Received : 28 October 2018
Revised : 16 December 2018
Accepted : 21 December 2018
Published: 31 December 2018

DOI: doi.org/10.21009/1.04206

The Design of Media on Two-Lens System Experiment (MTLSE) for Pre-service Physics Teachers

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Abstract

This article is a part of the research in designing a model of the geometrical-optics game on optics' courses for pre-service physics teachers (PPTs). This article describes the preliminary form of product, the result of validation, and PPTs' responses to the media on two-lens system experiment (MTLSE). The validation of this media has been done according to physics subject matter, instructional media and pedagogical experts. The implementation of MTLSE using the one-shot case study design involving 25 PPTs at one of the Islamic universities in Bandung. We collected the data of MTLSE validation and PPTs' responses through non-test techniques with questionnaire instruments. The data using quantitative descriptive analysis technique. The results of MTLSE validation can be good categorized. Besides, generally, the PPTs' responses are good categorized toward the implementation of MTLSE on optics' courses.

Keywords: design of media, two-lens system experiment, pre-service physics teachers

INTRODUCTION

Optics is a branch of physics that deals with the behavior and characteristics of light and other electromagnetic waves (Young & Freedman 2003). Geometrical optics is one branch of optics that discusses light based on the propagating properties of light that traveling in straight lines, explaining the reflection and refraction of light, and being the foundation for making the optical equipment (Saprudin 2018). The term geometrical optics appears as a result of the critical role of geometry in analyzing how the formation of images when the light rays reflected by a mirror and refracted through lenses (Young & Freedman 2003).

The two-lens system is part of the geometrical optics learning material that is found to still have low competency achievement (Saprudin, Liliasari, & Prihatmanto 2017). The results of concept analysis show that in general, the concepts in the geometrical optics learning material are dominated by concrete concept labels that are defined from real optical phenomena are easily found in everyday life applications (Saprudin 2018). However, the results of observations at the location of the study showed that the limitations of the physics experiment tools became one of the factors that caused the two-lens system experiment not to be carried out. It creates the pre-service physics teachers (PPTs) at the research location to have difficulty in understanding the concepts in this material.

The researchers have shown that in its implementation, the teaching and learning process of optics material that has been carried out is dominated by the application of various approaches, models, or methods of learning, and the use of various instructional media ranging from traditional media to the more sophisticated media. This geometrical-optics learning activity is inseparable from hands-on activities that are carried out in real physical activities or through the assistance of virtual media.

The learning approaches, models, or methods that have been applied in optics learning at the level of elementary school, middle school, and higher education includes learning through multiple representation (Hettmannsperger, Mueller, Scheid, & Schnotz 2016), active learning (Masters & Grove 2010), experiment-based learning (Even, Balland, & Guillet 2016; Grusche 2017), inquiry based learning (Kotsari & Smyrnaiou 2017; Srisawasdi & Kroothkeaw 2014), constructivism approach (Taşlidere 2013), STEM (King & English 2016), interactive engagement pedagogy (Sorensen, McBride, & Rebello 2011), problem solving (Warimun 2012), project based learning model (Oktarinah, Wiyono, & Zulherman 2016; Suranti, Gunawan, & Sahidu 2016), lesson study (Manrulu & Sari 2015), cooperative learning (Sutarno & Putri 2012), contextual learning (Suniati, Sadia, & Suhandana 2013), problem based learning (Hidayat, Danawan, & Hidayat 2013), science techology society (Gunarto & Hidayah 2014), Kolb's experiential learning model (Jannati 2016) and integrated science learning (Madesa & Permanasari 2015; Oktamagia, Fauzi, & Hidayati 2013).

