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COMPARATIVE ANALYSIS OF DIFFRACTION GRATING ON A HAIR AND A BROOM AS AN ALTERNATIVE EXPERIMENT IN SCHOOL

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Abstract. *Laboratory experiments in schools often face challenges, including inadequate teacher training, limited equipment and materials, and dense teaching content. This research proposes an alternative approach by using readily available materials in the school environment. In the diffraction experiment, banana leaf stems were replaced by coconut fiber and a strand of hair as experimental media. Fraunhofer diffraction, the bending of waves behind a narrow slit, became the focus of this experiment. The primary objectives were to understand the process of diffraction grating, measure the differences in spreading between a strand of hair and coconut fiber, and analyze the variables involved. The experimental data showed that a strand of hair had the farthest distance to the central bright spot with an average of 1.23 meters. While successfully creating a diffraction grating pattern using makeshift tools and materials, the difficulty in measuring the distance between bright spots highlighted a critical note for future improvements. In conclusion, this experiment provides new insights into light diffraction using resources available in the school environment. However, further research expansion and improved measurement accuracy should be the focus to support the development of more effective laboratory methods in overcoming facility limitations in the school environment.*
Keywords*: A Broom Fiber, A Stand of Hair, Diffraction, Grating*

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Abstrak. Eksperimen laboratorium di sekolah sering menghadapi tantangan, termasuk pelatihan guru yang tidak memadai, peralatan dan bahan yang terbatas, dan konten pengajaran yang padat. Penelitian ini mengusulkan pendekatan alternatif dengan menggunakan bahan-bahan yang mudah ditemukan di lingkungan sekolah. Dalam eksperimen difraksi, batang daun pisang diganti dengan serat kelapa dan sehelai rambut sebagai media eksperimen. Difraksi Fraunhofer, pembelokan gelombang di belakang celah sempit, menjadi fokus dari eksperimen ini. Tujuan utama adalah untuk memahami proses kisi difraksi, mengukur perbedaan penyebaran antara sehelai rambut dan serat kelapa, dan menganalisis variabel-variabel yang terlibat. Data eksperimen menunjukkan bahwa sehelai rambut memiliki jarak terjauh ke titik terang pusat dengan rata-rata 1,23 meter. Meskipun berhasil membuat pola kisi difraksi dengan menggunakan alat dan bahan darurat, kesulitan dalam mengukur jarak antara titik-titik terang menyoroti catatan penting untuk perbaikan di masa depan. Kesimpulannya, eksperimen ini memberikan wawasan baru tentang difraksi cahaya dengan menggunakan sumber daya yang tersedia di lingkungan sekolah. Namun, perluasan penelitian lebih lanjut dan peningkatan akurasi pengukuran harus menjadi fokus untuk mendukung pengembangan metode laboratorium yang lebih efektif dalam mengatasi keterbatasan fasilitas di lingkungan sekolah.
Kata kunci: Difraksi, Kisi, Sehelai Rambut, Serat Sapu

BACKGROUND

Some of the obstacles to the implementation 1) Low training for teachers, 2) Inadequate equipment and materials, 3) Overloaded curriculum, and so on (Yennita et al., 2012). The lack of laboratory equipment in many schools has prompted the idea of conducting experiments using easily available equipment (Gunawan et al., 2015) (Rahman et al., 2015). One of the phenomena observed is diffraction, which occurs when waves bend or spread through a narrow slit (Suwarna, 2010) (Hastiani & Toifur, 2014). Based on the research that has been done by previous researchers, banana leaf sheaths were used as experimental media but they were less effective, because there are cavities in the banana leaf sheaths that when exposed to water will cause the observed pattern to be unclear. Therefore, other objects such as broom fibers and a strand of hair were used to overcome this problem (Mutiarani et al., 2021).

