Enhancing conceptual understanding via Diffraction Grating Innovative Media (DIAGRAM)

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Abstract. Diffraction grating innovative media (DIAGRAM) is a physics experimental tool that can be implemented in the learning of diffraction grating material. This research endeavored to analyse students’ conceptual understanding on diffraction grating material after using the diffraction grating innovative media (DIAGRAM). Pre-experimental design was used as the method in this research with one-group pretest-posttest as the design and 10 female students and 1 male students from three schools in Indonesia which are in Banjaran, Pamarayan and Makassar participated. Starting from interpretation test using multiple choices test consisting of 8 questions and using google form, the stage then carried out learning activity utilizing the DIAGRAM and given a posttest in the end of the class. At the last data had been analysed by N-Gain. The come about of this consider were gotten by students’ increment in high category which is 0.73. To sum up, diffraction grating innovative media (DIAGRAM) can make enhancement of senior high school students’ conceptual understanding in diffraction grating material.

1. Introduction

Media is one of the ways of teachers to support learning process, enhance motivation and enjoyment of students [1,2,3,4,5,6,7,8]. Some media are integrated by technology and becoming expertise of pedagogic [9]. Actually, there are many type of media that can be used by teacher in the class, one of which is experimental tool. This tool leads students to opportunity to have an active role in learning both in demonstrations and experiments in the laboratory [10]. Moreover, students also can be more independence learning and enhance conceptual understanding by doing learning activity supported by experimental tool [11,12,13,14,15,16,17,18].

Furthermore, one of the foremost common themes in physics material at senior high school is diffraction [17,18]. Diffraction is the phenomena when wave encounters an obstacle or opening. In the teaching process about diffraction, to be able to see the appearance of diffraction, a grating must be used which will later become a light disturbance that creates a regular pattern of dark and light [19,20,21,22]. Simple grating can be made from plastic bags and other materials [23,24]. However, Students mostly do not understand the application in existence of diffraction grating being their physics material at senior high school [16] and the acknowledgment of typical diffraction patterns could be a troublesome understanding for understudies [25].

To solve those problems, students' understanding of diffraction grating material should be improved by experimenting in class [26]. Diffraction grating innovative media (DIAGRAM) is the solution. This experimental tool aims to support students and teachers to understand diffraction materials not only for determining the spot of light resulting by grating, but also index bias of the medium such as water, air and oil. Here is a figure of DIAGRAM when it is running.
Figure 1. The laser ray passes the grating and generates some spots of the light which have a distance.

The figure 1 shows that ray from laser passes the diffraction grating and generates some spot of the rays on the wall. The spots have a distance each other due to a diffraction grating that ray passes. This media can be used to a range of the spots not only in the air but also in the water or oil. Hence, it will be useful for teaching and learning about integration of diffraction grating and index bias concept. The fundamental concept of diffraction is:

\[ y = L \times N \times m \times \lambda \]  \hspace{1cm} (1)

The space of the light spot pattern is symbolled by \( y \), space of grating to screen is \( L \) and \( N \) is number of slits. \( \lambda \) as symbol of wavelength is the wave of laser ray used, then \( m \) is order of spot light. For example, when the student calculate the second of the ray spotted on screen, so the order (\( m \)) will be 2. This formula is a concept of diffraction by using air as a medium, then the media experiment also gives the opportunity to students to find new formula related to various medium such as water and oil.

\[ y = L \times N \times m \times \frac{n_1}{n_2} \lambda \]  \hspace{1cm} (2)

The new subject comes into \( n \) as the index bias of medium. Water, air and oil, for instance, have a different index bias each other. The diffraction grating innovative media (DIAGRAM) aims to pursue the fully understanding of diffraction concept by students. But it should be known extent to which students are having improvement. Thus, the aim of this research is to conduct a study measuring conceptual understanding of students by utilizing the DIAGRAM experimental tool in diffraction material. Hence, the framework of the research is below.
2. Method

2.1. Participant
Subjects are students who have not received diffraction material in physics subject. Participants in this study were 11 students consisted of 10 females and 1 male and studying at 3 different schools which are in Banjaran, Pamarayan and Makassar.

2.2. Research design
The purpose of the present study is to investigate the conceptual understanding of students after studying via diffraction grating innovative media (DIAGRAM). This study uses the embedded experimental model research design with a mixed method research approach.

Pretest and posttest would be analyzed to investigate changing of understanding of diffraction concept. Treatment is the teaching learning of diffraction material by using Diffraction grating innovative media (DIAGRAM).

2.3. Instrument
The instruments used are eight multiple choice questions. All questions are put in google form and the participants can directly answer in the form provided. The score of each question is 1 and the maximum score is 8. Here is the sample of the test.
2.4. Data Analysis

The statistical tools used for data analysis in the study is t-test statistic which aimed to test about there is or not a difference in mean between pretest and posttest. If t-test is smaller than t-table, there will have a difference in mean between pretest and posttest. Then, N-gain was used to assume an effect of treatment. The math formula of Gain.

\[ G = \text{posttest score} - \text{pretest score} \]  

Then, data should be calculated to get N-Gain (Normalization Gain) by comparing Gain gotten by student and score maximum by using this formula:

\[ \langle g \rangle = \frac{S_{\text{post}} - S_{\text{pre}}}{S_{\text{max}} - S_{\text{pre}}} \]  

The last analysis is interpretation of N-gain average by using Table 1.

