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Electricity Concepts' Test Construction, Validation, and Item Analysis for Senior High School General Physics 2

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Abstract

This study aimed to design (i.e. develop and validate) a test material for selected topics in Electricity in the context of Philippine Senior High School's General Physics 2. The draft test package underwent careful test construction, content-validation of faculty-experts, readability test for reading ease, pilot-testing with item analysis using Henning's and Ebel's scales. The test package was pilot tested among STEM students in a public national high school in Pangasinan, Philippines with a participation rate of 76.67%. Findings reported the increasing item retention rate of the following: Electric Fields (70.00%) > Coulomb's Law (71.43%) > Electric Charge (75.00%) > Electric Potential (83.33%) > Electric Flux (100.00%). The low number of item revision could be attributed to the careful planning of the researchers, as well as substantive feedbacks of the faculty-experts as content validators. Implications on the fitness of the test material for Pangasinan context is manifested because of the huge item retention rate, while recommendation for its use necessitates further revalidation. Distracter analysis on items retained is recommended. Finally, the institutionalization for this OBE strategy in the teaching of Assessment in Learning 1 is hereby recommended as well.

Keywords: *Assessment in Learning, Physics, Test Development, TOS, PSU*

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INTRODUCTION

Physics literacy plays a crucial part in global technological development as several aspects of science and technology apply concepts and principles of physics in their operations. However, the acquisition of scientific literacy in physics in our society today is not encouraging enough to the desirable standard (Adeleke & Joshua, 2015). Physics education researchers have developed several carefully constructed tests that explore student understanding of the basic concepts of force and motion. These tests have been administered at the beginning and end of many, many courses across the country (Wiemann and Perkins, 2005) The oldest and best-known test is the Force Concepts Inventory (FCI). The result was students receiving traditional instruction master, on average, less than 30% of the concepts that they did not already know at the start of the class. The result is largely independent of lecturer quality, class size, or institution (Hestenes, 1992). Eric Mazur, a highly renowned teacher at Harvard University, has studied students' understanding of concepts in electricity. Motivated by FCI results, Mazur gave his students an exam with a series of paired problems (Wiemann & Perkins, 2005). His and similar data show that students were able to correctly answer traditional test questions and complete traditional courses without understanding the basic physics concepts or learning the useful concept-based problem-solving approaches of physicists.

Is there a way to teach physics that does not produce such dismal results for the typical student? Our answer, and that of many others doing research in physics education, is unequivocally yes. Many of the same methods that have worked so well for advancing physics research also improve physics education. These methods include basing teaching practices and principles on research and data rather than on tradition or anecdote; using new technology tools effectively; and disseminating and copying proven results. Considerable evidence shows that this approach works. Classes using research-based teaching practices have shown dramatic increases in retention of information, doubling of scores on the FCI and other conceptual tests, and elimination of negative shifts in beliefs about physics (Weimann & Perkins, 2005).

Science is made up of a huge number of fields such as Physics, Chemistry, Biology and a lot more (Adeleke & Joshua, 2015). Physics is one of the science subjects mystified to be a tough and abstract discipline, and university physics courses do little to change this negative attitude towards physics (Blickenstaff, 2010). Yet, there have been research studies showing that students usually enjoy working in the laboratory (Deacon and Hajek, 2011). This course requires vast understanding, deep analysis and keen thinking. Further, it takes into account of all objects, matter, living things and everything in our surrounding as well as almost all processes are under the concept of physics.

The teachers play a very crucial role in teaching such physics concepts in order for the students to understand clearly. Teachers are always tasked to assess the student's learning to determine the learning gaps and learning development towards the lesson. There are three interdependent aspects of the educative processes such as planning, implementing and evaluating (Bilbad & Puritad, 2008). Learner's learning achievement can be clearly seen when the learners achieved the learning objectives. These include the changes in intellectual, emotional and physical domains of the learners. According to Chawla (2016), academic achievement refers to the degree of success or achievement achieved in a particular field. In order to measure academic success, educators use different types of assessment. Assessment is a continuous process that brings some valuable information about the learning process (Linn & Gronlund, 1995) employed by Haw (2020). According to Bhagat & Baliya (2016), an achievement test is a tool for teachers to measure

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the developed skills or knowledge proficiency of an individual into particular topic that has been taught. Moreover, this test design determines the strengths and weaknesses of the learners to a certain topic.

