



# Preliminary Development of Refutation Texts for Conceptual Change on Lunar Phases

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**Abstract.** The conceptual change model by Posner et al. states that students must be dissatisfied with the old conceptions, and the substitute conceptions must be intelligent, plausible, and fruitful to ensure the conceptual change. The previous study has obtained students' misconceptions about the Lunar Phase materials. These data are the basis for developing Refutation Texts (RT). This study aims to develop a set of valid and practical electronic modules equipped with RT as teaching material to overcome misconceptions. The method used was educational research and development, which consisted of three steps. This article reports the preliminary development step. As a result, there are fourteen forms of misconceptions about the lunar phases related to six essential materials, namely the Moon as an Earth's Satellite, the Rotation and Revolution of the Earth and Moon, the Moon's Movement, Lunar Phases, Lunar Eclipse, and Causes of Tides. It developed as many as fifteen units of RT for all the essential materials. These fifteen units of RT were embedded in a set of the Lunar Phase materials electronic module. Further research is recommended to test the RT-equipped electronic module's validity, practicality, and potential effect in overcoming misconceptions about the Lunar Phases.

**Keywords:** Refutation Text · Conceptual Change · Lunar Phases

## 1 Introduction

Physics is a branch of natural science that has a significant role in technology and science development. Physics learning should produce students with good scientific attitudes and skills and mastery of deep concepts [1]. One of the main problems in learning physics is that educators still find that students experience many misconceptions about physics concepts. Misconceptions disrupt the learning process negatively. So students must develop a sufficient conceptual understanding above the threshold concept to link with new materials [2]. Traditional learning does not effectively influence the conceptual understanding of students [3]. Certain learning is needed to improve students' conceptual understanding, called conceptual change learning [4]. This kind of learning can be used to assist in reducing the students' misconceptions [5].

Conceptual change is a challenging endeavor in teaching, particularly in science education, where many concepts are complex, controversial, or counterintuitive. Conceptual change is a fundamental process based on a certain theory. Science educators

and science education researchers need an effective model for dealing with conceptual change [6]. On the other hand, in the research [7], it was found that many misconceptions were experienced by junior high school students about the moon phase materials. The next research is required to remediate these misconceptions, namely with a learning strategy that refers to the theory of conceptual change.

Astronomical phenomena are often encountered by students in everyday life. They developed their way of thinking to describe astronomical phenomena while looking consciously or unconsciously at the sky day or night [8]. One of the basic concepts of astronomy, namely Lunar Phases and Lunar Eclipses, has been at the center of human development in the historical process since human existence and currently has an important place in modern knowledge [9]. To understand the mechanism of the Lunar Phases, one must conform to and incorporate some basic concepts, such as that the Moon is spherical, revolves around the Earth, shines by reflecting light from the Sun, and is always half bright and half dark [10].

The basics of astronomy in the Indonesian school curriculum are usually placed on Earth and outer space. However, in astronomy material, many misconceptions are found [11]. A common misconception among children and adults is the explanation for phases and eclipses by considering that the Lunar Phases happen when the Moon enters the shadow of Earth [12]. Students from different age groups have many ideas of common misconceptions about astronomical phenomena and concepts [13]. Research done by Koca [14] also reported that high school students have less knowledge about the size of the Earth and Moon, how Solar and Lunar Eclipses occur, celestial bodies in eclipse, and problems with the vitalization of eclipses in their minds. Furthermore, seventh graders have very limited beliefs about the apparent motion of celestial bodies, the cycles of day and night, Lunar Phases, and the seasons [15]. Students find it difficult to study Moon Phases due to ignorance and cannot visualize them [16].

The theory of conceptual change, known as the conceptual change model, suggests that conceptions will change if students are not satisfied with old conceptions and detect new substitute concepts as plausible, intelligible, and fruitful. Based on that, several methods and strategies, such as refutation text, were developed as conceptual change strategies. The refutation texts effectively lowered alternative conceptions and increased students' knowledge of science concepts [17]. The study by Beker et al. [18] showed that refutation texts were more useful in promoting conceptual change than non-refuting texts.

The refutation text describes unscientific beliefs, refutes them, and presents some reasons why they are untrue [19]. The refutation text conceptual change-oriented aims to activate mind conflict with a direct focus on students' misconceptions. Words in the refutation text remind students that what they will read next will likely conflict with their present understanding. By challenging students' misconceptions, refutation texts encourage students to explore their knowledge and evaluate suggested options [20]. Refutation text can cause a transformation in the direction of thought, from the circular to causal path, which is prominent in scientific understanding and evolves the basis for revising knowledge [21].

