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Investigation of Undergraduate Physics Students' Conception of Eclipses' Formation Using Three Tiers Diagnostic Test in Ilorin, Nigeria

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ABSTRACT

Background: Natural phenomenon explanation like eclipse is an important event that needs to be examined among all peers so as to ensure the scientific understanding of these natural happenings in our various environments.

Purpose: This study focuses on investigating the undergraduate physics students' conception of eclipses formation using a three-tier diagnostic test.

Method: The study was descriptive research of survey type that adopted the usage of a three-tier questionnaire to elicit information about the students' understanding of eclipses formation. The sample of the study consisted of 80 students (40 physics education students and 40 pure physics students), who were selected through convenience sampling technique. The three-tier diagnostic test consisted of four questions that were on the formation of total solar eclipse, annular solar eclipse, partial solar eclipse, and lunar eclipse, which was used to collect information. Each question consisted of three stages. Descriptive statistics like frequency count, percentage, and pie chart were used to determine the students correct conception, misconception, wrong conception, and guess answer

Results: The study found out that 20 students had correct conception, while 42 had misconception of the formation of total solar eclipse.

Conclusion: The study recommended that the study on students correct conception and misconception about the natural phenomenon should be carried out often.

1. Introduction

Nigeria, like every other country of the world, experienced the spectacular natural astronomy phenomenon called an *eclipse* on the 8th day of April 2024. This astronomical phenomenon called eclipse occurs in total, lunar, annular, and partial forms in different locations and parts of the world. Most locations in Nigeria experienced a partial eclipse, and some of the locations include Oyo and Kano, as published by media houses. Schlottman and Anderson (1993) asserted that it is important to study the happenings of natural events and phenomena, as it will aid invariant perceptual structure and address individual differences in understanding.

Slater and Gelderman (2017) asserted that students learning about eclipses lack a scientific and accurate understanding of why moon phases occur, while the learning default's belief is that the spherical moon in the night sky should always appear to be full and round. The authors further opined that learners often believe and hold the notion that minutes-long solar eclipses can only be seen from a specific geographic location, but hours-long lunar eclipses are visible to everyone on Earth's nighttime side.

Hewitt (1970) opined that studying natural phenomena and events is an important tool for understanding the probabilistic structure of phenomena that occur within a space or limited time. Yu (2020) asserted that natural events and phenomena investigation, such as dust events, helps to capture and understand the dynamics and complexity of natural events. Scheibe (1991) concluded that studying natural events and phenomena is important due to its ability to find and test natural laws, which express regularities related to repeatable events.

Investigating and observing natural and physical phenomena can foster students' sense of wonder and engagement with science content knowledge through self-directed inquiry (Hadzigeorgiou, 2021). Suprapto *et al*. (2018) carried out a study on Indonesian pre-service physics teachers' understanding of total lunar eclipses. The study was qualitative research, and the pre-service physics teachers' responses were rated on four levels of *dissatisfied (naïve), intelligible, plausible,* and *fruitful.* The findings of the study revealed that pre-service physics teachers showed a high level of reasoning about the lunar eclipse.

Students' knowledge of natural events is essential in the field of research in order to help educators identify students correct conceptions, misconceptions, wrong conceptions, and cultural beliefs about the causes of natural occurrences in our society. This would help researchers determine the students' superstitious beliefs held about natural happenings against scientific explanations. Correct conception of the causes of natural events enables students to differentiate between human-made and naturally occurring phenomena and enables them to promote and support accurate scientific explanations.

Rutgersson *et al*. (2021) opined that correct conception of the causes of natural events prepares students to make informed decisions about environmental issues and natural hazards, which is increasingly important in understanding climate change and weather conditions.

Desfandi *et al*. (2020) concluded that the usage of a 3-tier diagnostic test is an efficient test structure that can identify students' misconceptions of concepts in geography and also aid students' understanding. Milenkovic *et al*. (2016) advocated that a 3-tier diagnostic test affects the number of identified misconceptions and scientific knowledge assessment of students. Based on the review of literature and the focus of this study, two research questions were developed to guide the investigation: (RQ1) What are the correct conceptions and misconceptions held by physics students on the formation of eclipses? and (RQ2) What are the correct conceptions and misconceptions held by physics students on the formation of eclipses based on gender?

2. Methodology

The current study was descriptive research of survey type, which adopted the three-tier multiple-choice diagnostic test to ascertain the level of correct conception, misconception, guessed answers, and wrong conception of eclipse formation among physics education and pure and applied physics students. The data for this study were collected at one university located in the north-central geopolitical zone of the Federal Republic of Nigeria. The samples of the study consisted of 80 students (40 physics education students and 40 pure physics students), who were selected through a convenience sampling technique.