As the development of science and technology is getting faster, the use of instructional media is one alternative that can be done to improve the effectiveness of physics learning. Therefore, the use of diverse instructional media is one of the aspects of assessment in school accreditation, especially in the standard process (Rahman, Saprudin, Mubarak, & Hamid 2017; Saprudin & Hamid 2018). Various media used in optical learning include; the media of optical objects in the surrounding environment (Hasanah 2012), optics kit (Pratiwi, Murniati, & Fathurohman 2013; Prihatiningtyas, Prastowo, & Jatmiko 2013), studio optics (Sorensen et al. 2011), concept cartoon work sheets (Taşlidere 2013), pocket book (Laksita, Supurwoko, & Budiawanti 2013), physics flipbook (Hayati, Budi, & Handoko 2015), pop-up book (Ukhtinasari, Mosik, & Sugiyanto 2017), virtual simulation (Martínez, Naranjo, Pérez, Suero, & Pardo 2011; Permana, Widiyatmoko, & Taufiq 2016; Prihatiningtyas et al. 2013; Prihatiningtyas, Prastowo, & Jatmiko 2012; Srisawasdi & Kroothkeaw 2014), virtual laboratory (Collier, Dunham, Braun, & O'Loughlin 2012; Escobar, Sánchez, Beltrán Hoz, & González 2016), tracker (Rodrigues & Simeão Carvalho 2014), multimedia (García-Martínez et al. 2015; Gunawan, Harjono, Sutrio, & Sahidu 2013; Putri & Supardi 2015; Suniati et al. 2013; Sutarno & Putri 2012), prezi online (Utari, Kurniawan, & Fatmaryanti 2014), MOODLE or Modular Object-Oriented Dynamic Learning Environment (Sampurno, Maulidiyah, & Puspitaningrum 2015), games (Estiani, Widiyatmoko, & Sarwi 2015; Fitria & Widiyatmoko 2015; Novitasari, Supurwoko, & Surantoro 2013), augmented reality (Putri, Bakri, & Permana 2016), mobile network (Zhou, Zhao, & Chen 2017). The forms of games used in optics learning include edutainment-based science circuit adopted from monopoly games, games with UNO cards, and also information technology-based instructional media in the way of snakes and ladders.

As a first step in designing geometrical-optics games aimed for PPTs, researchers consider it necessary to create a media and experimental procedures that can provide learning experiences related to the concept of the two-lens system. Besides, this study describes the results of validation and PPTs' responses to the implementation of media on two-lens system experiment (MTLSE) in the optics course.

RESEARCH METHODOLOGY

This research conduct in a pre-experimental design with a one-shot case study design. In this research, one subject group namely 25 PPTs in one of the Islamic Universities in Bandung was subject to treatment in the form of lectures using the MTLSE, then after that, measurements were done regarding the PPTs' responses to the implementation of MTLSE in the courses. Before being used, MTLSE is validated in advance both from the material aspects of physics, instructional media, and pedagogics.

The subject of validation involved two physics material experts, two instructional media experts, and two pedagogical experts. The data related to MTLSE validation collected through non-test techniques with validation sheet instruments which packaged in the form of a questionnaire with closed-ended questions. The data associated with PPTs' responses to the implementation of MTLSE in lectures collected through the questionnaires. The data analysis techniques were carried out using quantitative descriptive analysis techniques.

RESULTS AND DISCUSSION

The Design of Media on Two-Lens System Experiment (MTLSE)

The central principle of MTLSE is to find various combinations of lenses at a certain distance that can produce the sharpest image under certain conditions. Multiple combinations of lenses with a certain distance between lenses found through experiments will be analyzed and compared with the results of mathematical calculations. The PPTs will also be required to think creatively in finding possible lens combinations, and also required to think critically in analyzing and comparing the data from experiments with mathematical calculation results.

The apparatus used in designing this MTLSE include; Econo curtain rails, 12mm plywood, 3mm thin plywood, 12mm aluminum clips, 12mm bolts, biconvex lenses (f = +50 mm, +100 mm, +150 mm, +200 mm and +250 mm), biconcave lens (f = -50 mm, -100 mm, -150 mm, -200 mm and -250 mm), arrow diaphragm, white screen, lens holder, screen holder, arrow diaphragm holder, measuring tape, LED lights source (MR16, 4.5W) and LED spotlight. The MTLSE design shown in FIGURE 1.

