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TOCUSO: Test of Conceptual Understanding on High School Optics Topics

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Abstract
Physics educators around the world often need reliable diagnostic materials to measure students' understanding of physics concept in high school. The purpose of this study is to evaluate a new diagnostic tool on High School Optics concept. Test of Conceptual Understanding on High School Optics (TOCUSO) consists of 25 conceptual items that measures fundamental topics learned in high school curriculum. TOCUSO was designed with the use of various Optics textbooks, Turkish University exam questions, and questions generated by the author. TOCUSO items were structured as multiple-choice questions. 12 physics faculty members at the school of science and education validated questionnaire items. SPSS program was utilized to calculate reliability values of the test. KR-20 value was found around 0.73, which shows TOCUSO is a reliable measurement questionnaire. TOCUSO was applied to 183 high school students enrolled in 10th grade at the time of data collection process in Kayseri providence in Turkey.
Abstract: Physics education, science education, diagnostic tests.

Introduction

One of the definitions of education as we know (Erturk, 1982) "by the individual through life, and their behavior is defined as the deliberate modifications to occur". On the other hand, learning is provided by way of repeated experience in the person's mind. Science concept is not restricted to teaching, and experiential way to reconcile with the teaching of life and need to be pointed out by the researchers (Cepni and Cil, 2009). Education and learning concepts and way of life in today's education as a common concept used in the constructivist approach are glaring examined. This paper discusses a new type of assessment instrument that measure student knowledge of optic concepts. A research-based, multiple choice and easy to administer diagnostic test was develop to gather information regarding college students' conceptual learning of optic concepts in physics. It can be utilized for two purposes: 1) Administration at colleges especially in freshmen science courses to collect student knowledge of modern concept prior to taking initial modern physics course (pre-test) and 2) Applying to senior and junior level students to check their learning in the courses (post-test) to evaluate the effectiveness of the course. Additionally, it can be used in AP physics courses at high schools.

We propose a new diagnostic test to measure students' conceptual knowledge of principles of optic topics. Over few decades since born of physics education research (PER), many diagnostic instruments that measure students' conceptual understanding of various topics in physics, the earliest tests developed in PER are Force Concept Inventory (FCI, Newtonian concepts), Force & Motion Conceptual Evaluation (FCME), Electric Circuits Conceptual Evaluation (ECCE), and Test of Understanding Graphs - Kinematics (TUG-K). Although these tests were generated and tested on the fields, they were mainly interested on freshman physics courses. Maybe only diagnostic test developed

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above freshman was the one initially used by researchers to investigate college students' understanding of optic physics concepts but unfortunately, its source or history is not known. The main purpose of this study is to declare of a new diagnostic test and reveal initial results of the diagnostic test of Test of Conceptual Understanding on High School Optics (TOCUSO).

Science is one of the main disciplines of physics and why the universe is investigating the events which can make inferences about events that have a structure likely to be. While acknowledging the existence of inter-disciplinary relationships and movements of the universe physics, biology and chemistry to review and consider the events are divided into perspective. Macro-micro world to the discipline of physics to the world he finds a lot of research and application area.

In the discipline of physics in itself; mechanical physics, magnetic physics, quantum physics, nuclear physics, optics, etc. divided into various areas of the form. Optical structure of the light, in different environments, and changes in-between these environments, refraction, reflection, change, etc.-viewing environment is one of the low-hanging branch of physics. Science is utilized in many fields on behalf of the optical physics. To give an example in all areas of daily life, using mirrors, telescopes used in astronomy, used binoculars, military and other fields, optical microscopes are used in all areas such as laboratories, taking into consideration the rules and these rules are valid, are produced. Science against the success of this discipline to other disciplines (Chemistry and Biology) is lower than that observed (Hoffmann, 1990; Duit, 1992). While teaching in this area is high student-teacher communication, teacher to keep a more passive position and may be appropriate to allow students to learn lasting life passing. Physical education and the new curriculum at every stage of secondary education in the optical field knowledge of physics, not only according to other subjects, mathematics, geometry, visual thinking and experimental activities vary in terms of being possible (Sengoren et al., 2006). Thus develops a positive attitude towards the optical course and a high level of readiness for this course, students not only the other areas of physics are entering into a mental process. If you need to tell an even more open space alone cover more than one aspect of the optical lessons are also significant.

Over last three decades, assessing student knowledge of various physics concepts such as Newton's Laws (Thornton et al., 1998), Force and motion (Hestenes et al., 1992), kinematics (Beichner, 1994), electricity (Sokoloff, 1993). The need for generating testing measurements emerged in 1990s when physics education research (PER) was initiated as becoming an independent area of research from the roots of science education research (SER). First versions of instruments for that purposes were generally quantitative and still most of them were quantitative probably because of statistical method prevalence on research among social sciences over 150 years. Also, qualitative method is too young to be developed in another young research discipline. However, some qualitative methods (Otero et al., 2009; Ireson, 1999) do exists in PER.