The three-tier diagnostic test consisted of four questions that were on the formation of total solar eclipse, annular solar eclipse, partial solar eclipse, and lunar eclipse. Each question consisted of three stages. The first stage of the process consisted of four options (one correct option and three distractors), from which the respondents were requested to choose the correct option for the question asked. The second stage of the diagnostic test was open-ended, in which the respondents were to justify and support the chosen option with a brief explanation of their understanding in the first stage, while the last stage dealt with the respondents' confidence level. The collected data were analyzed using descriptive statistics (frequency, pie chart, and bar chart).

2.1. Participants

Table 1 describes the demographic profiles of the respondents. Eighty respondents, comprising 40 physics education students and 40 pure and applied physics students, participated in this study and were selected through a non-probability sampling technique (convenience sampling). The choice of the respondents was necessitated because of their exposure to some astronomy courses in physics.

Table 1: Demographic Profile of the Respondents

Demographic Profile of Respondents		**N**	**%**
Gender	**Female**	16	20
	Male	64	80
Categories	**Education & Physics**	40	50
	Pure Physics	40	50
	Total	**80**	**100**

The table below explains the possible results while using three-tier diagnostic multiple-choice questions.

Table 2: Possible Results of the Respondents' Response and its Interpretations of Three Tiers Questionnaire

First Stage	Second Stage	Third Stage	Category
Correct	Correct	Confident	Correct Conception/ Understand/Master the Concept
Correct	Wrong	Confident	Misconception
Wrong	Correct	Confident	Misconception
Wrong	Wrong	Confident	Misconception
Correct	Correct	Not Confident	Guess the Answer
Correct	Wrong	Not Confident	Wrong Conception
Wrong	Correct	Not Confident	Wrong Conception
Wrong	Wrong	Not Confident	Wrong Conception

Source: Pramesti *et al.*, 2021

The instrument was validated by two experts in physics to check and validate the content and construct of the instrument to determine if it could measure the concept of eclipse formation, and by one psychometric expert to check for face validation. The inter-rater method was used to determine the reliability index of the study by administering the instrument to non-physics but science students. A coefficient value of 0.87 was obtained using Cohen's Kappa statistics.

3. Results

3.1. Research Question 1

RQ1: What are the correct conceptions and misconceptions held by physics students on the formation of eclipses?

The result in Table 3 and Figure 1 revealed that 20 physics students, representing 25.0% of the total sample size, had correct conceptions of the formation of a total solar eclipse. Forty-two physics students, representing 52.5% of the total sample size, had misconceptions about the formation of the total solar eclipse, while 8 students, representing 10%, had wrong conceptions about the formation of a total solar eclipse. Additionally, 10 students, representing 12.5% of the total sample size, were not sure and confident of their responses.

Table 3: Conception of Total Solar Eclipse Formation

	Frequency	Percentage	Valid Percent	Cumulative Percent
Correct Conception	20	25.0	25.0	25.0
Misconception	42	52.5	52.5	77.5
Wrong Conception	8	10.0	10.0	87.5
Guess Answer	10	12.5	12.5	100.0
Total	**80**	**100.0**	**100.0**	

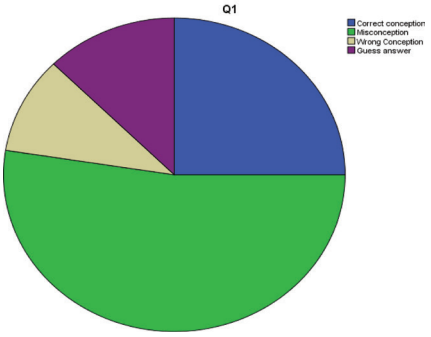

Figure 1: Conception of Total Solar Eclipse Formation

The results in Table 4 and Figure 2 revealed that 10 physics students, representing 12.5% of the total sample size, had correct conceptions of the formation of an annular solar eclipse. Forty physics students, representing 50% of the total sample size, had misconceptions about the formation of the annular solar eclipse, while 30 students, representing 37.5%, had wrong conceptions about the formation of the annular solar eclipse.