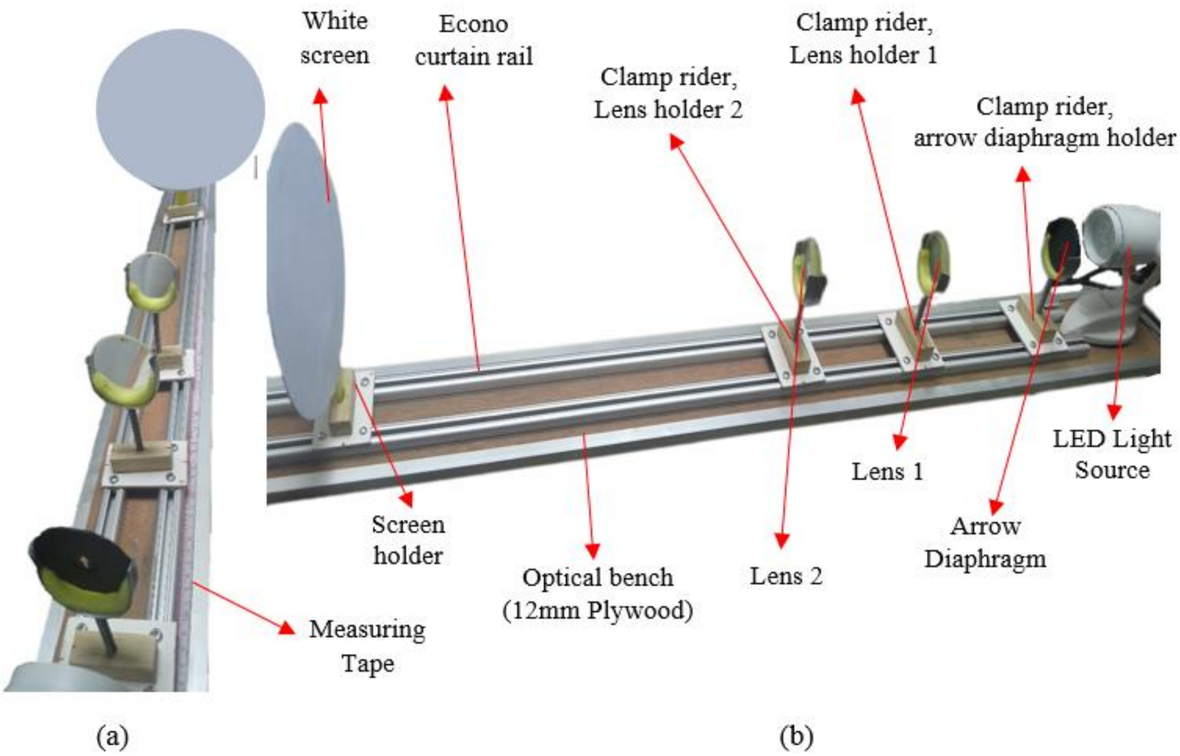
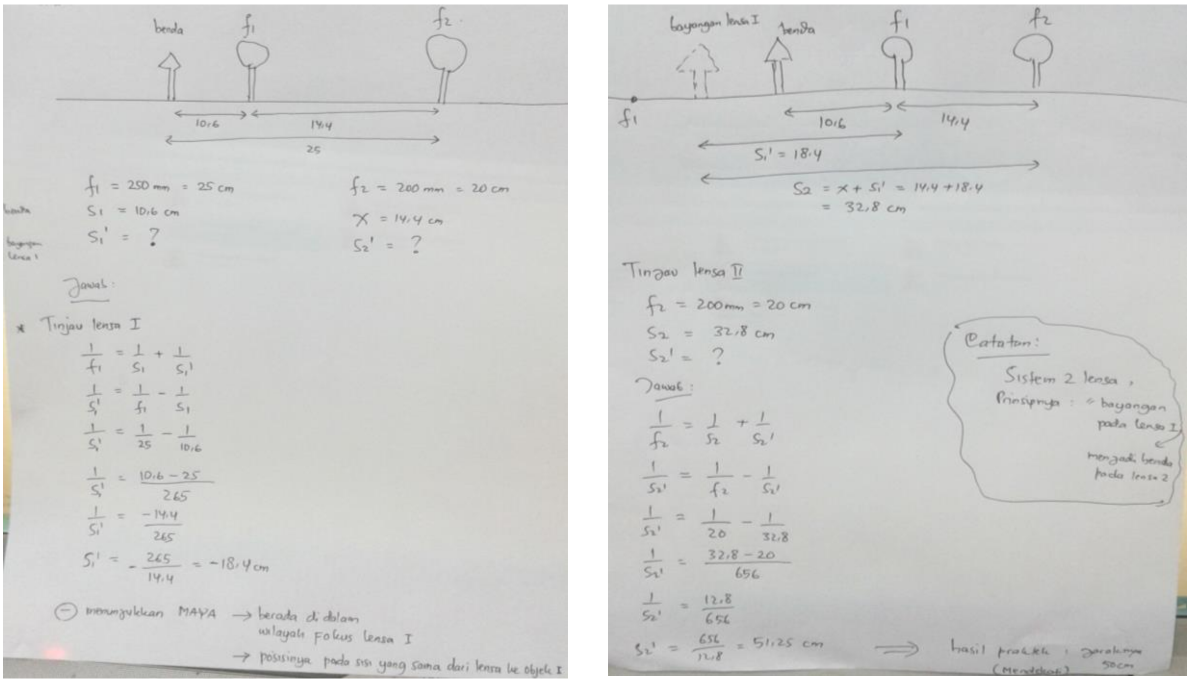


