Vol. 11 · July 2018
Print ISSN 2244-1824 · Online ISSN 2244-1816
https://doi.org/10.7719/irj.v11i1.588

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by PAIR, an ISO 9001:2008 QMS certified
by AJA Registrars, Inc.

Workbench in the Teaching of Optics to Junior High School

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Originality: 95% • Grammarly Score: 94 • Plagiarism:5%

ABSTRACT

Over the last 20 years, not much research has been carried out on improving teaching and learning process of Optics. The new technology in Optics teaching has a lot of advantages, which is impossible to be offered by any book. The study determined the status of textbooks in Physics of Optics in terms of availability, relevance of content, scope of subject-matter, and suitability; the degree of need for workbench in Optics; the validity of the proposed developed workbench in Optics as rated by Physics experts in terms of introduction, learning competencies, presentation of concepts, and exercises. The descriptive-developmental research design was used in the development of the workbench patterned from the ADDIE model. The content of the workbench was based on the competencies present in the K-12 science curriculum guide. The validity of the developed workbench was determined with the use of questionnaires. Results revealed that there is a limited number of textbooks for the subject Physics of Optics and there is an urgent need for a workbench in Optics. The content of the developed workbench is highly valid in terms of introduction, objectives, presentation of concepts and exercises. The developed workbench is strongly acceptable as instructional materials for students of Optics.

***Keywords* —** Physics, optics, workbench, descriptive-developmental research design, Philippines

INTRODUCTION

Science has become an indispensable tool in the economic development of a nation. Since Physics is at the forefront of the sciences, it became the basis of the technologies that prevail. By its very nature, Physics is the fundamental of all sciences. Physics describes and explains the universe as accurately and precisely as possible. The predictive power of Physics allows us to design and build new structures, machines, devices and equipment to improve the quality of life. To successfully achieve these, one must be an accomplished problem solver to one of the branches of physics which is Optics (Freedman, 2014).

Optics is one of the branches of Physics that deals with the study of light which involves all its properties and how it behaves, its interaction to matter and to all instruments used to detect it. Optics gives description to visible, infrared and ultraviolet lights. As light also regarded as an electromagnetic wave, other forms such as x-rays, microwaves, and the radio waves have the same properties (Tillery, S. J. Slater, & T. F. Slater, 2005).

Theories of Optics have progressed during the mid of 17th century with the formal and systematical written work of René Descartes, which discusses and explains different optical phenomena which includes reflection and refraction of light. His written works made a substantive difference from the Greek emission theory. Between the 1660s and early 1670s, when Sir Isaac Newton expanded the ideas of Descartes into his corpuscle theory of light, which stated that white light was a mix of colors that can be split with a prism. It was in 1690 when Christian Huygens made a proposal on wave nature of light based on the suggestion made by Robert Hooke in 1664. Hooke criticized Newton's Theory of Light until his death. Newton published his Optics at that time, and he was considered as the victor over the nature of light (Serway, & Vuille, 2009).

Not much research has been carried out on improving teaching and learning process of optics over the last 20 years. Wu, Chen, and Tzeng (2014) adopted the experimental research approach and test results of learning outcomes of students in optics and used this as a research tool. They carried out the experiment on remedial teaching with 92 samples of junior high schools in Miaoli County to look for the effects of electronic book usage in optics learning outcomes of students with low academic achievement. The results suggested that remedial teaching incorporating electronic books is better than the traditional remedial teaching according to the learning outcomes of students with low academic achievement. Furthermore, the development of a pedagogical system in Optics should be applied using updated pedagogical trends which will contribute to the quality of higher teaching-learning process (Yeras, & Peña, 2014).

However, it is essential to combine these potentialities of new technologies with some suitable pedagogical planning. According to (Anagnostakis, Mantadakis, & Papavasiliou, 2014) on their study "The New Technologies in the Teaching of Geometric Optics," this particular type of application has a lot of advantages, which it is impossible to be offered by any book, the full concretization of this idea will constitute, on one side, an innovative tool of learning for the improvement of educational process and on the other side, a driver for the revision of teaching of Natural Sciences. The need for such research became more intense with the introduction of Teaching standards and the new K-12 curriculum exercises which monitor and assess the quality of provision in education institutions.