Table 4: Conception of Annular Solar Eclipse Formation

	Frequency	Percentage	Valid Percent	Cumulative Percent
Correct Conception	10	12.5	12.5	12.5
Misconception	40	50.0	50.0	62.5
Wrong Conception	30	37.5	37.5	100.0
Total	**80**	**100.0**	**100.0**	

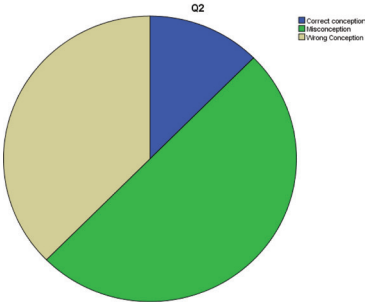

Figure 2: Conception of Annular Solar Eclipse Formation

Table 5: Conception of Partial Solar Eclipse Formation

	Frequency	Percentage	Valid Percent	Cumulative Percent
Correct Conception	12	15.0	15.0	15.0
Misconception	36	45.0	45.0	60.0
Wrong Conception	26	32.5	32.5	92.5
Guess Answer	6	7.5	7.5	100.0
Total	**80**	**100.0**	**100.0**	

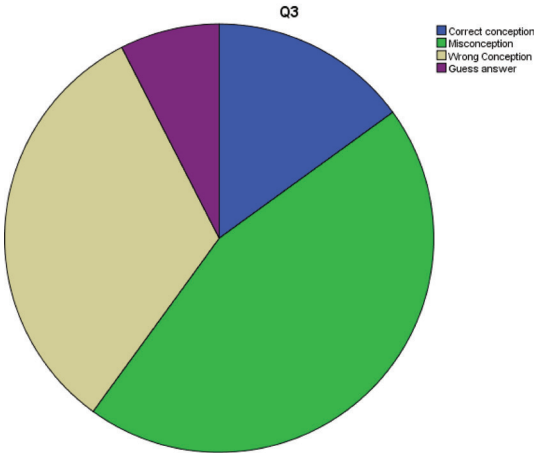

Figure 3: Conception of Partial Solar Eclipse Formation

The results in Table 6 and Figure 4 indicated that 12 physics students, representing 15% of the total sample size, had correct conceptions of the formation of a lunar solar eclipse. Forty-two physics students, representing 52.5% of the total sample size, had misconceptions about the formation of the lunar solar eclipse, while 26 students, representing 32.5%, had wrong conceptions about the formation of the lunar solar eclipse.

Table 6: Conception of Lunar Solar Eclipse Formation

	Frequency	Percentage	Valid Percent	Cumulative Percent
Correct Conception	12	15.0	15.0	15.0
Misconception	42	52.5	52.5	67.5
Wrong Conception	26	32.5	32.5	100.0
Total	**80**	**100.0**	**100.0**	

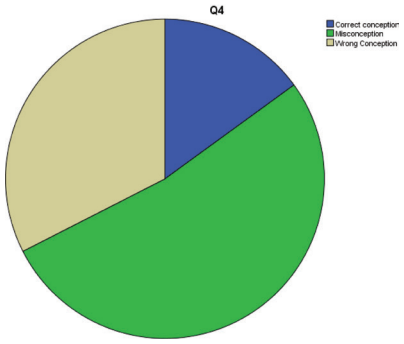

Figure 4: Conception of Lunar Solar Eclipse Formation

3.2. Research Question 2

RQ2: What are the correct conceptions and misconceptions held by physics students on the formation of eclipses-based gender?

The result in Table 7 and Figure 5 revealed that 20 (6 female and 14 male) physics students, representing 25.0% of the total sample size, had correct conceptions of the formation of a total solar eclipse. Forty-two (4 female and 38 male) physics students, representing 52.5% of the total sample size, had misconceptions about the formation of the total solar eclipse, while 8 (4 female and 4 male) students, representing 10%, had wrong conceptions about the formation of a total solar eclipse. Additionally, 10 (2 female and 8 male) students, representing 12.5% of the total sample size, were not sure and confident of their responses.

Table 7: Conception of Total Solar Eclipse Formation based on Gender

		Correct Conception	Misconception	Wrong Conception	Guess Answer	Total
Gender	**Female**	6	4	4	2	16
	Male	14	38	4	8	64
Total		**20**	**42**	**8**	**10**	**80**

The result in Table 8 and Figure 6 revealed that 10 (4 female and 6 males) physics students representing 12.5 percent of the total sample size had correct conception of the formation of annular solar eclipse. 40 (8 female

and 32 male) physics students representing 50.0 percent of the total sample size had misconception about the formation of the annular eclipse formation while 30 (4 female and 26 male) students' representing 37.5 percent had wrong conception about the formation of annular solar eclipse.

