Construction and Validation of Outcomes-Based Worktext in Calculus

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Abstract

This study focused on the development of an outcomes-based worktext in Calculus, and determines its level of acceptability. The basis in the development of the worktext was the revised outcomes-based syllabus of the course Calculus. Prerequisite courses such as algebra, advanced algebra, trigonometry, and analytic geometry taken by students based on their curriculum were identified. The revision of the syllabus was done by the Mathematics faculty members, recommended by the Chairman of the Department and approved by the Dean of the College of Arts and Sciences. The content of the course was based from CMO #19 s. 2007. The developed outcomes-based worktext followed the ADDIE (Analysis, Design, Develop, Implement and Evaluate) model. The worktext was validated by the faculty members in Mathematics who are experts in the field. The worktext has the following parts; desired learning outcomes, recall, motivation, activity, lesson proper, skills building/application, generalization, reflection, and assessment. The respondents chosen purposively in evaluating the acceptability of the worktext were the students enrolled in the course Calculus. The acceptability of the worktext was rated with the following criteria: Content *(M= 3.37, SD= 0.54)* Organization *(M=3.46, 0.56)* Style and Presentation *(M= 3.26, 0.68)* and Activities *(M=3.37, SD 0.44)*. All these criteria were rated moderately acceptable by the respondents. Based on the findings, with the revision in the curriculum by the Commission on Higher Education (CHED), from content-based curriculum to competency-based or outcomes-based curriculum, instructional materials should also be aligned to curricular change.

Keywords: calculus, outcomes-based education, worktext

An instructional material is a teaching resource that supports instruction or learning in the form of print, video, film, electronic, or on-line-based materials. Worktext is one of the print instructional materials. Instructional theories play an important role in developing and designing instructional-aid or materials. These theories help in shaping and defining the outcome of the instructional material. The developed worktext anchored on the theories underpinning outcomes- based education, such as Behaviorism, Social Reconstructivism, Critical theory, and Pragmatic theory (Wydeman, 2002). Spady (1994) defines OBE as a comprehensive approach to organizing and operating an education system that is focused in and defined by the successful demonstrations of learning sought from each other and by the end of the educational experience, each student should have achieved the goal. Activities in the worktext were provided, students were given instructions on what to do, and instructions were structured so that it can easily understand by the learner. In OBE, the learner's progress is based on his/her demonstrated achievement, and each learner's needs are catered to by means of a variety of instructional strategies and assessment tools (Van der Horst and McDonald ,1997). CHED (2014) defines OBE as an approach that focuses and organizes the educational system around what is essential for all learners to know, value, and be able to do to achieve the desired level of competence. To achieve the desired level of competence of learners, teachers should look into what is essential for them. Thus, this study used outcomes-based approach in teaching calculus utilizing the developed worktext.

The study aimed to construct and validate the developed outcomes-based worktext in Calculus and determine its level of acceptability with respect to the contents, activities, style and presentation and organization.

Materials and Methods

This study is a quantitative research that employed developmental research. Developmental research, as opposed to simple instructional development, is defined as the "systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet the criteria of internal consistency and effectiveness" (Seels and Richey, 1994). This was used in order to come up with an "obedized" worktext in calculus which aimed at enhancing the students' performance in the course. The developed outcomes-based worktext utilized the ADDIE model. According to McGriff (2000), the ADDIE model is a systematic instructional design model consisting of five phases: (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation.

The development of the worktext followed the process flow diagram shown in figure 1.