THEORETICAL FRAMEWORK

A narrow slit with many numbers is interpreted as a grating (Ariani & Saparini, 2015). Diffraction is defined as the bending of waves behind an obstacle that produces a "shadow area" (Santosa, 2012) (Datangeji et al., 2019). There are two types of light diffraction, namely: Fraunhofer diffraction and Fresnel diffraction (Rosyidah et al., 2008). Fraunhofer diffraction occurs when the light source and screen are placed at a

distance from the slit, meaning that the incoming-outgoing light beams must be parallel to the direction of propagation. Fresnel diffraction occurs when the source-slit and slit-screen distances are close, meaning that the light beams do not have to be parallel and the slit is not narrow. If we look at the experiment we did, it belongs to the type of Fraunhofer diffraction (Al Kahfi & Yanuarief, 2019) (Sarojo, 2011).

There are two types of light diffraction, namely Fraunhofer diffraction and Fresnel diffraction. Fraunhofer diffraction occurs when the light source and screen are placed at a distance from the slit, meaning that the incoming-outgoing light beams must be parallel to the direction of propagation (Qadar et al., 2019). Fresnel diffraction occurs when the source-slit and slit-screen distances are close, meaning that the light beams do not have to be parallel and the slit is not narrow. If we look at the experiment we did, it belongs to the type of Fraunhofer diffraction (Untung, 2014). This experiment aims to achieve a number of objectives, such as understanding the process of grating diffraction, measuring the difference in grating diffraction spread between a strand of hair and a broom fiber, and analyzing various variables involved in the experiment (Sarah Mursida et al., 2020).

METHOD

This research is a quantitative experimental study that uses data from the light scattering patterns. The method used in this research is to observe the diffraction of light that passes through objects shaped like fibers with different types, such as using a strand of hair and broom fibers (palm and plastic) with a light source from a green laser pointer 303 and the cross-section of the object is made of cardboard that is shaped rectangular. The data obtained are the distance from the laser to the grating and the distance from the grating to the central bright spot for each object. The tools and materials, circuit scheme, and experimental steps are shown in Figure 1, Figure 2, and Figure 3 respectively.

This experiment aims to observe the scattering of light that passes through objects shaped like fibers. The tools and materials used are cardboard, cutter, plastic, double tape, hair, broom fibers, laser pointer, two tripods, and meter. The cardboard is cut into a rectangular cross-section with an outer size of 10 x 7.5 cm and an inner size of 7 x 5 cm. The object to be observed is wrapped in plastic and attached to the cross-section using double tape. The cross-section of the object is mounted on the second tripod, while the laser pointer is mounted on the first tripod. Both tripods are aligned and face the white

wall that serves as a screen. The laser is turned on and directed right at the object. The light that passes through the object will spread on the white wall, and this light scattering is observed. The distance between the object and the central bright spot and the distance between the laser and the object are measured using a meter. The experiment is done three times with different objects, namely hair, palm fiber broom, and plastic broom.