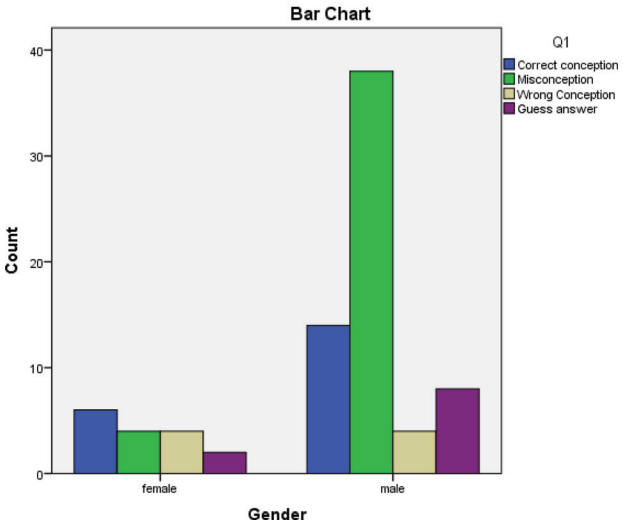

Figure 5: Conception of Total Solar Eclipse Formation based on Gender

Table 8: Conception of Annular Solar Eclipse Formation based on Gender

		Correct Conception	Miscon-ception	Wrong Conception	Total
Gender	Female	4	8	4	16
	Male	6	32	26	64
Total		**10**	**40**	**30**	**80**

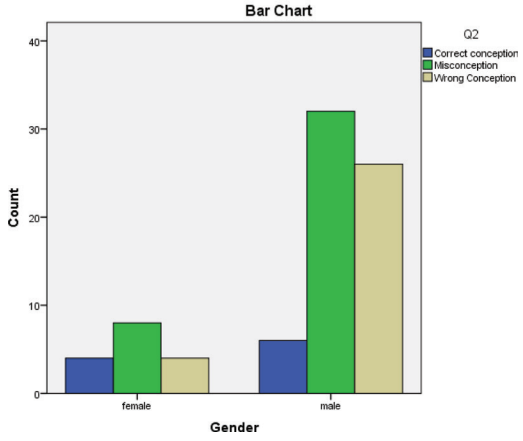

Figure 6: Conception of Annular Solar Eclipse Formation based on Gender

The results in Table 9 and Figure 7 revealed that 12 (6 female and 6 male) physics students representing 15.0 percent of the total sample size had correct conception of the formation of partial solar eclipse. 36 (4 female and 32 male) physics students representing 45.0 percent of the total sample size had misconception about the formation of the partial eclipse, while 26 (4 female and 22 male) students representing 32.5 percent had wrong conception about the formation of partial solar eclipse, and 6 (2 female and 4 male) students representing 7.5 percent of the total sample size were not sure and confident of their responses.

Table 9: Conception of Partial Solar Eclipse Formation based on Gender

		Correct Conce-ption	Miscon-ception	Wrong Concep-tion	Guess Answer	Total
Gender	Female	6	4	4	2	16
	Male	6	32	22	4	64
Total		**12**	**36**	**26**	**6**	**80**

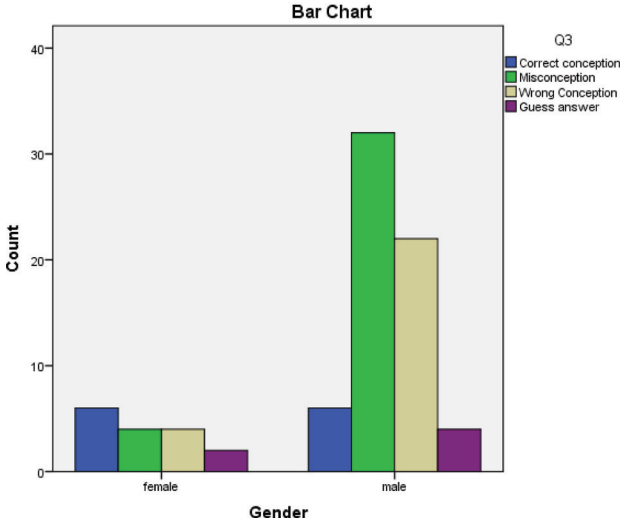

Figure 7: Conception of Partial Solar Eclipse Formation based on Gender

The results in Table 10 and Figure 8 revealed that 12 (2 female and 10 male) physics students, representing 15.0% of the total sample size, had correct conceptions of the formation of a lunar solar eclipse. Forty-two (10 female and 32 male) physics students, representing 52.5% of the total sample size, had misconceptions about the formation of the lunar solar eclipse, while 26 (4 female and 22 male) students, representing 32.5%,

had wrong conceptions about the formation of the lunar solar eclipse.