Various studies have been conducted regarding refutation texts [22–26]. However, research about refutation texts in science classes is still limited. Moreover, no refutation

text has been developed in Indonesian for Lunar Phase materials. In addition, developing technology can help build students' knowledge by providing effortless access to obtain information from learning sources such as electronic module teaching materials [27]. Therefore, this research aims to develop valid and practical electronic module teaching materials equipped with refutation texts on Lunar Phase materials.

## 2 Method

This study is an introductory part of research on developing teaching materials for the electronic Lunar Phase materials module equipped with refutation texts based on conceptual change for junior high school students. The research method used is development research. Development research consists of three stages. There are the preliminary stage, the development stage, and the evaluation stage. In the preliminary stage, a necessities analysis was carried out consisting of an analysis of essential materials or important concepts in the Lunar Phase materials, an analysis of the applicable curriculum, and an analysis of students' misconceptions about the Lunar Phases. The development stage involves developing a prototype of electronic module teaching materials and the refutation text. And at the evaluation stage, evaluating and revising the electronic module teaching materials, which are equipped with refutation texts based on conceptual changes that have been made so that they become valid and practical. This research was only conducted in the preliminary stage.

This development research develops refutation texts using a strategy or method based on conceptual change. Four conditions must be needed so that understanding of concepts can be changed. Namely, dissatisfaction with the old idea and a substitute idea is intelligent, plausible, and fruitful [28]. Various approaches focus on altering text content to address problems to support correct understanding. One empirically validated change applies the usefulness of a refutation text, which defines its misconceptions as imprecise, and provides a more precise concept [29]. There are three components in the refutation texts, namely the misconception section, the refutation section, and the scientific explanation section of the refutation [30].

This study was conducted at Universitas Sriwijaya. The subject of this study is the teaching material of the moon phase material electronic module equipped with refutation texts based on the conceptual change that was developed. This preliminary study was done by identifying the forms of misconceptions experienced by students and regarding essential concepts in the Lunar Phase materials used to determine the amount of developing refutation texts.

## 3 Results and Discussion

The deep connection between physics and astronomy and the person's intensive curiosity in comprehending celestial bodies have encouraged researchers to understand students' perceptions of the fundamental concepts of astronomy [31]. This study begins with a needs analysis to develop refutation texts based on conceptual changes. The development of a refutation text based on conceptual change in Lunar Phase materials refers to the theory of conceptual change, which awakens dissatisfaction in students' minds

and then provides substitute conceptions that are intelligible, plausible, and fruitful. In learning, it is necessary to identify students' prior understanding before teaching new facts or concepts so that they do not confuse students' misconceptions but can annihilate misconceptions [32]. If misconceptions are not handled in the early stage, students are likely to maintain these alternative conceptions to a higher stage [15].

Even though the Moon is so close to Earth and apparent in the night sky, students are still unknown with general astronomy learning of Lunar Phases and their causes [33]. Research conducted by Yetter et al. [34] stated some students were not able to connect the thought that the Earth passing the Moon causes the Lunar Phases, but they can take the concept of a Solar Eclipse that results from the Moon passing between the Earth and the Sun. In addition, in research [35], students and even teachers have alternative conceptions as the Moon does not rotate on its axis; anywhere at night, we can watch Lunar Eclipses; from particular belts on the Earth, we can watch the Solar Eclipses, and Solar Eclipses constantly take lengthier than Lunar Eclipses in specific geographic areas. The conditions of misconceptions the junior high school students participated in on the Lunar Phase materials obtained in previous studies [7] can be seen in Table 1.

**Table 1.** Various Forms of Misconception on the Lunar Phases

No	Misconception Form
1	Students assume that the Moon emits its light and only shines at night.
2	Students assume that the full moon cycle occurs when the Sun's rays on the Moon are covered by the Earth, making the Moon look like a waning moon.
3	Students assume that the image of the crescent Moon is a picture of the half Moon and the final convex moon.
4	Students assume that the Moon moves relatively from east to west.
5	Students assume that the Sun or stars or asteroids are natural satellites of the Earth.
6	Students assume that the Moon evolves in one year because the Moon and the Earth revolve around the Sun at the same time.
7	Students assume that the Earth faces the Moon during the day due to the rotation and revolution of the Earth.
8	Students assume that the Earth's rotation is the Earth around the Sun.
9	Students assume that the Moon's rotation affects the tides.
10	Students assume that a lunar eclipse occurs because the Moon is blocked by sunlight.
11	Students assume that a solar eclipse occurs when the Moon, Earth, and Sun are in a straight line.
12	Students assume that the phase of the Moon whose entire surface faces the Earth is the new Moon.
13	Students assume that the crescent Moon occurs when the position of the Moon forms half so that the illuminated surface of the Moon is only partially visible from the Earth.
14	Students assume that the final convex moon phase is when the right part of the Moon appears shining, and the left part looks dark.