FIGURE 1. The Display of Media on Two-Lens System Experiment (MTLSE); (a) front view, (b) side view

FIGURES 2, 3a and 3b show the sample result of PPTs' experimental data and mathematically analysis.

Types of lens 1	Types of lens 2	Focal length of lens 1 (mm)	Focal length of lens 2 (mm)	Distance of the object from the lens 1 (cm)	Distance of the image from the lens 2 (cm)	Distance between two lens (cm)	Image form
bikonveks (+)	bikonveks (+)	250	200	10,6	50	14,4	Inverted, Enlarged

FIGURE 2. Photo Sample of PPTs' Experimental Data



(a) (b)

FIGURE 3. Photo Sample of Mathematical Analysis

Validation Result of Media on Two-Lens System Experiment (MTLSE)

TABLE 1, TABLE 2, and TABLE 3 show the results of validation by physics matter, instructional media, and pedagogical experts.

TABEL 1. Results of MTLSE Validation by Physics Material Experts

Aspects	Indicators	Percentage (%)
Describing physics phenomena	MTLSE has clarity of objects and physics phenomena	80
Possible lens combination variation	MTLSE produces a variety of lens combinations that can be found by PPTs	70
Suitability of experimental results with mathematical calculation results	The results of the two-lens system experiment with MTLSE can be mathematically proven	80
Provides clarity on the concept of a two-lens system	MTLSE can increase transparency to the concept of image formation by the lens	70
	Average	**75**

TABEL 2. Results of MTLSE Validation by Instructional Media Experts

Aspects	Indicators	Percentage (%)
Efficiency	Ease of assembling MTLSE	80
	Ease of operating the MTLSE	70
	MTLSE can be used in groups	80
	MTLSE does not take long to use	60
	MTLSE is easy to carry and store back in its place	80
Accuracy and Precision	Accuracy of measurement	70
	The consistency of experimental results	80
	Clarity of the images formed	80
Durability	The MTLSE is resistant to environmental vibrations that can change measurement results	80
	The resilience of the components in each stand or each clamp rider	60
	The lens used is resistant to scratches	70
	The lens used is not easily broken if it falls	60
Safety	The light source used is safe for the eyes	80
	The power source used is safe for the user	80
	Construction tools are safe for users	80
Aesthetics	MTLSE has an interesting shape	70
	Average	**74**