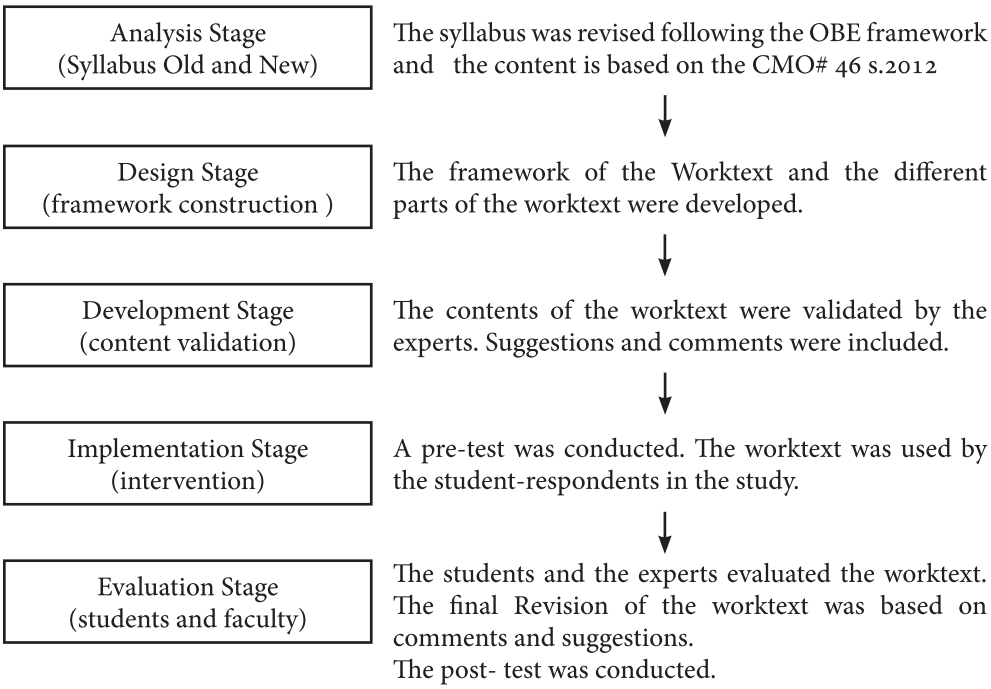


Figure 1. The process flow diagram for the development of worktext.

Analysis Phase

The level of skills and competencies of the learners were looked into in this stage. This was done by identifying the mathematics courses which the students had already taken based on the curriculum. The prerequisite subjects such as algebra, advanced algebra, trigonometry, and analytic geometry, indicated the students' readiness in dealing with various topics included in calculus. The course description of calculus as reflected in CMO #19 s.2007 was the basis for the revision of the syllabus and also the researcher's expertise for having been a teacher of calculus for many years. The syllabus was patterned after the outcomes-based education format of the University. The chairman of the Mathematics Department verified the revised syllabus which was further subjected to the approval of the dean of the college.

Design Phase

The researcher constructed the framework of the worktext to make the design effective. A framework refers to the different parts of the worktext and was based on the OBE curriculum. The different parts of the worktext

are: desired learning outcomes, recall, activity, analysis, motivation, lesson proper, skills building/applications, generalization, reflection and assessment. Different instructional strategies were created on the basis of the desired learning outcomes. Selecting a form of the course or how to deliver the content of the different topics was considered. The researcher assigned a time frame for every part of the worktext.

Development Phase

This stage was anchored on the analysis and design stages. Instructional materials were created using the different parts identified in the design stage. Thereafter, the worktext was subjected to validation by five experts in mathematics who were also handling calculus classes. Revisions were made following their suggestions and recommendations.

Implementation Phase

The worktext was used as the primary tool in teaching the course Calculus. This was tried out to the group of students taking the course who were selected purposively. The researcher made some corrections based on the observed implementation process. The different activities were performed and outputs were collected.

Evaluation Phase

Students were asked to assess the acceptability of the worktext. An adapted instructional materials questionnaire from the evaluation committee of the West Visayas State University was utilized for this purpose. The ratings, comments, and suggestions of the students, together with the recommendations of the observers, were considered in the finalization of the worktext. Before the start of the intervention, a pre-test was given in order to assess students' performance after which, a post-test was given. The results were analyzed and interpreted as to the effect of the students' performance using the worktext.

The participants of the study were the faculty members who were experts in the course Calculus. They validated the content by giving comments and suggestions for the enhancement of the worktext. The students enrolled in Calculus evaluated the worktext as to its acceptability after the use of the worktext in the class.

The instrument used in evaluating the worktext as to its acceptability was the adapted instructional evaluation form of West Visayas State University, Iloilo City. The worktext was evaluated on the basis of content, organization, style and presentation, and activities.

Results and Discussion

Outcome is the result of the learnings in an institution. Spady (1994) defined "outcome" as a culminating demonstration of learning. It is what the student should be able to do at the end of a course. Outcomes involve actual doing, rather than just knowing or verifying other purely mental processes. This means that an outcome is not a collection or average of previous learning experiences, but a manifestation of what learners can do once they have completed all tasks and add new learning experiences to previous ones. This also means that outcomes are not simply those that students believe, feel, remember, know, or understand; instead, these are what students actually can do with what they know and understand.

