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Development of Worktext in Mathematics in the Modern World

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Abstract

Learning resources are crucial to boosting students' academic performance. This study aimed to develop and validate a worktext for Mathematics in the Modern World (MMW). Specifically, it sought to determine the availability and adequacy of instructional materials in the said mathematics course; describe the components of the worktext; evaluate the worktext in terms of objectives, content, format, organization, language, and usability; and determine the readability of the worktext. Findings showed a need to develop a worktext in MMW to address the inadequacy of teaching and learning resources in MMW in the university. The worktext in MMW is simple yet rich in content and contains varied activities. It is highly valid and can be used as instructional material in the teaching and learning of MMW. The contents of the worktext are written so that it is clear to the target readers can read it.

Keywords: Worktext Development, Learning Material, Validation, Mathematics in the Modern World.

Introduction

Making sense of the world, communicating, and acting as a bridge to societal advancement are all made possible by mathematics. It also plays a role in promoting involvement in constructive life activities. Thus, teaching mathematics creates the opportunity for the students to understand what they know and need to learn. Building a rich learning environment that boosts a positive way of thinking and potential growth in mathematics learning and teaching is essential.

Teachers must have a thorough grasp of their students to help students engage with, explore, and integrate their mathematics

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knowledge, abilities, and understanding with other learning areas and the outside world. Teachers must be adept at choosing and using diverse instructional strategies and learning materials. Educators must change the way students view mathematics and the way they think about their relationship with it. Most importantly, there is a need to change the way students feel about themselves. Cadorna et al. (2016) explored the pathological fear of mathematics among male and female college students. Students fear math because of their friends' influence, personal capacity, and the nature of math as a complex subject.

In 2020, the country shifted into the new normal for education because of the COVID-19 pandemic. According to The Star (2020), there are four aspects in the transition to the new normal: (1) shift of learning space – from public space to personal space, (2) shift of delivery (teaching) methods – from one size fits all into individualized and differentiated learning, (3) shift of responsibility in the teaching and learning process, and (4) shift in learning evaluations. Hence, all universities adopted flexible learning as a style of education recommended by the Commission on Higher Education to address the new normal education. Flexible learning is an approach that suggests instructional designers provide learning facilities that give learners choices for time and/or place for learning in a customized way (IGI Global, 2020). One method to use in flexible learning is the use of worktext.

For tertiary education, CHED started implementing the CHED CMO 20 series of 2013, known as the "General Education Curriculum: Holistic Understandings, Intellectual and Civic Competencies," in School Year 2018-2019. The new general education curriculum aligns with the K–12 program, the Philippine Qualifications Framework (PQF), and the ASEAN Qualifications Framework (AQF), having gone from 63 to 36 units. The outcomes-based curriculum trains students to be ready for a job after graduation. The 36 units of courses in the new curriculum include Mathematics in the Modern World (MMW). CHED (2013) describes it as the "Nature of mathematics, appreciation of its practical, intellectual, and aesthetic dimensions, and application of mathematical tools in daily life."

All undergraduate students, regardless of major, must study Mathematics in the Modern World as part of their academic education. They are exposed to many fields of knowledge and methods for understanding social and natural reality, and developing the intellectual skills and civic virtues necessary for citizenship in the community, the nation, and the world. In this course, students are expected to acquire a greater appreciation of mathematics and be more equipped with skills by engaging them with tasks where they develop mathematical thinking and reasoning. It opens more

opportunities for students to apply what they have learned in their basic education. Students are brought closer to the world to use their knowledge and skills on what they want to see.

Teachers of the new general education courses attended training to prepare them to teach the subject in its content (Taban et al., 2023). During the training, teachers received handouts and limited references. Since the content of Mathematics in the Modern World is diverse, it is a combination of different topics in mathematics that focus on its application to real-life situations. Teachers utilize various sources, such as printed books and online resources, for every content topic.

Compared to the simple chalk-and-talk teaching style, education has developed into various instructional strategies to meet contemporary demands. One of these strategies includes using instructional materials to make the teaching-learning process enjoyable. Throughout the delivery of educational programs, instructional materials play a key role in the teaching-learning process. Thus, aside from the training conducted for teachers, they need instructional materials to support and enrich the new curriculum. Instructional materials in the teaching-learning process are significant throughout the delivery of educational programs (Aureada, 2017). Since students react to information in various ways, they must be chosen based on their suitability, subject matter, and methodology. (Zimmer, 2008, as cited in the study of Selga, 2013).