TABEL 3. Results of MTLSE Validation by Pedagogical Expert

Aspects	Indicators	Percentage (%)
Linkages with the curriculum (Syllabus/ GBRP/ RPS/ SAP)	MTLSE provides learning experiences by the demands of the KKNI (IQF)	80
	MTLSE has clarity of objects and physical phenomena	80
Suitability with the level of intellectual development	Suitability of the MTLSE with the level of the intellectual development of PPTs	80
Practicing science process skills	MTLSE provides a learning experience especially on observing (making observations)	90
	MTLSE provides a learning experience on classifying	60
	MTLSE provides a learning experience on interpreting	60
	MTLSE provides a learning experience on predicting	70
	MTLSE provides a learning experience on communicating	60
	MTLSE provides a learning experience on questioning	60
	MTLSE provides a learning experience on hypothesizing	60
	MTLSE provides a learning experience on designing an experiment	70
	MTLSE provides a learning experience using tools/ apparatus/ materials/ sources	80
	MTLSE provides a learning experience on applying concepts	80
	MTLSE provides a learning experience to carry out experiments/investigations	80
Developing Higher Order Thinking Skills (HOTS)	MTLSE potentially to developing creative thinking skills	80
	MTLSE potentially to developing critical thinking skills	80
	Average	**73**

Overall, the results of MTLSE validation according to the physics matter experts are categorized as good (75%), according to the instructional media experts are classified as good (74%), and according to the pedagogical experts are classified as good (73%). Based on that, MTLSE can be declared as feasible for use in the optical course.

PPTs' Responses toward The Implementation of MTLSE

PPTs' responses are focused on two target focuses namely; 1) PPTs' responses toward MTLSE and 2) PPTs' responses toward two-lens system experiment design. TABLE 4 and TABLE 5 show the PPTs' responses.

TABLE 4. PPTs' Response to MTLSE and Experimental Design of Two-Lens Systems

No	Indicators	Percentage (%)
1	PPTs' responses to MTLSE	77
2	PPTs' responses to the two-lens system experiment design	79

TABLE 5. PPTs' Responses Toward MTLSE

No	Statements	Percentage (%)
1	This MTLSE display is impressive to use	84
2	MTLSE is easy to operate	88
3	The final image produced by MTLSE can be observed on the screen	85
4	Shifting tool components of MTLSE are easy to do	83
5	The light source at the MTLSE does not interfere during the observation	46
6	I have experimented with two lens systems	78
7	This two-lens system experiment is a new thing for me	75
8	The use of MTLSE can increase my motivation to study physics more deeply	78
9	MTLSE can make it easier to understand the material related to the image formation on the two-lens system	80
10	With MTLSE, the two-lens lab experiment becomes more interesting	83
11	I feel the subject matter lasts longer in memory if explained using MTLSE	80
12	The challenge of determining the lens combination that produces the sharpest image/ shadow is an interesting thing to solve	77
13	I was demanded to think creatively to find a lens combination that produced the sharpest image/ shadow	78
14	From the various lens combinations found, I am required to think critically in producing the best lens combination	78
15	Through this MTLSE, I was motivated to find as many lens combinations as possible	78
	Average	**78**

Overall, PPTs gave good responses to the MTLSE and also to the two-lens system experiment design. It is indicated by the total score of 1415 from a maximum score of 1800. The results of the questionnaire suggest that this experimental design is considered as something new for PPTs at the research location.

CONCLUSION

The main principle of MTLSE is finding various combinations of lenses at a certain distance that can produce the sharpest image under certain conditions. Different lens combinations that found through experiment will be analyzed and compared with the results of mathematical calculations. Some of the advantages of MTLSE that have been designed include; a) easy to operate, b) the image that formed by two-lens system can be clearly observed on the screen, c) shifting the components of MTLSE (the object distance, image distance, and the distance between two lenses) are easy to do, and d) using LED light source so do not disturb the eyes during observation.

The results of MTLSE validation according to physics material, instructional media and pedagogical experts can be categorized as good. Besides, PPTs' responses to the implementation of MTLSE are categorized as good. The products and experiment designs produced will be used to design a geometrical-optics game model that can be used in optics course for PPTs.

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