Since textbook and other instructional materials like workbench have a direct impact on what is taught in schools and how it is taught, the curriculum development and curriculum materials are sensitive matters which are of great importance.

As a Physics professor, the researcher noticed that there are no adequate learning materials when it comes to the study of Optics. Also, the researcher observed that when there are assignments and other course requirements given to students, the internet is always an alternative source of reference for information of the course. With the internet as a source of information due to lack of textbooks, the students or learners may become overwhelmed with too many information that they can derive. Pefianco and Mercado (1996) stated that the teacher not only has the responsibility of generating ideas, moving information and learning but also utilizing the various technological options available.

This motivated the researcher to develop and validate a workbench in physics of optics which can be utilized by the students. This is in consonance with the thrust of the University where he is currently employed. The Tarlac Agricultural University is formerly known as Tarlac College of Agriculture which encourages faculty members to prepare and develop their own instructional materials for their professional development and students benefit.

OBJECTIVES OF THE STUDY

The study aimed to develop a workbench in the teaching of Optics to improve the understanding and problem solving skills of junior high school students.

METHODOLOGY

In this study, the descriptive-developmental research design was used. This method is applicable in developing and validating an instructional material such as a workbench. The descriptive research method was employed to determine the status of textbooks used in Optics as to their availability, relevance of content, the scope of subject matter and suitability. The entire concept of the workbench is based from CMO No.30 s. 2004 and on the idea of helping the students improve their working memory capacity and problem solving skills. Also, the developed workbench underwent evaluation by the experts.

Concerning the research problem, the data needed were drawn from the responses and answers of the Physics instructors. The responses of the respondents were the much-needed data in assessing the status and need, validating, and evaluating the workbench. The study utilized the descriptive developmental method of research for the development and validation of the workbench in Optics. The ADDIE Model was used in the development process. Survey on the status of textbooks and the need for instructional materials was conducted using questionnaires. Regarding the development of the workbench, widely used books, manuals, and journals authored by well-established experts locally and internationally were the sources of data.

The sampling method used was total enumeration coming from 4 state colleges and universities (SUC's) from region 1 & 3. Four physics teachers, four Information Technology experts, and four language experts evaluated the developed material. The workbench was revised through the responses that were gathered by the researcher from the evaluators since the validity of the workbench produced depends on how they assessed the significant points of the workbench.

This study used two instruments, the first instrument for the status and need for a workbench in Optics, the second instrument for Physics experts. To gather the data needed in the study, the instrument for status and need for a workbench in Optics has two parts; first part determined the status of textbooks used in Optics while the second part looked into the degree of necessity for a workbench in Optics. The instrument for the Physics experts was from the set of questionnaire that has four sections, namely: 1) introduction, 2) learning competencies, 3) presentation of concepts and 4) exercises.

RESULTS AND DISCUSSION

Table 1. Summary of Availability, Relevance, Scope & Suitability of Textbooks in Optics

Respondents (N = 16)					
Responses	Yes	%	No	%	Total
1. Do you have your own textbook in Physics of Optics?	5	31.27	11	68.75	16
2. Are textbooks in Optics available in the library?	7	43.75	9	56.25	16
3. Are textbooks in Optics Available in the local bookstore?	2	12.5	14	87.5	16
4. Does the textbook contain the necessary topics for understanding the concept of Optics?	10	62.5	6	35.5	16
5. Does the textbook realistically cover within the limits of the school term which it is to be used?	4	25	12	75	16
6. Does the textbook cover the scope of the subject-matter intended for junior high school?	4	25	12	75	16
7. Does the scope of the textbook covers the necessary topics for understanding the topic Optics?	9	56.25	7	43.75	16
8. Does the textbook sufficiently cover the topics intended for junior high school?	6	37.5	10	62.5	16
9. Is the content appropriate for the students' level of comprehension?	4	25	12	75	16
10. Is the content appropriate to the students' interest?	5	31.25	11	68.75	16

It can be gleaned that 5 out of 16 teachers or 31.25 % have their own textbook in Optics compared to 11 or 68.75 % who said that they do not have their own textbook. Furthermore, 7 or 43.75 % claimed that textbooks in Optics are available in the library while 9 or 56.25 % responded that textbooks in Optics are not available in the library. Majority of these teachers, 14 or 87.75 % said that textbooks in Optics are not available in the local bookstore.