Teaching mathematics at the tertiary level demands instructional materials, which lead to independent learning. These materials assist in learning by encouraging students to explore information individually while offering repetition. Instructional tools should not be used in place of a good teacher; instead, they should be used to supplement the learning process. (Torrefranca, 2017).

International authors' subjects are presented in a different language than students easily understand. (Aureada, 2017). In some textbooks, average students need help comprehending the lessons. To encourage the student, the themes and logical exercises must be presented to fit the Filipino mentality. As a result, many students think the course is challenging, which deters them from learning the ideas. Therefore, when creating instructional materials, environmental elements that connect the teachings to the learners' context should be considered.

However, instructional resources in MMW are still limited. Existing Mathematics in the Modern World books have either limited activities, need to be localized, or are CHED compliant. Besides, the available books are expensive, and students may need help to afford to buy them. Because students can work directly on their books, workbooks, and worktexts are frequently preferred in classrooms. Gray (2007)

concluded that using workbooks/worktexts is beneficial, resulting in higher scores on standardized and increased power of self-direction, helps in retention, skill in fundamental processes, reasoning ability, and solving problems. Aureada (2017) mentioned that instead of designing the text to match the course, the design of the worktext should fit the course. Students should use it as a guide, mainly when they can write notes or comments in each class.

Also, the large number of students with low grades in this subject and the complaint of mathematics teachers about the students' poor mathematical skills are some alarming proofs of the students' mathematical difficulty (Rabanal & Domondon, 2023). In the study of Agup and Ebojo (2022), they also found that students have a fair level of engagement in Mathematics that served as their basis in formulating an action plan for student-teacher interaction. The action plan included the provision of learning resources that supplement the learners' needs. The shortage of textbooks appropriate for students' levels was also mentioned by the researchers and math teachers as a contributing factor. In order to effectively instruct a class as a whole or a single student, teachers must create or prepare instructional materials that are appropriate for certain groups of students in their classroom. This supports the recommendations made in the study by Garcia (2020) that it is highly encouraged that teachers make their instructional materials to facilitate the teaching-learning process and improve students' performance.

Workbooks are "worktexts," containing instruction and practice, providing drill and review (Knapp, 2006). These methods encourage independent work, track progress, and provide skill-specific review and repetition. Espinar and Ballado (2016) stated that Gray (2007) concluded that workbooks/worktexts are helpful, resulting in higher standardized test scores and increased self-direction, retention, fundamental process abilities, reasoning capacity, and problem-solving ability.

Based on the preceding circumstances, the researchers conceptualized developing a worktext in Mathematics in the Modern World (MMW) that the University of Northern Philippines can use. Learning resources are crucial to boosting students' academic performance; thus, validating and determining the degree of acceptability of a worktext in this course is appropriate. Because the courses are delivered in a language and context appropriate for the students' level, this enables the students to pick up the information more quickly.

Theoretical Framework and Literature Review

This study is based on the Elaboration Theory of Reigeluth, the Subsumption Theory by Ausubel, and the Scaffold Learning Theory of Vygotsky. The Elaboration Theory of Reigeluth relies upon the idea that instruction is offered to learners in increasing order of difficulty (Pappas, 2014). Hamidia et al. (2011) mentioned that Reigeluth assumes that guidance is made up of layers, each building on the concepts that have come before. It reinforces the previous ideal by elaborating on it, thus enhancing retention. Merill's Instructional Design Theory includes a set of procedures needed to design and develop instructional materials that systematically emphasize what to do instead of how to do it or why it works. It has the following primary phases: Analysis, Design, Development, Implementation, and Evaluation (Merill et al., 1996, cited by Cruz, 2014). Thompson (2001) emphasized the importance of instructional theories and models in designing instructional material and claimed that these designs and theories guide speeding up the process because of a team or group presence. The theories and models also cover every stage of effective instructional design, ensuring that all instruction components are present, connected, and supportive of one another.

The basic phases of Instructional Design Theory, according to Reigeluth (1999), can help develop the skills needed to improve the quality of instruction. This theory was important in the present study because it guided the writers of the proper procedures, appropriate content, and the skills to be built-in in developing the proposed worktext in MMW.

As Kearsely and Culatta (n.d.) discussed, the Ausubel Subsumption Theory looks at how students absorb substantial amounts of useful information through oral and written presentations in a classroom setting. During information receipt, it concentrates on the superordinate, representational, and combinatorial processes. Subsumption is a key learning process in which incoming information is connected to pertinent concepts in the preexisting cognitive structure on a substantive, non-verbatim basis. He suggested employing sophisticated organizers to assist the students in connecting new learning material with previously learned concepts. The created worktext began by presenting the subject's broadest concepts before further differentiating them in terms of detail and specificity.

This study is also based on the Scaffold Learning Theory of Lev Vygotsky, who postulated that knowledge acquisition might be more successful when a scaffold assists it (Hung et al., 2008). Once a learner has mastered a task using scaffolding, he can complete it without scaffolding. The researchers believed that the worktext developed in

this study would serve as a scaffold supporting the teaching-learning process.

Reyes and de Guia (2015) stressed that textbooks are critical in all educational institutions worldwide. It has been discovered that using textbooks makes students feel more confident about their success and achievement. Textbooks, like worktexts, are beneficial resources for independent learning, teacher presentation materials, ideas and activities, and a source of information for students, according to Rowell and de Guia (2015).

Tomlinson (2011) provided some principles for preparing learning or instructional materials. Instructional materials should aspire to (and must aspire to) the following goals: Impact, assist learners in feeling at ease, assist learners in developing trust, be viewed as essential and beneficial by learners, necessitate and encourage learner investment, prepare learners to acquire the points taught. It considers the various learning styles of individuals and the fact that the beneficial results of training are typically delayed. Instructional materials are crucial in the educational process because they enhance students' academic skills.

Dahar and Faize (2011) evaluated the impact of instructional material availability and use on students' academic performance in Punjab, Pakistan, and found them to have less availability, misallocation, and deficiency in the use of instructional material. These problems lead to resource waste, less effectiveness of instructional material, and lower academic performance.

Moreover, various developed worktext were validated in terms of their content validity and level of acceptability (Espinar & Ballado, 2017; Reyes & de Guia, 2017), adequacy and content, format, and readability (Selga, 2013), and in terms of subject matter content, organization and presentation, language and style, and usefulness as measures of the acceptability of the material (Cruz, 2014), and content characteristics and instructional characteristics (Alicar-Cadorna & Cadorna, 2009). Meanwhile, Yulastri et al. (2017) evaluated the developed material on entrepreneurship in terms of its content, format, presentation, practicality, and effectiveness.

The researchers used the above readings to design and develop the worktext in MMW. The criteria or indicators used by the above-cited researchers were the basis for the content validation of the worktext.

Research Objectives

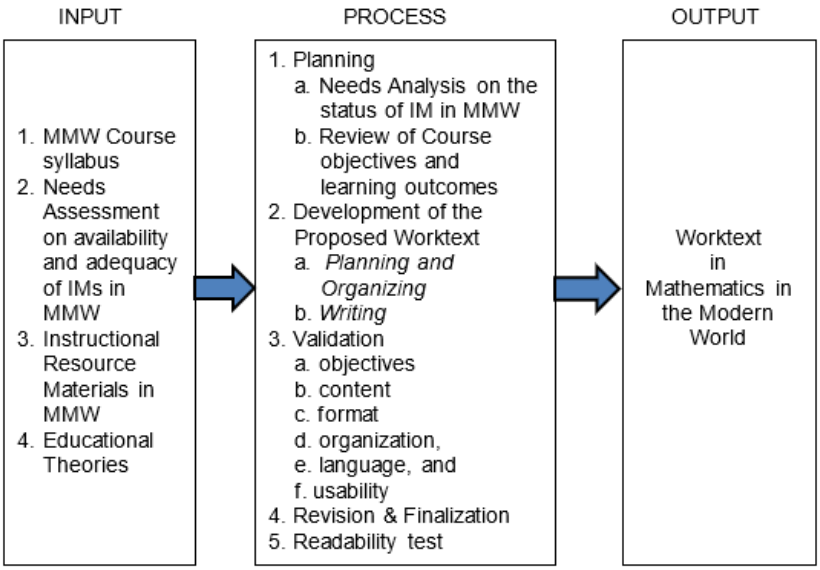
This study aimed to develop and validate a worktext for Mathematics in the Modern World (MMW). Specifically, it sought to determine the availability and adequacy of instructional materials for teaching and learning MMW; describe how the following topics - Mathematics in

our World, Mathematical Language and Symbols, Problem-Solving and Reasoning, Data Management, Mathematics of Finance, and Geometric Designs may be developed into a worktext; evaluate the worktext in terms of objectives, content, format, organization, language, and usability; and determine its readability.