In this study, it aimed to develop an achievement test of which the validity and reliability are ensured. Multiple-choice type of test was used to assess the learning of the students. Multiple-choice tests are the tests which have only one true answer which is selected from within other obfuscatory answers (Öncü, 1999) utilized by (Kara & Celikler, 2015). Multiple-choice tests are the tests with objective grade which does not tend to differentiate from person to person and are able to be graded in a short time (Gronlund & Lind, 1990) adopted by (Kara & Celikler, 2015). These tests also allow for a comprehensive evaluation to be made and, with ably written items, for assessing high-level talents (Worthen, Borg & White, 1993) employed by (Kara & Celikler, 2015). And also, according to Kamaruzaman (2003) adopted by Haw (2020), item analysis needs to be done to determine whether a constructed item is good or weak. Good and weak items can be specified with a Difficulty Index (F) value. Assessment is digitalization of the qualifications, expressing the observed qualifications via numbers and symbols. Evaluation, on the other hand, is a decision-making process relating to the assessed qualification, by comparing the results obtained from the assessment process with certain criteria (Özçelik, 1992) employed by (Kara & Celikler, 2015).

METHODOLOGY

In this study, the researchers utilized the descriptive survey method with the test question through Google forms as the main tool in data gathering. According to Garcia (2010), descriptive survey research aims to describe systematically, functionally, accurately, and objectively a situation, problem, or phenomena. And it is used in securing opinions and trends through the use of questionnaire. In the preparatory stage, the researchers reviewed the topics based on the 2020 version of the K12 Curriculum Guide that is considered as a very necessary input. This data serves as guide and basis for the development and progress of the achievement test. In the development stage, the researchers constructed an initial Table of Specifications that was used in formulating the multiple choice test together with the application of the principles in constructing a multiple choice-type (Navarro & Santos, 2012).

The test items were content-validated by the content-validators with educational and work qualifications are relevant to Science – Physics as concentration (See Table 1). The test items after content-validation underwent series of revisions until such the time that the lead evaluator issued a go signal that the entire test package is already ready for senior high school's test pilot. Finally, the test package was tested for readability at *https://readabilityformulas.com/free-readability-formula-tests.php* and registered a reading score for grade 11 students, which is appropriate for the test takers grade level (Grade 11). For item analysis, the measure of the index of difficulty as suggested by Henning, 1987 was and the measure of index of discrimination by Ebel, 1979. Finally, the test package was digitally administered to 76.67% of STEM students in a public national high school in Pangasinan, Philippines.

Table 1. The Educational and Work Qualifications of Content Validators

Evaluator	Educ Qualifications	Work Qualifications	Content Concentration	Years in Service
A	LPT, MAEd	PSU College Instructor	Science Ed, Physics	5
B	LPT, MAEd	DepEd Master Teacher	Science Ed, Physics	5
B	LPT, MAED, EdD	Tarlac, College Instructor	Science Ed, Physics	14

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RESULTS

Report of Item Analysis Segmented per Topic

Table 2: Indices of Difficulty and Discrimination of the Periodic Test in Electricity

Topic 1: Electric Charge

8	0.26	Difficult	0.67	Very Good Item	Retain	Retain: 75.00%
9	0.26	Difficult	0.67	Very Good Item	Retain	
10	0.26	Difficult	0.33	Good Item	Retain	
11	0.26	Difficult	0	Poor Item	Revise	
12	0.26	Difficult	1	Very Good Item	Retain	
13	0.22	Difficult	0.5	Very Good Item	Retain	
14	0.35	Medium	0	Poor Item	Retain	
15	0.3	Difficult	0.17	Poor Item	Revise	

Topic 2: Coulomb's Law

1	0.44	Medium	-0.17	Poor Item	Retain	Retain: 71.43%
2	0.35	Medium	0.67	Very Good Item	Retain	
3	0.3	Difficult	0.17	Poor Item	Revise	
4	0.39	Medium	0.17	Poor Item	Retain	
5	0.22	Difficult	0.17	Poor Item	Revise	
46	0.35	Medium	0.33	Good Item	Retain	
47	0.3	Difficult	0.5	Very Good Item	Retain	

Topic 3: Electric Fields

6	0.35	Medium	0.33	Good Item	Retain	Retain: 70.00%
7	0.3	Difficult	0.17	Poor Item	Revise	
16	0.35	Medium	0	Poor Item	Retain	
17	0.3	Difficult	0.17	Poor Item	Revise	
18	0.3	Difficult	0.17	Poor Item	Revise	
44	0.3	Difficult	0.83	Very Good Item	Retain	
45	0.22	Difficult	0.5	Very Good Item	Retain	
48	0.35	Medium	0.67	Very Good Item	Retain	
49	0.39	Medium	0.17	Poor Item	Retain	
50	0.3	Difficult	0.5	Very Good Item	Retain	