Table 1 displays fourteen misconceptions about the Lunar Phase materials that junior high school students experience. Based on these misconceptions, it will be continued with curriculum analysis. The applicable curriculum is analyzed for its suitability with misconceptions and the concept of Lunar Phase material which will be the basis for developing a refutation text. The curriculum is more than just an education framework, a set of instructional materials, and a list of matters to be covered. Curriculum study constructs curriculum content, meaning, and practice [36].

The curricula currently used in Indonesia currently are the 2013 Curriculum and the Independent Curriculum. The two curricula show that Lunar Phase materials are Natural Science materials given to seventh-grade junior high school students. There is a slight difference between 2013-Curriculum and the Independent Curriculum in naming the competencies that are expected to be achieved by students, namely Kompetensi Dasar (Basic Competencies) in the 2013-Curriculum and Capaian Kompetensi (Competency Achievement) in the Independent Curriculum. Table 2 shows the differences in competencies in Lunar Phase materials for the two curricula.

Table 2 shows the main material in the two curricula is about the solar system. The topic developed in the refutation text is a sub-topic of the material of the solar system, namely the Lunar phases. The Lunar phases material are developed as a refutational text according to the findings of the previously discussed misconceptions. The refutational text as a tool used to correct misconceptions requires an explanation of the content students can understand. So that misconceptions do not become a barrier to learning

**Table 2.** Differences in Competency in the Lunar Phase of the Two Curricula

2013-Curriculum	Independent Curriculum
Analyze the solar system, the Earth's rotation and revolution, the Moon's rotation and revolution, and their impact on life on Earth.	Students elaborate on their understanding of the relative position of the earth-moon-sun in the solar system and understand the structure of the Earth's layers to explain natural phenomena that occur in the context of disaster mitigation.

**Table 3.** Essential Concepts in Lunar Phase Materials

No	Essential Concepts
1	Moon as Earth's satellite
2	Rotation and revolution of Earth and Moon
3	Moon movement
4	Lunar phases
5	Lunar eclipse
6	Causes of tides

the correct concept, the refutation text can be recommended for students to change the misconceptions they experience into a true concepts [37].

Knowledge and learning the concepts of physics material can be useful for someone in their environment and daily life [1]. So, students need to understand the concepts in Lunar Phase materials to revise their misconceptions. The essential concepts in the Lunar Phase materials can be seen in Table 3.

Based on Table 3, it is found that there are six essential concepts in the Lunar Phase materials. These essential concepts and the students' misconceptions have been obtained and became a reference in developing a refutation text for the Lunar Phase materials. The amount of developing Lunar Phase Materials refutation texts based on the conceptual change can be seen in Table 4.

Table 4 combines Table 1 and Table 2, combined with the amount of text developed. Table 4 is a guide to developing the number of refutation texts. There are six essential concepts in the Lunar Phase materials and fourteen misconceptions experienced by students. Two refutation texts are developed on the concept of the Moon as a satellite of the Earth. Three refutation texts are developed on Earth's and Moon's rotation and revolution. One refutation text is developed in the concept of the movement of the Moon. In the concept of the Lunar phases, six refutation texts are developed. In the concept of the Lunar Eclipse, two refutation texts are developed. Finally, on the concept of the cause of the tides, only one refutation text is developed.

Table 4 shows the most developed refutation text is about the concept of Lunar Phases, and the least developed refutation text is about the concept of the Moon movement and the causes of tides. In the refutation text, there are three main components, namely the misconception section, the refutation sentence section, and the scientific explanation section. The sections covered in the refutation text can be seen in Fig. 1.