The developed worktext in calculus was based on the outcomes-based approach. The contents were based on the course description of the subject as reflected in the CMO No.19 s.2007. The different parts of the worktext were identified; the desired learning outcomes, recall, analysis, motivation, lesson proper, skills building/applications, analysis, generalization, reflection, and assessment. Each part is discussed as follows.

Desired learning outcomes

These describe a clear picture of the behavior of the student at the end of the course. They guide the teacher on what to focus on a particular topic and the students idea on what they have to learn and comply after the lesson. According to Spady (1994), the ability to demonstrate learning outcome is the key point which involves performance to show significant learning. In this study, the key point is the teacher who sets what the students should do to achieve the outcomes.

Recall

This includes review of the topics that were previously discussed and allows students to enrich their understanding of the past lessons and be able to relate to the new ones.

Activity

This comprises application of the recall-part either by problem solving or justification. This provides students with time to think critically on how to solve as they analyze the situation or problem. The developed worktext has activities such that students would think critically in order to come up with the result (Cooper,1995)

Motivation

This encourages students to think of real-life examples or situations for a particular topic. It stimulates the interest of the students and helps them to relate the various concepts of calculus in real life. Motivation is something that energizes, directs, and sustains behavior; it gets students moving, points them in a particular direction, and keeps them going (Reeve, 2006).

Lesson proper

This covers the content of the topic. The teacher presents to the class what the students have to learn on the basis of the desired learning outcomes. Spady (1994) claims that significant content is essential, but that content alone is insufficient as an outcome. Rather, knowledge of content must be manifested through a demonstration process of some kind.

Skills building/application

This includes the different exercises to stimulate students' understanding of the concepts during the lesson proper. This measures the students' learning acquisition regarding the lesson presented.

Generalization

This comprises the summary of the different concepts discussed. It shows the retention and mastery of the students as regards the different topics discussed.

Reflection

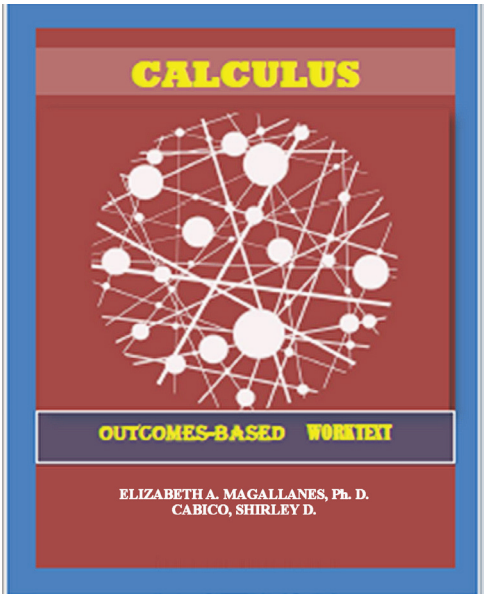
This includes the students' idea or own interpretation of the content presented in the lesson proper. It shows how the students relate mathematical concepts to real-life situations. Students are more reflective on their response if the teacher increases the waiting time during class discussion; (Rowe 1978) thus, the number of students responding to the teachers also increases.

