented	4.58	VMV	4.52	VMV	4.55	VMV
6. time bound	4.48	VMV	4.28	VMV	4.38	VMV
Overall	4.75	VMV	4.44	VMV	4.6	VMV

Table 2 presents the evaluation of the worktext's content validity with respect to its lesson objectives. Both teachers and students evaluated the worktext's Lesson Objectives "very much valid" with evaluation means of 4.75 and 4.44, respectively and an overall mean of 4.60.

This indicated that most of the respondents assessed the lesson objectives to be very much valid. It can be seen on the table that the teachers' ratings were higher than the students' evaluation. This means that the teachers are more knowledgeable in the scope and coverage of the course and in identifying if the objectives are stated in SMART (Specific, measurable, attainable, result oriented, and time bound) way. In like manner, the teachers know better if the stated objectives are relevant to the course.

The results are similar to the findings of Sacramento (2018) which states that objectives are very important in making the lesson and in choosing the appropriate strategies and instructional materials. Furthermore, San Antonio (2016) stated that instructional materials should proposed according to their relevance to the objective, learners would remember the lesson and the message that the teacher wants to impart.

Table 3. Respondent's Evaluation on the Validity of the Worktext's Lesson Inputs

Lesson Inputs	Experts		Students		Overall	
	Mean	VI	Mean	VI	Mean	VI
The lesson inputs of the worktext ...						
1. give insights and ideas of what the activity is all about	4.49	VMV	4.72	VMV	4.61	VMV
2. provide background of concepts and information about the topic	4.26	VMV	4.39	VMV	4.29	VMV
3. attract students' attention	4.19	VMV	4.39	VMV	4.29	VMV
4. arouse students' interest	4.19	VMV	4.56	VMV	4.38	VMV
Overall	4.28	VMV	4.52	VMV	4.4	VMV

With respect to the lesson inputs, the teacher and student respondents evaluated the worktext "very much valid" with evaluation means of 4.28 and 4.52, respectively and a section mean of 4.40.

It shows that the respondents' evaluation in almost all statements had very small differences. Both found the worktext interesting and could arouse students' attention. However, the respondents' evaluation on almost all the items revealed higher than the teachers did. This points out that for the students the lesson inputs had enough information, while the teacher found it insufficient. This implies that there is a need to augment the lessons presented in the developed worktext. This is supported by their suggestions to provide additional information, additional examples, and to provide background information about the topic.

As stated by Cayabyab (2017) to improve satisfactory learning experience regardless of the subject, the input of the instructional materials should be selected with respect to relevance, meaningfulness, and feasibility to attain a specific goal.

Table 4. Respondent's Evaluation on the Validity of the Worktext's Lesson Application

Lesson Application	Experts		Students		Overall	
	Mean	VI	Mean	VI	Mean	VI
The lesson application of the worktext is....						
1. in consonance with the course objectives	4.74	VMV	4.45	VMV	4.6	VMV
2. relevant to the lesson objective/s	4.74	VMV	4.7	VMV	4.72	VMV
3. properly sequenced	4.51	VMV	4.41	VMV	4.46	VMV
4. can be accomplished according to schedule	4.18	VMV	4.33	VMV	4.26	VMV
5. interesting	4.41	VMV	4.78	VMV	4.6	VMV

6. adequate to develop students' mathematical knowledge and skills	4.44	VMV	4.7	VMV	4.57	VMV
7. appropriate to students' abilities	4.38	VMV	4.56	VMV	4.47	VMV
8. sufficient to determine the mastery level of students	4.24	VMV	4.54	VMV	4.39	VMV
Overall	4.46	VMV	4.56	VMV	4.51	VMV

The table presents the respondent's evaluation on the validity of the worktext's lesson application. The lesson application was rated by teachers and students as "very much valid" with means of 4.46 and 4.56, respectively and an overall mean of 4.51.

Though the respondents strongly agreed to these items, it could be noted that among other criteria, the means showed the highest difference in the item "the worktext is interesting". The students had a higher mean compared to the teachers which denotes that for the students the lesson application or the different exercises are interesting. In contrary, the teachers showed the lower mean because for them this part needs to be improved as shown in their suggestions that this should include chapter test/achievement test, and additional exercises.

This confirms the findings of Ibanez (2015) who found out that the developed instructional materials are useful in helping learners become interested on the concept presented which becomes easy to understand if presented with illustrations. This also supports Menses (2019) her study revealed that the application of the developed module allows the students to analyze and apply the use of the concept on the given exercises and illustrations provided in each topic, thus, the developed module is very applicable to the learners.

Table 5. Respondent's Evaluation on the Validity of the Worktext's Lesson Enrichment

Lesson Enrichment The lesson enrichment of the worktext	Experts		Students		Overall	
	Mean	VI	Mean	VI	Mean	VI
1. is adapted to the students' level of comprehension	4.67	VMV	4.54	VMV	4.61	VMV
2. is challenging	4.64	VMV	4.86	VMV	4.75	VMV
3. is well-constructed	4.61	VMV	4.74	VMV	4.68	VMV
4. stimulates higher order thinking skills	4.61	VMV	4.7	VMV	4.66	VMV
5. is adequate and enough to determine students' mastery level	4.37	VMV	4.46	VMV	4.42	VMV
6. measures what has been learned	4.57	VMV	4.5	VMV	4.54	VMV

7. enhances mathematical understanding and skills	4.74	VMV	4.86	VMV	4.8	VMV
8. facilitates developing high level mathematical problem solving and thinking skills	4.71	VMV	4.7	VMV	4.71	VMV
Overall	4.62	VMV	4.67	VMV	4.65	VMV

The table presents the respondent's evaluation on the validity of the worktext's lesson enrichment. As for the assessment on lesson enrichment, the teachers and students rated the section "very much valid" with evaluation means of 4.62 and 4.67 respectively, and a section mean of 4.65.