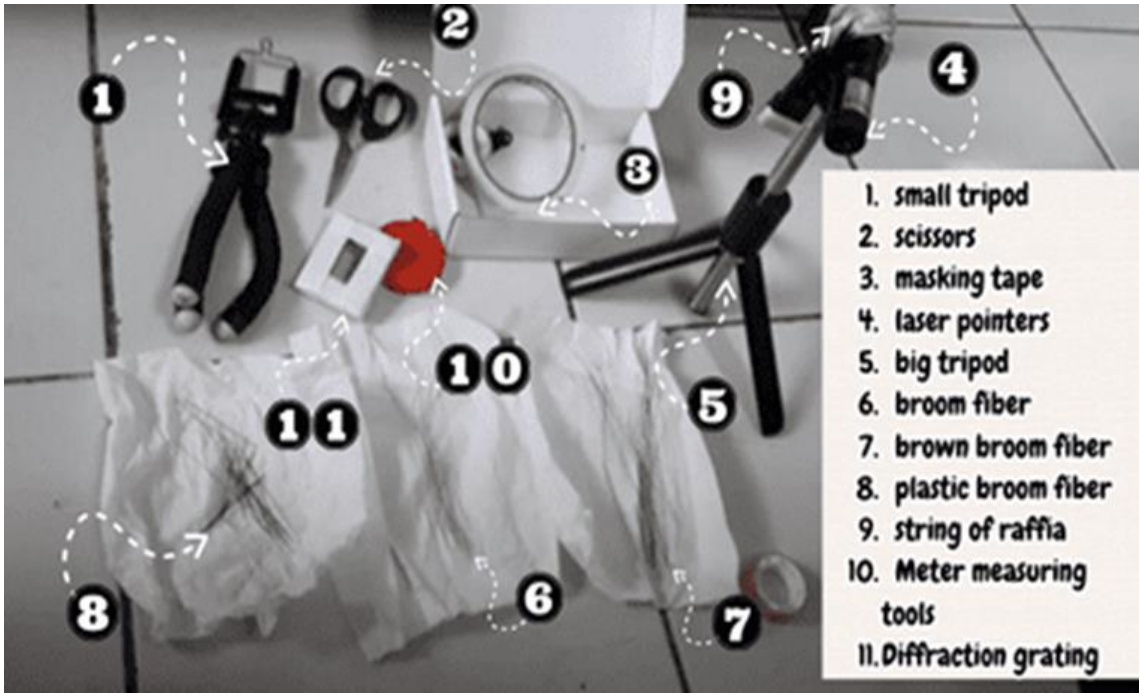

Figure 1. Tools and Materials

Photo Source: Documentation During the Experiment

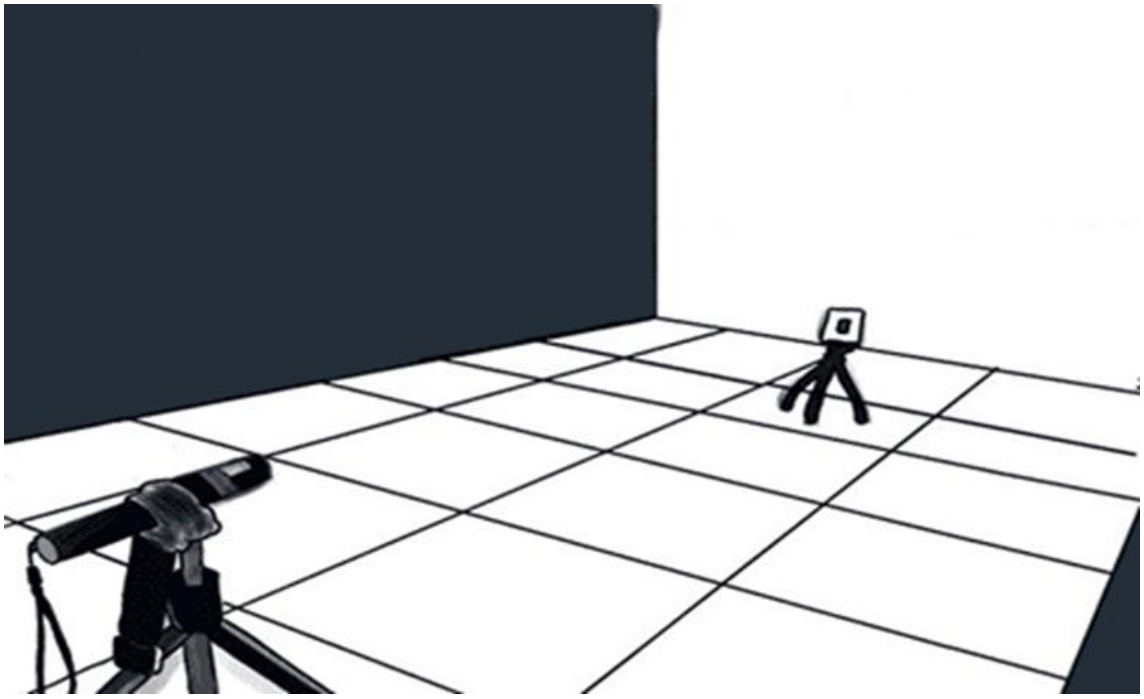

Figure 2. Schematic of the Experiment Series

Image source: self-made

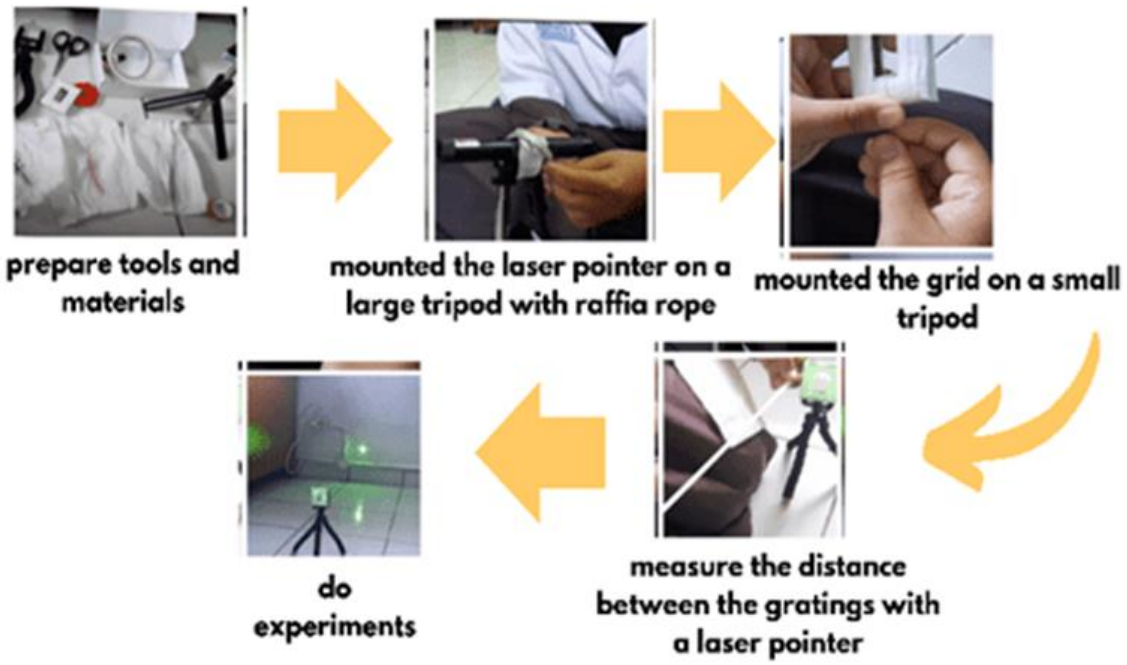

Figure 3. Experimental Steps

Photo Source: Documentation During the Experiment

RESULTS AND DISCUSSION

Some constraints in the implementation of experiments in schools, such as low training for teachers, limited availability of tools and materials, and dense teaching materials, have been a major concern (Yennita et al., 2012). As a solution, experiments using equipment that can be easily found around the school become an alternative to overcome these limitations (Rahman et al., 2015). In this context, the phenomenon of diffraction becomes the focus of the experiment, where waves experience bending or spreading when passing through a narrow slit (Suwarna, 2010). Previous studies have tried to use banana leaves as an experimental medium, but their effectiveness is limited due to the presence of cavities that can affect the observation results(Mutiarani et al., 2021). Therefore, this study tries to use other objects, such as broom fibers and a strand of hair, as a substitute for banana leaves.

A narrow slit in the context of diffraction is interpreted as a grating, which can produce a shadow pattern behind the barrier (Santosa, 2012). There are two types of light diffraction: Fraunhofer and Fresnel (Rosyidah et al., 2008). Fraunhofer diffraction occurs when the light source and the screen are placed far from the slit, so that the light beams enter and exit parallel to the direction of propagation. In this experiment, it can be concluded that the type of diffraction that occurs is Fraunhofer diffraction (Sarojo, 2011).

This experiment has main objectives, such as understanding the process of grating diffraction, measuring the difference in spreading between a strand of hair and broom fibers, and analyzing the variables involved in the experiment (Sarah Mursida et al., 2020). Based on the experimental results, it was found that the distance from the grating to the farthest bright center point was on a strand of hair with an average distance of 1.23 m. Based on the comparison with previous studies that used banana pseudostem, this device successfully obtained a better diffraction pattern because it was not obstructed by water. