Global Journal of Engineering Education

Improving engineering students' achievement in solid mensuration by using an obedized work text

Erovita T.B. Agustin & Darin J.C. Tindowen

University of Saint Louis
Tuguegarao City, Cagayan, Philippines

ABSTRACT: Outcomes-based education (OBE) has been a new educational reform, especially among higher education institutions in the world. With this, teachers need to carefully design activities placing the students at the centre of the education, viz. by creating instructional materials and work texts. The quasi-experimental research described in this article was conducted to assess the effectiveness of using obedized work texts to improve the achievement of engineering students in solid mensuration employing a pre-test/post-test method for an experimental and control group. The results reveal that students from the experimental group achieved higher scores than students from the control group. Hence, the use of obedized work text was effective in improving engineering students' achievement in solid mensuration.

Keywords: Solid mensuration, engineering students, obedized work text, outcomes-based education

INTRODUCTION

Solid mensuration is highly important in engineering and architecture and is used extensively in engineering. Using mensuration is necessary for engineers in any project and understanding objects in three-dimensional space helps engineers create models and scenarios, and solve problems mathematically before actually using or building any object. Some lessons in solid mensuration are too complicated to analyse, so it is difficult for the students to understand the subject.

Solid mensuration is one of the major mathematics courses in the engineering curriculum in the Philippines and is a pre-requisite for differential calculus. Many studies reveal that students perform badly in many mathematics subjects, such as calculus and solid mensuration [1-4].

In past years, students were exposed to the traditional method of learning the course [2]. The lessons were presented in a lecture format, where the teacher explained new concepts and then provided examples of the new concepts. The only instrument of instruction was a textbook, which was used as a standard source of information for formal study of a subject and an instrument for teaching and learning [5]. Furthermore, in most cases, teachers put emphasis on the traditional approach to teaching the subject, which focused on computational procedures rather than understanding the underlying concepts. As a result, students viewed the subject as boring and strictly procedural; at the end, many failed to manifest proficiency in the subject, moreover they did not know how to apply concepts in real-life situations [2][6-8].

With the current shift from inputs-based education (IBE) to outcomes-based education (OBE), particularly at the tertiary level, it is necessary for the teachers to carefully design activities placing the students at the centre of the education. It is believed that applying OBE in the classroom will help students really understand the lesson, since they are now the centre of the teaching and learning process [9][10]. Teachers handling solid mensuration must, therefore, use instruction suited to the level of understanding of their students. They must employ current instructional materials as tools to make instruction more effective, efficient and appealing to the learners.

One way to enhance instruction is to provide the learners with carefully developed lessons. Teachers must design activities that engage students in the learning process, activities that build mastery of concepts in solid mensuration and consequently, activities that support learners with varying levels of ability and skills. Numerous studies over the years have introduced a range of instructional materials such as work texts, workbooks and modules to meet the learners' needs and equip them with skills required for their level [11-13].

It is recognised that there is a need for more effective supplementary material. Reported in this article is the development of simplified instructional outcome-based education material (OBEdized material) for solid mensuration, to enhance students' learning and to stimulate their interest in the subject.

Obedized Work Text for Solid Mensuration for Engineering Students

The obedized work text for solid mensuration includes six chapters and 14 lessons. The content covers cubes, rectangular parallelepipeds, prisms, right circular cylinders, pyramids, cones, frustum of regular pyramids, prismatoids, truncated prisms, truncated cylinders, surface area and volume of a sphere; a zone including spherical segment and spherical sector, and Pappus's theorem.

Each chapter consists of the following:

1) Topic, which is the lesson to be learned.
2) Learning outcomes, which describe what the learner should know and be able to do at the end of each lesson.
3) Concept development, which allows students to investigate, explore and discover concepts on their own.
4) Key concepts, which is a summary of ideas or concepts drawn from students' discovery, investigation and exploration.
5) Guided practice, which serves as an approach to instruction where the teacher leads the activity but solicits help from students.
6) Self-test, which consists of items for additional drill and practice.
7) Evaluation to assess students' learning.

The format of the work text was carefully designed to capture easily the attention of the learners.

METHOD

Adopted in this study was a quasi-experimental method of research. Specifically, a pre-test and post-test of matched group in which two different learning environments were compared to measure whether the use of the obedized work text improved the achievement of engineering students in the Solid Mensuration course. The experimental group was taught using the obedized work text, while the control group was taught using the textbook in solid mensuration.