Table 10: Conception of Lunar Solar Eclipse Formation based on Gender

		Correct Conception	Misconception	Wrong Conception	Total
Gender	**Female**	2	10	4	16
	Male	10	32	22	64
Total		**12**	**42**	**26**	**80**

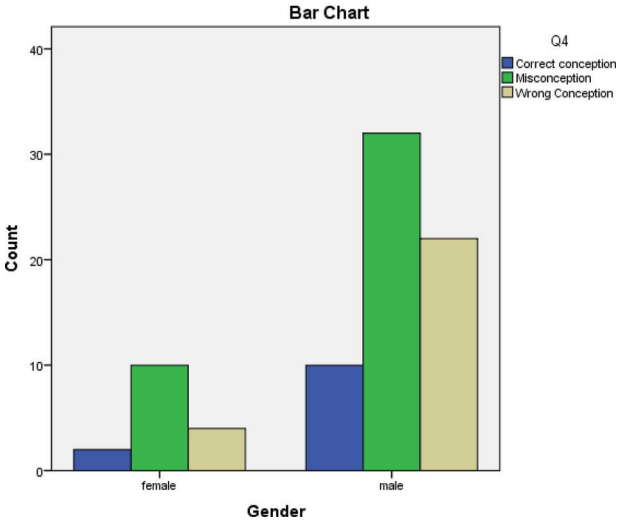

Figure 8: Conception of Lunar Solar Eclipse Formation based on Gender

4. Discussion

This study explores undergraduate physics students' knowledge of the scientific explanation behind the formation of total, annular, partial, and lunar eclipses. The study employed a three-tier diagnostic test that was self-developed by the researchers and validated by experts in physics and astronomy.

Research question one focused on the undergraduates correct conceptions and misconceptions of the scientific explanation of the formation of total, annular, partial, and lunar eclipses. The results in Tables 3 to 6 indicated that 20, 10, 12, and 12 undergraduate physics students had correct conceptions of the scientific explanation of the formation of total, annular, partial, and lunar eclipses respectively, while 42, 40, 36, and 42 undergraduate physics students had misconceptions of total, annular, partial, and lunar eclipse scientific explanations of their formations.

Research question two examined the gender difference in undergraduate physics students' understanding of the scientific explanation of eclipse formation. Six female and fourteen male undergraduate physics students had corrected conceptions of the total solar eclipse's scientific explanation, while four female and thirty-eight male students had misconceptions. Four female and six male undergraduate physics students had corrected conceptions of the scientific explanation of annular eclipse formation, while eight female and thirty-two male students had misconceptions. Six female and six male undergraduate physics students had corrected conceptions of the scientific explanation of partial solar eclipse formation, while four female and thirty-two male undergraduate physics students had misconceptions. Two female and ten male undergraduate physics students had corrected conceptions of the scientific explanation of lunar eclipse formation, while ten female and thirty-two male undergraduate physics students had misconceptions.

The findings of this study are in line with Semercioglu and Kalkan (2021), who concluded that 24 science teachers were able to answer questions on the formation of the lunar eclipse. The study further revealed that five science teachers were able to answer questions correctly on the formation of an eclipse in the presence of a full moon. Furthermore, the results indicated that science teachers have general knowledge about the alignment of the sun, earth, and moon required for a lunar eclipse to occur. The results of the study conducted by Kiroglu *et al.* (2019) revealed that respondents had a low understanding of lunar eclipse rotation prior to exposure to learning instruction designed to remediate their low knowledge.

5. Conclusion

The study was carried out to ascertain university physics students' understanding and scientific explanation of the natural astronomical phenomenon eclipse. The study adopted a three-tier diagnostic test to determine respondents' levels of correct conception, misconception, wrong conception, and guess answers. The results shown in the tables above revealed that most undergraduate physics students had misconceptions about the scientific explanation of the formation of total, annular, partial, and lunar eclipses. The results also revealed that male physics students had better

knowledge of eclipse formation's scientific explanation compared to their female counterparts, although their population was not equal.

6. Recommendation

Based on the findings above, the study recommends that students should be exposed to the importance of studying natural events and astronomical phenomena that are periodical. The study also recommends that this type of research should be replicated at other levels of education.

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Authorship Contribution

All authors contributed equally to the study's design, analysis, and manuscript preparation. All approved the final version.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Declarations

The authors declare that this work is original, has not been published or submitted elsewhere, and adheres to ethical research standards. All authors significantly contributed to the research and preparation of the manuscript, approved the final version, and confirmed that there are no conflicts of interest. Proper acknowledgment has been given to all sources and support.

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