Topic 4: Electric Flux

19	0.35	Medium	-0.33	Poor Item	Retain	Retain: 100.00%
20	0.26	Difficult	0.67	Very Good Item	Retain	

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36	0.39	Medium	0.17	Poor Item	Retain	
37	0.26	Difficult	0.33	Good Item	Retain	
38	0.35	Medium	0.67	Very Good Item	Retain	
41	0.3	Difficult	0.5	Very Good Item	Retain	
42	0.22	Difficult	0.5	Very Good Item	Retain	
43	0.48	Medium	0.17	Poor Item	Retain	

Topic 5: Electric Potential

21	0.26	Difficult	0	Poor Item	Revise	Retain: 83.33%
22	0.35	Medium	0.33	Good Item	Retain	
23	0.35	Medium	0.67	Very Good Item	Retain	
24	0.3	Difficult	0.5	Very Good Item	Retain	
25	0.44	Medium	0.33	Good Item	Retain	
26	0.3	Difficult	0.17	Poor Item	Revise	
27	0.44	Medium	0.33	Good Item	Retain	
28	0.3	Difficult	0.17	Poor Item	Revise	
29	0.44	Medium	0	Poor Item	Retain	
30	0.39	Medium	0.17	Poor Item	Retain	
31	0.39	Medium	0.17	Poor Item	Retain	
32	0.39	Medium	0.5	Very Good Item	Retain	
33	0.35	Medium	0.67	Very Good Item	Retain	
34	0.48	Medium	-0.17	Poor Item	Retain	
35	0.3	Difficult	0.5	Very Good Item	Retain	
39	0.26	Difficult	1	Very Good Item	Retain	
40	0.35	Medium	0.67	Very Good Item	Retain	

Statistical analysis reported that the highest score was 43 and the lowest was 20, with a range of 23. The result for mean score was 31, with the median of 31 and mode of 9 for 20, 22, 24, 25, 29, 31, 34,37, and 39. Results showed that 48% (24 of 50) of the items are of medium difficult and 52% (26 of 50) are difficult. Further, in terms of the power of the items to discriminate, 44% (22 of 50) are poor items, 14% (7 of 50) were good items while 42% (21 of 50) of the items were very good items to discriminate highly-performing from low-performing students. According to Boopathiraj & Chellamani (2013), the items of moderate difficulty are preferred over items with low or high difficulty. The items found in the study with medium difficulty were considered for 'retention'. Items which were either difficult and marginal were considered for 'revision' as adopted from Camara, 2021. The findings in this study served as the basis for the final revision of the achievement test.

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Table 2 displays that selected topics in Electricity were retained on the basis of their validity and the results of the item analysis based on Henning's and Ebel's indices scale, and arrange in increasing item retention rate: Electric Fields (70.00%) > Coulomb's Law (71.43%) > Electric Charge (75.00%) > Electric Potential (83.33%) > Electric Flux (100.00%). It is very interesting to note that none of the topics registered below 50% item retention rate, which is a good indicator that the test package may have been considered fit for the population included. None of the items was rejected, and those that were not retained were considered for revision for the final draft of the test package.

CONCLUSIONS

In terms of the process, this study has attempted to utilize the principles of assessment particularly in test construction, writing of table of specifications, test item analysis, test content validation, interpretation of indices using established scales, testing written test items for readability index, and utilize real results from the field in order to develop, validate and ascertain the effective use of a test material, thereby providing a sound basis for a possible institutionalization of such an activity among course syllabi in Assessment of Learning 1, not to mention its ability to put on collaboration between undergraduate students of the course and external panel teaching the subject, as well as other college students whose content expertise may be use to the present undertaking.

In terms of the findings, the researchers conclude that the test material is a valid and reliable test for testing at least the five (5) selected topics in electricity. The high item retention rates in each selected topics is a manifestation of careful writing and planning of the researchers and their team in their attempt to provide a working material in electricity for Pangasinense, in a context of online learning. Though, while the test material has been content-validated, and was found valid, and effective based on the indices, further modification is required for items considered for revision based on the pilot test. Furthermore, distracter analysis is warranted among the items that were found poorly discriminating yet were decided to be retained by the researchers.

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LIMITATIONS

Due to restrictions in both mobility and technology, the researchers have thus far employed the use of the test package to a public national high school in the Philippines, and potential users of the test material should consider various educational and academic contexts prior its use. This output is developed using the 4AA Model as developed by Dr. Camara to reduce instructional planning for academic writing sessions.

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