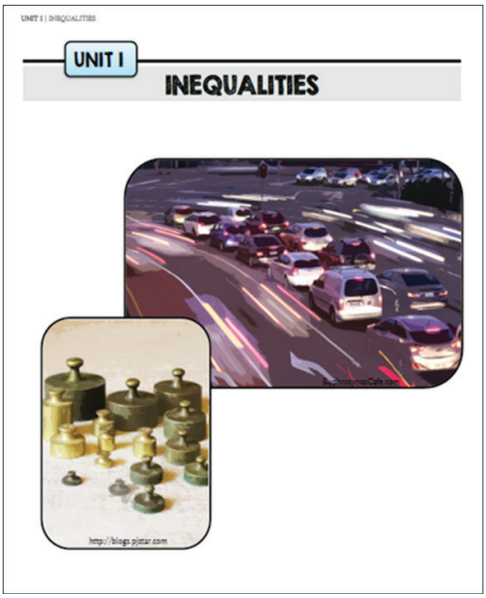
Assessment

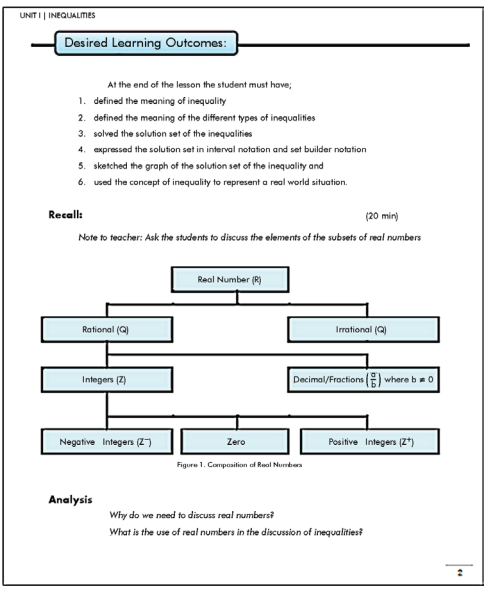
This provides different exercises about mathematics concepts presented in each unit. It evaluates students' learning and answers the desired learning outcomes. A variety of alternative assessments in mathematics must be used to generate the information a mathematics teacher needs to determine what his/her students are thinking, how his/her students are reasoning, and what the next instructional steps should be (Senk, et al . 1997). Assessments reveal how well students have learned what the teacher wants them to learn while instruction ensures that they learn it. For this to occur, assessments, learning objectives, and instructional strategies need to be closely aligned

so that they reinforce one another. Gensee and Upshur (1996) state that classroom assessment and evaluation are concerned primarily with improving instruction so that student learning is enhanced. Assessment in the worktext is important since it involves one or more processes that identify, collect, analyze, and report data that can be used to evaluate achievement of learning outcomes. Effective assessment uses relevant direct, and indirect, quantitative and qualitative measures appropriate to the learning outcomes.

A sample of the developed outcomes-based Worktext in Calculus is shown below.







UNIT 1 | INEQUALITIES

LESSON PROPER: **(60 min)**

Write algebraically the relationship of two quantities given the following mathematical phrases:

- one value is greater than another value.
- one value is lesser than another value.
- one value is greater than or equal to another value.
- one value is lesser than or equal to another value.

Note: Students will be asked to write at least five common words used for the different inequality symbols.

$<$ $\leq$ $\geq$ $>$

UNIT 1 | INEQUALITIES

Skills Building / Application: **(90 min)**

INSTRUCTIONS: This is a group activity. Find the solution set in interval notation, set builder notation then graph it on the number - line. Use extra paper for your answer and be ready for presentation.

1. $-(4x-6) \geq 2(3x-4)$

2. $\frac{2}{3}(2x+3) \leq -2(5x-4)$

3. $\frac{3}{4}(x-3) < \frac{1}{2}(5x+2)$

4. $(3x+1) > 2(5x-2)$

5. $2 < x-1$

6. Make a real life situation which you can apply the concept of linear inequality.

Analysis

In your own words, how do youo define linear inequality?

UNIT 1 | INEQUALITIES

Activity: Real Numbers: **(30 min)**

INSTRUCTION: This is an individual activity

1. Classify the following real numbers as to Rational or Irrational. Write your answer on the space provided.

_____a.)0.12 _____d.)0.111---

_____b.) $\frac{2}{3}$ _____e.) -10

_____c.) $\sqrt{3}$ _____f.) x

2. Illustrate the numbers from a to f of item no. 1 in the number-line and write at least 5 relationships with one another.

Analysis

What are rational and irrational numbers?
Are these numbers can be found in the number-line?

UNIT 1 | INEQUALITIES

Generalization: **(30 min)**

Discuss in your own words how to find the solution set of the different types of inequality such as Linear Inequality, Compound Inequality, Quadratic Inequality, Rational Inequality, and Inequality involving Absolute Value.

Reflections: **(20 min)**

With your knowledge in solving inequalities, how will you relate these concepts to real life situations?