It can be noted, however, that when the researcher asked them what textbooks they have, majority of them said that downloaded e-books and photocopies of books that they got during their professional development. The findings strengthened the claim of Selga (2013) that there is a deficiency in the availability and adequacy of the instructional materials in Science and Technology; hence, there is a need to develop a work text in the said discipline.

As regards to textbooks' relevance of the content, 10 out of 16 or 62.5 % of respondents said that the available textbooks contain the necessary topics for understanding the Physics of Optics. Furthermore, 12 or 75 % of teachers said that the textbook used does not realistically cover within the limits of the school term for which it is to be used. Similarly, the textbooks used do not cover the scope of subject-matter intended for junior high school students as revealed by the responses, 12 or 75 % which is the majority.

There is a need to simplify the content and scope of subject-matter because the textbooks were written to cover all the topics up to graduate level. Overall, a total of 10 of the 16 respondents, considered the content of the textbooks in Physics of Optics as relevant.

For the scope of the subject-matter, respondents were asked if the available textbooks sufficiently cover the subject-matter intended for the junior high school students.

It shows that 9 or 56.25 % said "YES" the scope of the textbook cover the necessary topics for understanding the topic Optics. On the other hand, when asked if the textbook sufficiently cover the topics intended for junior high school, majority of the respondents said "NO" which is 10 or 62.5 %. This is because the textbooks are intended to cover discussions up to the graduate level. This supports the statement of Rahman (2006) that developing a course material need a wide range of knowledge and expertise.

On the overall, the respondents believed that the scope of the textbooks in Optics is enough for understanding the topics for higher learning level, but not intended for junior high school. Therefore, there is a need to simplify its content.

It can also be seen that the suitability of textbooks in Optics shows that majority of the respondents or 75 % agrees that the content of the textbooks is not appropriate to students' level of comprehension. Furthermore, it is statistically similar that the content of the textbooks is also not appropriate for students' interest for it has 68.75 % of the respondents claimed. This makes clearer on the findings of Kesidou and Roseman (2002) that there is a need for instructional materials to align with the national science education standards and that take into account what is known about the teaching and learning of science.

As a whole, the respondents believed that the textbooks are not simplified to enhance students' interest in the subject, and it is not appropriate to students' level of comprehension.

The Degree of Need for a Workbench in Optics

Table 2. The Need and the Degree of Need for a Workbench in Optics

	Respondents (N = 16)				
Responses	Yes	%	No	%	Total
1. Is there a need to develop a workbench in Optics for junior high school students under Philippine conditions?	16	100	0	0	16
	Very Urgent	Urgent	Not Urgent		Total
2. What is the degree of need for a workbench in Optics?	6	8	2		16

Table 2 shows a summary of the responses of the respondents when asked if there is a need for a workbench in Optics in junior high school under the Philippine conditions. All respondents answered "YES" or 100 %. It can be concluded that the respondents believed that a workbench in Physics of Optics specifically prepared for junior high students under Philippine condition is needed. This strengthens the suggestion made by Jeong & Kim (2012), that the developed materials should construct effective teaching strategies, teaching methods, and teaching content.

It can also be gleaned in Table 2 the degree of need for a workbench in Optics. It shows that 6 or 37.5 % believed that it is very urgent to have a workbench in Optics, while 8 or 50% said it is urgent and only 2 or 12.5% responded not urgent. In conclusion, the need for a workbench in Optics is urgent.

The Validity of the Workbench in Optics

The experts determined the validity of the workbench along with the following conditions: (1) the workbench as validated by Physics experts in terms of introduction, learning competencies, presentation of concepts, exercises; (2) the workbench in Optics as validated by Language experts in terms of content, and language used; (3) the workbench as evaluated by Information Technology experts in terms of content, language used, courseware presentation, and exercises, and pictures and animations.

The Validity of the Workbench in Optics as Validated by Physics experts

Physics experts were asked to validate the workbench because they are the ones who are really concerned with the subject area and knowledgeable enough on the introduction, learning competencies, presentation of concepts, and exercises, pictures and animations in Optics.

On Introduction

The very aim of the workbench is to get the interest of the learners, read, and understand the lessons in Optics. The introduction of the workbench was carefully done to ensure its affectivity because the researcher wants to make sure that the material grabs the learners interest so that they will continuously get hooked in reading and answering the workbench. The introduction was made brief and concise and the main ideas are clearly stated thus giving the learners a profound understanding of the concepts that lead them to the next topic.