Conceptual Framework

This study was guided by the research design presented in Figure 1 below.

Figure 1. The Research Paradigm



The study used the Input-Process-Output model of research. The MMW course syllabus with the course content standards, course objectives, learning competencies for each topic, assessment of the available instructional materials for MMW, and the educational theories on which the study is based are parts of the input variables. The process variables include analyzing the data gathered on the availability and adequacy of instructional materials in MMW, preliminary planning, the processes involved in developing and validating the proposed worktext, revisions based on the suggestions of the evaluators, and the readability test done by chapter. The expected output of the study is the developed MMW Worktext.

Research Methodology

This study used the research and development (R&D) design and descriptive and development methods. According to Yulastri et al. (2017), the implementation of R&D is an attempt to develop, produce,

and validate a production used in learning. Putra (2012) supported Yulastri when he claimed that methods of R&D are research that deliberately and systematically aims at seeking findings, formulating, refining, developing, producing, and evaluating the product's effectiveness. However, in this study, the effectiveness of the worktext will be outside the scope of the study. It was conducted at the University of Northern Philippines.

Eight teachers handling MMW subjects in the university were asked about the availability and adequacy of learning materials for MMW. While five mathematics professors and two (2) language editors, regardless of gender, validated the worktext based on the proposed criteria.

There were two sets of questionnaires used in the study. The first set was the instrument to gather data on the availability and adequacy of instructional materials in teaching MMW. The second set was the validation instrument, adapted from Salavaria (2014) and varied sources, and was Content validated by experts in IM development. The validation instrument, a 5-point Likert scale, covered the following criteria: objectives, contents, organization, format, language, and usability.

The general flow of the study comprises four phases: Phase 1 – Preparation, Phase II – Development, Phase III – Validation, and Phase IV – Revision and Finalization. The planning phase included gathering and analyzing information on the availability and adequacy of instructional materials in MMW, reviewing the course syllabus, improving learning competencies, gathering information on reference materials, proposal making, outlining, and deciding on the worktext format to be followed. The development phase involves writing sections of the worktext with the following parts: learning competencies, presentation of the concepts, illustrations and worked-out examples, exercises, and self-tests. At the end of each chapter are summative tests. The validation phase covered the evaluation of the proposed worktext based on objectives, content, format, organization, language, and usability. The revision and finalization phases covered incorporating the evaluators' suggestions and compliance with them. This phase also included the completion of the final draft of the proposed worktext in MMW. Lastly, the worktext undergoes the readability test.

Data were analyzed using frequency count and documentary analysis to describe the adequacy and availability of instructional materials in MMW. Weighted mean was used to determine the validity of the worktext in terms of the set criteria. The Flesch Reading Ease and Flesch-Kincaid Grade Level were determined using the Tests Document Readability Calculator of Online-Utility.org. To interpret the Flesch-Kincaid Grade Level and Flesch Reading Ease results, the

researchers adopted the norms used by Rudolph Flesch, as presented by Wylie (2018).

Results and Discussions

1. Adequacy and Availability of Instructional Materials in MMW

The result shows that almost all mathematics teachers in the Modern World (MMW) use textbooks as instructional material, and are readily available. The identified textbooks available are by Richard Aufmann et al. (Rex Book Store), Ethel Cecille Baltazar et al. (C & E Publishing), and Mary Joy Rodriguez et al. (Nieme Publishing House Co. LTD). E-books are also available. However, other instructional materials like worktext are not available. Teachers disclose they had only 1 – 2 copies of textbooks in MMW. Some teachers noted that they borrow from their colleagues. However, the teachers acknowledge that these textbooks have limited functions. The contents are not enough to meet the needs of learning and understanding MMW; limited information and examples about the topics presented, no hands-on or application activity is given in the book, and the contents are not aligned with the topics included in the course syllabus in MMW used in the university. The fact that most teachers possess textbooks only and no other materials available shows an inadequate number of teaching and learning resources in MMW.

Yusta et al. (2016) mentioned that the availability and adequacy of a wide variety of instructional resources could stimulate learners' interest and active engagement in mathematics. Hence, the development of a worktext was considered to supplement the need for instructional materials to be used by the mathematics faculty in teaching MMW.