This means that the evaluators rated the worktext's lesson enrichment very much valid. Both groups of respondents strongly agreed that the lesson enrichment facilitates high level mathematical thinking skills and is challenging. It could be seen on the table that though the lesson enrichment was evaluated in general as very much valid, there was a little difference in the evaluation of the respondents. One striking statement in this section is "the lesson enrichment enhances mathematical understanding and skills" which showed the highest average evaluations of respondents. This is an indication that both the teachers and students found the presented activities in the lesson enrichment helpful in enhancing mathematical understanding and skills.

The results are parallel to the study of Dela Cruz (2015) on her developed module in selected topics in Mathematics where the enhancement activities are very enjoyable and interesting and enable the learners to participate actively in the teaching-learning process. It also discussed that the developed module has the required characteristics of an instructional material that would really improve the performance of the learners in Mathematics.

Table 6. Summary Result of the Evaluation on the Worktext's Validity

Criteria	Experts		Students		Overall	
	Mean	VI	Mean	VI	Mean	VI
1. Lesson Objectives	4.75	VMV	4.44	VMV	4.68	VMV
2. Lesson Inputs	4.28	VMV	4.52	VMV	4.4	VMV
3. Lesson Application	4.46	VMV	4.56	VMV	4.51	VMV
4. Lesson Enrichment	4.62	VMV	4.67	VMV	4.65	VMV
Grand	4.53	VMV	4.55	VMV	4.54	VMV

The table presents the summary result of the evaluation on the worktext's validity. As far as the validity of the worktext is concerned, the teachers and students registered a grand mean evaluation of 4.53 and 4.55 with an overall grand mean of 4.54, which means that the content validity as a whole is "very much valid". This indicates that the respondents strongly agreed that its different parts as to the lesson objectives; lesson

inputs, lesson application, and lesson enrichment are useful, appropriate and very much related to the different topics included in the course Basic Calculus. This further indicates that the validity measures done by the evaluators determine the students' knowledge, skills, and other attributes.

The lesson objectives revealed the highest average of 4.68, which is an indicator that this is the strongest point among the four parts of the worktext. This is supported by the comments of the respondents to wit: objectives clearly coincide its respective lesson inputs; the objectives are stated following the SMART principle; reflects the application; authentic and suitable. In contrary, the lesson inputs section has the lowest mean of 4.40 among the different parts of the worktext, although this still falls on the "very much valid" category, there is a need to improve this part of the worktext.

Comments Suggested for the Revision of the Worktext

While the content validity was rated very high by both teachers and students, there were specific comments and suggestions on the different aspects of the worktext from the teacher and student respondents. Comments and suggestions on the revisions of the different parts were provided in the open-ended part of the evaluation questionnaire. For lesson objectives, suggestions for improvement focused on providing time allotment to every lesson. This is the only suggestion of the respondents in this area. The time allotment will be a guide on how long the students will work on a certain lesson.

As to the Lesson inputs, revisions are suggested on the provision of more illustrations to visualize mathematical concepts with the highest frequency; additional real-life examples with the second highest frequency; a detailed explanation on the process be shown the third in rank; and more background information, adequate explanation of terms used, and improving the font size/style. These are the focus of the revisions under the lesson inputs.

For the lesson application, the provision of an achievement test/chapter test and improvement of spacing of items were the most suggested. Other suggestions were the improvement of directions or instructions and the provision of more exercises.

As to the lesson enrichment, revisions of the worktext include provisions of games, puzzle and mind bloggers and trivia. Online resources/ mathematics websites were also suggested to provide additional resources to the worktext.

SUMMARY AND CONCLUSIONS

Based on the result of this study, the two groups of respondents agreed that the developed worktext possesses content validity and it is in line with the course syllabus of Basic Calculus; the lesson objectives is content valid and the objectives followed the principle of SMART and relevant to the course topics of Basic Calculus; the lesson inputs section has content validity and the lessons presented clearly the key concepts and the background information needed to understand the lesson; similarly, the lesson application of the worktext possesses content validity. The activities and exercises in this section are relevant and in consonance with the course syllabus. All activities are adequate, sufficient, and appropriate to its intended users. The lesson enrichment

section also holds content validity. This part of the worktext is challenging and enhances the mathematical skills of the students.

Comments for improvement on content validity focused on time allotment for lesson objectives; explanations, illustrations, and examples for lesson inputs; test and instructions for lesson application; trivia and online resources for lesson enrichment.

RECOMMENDATIONS

The worktext should be considered as an instructional material and be used in the teaching-learning process of the course. The worktext should be tried out in other school to further improve its effectiveness and practicability. Teachers/professors should be motivated to make their own worktext/module/ instructional materials. The school administration should provide support in the production of this worktext, and other instructional materials produced by faculty members. Since the worktext was subjected for validation only. Hence, further study on a wider scope should be conducted.

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