Table 3.1 shows that the mean score given by Physics experts on the introduction is 4.75 with a verbal description of very valid. They found that the introduction of the workbench grabs the readers' interest and have sentences that clearly state the main idea that set up the rest of the paragraph. This is associated with the findings of Gravoso, Pasa, Labra, and Mori (2008) on their study "Design and Use of Instructional Materials for Student-Centered Learning" which states that instructional materials can change and improve the quality of learning outcomes if designed to support knowledge construction.

Table 3.1 Validity of the Workbench on Introduction as Validated by Physics Experts

STATEMENTS	Mean Scores	Verbal Description
1. The sentences clearly state the main idea and sets up the rest of the paragraph.	**4.69**	HighlyValid
2. Key ideas are clear.	**4.75**	Highly Valid
3. There is a clear transition that leads the reader seamlessly to the next paragraph.	**4.75**	Highly Valid
4. The beginning grabs the reader, and gives clues as to what is coming.	**4.81**	Highly Valid
Overall Mean Score	**4.75**	**Highly Valid**

Legend: 5 – Highly Valid, 4 – Valid, 3 – Moderately Valid, 2 – Slightly Valid, 1 – Not Valid

On Learning Competencies

Table 3.2 Validity of the Workbench on Learning Competencies by the Physics Experts

STATEMENTS	Mean Scores	Verbal Description
1. The objectives are clearly stated.	**4.81**	Highly Valid
2. The objectives take into account the needs of the learners.	**4.81**	Highly Valid
3. The objectives are relevant to the lesson.	**4.81**	Highly Valid
4. The objectives include creative and critical thinking.	**4.75**	Highly Valid
5. The objectives of each lesson support attainment of the general objective.	**4.81**	Highly Valid
Overall Mean Score	**4.80**	**Highly Valid**

Legend: 5 – Highly Valid, 4 – Valid, 3 – Moderately Valid, 2 – Slightly Valid, 1 – Not Valid

The workbench was developed considering the competencies found in the K-12 Science Curriculum Guide by the Department of Education. This was done to ensure that the workbench is aligned with the Science skills and processes present in the Curriculum.

As shown in Table 3.2, the overall mean given by the Physics experts is 4.80 with a verbal description of highly valid. The experts found the objectives of the workbench clearly stated. The Physics experts further revealed that the learning competencies of the workbench take into account the needs of the learners and include creative and critical thinking that supports the attainment of the general objective. The evaluators also commented that the learning competencies are intelligently constructed for Physics students. Thus, this affirms the findings of Metin and Birisçi (2010), in their study that it is important for students to be actively involved in the learning process. Proper learning materials must be prepared and used for meaningful learning outcomes.

On Presentation of Concepts

Simplicity was the key word to describe the presentation of concepts for easy understanding of the students. The lessons were properly sequenced and well-organized to achieve the objectives of the lessons. Moreover, the presentations of the concepts were made using the deductive method which stressed that it started with general concepts and proceeds to specific examples. This was done because the students need to know and understand the concept first before analyzing the examples. The workbench presented the concepts in simple boxes which include the Equation Box that gives students' list of possible equations needed in solving certain problems and Problem Solving Techniques which provide learners the needed strategies in solving problems. This method also facilitates the learning process by using different intelligences for students' learning differences. Pallard and Seeber, (1984) cited that the visual - spatial ability of the students contributes significantly to the students' performance in Physics. These gains were related to test items that utilized graphical form and to laboratory work.

Table 3.3 Validity of the workbench on Presentation of Concepts by Physics experts

STATEMENTS	Mean Scores	Verbal Description
1. The workbench presents lessons which are properly sequenced and well organized.	4.69	Very Valid
2. The content, procedure and illustrations in each lesson are clear, precise and simple.	4.88	Very Valid
3. The method can facilitate the learning process using different intelligences.	4.69	Very Valid
4. The activities promote balance collaboration and interaction among learners.	4.75	Very Valid
5. The method used can stimulate student's interest and their ability to draw a conclusion.	4.69	Very Valid
Overall Mean Score	**4.74**	**Very Valid**

Legend: 5 – Highly Valid, 4 – Valid, 3 – Moderately Valid, 2 – Slightly Valid, 1 – Not Valid

The data in Table 3.3 shows the evaluation rating of the Physics experts in terms of presentation of concepts with an overall rating of 4.74 and a verbal description of highly valid. Furthermore, the experts found that the workbench presents lessons that are properly sequenced and well-organized. They also found out that the illustrations in each lesson are clear, precise, and simple, activities promote balanced collaboration and interaction among learners.

