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Procedia - Social and Behavioral Sciences 191 (2015) 2195 – 2197

Procedia
Social and Behavioral Sciences

WCES 2014

Students' Mental Models of Light to Explain the Compton Effect

Ozgur Ozcan[a] *, Cem Gercek [a]

[a] *Assoc. Prof., University of Hacettepe, Department of Secondary School Science and Mathematics, Beytepe, Ankara, 06800, Turkey.*

Abstract

Light is one of the interesting concepts used for explaining the important processes in modern physics. Because of this reason the students have some misunderstandings and difficulties about light and related phenomena. The present study aims to determine pre-service teachers' understanding of and difficulties with light concept via mental models of light utilized by the students for the explanations of Compton Effect. This research has been carried on the group of 25 students studying in the departments of physics education at a Government University in Turkey. As a data collection tool open – ended questions pertaining drawings and explanations were used. The participants consist of 15 female and 10 male students and they ranged from 22 to 24 years of age. According to the results of this study three mental models which were named as hybrid model, ray and particle model were determined used by the students while explaining the Compton Effect. Implications of our findings for teaching are discussed.

Selection and peer-review under responsibility of the Organizing Committee of WCES 2014

Keywords: Mental models, moderns physics, Compton effect

1. Introduction

In contrast to classical physics modern physics has many varied concepts. Therefore, it has some certain learning difficulties for students and students have misconceptions in regard to modern physics (Bao & Redish, 2002; Johnston, Crawford & Fletcher, 1998). In the related field there are many studies. These studies commonly focus on learning difficulties of students in relation to the concepts of modern physics (Fischer & Lichtfeld, 1992; Müler & Wiesner, 2002; Özcan et al. 2009). These studies conclude that the major reason for these learning difficulties is the prior knowledge of students. Previous knowledge of students mostly is not parallel to scientific knowledge, leading to learning difficulties (Duit, 1995; Treagust, Duit & Nieswandt, 2000). Learning difficulties occur when students cannot correctly imagine the problems at hand (Gentner 1983; Greca and Moreira, 2000; Johnson-Laird, 1983). Prior knowledge or ideas are called alternative concepts or misconceptions. Studies on misconceptions led to the use of the term, "mental model", in physics education studies. The term, mental model, refers to internal representations

* Özgur Özcan. Tel.: +90-312-297-8615
E-mail address: ozcano@hacettepe.edu.tr

Selection and peer-review under responsibility of the Organizing Committee of WCES 2014
doi:10.1016/j.sbspro.2015.04.454

which act as analogical structure of process or situations (Greca & Moreiro, 2001). Greca and Moreira (2001) argue that mental models should be constructed in order for scientific theories to be understood or comprehended. Norman (1983) states that there is a linear relationship between the conceptual models and mental models. Studying and analyzing mental models of students provides researchers the opportunity to understand how students construct the concepts in learning processes (Park, 2006). Although student misconceptions have been studied extensively, the misconceptions about Compton Effect and the mental models of students about it have not been analyzed. The current study aims to identify the learning and conceptual difficulties experienced by students in context of Compton Effect via mental models.

2. Method

1.1 Sample

The participants of the study are 25 undergraduate students who are studying physics education in a public university in Turkey. Ten of them are males and fifteen females. Their age range varies between 22 and 24. All of the participants took the courses of modern physics and quantum physics.

1.1. Data collection and Analysis

The data of the study were collected through open-ended items and student drawings and explanations. The answers of the participants to the open-ended items were analyzed through content analysis which is part of qualitative research technique (Strauss & Corbin, 1990). Student drawings and explanations were analyzed using coding scheme developed by authors.

3. Results

This section presents the analyses of the answers of the participants to the open-ended items and Table 1 shows the mental models employed by them in explaining the Compton Effect. Mental models used by the participants are identified as “Wave-Particle Model” (WP-M), “Beam Mode” (BM) and “Particle Model” (PM).

Tablo 1: Mental models used in relation to Compton Effect

	Students’ Preferred Model			Total (N)	Blank
	Wave-Particle Model	Beam -Model	Particle Model		
Compton Effect	12	3	7	25	3

The findings indicate that the participants mostly employ the Wave-Particle model while explaining Compton Effect. In addition alternative ideas of the participants were identified through their drawings. Some of the alternative ideas (AI) are given as follows:

AI (1): *In this event photon transmits some of its energy to electron so that wave length of the photon increases. This change in the wave length means that in this event photon moves in the form of sinus waves.*

AI (2): *This event indicates that light rays behave like a wave. Because the wave length of photon changes.*

Pictorial representation developed by the participants about the Wave-Particle model which simultaneously emphasizes the wave and particle features of also supports their alternative ideas. The common point in student drawings is that photon is represented as a particle which moves in the form of a wave.

4. Discussion and recommendation

This study revealed mental models used by students in explaining the Compton Effect which is part of modern physics. Some students explained it using wave-particle model. This finding can be accounted for as follows:
1. The most significant reason for students to use wave-particle model to account for photon is that those experiments that focus on wave characteristic of light are much more detailed than those which focuses on particle characteristic of light.
2. The photon concept may be given as having both characteristics of wave and particle in textbooks and lectures.

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