2. Description of the Developed Worktext in MMW

The worktext in MMW was developed in response to the initiative of the University of Northern Philippines in transitioning to the New Normal Education brought about by the COVID-19 pandemic. This is also in consonance with CHED Memorandum Order No. 20, series of 2013 "The new General Education aims to expose students to various domains of knowledge and ways of comprehending social and natural realities, developing the process of intellectual competencies and civic capacities."

The worktext was developed parallel to the course syllabus in MMW used at the University of Northern Philippines. It consists of six chapters, four major topics, and the other two electives. The four major chapters are Mathematics in Our World, Mathematical Language and Symbols, Problem Solving and Reasoning, and Data Management. The two electives are Geometric Designs and

Mathematics of Finance, which the mathematics faculty perceive to be the most essential topics for students in the university. Hence, these four major chapters and two electives are being taught to all students taking the course Math 101-Mathematics in the Modern World at the university.

The worktext is written and presented following the basic parts such as the worktext main cover page, foreword, table of contents, and main body. The main body comprises the sequence of the six chapters in MMW. Each chapter has a cover page comprising the chapter number and title, a figure depicting the topic, lessons outline, and learning outcomes. After the chapter cover page is the sequence of the lessons, it starts with an overview and is followed by a discussion of the lesson. Discussions of the lesson include relevant concepts and examples to illustrate the concepts presented. Exercises or varied learning activities are provided after the discussion, serving as self-assessments for the students. After all, lessons are presented, a summary highlights the essential concepts, and a chapter test serves as the summative test. Each chapter is ended with references to acknowledge some sources used in the worktext and may allow students to access for further reading.

The worktext was developed to provide the students not only a material for their learning but also provide mathematics faculty an instructional material they may use to teach MMW. This addresses the need for more teaching and learning resources in MMW, as presented in the previous result of this study.

3. Evaluation of the Worktext

The results of the evaluation of the worktext in terms of content, format, organization, language, and usability; and determining its readability are presented in Table 1.

Table 1. Validity of the Worktext in MMW

Criteria	M	DR
a. Objectives		
Nature	4.89	Highly Valid
Purpose	4.94	Highly Valid
Procedure	4.89	Highly Valid
Overall	4.90	Highly valid
b. Content		
Logical Presentation	4.83	Highly Valid
Consistency	4.83	Highly Valid
Quality	4.89	Highly Valid
Overall	4.85	Highly valid
c. Format		

Structure	4.74	Highly Valid
Layout	4.80	Highly Valid
Quality	4.86	Highly Valid
Overall	4.80	Highly valid
d. Organization		
Coherence	4.83	Highly Valid
Unity and Ideas	4.74	Highly Valid
Emphasis	4.89	Highly Valid
Relevance to Discipline	4.69	Highly Valid
Overall	4.79	Highly valid
e. Language		
Communicative Function	4.63	Highly Valid
Language Function	4.83	Highly Valid
Overall	4.73	Highly valid
f. Usability		
Effectiveness	4.86	Highly Valid
Satisfaction with the content	4.89	Highly Valid
Overall	4.88	Highly valid
As a whole	4.83	Highly Valid

On Objectives. The worktext is highly valid as regards objectives (M= 4.90). It is also highly valid in all three criteria: nature, purpose, and procedure. The evaluators strongly agree that the objectives of the worktext are well-written in such a way that they attain the nature, purpose, and procedure intended for the course. They believe that the objectives clearly define what is to be learned, satisfy the curriculum requirement, and address skills or technical procedures needed in the subject.

On Content. The evaluators generally find the worktext's contents highly valid (M=4.85). This is manifested by their strong agreement that the contents of the worktext meet all the criteria. Moreover, the developed worktext obtained the highest mean rating along quality (M= 4.89), described as highly valid, which indicates that the contents of the worktext provide real-life applications of the lesson, present appropriate activities to the students and develop the ability to work individually. Also, the worktext is highly valid in both the logical presentation and consistency of the contents. However, there is a need to use smooth, integrated, comprehensive, relevant, and concrete evidence from sources to provide a relationship between previous and present ideas and apply activities to diverse student abilities. Generally, the contents of the worktext give clear and easy-to-follow instructions and maintain focus on the topic throughout the response. This result conforms with the study of Aureada (2017), in

which his developed worktext in Logic for college students has shown that the relevance of the contents is strongly evident.