### Table 1. Interpretation of N-gain average

| Nilai \( \langle g \rangle \) | Kategori   |
|-----------------------------|------------|
| 0.00 \(<\langle g \rangle \leq 0.30\) | Low        |
| 0.30 \(<\langle g \rangle \leq 0.70\) | Moderate   |
| 0.70 \(<\langle g \rangle \leq 1.00\) | High       |

3. Result and Discussion

3.1. The increase of students’ conceptual understanding score

In this article, an increase in the score of students’ understanding of diffraction concept is discussed. Table 2 shows descriptive data understanding the concepts of diffraction.

### Table 2. Descriptive statistics of students’ conceptual understanding score of diffraction

|               | Pretest | Posttest |
|---------------|---------|----------|
| Min           | 12.5    | 25       |
| Max           | 62.5    | 87.5     |
| Mean          | 32.95   | 54.54    |
| Std. Dev      | 18.76   | 19.58    |
Based on Table 2, it can be said that the score for the students’ pretest-posttest conceptual understanding has increased. The average of conceptual understanding score increased from 32.95 to 54.54. In addition, the minimum and maximum scores of student scores also increased. But this needs to be tested statistically. To test the differences between the pretest-posttest scores, a paired sample t test was used. Before using the statistical test, it is first confirmed that the data normally distributed. Based on the descriptive statistics table, the L-test was smaller than L table so it can be said that the data is normally distributed, therefore the t-test can be used. The results of the paired sample t test are shown in Table 3.

### Table 3. Paired Samples Test

| Paired Differences | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | t | df | Sig. (2-tailed) |
|--------------------|------|----------------|-----------------|------------------------------------------|---|----|----------------|
| PRETEST - POSTTEST | -134.09091 | 394.53655 | 118.95725 | -399.14417 - 130.96235 | -1.127 | 10 | .286 |

The results of the paired sample t test as shown in Table 3 show that $t = -1.127$ and $\text{sig. (2-tailed)} = 0.286$ so it can be concluded that there is a significant difference between the pretest score and the posttest score. $\text{Ngain}$ and $\text{d-effect size}$ are used to see the increase due to the implementation of diffraction grating innovative media (DIAGRAM). Based on the results of the analysis obtained $\text{Ngain} = 0.73$. This value shows that there is a strong influence on the implementation of diffraction grating innovative media (DIAGRAM) in improving understanding of the concept diffraction.

The result also has supported the previous study which has been researched by Ana Susac et al. with the research title “Effect of students’ investigative experiments on students’ recognition of interference and diffraction patterns: An eye-tracking study”. The study found that students’ acknowledgment interference and diffraction designs can be made strides by presenting hands-on investigative tests within the classroom.

### 3.2. Students’ responses for learning via diffraction grating innovative media (DIAGRAM)

The responses from students after learning diffraction concept using diffraction grating innovative media (DIAGRAM) is shown in Table 4.

### Table 4. The tabulation of student responses to the diffraction grating innovative media (DIAGRAM)

| Aspects     | Absolutely agree | Agree | Disagree | Absolutely disagree |
|-------------|------------------|-------|----------|---------------------|
| Media display | 2.66             | 6     | 2        | 0                   |
| Convenience | 2                | 7.14  | 1.8      | 0                   |
| Motivation  | 2.6              | 6     | 2.4      | 0                   |
| Efficiency  | 2.66             | 5.33  | 2.66     | 0.33                |
| Total average | 2.38           | 6.33  | 2.16     | 0.05                |
were almost 3 people who stated that it was absolutely agree for those positive aspects. Moreover, convenience aspect had been a number one for students stating agree comparing to others even the absolutely agree, it was at 7.14. However, for the efficiency one, it took 0.33 average student said absolutely disagree. The result of students’ responses for diffraction concept using diffraction grating innovative media (DIAGRAM) is strongly good.

The result of understanding concept and responses from students towards diffraction grating innovative media (DIAGRAM) can be concluded that this media is very good to be applied in school. Other innovations study also support or even a combine with this finding. For instance a learning model from Suyidno [27] called Creative Responsibility Based Teaching (CRBT). As a need of 21 century, students need an improvement not only for conceptual understanding in physics but also a scientific creative which can be added by using this model. Hence both DIAGRAM and CRBT are the combination in teaching and learning that can be investigated in the further study.

4. Conclusion
Based on the results of research that has been done, seen in each score obtained, only four scores are in low category. While five participants gained moderate category of interpretation. This result indicates that Diffraction grating innovative media (DIAGRAM) supposed to enhance the conceptual understanding of students in diffraction material.

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