Twenty-five participants were taken from each of the engineering classes in solid mensuration and were grouped into two: the experimental group and the control group. The participants of the two groups were identified and carefully matched based on their average grade in college algebra and plane and spherical trigonometry, which are pre-requisites for solid mensuration. Students with an average grade of 76-90 were included in the study. The result of the pre-test administered before the conduct of the study was also considered in the selection.

Research Instrument

In this study, a pre-test/post-test was administered to the student respondents. The pre-test/post-test was piloted for validation to the students who had already finished solid mensuration. The pre-test/post-test consisted of 45-item multiple choice questions that specifically measured competencies required of students of solid mensuration.

Data Gathering Procedure

1. Pre-treatment phase: the researchers made use of the course syllabus in solid mensuration to review the competencies of the course as a basis for formulating the learning outcomes. Also, survey of books available at the university library, an interview with experts, library work and use of the Internet were employed for concept development and drill activities to come up with the initial draft of the obedized work text in solid mensuration. It is composed of Topic, Learning outcomes, Key concepts, Guided practice, Self-test and Evaluation. Lessons were organised based on the course syllabus to ensure the content was sufficient and the examples progressive. The initial draft of the proposed work text was presented to experts to elicit suggestions and comments regarding the course content, manner of presentation and usefulness of the material. Refinement in the proposed work text was made based on the evaluation, comments and suggestions of the experts. A pre-test was administered to both experimental and control groups before the use of the proposed work text, to initially determine the extent of knowledge on the topics to be introduced to them.

2. Treatment phase: the proposed work text was utilised by the experimental group for 33 hours for a total of 22 meetings. The control group was taught using the textbook for solid mensuration for the same duration. Throughout this period, the lessons, referenced through Internet sites for additional information and learning conditions, were the same for both groups. Parallel items in the quizzes and assignments were administered.

3. Post-treatment phase: after the topics had been taught through the proposed obedized work text in the experimental group and the textbook in the control group, the same post-test was administered to the two groups. Their scores were evaluated and compared to determine if there was any significant difference.

Data Analysis

A pre-test/post-test results scale was used in interpreting the pre-test/post-test results of the student respondents (see Table 1).

Table 1: Pre-test/post-test results scale.

Range	Qualitative description
40 - 45	E (Excellent)
34 - 39	VG (Very good)
28 - 33	G (Good)
22 - 27	F (Fair)
0 - 21	P (Poor)

A *t*-test for independent samples was applied. It was employed to test the significant difference between the pre-test scores of the control group and the experimental group, and post-test scores of the control group and the experimental group. Also, the *t*-test for dependent samples was applied. This was used to test the significant difference between the pre-test and post-test scores of the control group and the pre-test and post-test scores of the experimental group.

RESULTS AND DISCUSSION

Table 2: Pre-test and post-test mean performances of the control and experimental groups.

Scores	Control group (n = 25)				Experimental group (n = 25)			
	Pre-test		Post-test		Pre-test		Post-test	
	F	%	F	%	F	%	F	%
40-45 (E)								
34-29 (VG)							20	80.00
28-33 (G)		`	4	16.00			5	20.00
22-27 (F)	3	12.00	18	72.00	3	12.00		
0-21 (P)	22	88.00	3	12.00	22	88.00		
Total	25	100.00	25	100.00	25	100.00	25	100.00
Mean scores	16.96 (Poor)		25.08 (Fair)		16.64 (Poor)		34.20 (Very good)	

As shown in Table 2, 88% of the respondents in the control group and experimental groups had *poor* performance and 12% had *fair* performance in the pre-test. Both groups obtained a pre-test mean score interpreted as *poor*. The value indicates that both groups are not adequately prepared for the important concepts in solid mensuration. As shown also in Table 2, the control group obtained a post-test mean score of 25.08 interpreted as *fair*, while the experimental group obtained a post-test mean score of 34.20 interpreted as *very good*.

The findings indicate that there was an improvement in the performance of the experimental group in solid mensuration after exposure to the obedized work text, because 100% in the experimental group performed above the range of fair performance in the post-test as compared to the control group with 16%. The results indicate that the use of the proposed work text for solid mensuration contributes to the improvement of students' performance in solid mensuration.