Recent researches (Beichner, 1994; Fischler and Lichtfeldt, 1992; Ireson, 1999; Zollman, 2001) pointed out upper secondary students with the most misconceptions among concepts of physics stem from electricity and magnetism concepts. Nevertheless, concepts of current, voltage, and electric field can be easily taught students via more concrete applications. Physics teacher still should focus on students' conceptual understanding of critical topics such as circuit and parts of electric circuit because it will be easier to let them construct their own concepts regarding main ideas of electricity and magnetism. As science teachers, we shouldn't use fast pace when we are detailing any concepts in Physics because it is very crucial that students sometimes are required more time to digest the concepts and create analytical thinking strategies essential in physics education. At many public high schools,

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electric and magnetic concepts are introduced to the students in 8th grade and are elaborated more in the following years until they graduate from high school. Therefore, our hands-on activity and applications of these concepts are designed for grade 8 and grade 9 level students. Our purpose at this activity is to introduce an application of electric concepts in an enjoying way of learning environment. It can be used for demonstrations in the classroom as well as applying it as a laboratory experiment.

In many areas, as well as the use of various different levels of optical education and training programs and courses taught in classrooms. Optical physics courses and these courses in the curriculum of primary education, secondary education as an important find a place for him. Optics in place in our lives, considering the optical gains in education, the subject attempted to join the teaching requirements becomes clear. Secondary purpose of this study of secondary school students receive step lesson on the optics and physics at the level of information to determine the attitude of this issue.

For this purpose, our country, the Student Selection and Placement Center (SSPC) Student Selection Exams (OSS), which asked questions about optical physics questions, Physics (Cuttnell & Johnson, 2009) created a test consisting of questions prepared by utilizing it. The test to determine students' level of knowledge of optics was created 25 multiple-choice questions. Measure the conceptual understanding of the questions are analyzed and evaluated the selection of questions, however, the issue of Optics and evaluation of sub-areas has been adequately represented. After selecting the questions to get expert opinions on the question of Erciyes University Faculty of Education Elementary Science Education and Department of Physics, Erciyes University Faculty of Arts and Sciences presented evaluations of the teaching staff. There are no questions generated as a result of the opinions of experts removed the first phase of the test was applied to students with a grade of secondary education.

Method

At the end of these applications were sought answers to the following questions:

i) What are secondary students' levels of knowledge of optics concepts?
ii) What are the secondary school students' attitudes towards optics?

The data collection process took place during second term of 2009-10 academic years at Erciyes University in Kayseri in Turkey. Participants of the study were selected among three different faculties, school of science, school of engineering and school of education. Disciplines at both faculties were the only students enrolled in modern physics similar content in science education, physics and chemistry.

Taken as a whole, approximately 7500 students are studying in these departments. TOCUSO was administered to around 2350 students and data collected from 540 among them. Participated students were enrolled in different grades freshman to senior year. Some of them already took a modern physics mandatory course already but all of them studies modern physics topics at high school. Therefore, they are familiar and learned the concepts before.

In order to assess student learning in modern physics courses, a new diagnostic instrument was developed and administered to 540 students. In order to overcome linguistic problems, the test is a 30 multiple choice questions and was assessed in their primary language (Turkish). English version of the selected questions is included in appendix section. The questions measure their conceptual knowledge

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of modern physics topics rather than mathematical ability of problem solving. It does not include any types of problem based questions and calculations. However, there are some real life questions to probe their learning of applications of the concepts. We aimed to generate a qualitative diagnostic instrument for physics and science educators to use for both as pre and post test for any students in college studying modern physics. Teachers or professors can also use this test to get an idea of how students are learning the concepts at any time during courses periods. Besides, we intended to create a useful data collection tool to assess prevalence student ideas regarding concepts of modern physics. We believe we have achieved both goals.

Results and Conclusion

As indicated in the previous sections, TOCUSO passed tests of validity and reliability that shows that it can be easily adapted and utilized. Although 0.73 is a very good result for a reliable data collection instrument, test can be revised to reach a higher score. Possible reason for the outcome might be unclear questions (e.g. question 21) as discussed before. Another cause for such low scores of some items in the test might stem from the language because students sometimes learn technical conceptual terms differently therefore if we use it for different meaning then they failed to answer it correctly. We can alter these questions and eliminate students' misunderstandings to get correct responses.

The only items of the test with averages lower than 20% percent of responded correctly were questions 1, 2, 14, 15, 17, and 20. As we predicted above, these questions focus on fundamental concepts of quantum theory so maybe when we prepare questions about it we should be more careful to misguide the students to the incorrect answers. In conclusion, the performance of TOCUSO implies that additional research on instructional approaches of the concepts is needed to investigate the test. In this article, we provided preliminary results of a new diagnostic measurement tool for concepts of modern physics and hope as more researchers use it to evaluate and to create more effective data collection materials.