On Format. The developed worktext is highly valid in its format (M= 4.80), wherein all three criteria are rated highly valid, with the highest mean on quality (M= 4.86). The results show the consistency of illustrations and text in the material. That is, it was well written by observing a uniform format. Though the experts strongly agree on all the five indicators of structure, emphasis should be given to exhibiting a visually appealing and stimulating format and demonstrating accurate and well-integrated graphics and illustrations into the text.

On Organization. The developed worktext is highly valid regarding its organization (M= 4.79). Moreover, all four criteria on the organization are highly valid, wherein emphasis got the highest mean (M= 4.89) on emphasis while relevance to the discipline got the lowest mean (M= 4.69). The results show room for improvement by integrating an inviting lead that grabs the readers' attention, embracing a strong conclusion that brings an ending to what is written, and making connections between disciplines. One of the validators even suggested that "every after a unit, there should be a generalization or a summary of the lessons presented."

On Language. The developed worktext is highly valid in its language (M=4.73). It is also highly valid on its two criteria: language function and communicative function. This is attributed to the suggestion of the two language evaluators that the worktext would be better if the tone of the discussion part of the lessons were more conversational. One of them added that some parts of the worktext are where the "voice" is very formal.

On Usability. Its usability is measured based on effectiveness, efficiency, and satisfaction with content use. The developed worktext is highly valid regarding usability, with an overall mean rating of 4.88. The validators strongly agree with all the usability indicators based on the results. It is commendable to point out that the worktext is effective as this adapts to students' interests and abilities, efficient as it uses a design that supports ease of learning and encourages students to complete the given tasks, and satisfying in the Content use as it develops new knowledge and skills, stimulates enthusiasm for further learning, and presents intellectual stimulating learning activities. The results conform to the findings of Taban (2021) that the modules developed for learning mathematics subjects had high usability because in using the modules, the students know what to do and how to do the learning activities included in the module. Similarly, Devesh & Nesseri (2014) found that learning Mathematics is useful, easier, and more interesting using modules.

The developed worktext in MMW is generally highly valid (M= 4.83). This implies that the worktext exceeds the minimum validity rating as per the evaluation of the validators. Hence, these may be used as instructional material in the teaching and learning of MMW. This result affirms the study of (Telaumbanua et al., 2017) that the purpose of using learning materials is appropriate as these are arranged systematically according to a curriculum, packed in the smallest learning units, and enable students to study within a particular time independently.

4. Readability of the developed Worktext in MMW

To maximize the use of this worktext, the Content of the worktext needs to reflect the readability expectations of the readers. Scores for readability help determine whether the intended reader will likely understand the published material. The readability index here shows how many years of schooling are required for someone to comprehend the material clearly on their first reading. Using the Tests Document Readability - Readability Calculator of Online-Utility.org, Table 2 presents the results of Readability tests of the six chapters of the Worktext in Mathematics in the Modern World.

Table 2. Flesch Kincaid Readability Test Results

Chapter	Flesh Kincaid Grade Level	Flesch Reading Ease
1. Mathematics in our World	8.89	56.55
2. Mathematical Language and Symbols	4.86	78.50
3. Problem Solving and Reasoning	5.45	75.46
4. Data Management	7.10	64.51
5. Mathematics of Finance	7.14	65.03
6. Geometric Designs	8.22	61.39

The Flesch-Kincaid Grade Level indicates that the average student in that grade level can read the text. As reflected in the table, it can be noticed that all the Chapters in the worktext have a Flesch Kincaid Grade Level of less than 9. Besides, the Flesch Reading Ease scores range from 56.55% to 78.50%, which indicates that the estimated school grade completed of average students who can read the worktext is Grade 7th or 8th and some high school. Similarly, the reading levels of the different Chapters range from Standard to Fairly Hard. Also, about 54 percent to 83 percent of adults can read these reading levels. The results indicate good readability because the readability grade levels are below the target readers who are first-year college students. So, even a high school student is expected to understand the worktext developed.

Conclusions and Recommendations

Based on the findings of the study, the following conclusions are drawn (1) there is a need to develop a worktext in MMW to address the inadequacy of teaching and learning resources in MMW in the university; (2) the worktext in MMW is simple yet rich in content and with extensive activities; (3) the worktext in MMW is highly valid so it can be used as an instructional material in the teaching and learning of MMW; and (4) the content of the worktext were written in a way that its target readers can read it.

A follow-up study may be conducted on the effectiveness of the developed worktext in improving the teaching-learning processes. A final revision of the worktext, which passes the standards and protocol set by the Instructional Materials Development Committee of the university, shall also be initiated for future publication and copyright registration.

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