The result is supported by previous studies that instructional materials contribute to the achievement of objectives of the subject and provide for the development of higher cognitive skills [14][15]. The results are also affirmed by the findings of previous studies that effective utilisation of instructional materials helps maximise the chances of student participation and improves students' performance in academic assessments [16][17].

Table 3: Test for significant difference in the pre-test performance of the control and experimental groups.

Groups	N	Mean	SD	*t*-value	*p*-value	Interpretation
Control group	25	16.96	2.64	0.341	0.736	Not significant
Experimental group	25	16.64	3.38			

The *p*-value of 0.736 (see Table 3) reveals there was no significant difference between the pre-test scores of the groups. Therefore, the groups were essentially equal in terms of their pre-entry concepts in solid mensuration, revealing that students in the experimental and control groups were equivalent.

Table 4: Test for significant difference in the post-test performance of the experimental and control groups.

Groups	N	Mean	SD	*t*-value	*p*-value	Interpretation
Control group	25	25.08	3.187	-11.863	0.000	Significant
Experimental group	25	34.20	2.614			

The *p*-value of 0.000 in Table 4 reveals that the post-test mean performances of the two groups differed significantly. The post-test mean score of the experimental group was significantly higher than the control group; therefore, it can be concluded that the experimental group performed better than the control group. Hence, the use of the proposed work text was effective in improving the performance of the students in solid mensuration. Other studies also affirmed that instructional material was found to be effective in improving students' understanding and performance [9][12][14].

Table 5: Test for significant difference between the pre-test and post-test performances of the control and experimental groups.

Groups	Test	Mean	Mean difference	*t*-value	*p*-value	Interpretation
Control group	Pre-test	16.96	8.12	-9.67	0.000	Significant
	Post-test	25.08				
Experimental group	Pre-test	16.64	17.56	-23.052	0.000	Significant
	Post-test	34.20				

As shown in Table 5, the pre-test mean score of the control group was 16.96, while the post-test mean score was 25.08. The difference of 8.12 in the pre-test and post-test mean scores reflects a significant increase in the performance of the students in the control group. The *p*-value of 0.000 indicates that the mean score after the experiment was significantly higher than the mean score before the experiment. A similar result was observed for the experimental group. The mean difference of 17.56 provides evidence that the performance of the students in the post-test was higher than in the pre-test.

The *p*-value of 0.000 reveals a significant difference in the pre-test and post-test scores of the students. The students in the experimental group achieved higher scores than the control group, as seen in the results of their mean difference.

The result clearly shows that that the obedized work text in solid mensuration helped in improving the students' performance in the experimental group. The results of this study are consistent with the findings of previous studies that the use of instructional material in the teaching and learning process was found to be significant in affecting the performance of the students [14][18][19]. Further, modules were valid as instructional material, as revealed by the high performance of the experimental group in their pre-test and post-test results [20].

CONCLUSIONS

The application of the obedized work text in teaching solid mensuration is effective in improving engineering students' achievement in solid mensuration. It is recommended that mathematics instructors teaching engineering are encouraged to develop their own instructional materials to facilitate better teaching and learning.

REFERENCES

1. Huang, C.H., Engineering students' generating counterexamples of calculus concepts. *Global J. of Engng. Educ.*, 16, **2**, 93-97 (2014).
2. Mendezabal, M.J.N. and Tindowen, D.J.C., Improving students' attitude, conceptual understanding and procedural skills in differential calculus through Microsoft mathematics. *J. of Technol. and Science Educ.*, 8, **4,** 385-397 (2018).
3. Laguador, J.M., Students' interest in engineering and average final grade in mathematics as factors in program retention. *Inter. J. of Multidisciplinary Research*, 5, **1,** 1-1 (2013).
4. Gambari, I.A., Ezenwa, V.I. and Anyanwu, R.C., Comparative effects of two modes of computer-assisted instructional package on solid geometry achievement. *Contemporary Educ. Technol.*, 5, **2,** 110-120 (2014).
5. Nicol, C.C. and Crespo, S.M., Learning to teach with mathematics textbooks: how preservice teachers interpret and use curriculum materials. *Educ. Stud. in Mathematics*, 61, **3,** 331-355 (2006).
6. Maffei, A., Neves, P., Dias-Ferreira, J. and Barata, J., Characterisation of the student perception of the concept of flexibility in the manufacturing domain: highlighting the patterns of effective learning. *Global J. of Engng. Educ.*, 16, **2,** 80-87 (2014).
7. Fluck, A., and Dowden, T., On the cusp of change: examining pre-service teachers' beliefs about ICT and envisioning the digital classroom of the future. *J. of Computer Assisted Learning*, 29, **1**, 43- 52 (2013).
8. Jazuli, A., Setyosari, P., Sulthon and Kuswandi, D., Improving conceptual understanding and problem-solving in mathematics through a contextual learning strategy. *Global J. of Engng. Educ.*, 19, **1,** 49-53 (2017).