Table 1

Mean Result on the Level of Acceptability of the Developed Outcomes-based Worktext in Calculus

	M	Description	*SD*
A. Contents	3.37	Moderately Acceptable	0.54
1. The contents of the worktext are parallel to the desired learning outcomes.	3.26	Moderately Acceptable	0.74
2. The lessons included in the worktext contain clear instructions.	3.26	Moderately Acceptable	0.61
3. The concepts and ideas presented apply critical and problem solving skills using algebraic method.	3.51	Very Acceptable	0.56
4. The concepts and ideas presented apply critical and problem–solving skills using analytic method.	3.46	Moderately Acceptable	0.69
B. Organization	3.46	Moderately Acceptable	0.56
1. Contents of the worktext are well–organized.	3.26	Moderately Acceptable	0.61
2. Lessons and activities of the worktext are arranged in ascending order of difficulty.	3.31	Moderately Acceptable	0.76
3. Organization of the lessons and activities develops problem solving skills.	3.23	Moderately Acceptable	0.55
4. Worktext is adept and appropriate.	3.29	Moderately Acceptable	0.62
5. Worktext is useful supplement to reinforce the transfer of learning.	3.40	Moderately Acceptable	0.51
C. Style and Presentation	3.26	Moderately Acceptable	0.68
1. The worktext has adequate margins, legible type face, and comfortable type size.	3.31	Moderately Acceptable	0.68
2. The work text is presented at a pace that allows recall and reinforcement of activities.	3.26	Moderately Acceptable	0.70
3. The worktext has sufficient space provided for students' responses.	3.34	Moderately Acceptable	0.73
4. The worktext is presented in a technically appropriate manner.	3.26	Moderately Acceptable	0.61
D. Activities	3.37	Moderately Acceptable	0.44
1. Worktext provides a variety of learners' activity.	3.29	Moderately Acceptable	0.83
2. Activities are relevant to the topics.			
3. Activities are relevant to the desired learning outcomes of the lesson.	3.26 3.34	Moderately Acceptable Moderately Acceptable	0.66 0.68
4. Activities are relevant, interesting, and self-motivating to the learners.	3.57	Very Acceptable	0.61
5. Activities are presented from simple to more complex examples.	3.40	Moderately Acceptable	0.60

Note: Interpretation is based on the following scale. Very Acceptable (3.51 – 4:00); Moderately Acceptable (2.51 – 3.50); Acceptable (1.51 – 2.50); Barely Acceptable (1:00 – 1.50).

The worktext was evaluated by the faculty members of the Mathematics Department on the basis of content, organization, style, presentation, and activities. All these criteria were rated moderately acceptable. The respondents were also asked to write their reflections and observations on the use of the developed outcomes–based worktext in calculus. These observations and comments were also used as basis in the revision of the worktext; some of these were: they understand the lesson well and is of great help to them. Activities and questions in the worktext help them improve their higher–order thinking skills. They need more activities that would enable them to interact with their classmates; spaces should be provided for the solutions, the lines on the space for the solution should be removed, considering that it is a mathematics subject.

Conclusions and Recommendations

The OBE developed worktext in calculus has the following parts: desired learning outcomes, recall, motivation, lesson proper, activity, skills building/applications, analysis, generalization, reflection, and assessment. The respondents evaluated the developed outcomes-based worktext to be moderately acceptable; thus, it can be utilized as an instructional material in the teaching of calculus. The developed worktext helped address the needs of the students to successfully hurdle the challenges in learning the course.

Based on the findings and conclusions, the following recommendations are advanced:

With the revision in the curriculum by the Commission on Higher Education (CHED), from content-based curriculum to competency-based or outcomes-based curriculum, instructional materials should also be aligned to curricular change. The result of this study may provide the (CHED) information on the performance of the students in calculus for them to revisit the program and make revisions if necessary. The developed outcomes-based worktext in Calculus will be helpful to teachers who will be working with instructional materials that are outcomes-based. Future researchers may conduct similar studies in line with the development of instructional materials; book writers may write books based on OBE curriculum.

Related studies on the effects of the proposed instructional material on the attitudes of the students towards the subject matter may be undertaken to determine the level of acceptability of the developed outcomes-based worktext in Calculus involving experts and calculus teachers as the respondents of the study and with a control group. School administrators may consider conducting trainings and seminars to faculty members to enhance their teaching skills and develop new techniques, specifically the OBE approach, in delivering lessons in class.

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