Figure 1 is a form of design or prototype that illustrates the results of the development of the refutation text. In this case, an example is the concept of the Moon as an Earth's Satellite. It is shown in the example how the refutation text in its sections provides information about the students' misconceptions experienced. That text refutes these misconceptions and explains the errors of these misconceptions with scientific answers. This corresponds to [38], which indicates in the refutation text that individuals may find components of refutation that are personally applicable because the misconceptions in the text are similar to the conceptions owned by individuals. Then the refutation sentence can guide individuals to thoroughly and critically define scientific explanations by refusing the misconceptions explicitly.

Refutation text supports overcoming misconceptions [39]. Refutation text facilitates revision of understanding by setting competing thoughts aside and refuting thoughts considered misconceptions [40]. Refutation text forms a new conceptual structure from multi-word pieces that align with the true conception at the expense of existing multi-word pieces that have supported declarative understanding processing [20]. Refutation text is written to invite readers to make a straight comparison between their prior understanding and text information. Readers seeking to comprehend refutation texts through sustaining coherence or settling cognitive conflicts tend to experience knowledge and conceptual change [41].

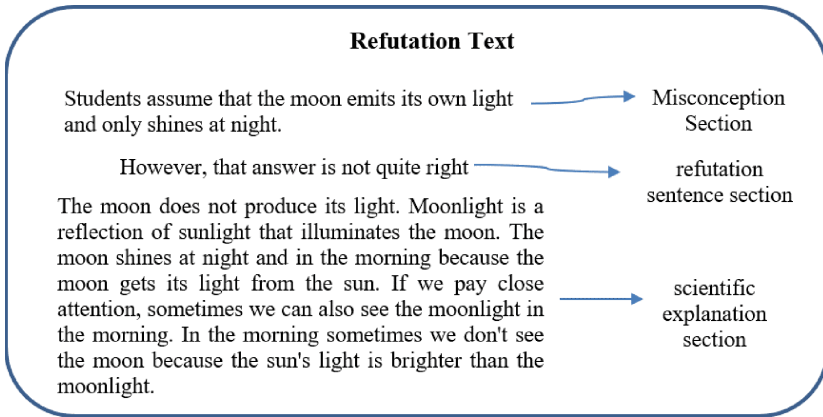
**Table 4.** Number of Lunar Phase Refutation Text

Essential Concepts	Misconception	Amount
Moon as Earth's satellite	Students assume that the Moon emits its light and only shines at night.	1
	Students assume that the Sun or stars or asteroids are natural satellites of the Earth.	1
Rotation and revolution of Earth and Moon	Students assume that the Moon evolves in one year because the Moon and the Earth revolve around the Sun at the same time.	1
	Students assume that the Earth faces the Moon during the day due to the rotation and revolution of the Earth.	1
	Students assume that the Earth's rotation is the Earth around the Sun.	1
Moon movement	Students assume that the Moon moves relatively from east to west.	1
Lunar phases	Students assume that the full moon cycle occurs when the Sun's rays on the Moon are covered by the Earth, making the Moon look like a waning moon.	1
	Students assume that the image of the crescent Moon is a picture of the half Moon and the final convex moon.	2
	Students assume that the phase of the Moon whose entire surface faces the Earth is the new Moon.	1
	Students assume that the crescent Moon occurs when the position of the Moon forms half so that the illuminated surface of the Moon is only partially visible from the Earth.	1
	Students assume that the final convex moon phase is when the right part of the Moon appears shining, and the left part looks dark.	1
Lunar eclipse	Students assume that a lunar eclipse occurs because the Moon is blocked by sunlight.	1

*(continued)*

**Table 4.** (continued)

Essential Concepts	Misconception	Amount
	Students assume that a solar eclipse occurs when the Moon, Earth, and Sun are in a straight line.	1
Causes of tides	Students assume that the Moon's rotation affects the tides.	1

**Fig. 1.** Refutation Text Draft.

## 4 Conclusion

The results of this study obtained 15 refutation texts that were developed for important concepts containing misconceptions in the Lunar Phase material. In this study, the refutation text developed was based on the theory of conceptual change. Based on this theory, four conditions must be met to change conceptual understanding. Namely, there is student dissatisfaction with the old concept, and students get a substitute concept that is reasonable, understandable, and useful. The refutation text based on the conceptual changes in the Lunar Phase material developed can be used by teachers as additional teaching material in learning activities at school. Through this refutation text, students can improve their understanding to change their misconceptions or preconceptions into the correct ones. Then, this research is not limited to the development of refutation texts; further research at the development and evaluation stage is needed to create teaching materials of the electronic modules for moon phase materials equipped with refutational texts based on valid and practical conceptual changes.

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