9. Laguador, J.M. and Dotong, C.I., Knowledge versus practice on the outcomes-based education implementation of the engineering faculty members in LPU. *Inter. J. of Academic Research in Progressive Educ. and Develop.*, 3, **1**, 63-74 (2014).
10. Borsoto, L.D., Lescano, J.D., Maquimot, N.I., Santorce, M.J.N., Simbulan, A.F. and Pagcaliwagan, A.M., Status of implementation and usefulness of outcomes-based education in the engineering department of an Asian university. *Asian J. of Manage. Science and Econ*, 1, **1**, 31-42 (2014).
11. McDonald, J.K., Yanchar, S.C. and Osguthorpe, R.T., Learning from programmed instruction: examining implications for modern instructional technology. *Educ. Tech. Research and Develop.*, 53, **2**, 84-98 (2005).
12. Isman, A., Instructional design in education: new model. *Turkish Online J. of Educ. Tech.*, 10, **1**, 136-142 (2011).
13. Solomon, D.L., Toward a post-modern agenda in instructional technology. *Educ. Tech. Research and Develop.*, 48, **4**, 5-20 (2000).
14. Wallace, E.D. and Jefferson, R.N., Developing critical thinking skills: assessing the effectiveness of workbook exercises. *J. of College Teaching & Learning*, 12, **2**, 101-108 (2015).
15. Yildirim, N., Kurt, S. and Ayas, A., The effect of the worksheets on students' achievement in chemical equilibrium. *J. of Turkish Science Educ.*, 8, **3**, 44-58 (2011).
16. Torio, M.Z.C., Development of instructional material using algebra as a tool in problem solving. *Inter. J. of Educ. and Research*, 2, **1**, 569-586 (2015).
17. Machaba, M.M. and Mokhele, M.L., Approaches to teaching mathematical computations: what foundation phase teachers do! *Mediterranean J. of Social Science*, 5, **3**, 388-394 (2014).
18. Sunandar, M.A., Zaenuri, Z. and Dwidayati, N.K.., Mathematical problem solving ability of vocational school students on problem based learning model nuanced ethnomatematics reviewed from adversity quotient. *Unnes J. of Mathematics Educ. Research*, 7, **1**, 1-8 (2018).
19. Nardo, M.T.B. and Hufana, E.R, Development and evaluation of modules in technical writing. *American J. of Educ. Research*, 2, **6,** 341-350 (2014).
20. Isnin, S.F., Mustapha, R. and Othman, W.M., Engineering students' perspectives on the need of a new module in technical report writing at Polytechnic in Malaysia. *J. of Engng. Science and Technol.*, 13, **1,** 31-38 (2018).

BIOGRAPHIES

The lead author and researcher is Dr Erovita Teresita B. Agustin, an Assistant Professor of Mathematics in the School of Engineering, Architecture, Interior Design and Information Technology Education, as well as the Mathematics and Science Co-ordinator of the Senior High School at the University of Saint Louis, Tuguegarao City, Cagayan, Philippines. She obtained her BS in mathematics at the University of the Philippines - Baguio; and Master of Mathematics and Doctor in mathematics education at Saint Paul University. She is a member and at present the area representative - Cagayan Province of the Mathematical Society of the Philippines and the former President of the Mathematical Modelling of the Philippines Inc.

Dr Darin Jan C. Tindowen is at present a graduate instructor of the University of Saint Louis teaching Research Methods and Education courses. He is the present Head of the Centre for Social Innovation, Local Knowledge and Educational Research of the University. He finished his Bachelor of Arts in philosophy and interdisciplinary studies at Saint Louis University, Baguio City. He has also earned his Master of Arts in religious education and Doctor of philosophy in educational management at Saint Paul University Philippines. He is an associate member of the National Research Council of the Philippines (NRCP) and a member of the Asia-Pacific Consortium of Researchers and Educators (APCORE). He has published several articles in international refereed journals indexed in Scopus and ISI journals.