According to the Physics experts, lessons in the workbench are well presented and easy to understand by the learners and readers. They also further commented that the workbench is useful to teachers because it provokes interest and appreciation of learners towards learning physics. Thus, making them more active in learning. This is also aligned with the findings of Metin and Birisçi (2010) that the teacher enriches students learning, understanding and skills for them to apply their newly structured knowledge to a wider scope of information and enough requisite skills.

On Exercises

The researcher designed the questions and exercises in such a way that the learners will enhance their working memory capacity. These include: Think-Pair-Share which has activities that learners need to find a partner in answering the follow-up questions, "Self-Check and Can You Remember?" which include at least one to two questions primarily designed to check students' understanding about the lesson presented, Solved Problems, which gives students sample problems with solutions on how the given equations are applied. Students can work alone or form a group for easy understanding on the concept of problem-solving. Experiment Time that comprises group activities where students are expected to apply their learning on the rules, laws, and procedures; and You Are Challenged! and Enrichment which challenges the students' mastery of skills and knowledge on how the ideas in the lesson should end up. Students are expected to work alone on this part. According to Solaz-Portoles and San Jose–Lopez (2009), the ability to maintain information in a highly activated state via controlled attention may be important for integrating information from successive problem-solving steps. Working memory capacity may also be involved in a number of cognitive variables working as predictors of achievement in science.

Table 3.4 Validity of the workbench in terms of the Exercises by the Physics experts

STATEMENTS	Mean Scores	Verbal Description
1. The workbench provides a variety of relevant evaluation measures.	4.81	Highly Valid
2. It has a clear and insightful problem statement with evidence of the most relevant contextual factors.	4.81	Highly Valid
3. The problem statement is adequately detailed.	4.69	Highly Valid
4. Identifies multiple approaches/strategies for solving the problem that applies within a specific context.	4.69	Highly Valid
5. Proposes one or more solutions that indicate comprehension of the problem, and mastery of the lesson.	4.69	Highly Valid
Overall Mean Score	**4.74**	**Highly Valid**

Legend: 5 – Highly Valid, 4 – Valid, 3 – Moderately Valid, 2 – Slightly Valid, 1 – Not Valid

It can be gleaned from Table 3.4 that the overall mean score given by the Physics experts under exercises is 4.74 with a verbal description of highly valid. Experts found that the workbench provides a variety of relevant assessment measure, has clear and insightful problem statement with evidence of most relevant contextual factors, and has an adequately detailed problem statement. They also found out that the exercises identify multiple approaches and strategies for solving the problem and propose one or more solutions that include comprehension of the problem and mastery of the lesson. The findings now linked to the Structural Cognitive Modifiability Model (SCM) a theory pioneered by Feuerstein (1990) whose main premise is that intelligence is not a static or fixed trait. The evaluators also commended the workbench for its simplicity, yet it conveys creativity and facilitates learning among learners.

Table 3.5 Summary on Validity

Features	Grand Mean	Interpretation
Introduction	4.75	Highly Valid
Learning Competencies	4.80	Highly Valid
Presentation of Concepts	4.74	Highly Valid
Exercises	4.74	Highly Valid

On the overall, the Physics experts found the instructional materials useful in teaching Optics. Though it has a highly valid rating in all components, the workbench has still room for improvement because the grand mean is not perfect.

CONCLUSIONS

There are limited textbooks for the Physics of Optics, and there is a need to develop a workbench in Optics is urgent. The content of the developed workbench is very valid in terms of introduction, learning competencies, presentation of concepts and exercises, language used and pictures and animations. The developed workbench is highly acceptable as instructional materials for students of Optics.

TRANSLATIONAL RESEARCH

The developed instructional material of the study could be translated into a webpage and book based material for easier access to teachers who are teaching Optics. Furthermore, they could also look into its impact to students.

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