Next, we need to check the items in terms of their validity and reliability corresponding to the quality of the instrument. Validity is the measure of how well each item measures what it should measure. We asked 19 professors at physics department and 3 professors at school of education review the questions at the same university where data was collected. They rated each item with scoring them as 10 being the high and 0 being low for both reasonableness and appropriateness of them. The resultant of their scoring is displayed in Table 3. All of the items were rated as appropriate and reasonable for the students.

Question	Content Mean	SD	Logical Mean	SD	Appropriate Mean	SD
1	9.32	1.41	9.12	1.51	9.09	1.57
2	9.12	1.98	9.85	0.52	9.45	1.59
3	9.01	1.87	9.98	0.58	9.55	2.02
4	9.50	1.45	9.00	0.75	9.41	1.42
5	8.98	2.10	9.23	0.15	9.12	0.98
6	9.68	1.65	9.52	1.27	9.87	1.65
7	9.52	1.54	8.20	0.95	9.01	1.78
8	9.32	1.58	9.85	0.69	8.58	1.87
9	9.45	1.65	9.24	1.88	9.87	1.98
10	9.52	1.69	9.45	1.40	9.65	1.85
11	9.48	1.70	9.30	1.26	9.54	1.26
12	9.49	1.87	9.21	0.96	9.89	1.56
13	9.29	1.32	9.20	1.48	9.65	1.41
14	9.32	1.98	9.54	1.56	9.23	1.23
15	9.45	2.30	9.45	0.99	9.12	1.85
16	9.12	1.85	9.47	1.57	9.15	1.45
17	8.65	1.80	9.12	1.69	9.54	1.47
18	8.85	1.65	8.95	1.33	9.36	1.59
19	8.98	1.20	9.12	1.89	9.85	1.65
20	9.12	1.45	9.60	1.88	9.12	1.98
21	9.98	1.69	9.50	1.35	9.25	1.75
22	9.95	1.49	9.48	0.69	9.58	1.32
23	9.80	1.58	9.12	1.03	9.78	1.98
24	9.75	1.54	9.32	1.53	9.23	1.45
25	9.70	1.65	9.18	1.98	9.10	1.99
26	8.95	1.66	9.21	1.43	9.15	2.25
27	9.25	1.53	9.85	0.12	9.19	1.20
28	9.30	1.75	8.98	1.18	9.27	1.30
29	9.20	1.36	8.95	1.90	9.53	1.50
30	9.45	1.35	9.10	1.62	8.98	2.00

Table 3. Validity (Content, logicalness and appropriateness) of the TOCUSO questions

Discussion

This scale was developed in light of the findings above, the level of high school students understand the concepts of optical measure. The scale redundancy is found as of 0.73. This indicates that the scale is a highly reliable tool.

Test mean score of 41% might be seen low score but compared to the students' grades in a regular modern physics course, it is considered an average score. Averages scored of midterms and finals in modern physics course can be even lower because of difficult concepts related to optic physics topics (e.g. wave function and hydrogen atom application). Although it is not our goal to discuss how

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difficult the concepts of optic physics is, when evaluating students' achievement scores of TOCUSO, one should take this into account to make sure the potential explanation of the results.

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Appendix: Sample TOCUSO Questions

3. Focal length of 2 m and 3 m in front of two lenses is placed in a body. Image of the object is 6 meter long. Which of the following is true corresponding the object size?

A) Bigger than the body. B) Same size as the body.
C) Smaller than the body. D) No relation with the body size.

4. A point light source positioned in front of a curtain with two balls. According to the screen is as shown in shadow

I. Radii of the balls are equal.
II. Centers of the balls is equal to the light source.
III. Centers of the balls with the same light source is on the right.

Which one (s) are absolutely wrong judgement?

A) Only I B) Only II C) Only III D) I and II E) II and III

11. A light beam, transparent X environment, passing through a transparent medium incidence angle of Y α, β is the refraction angle. Angle β does not depend on which of the following?

A) Angle α B) X environment refractive index
C) A medium refractive index D) Light color E) Light intensity

16. Microphones designed to amplify weak sounds of megaphones. Around the microphone for sound waves in the shell acts as a mirror. Which of the following mirrors is the most suitable for this task?

A) Convex mirror B) Concave mirror C) Flat mirror D) None of them

17. Funny mirrors at a fair in a concave mirror are placed in the same partition. One of the staff members can not be seen when you look in the mirror. Where does the employee stand relative to it?

A) In the center of the mirror
B) The focal point of the mirror
C) Located between the mirror center and focal point
D) The highest point of the mirror with the focal point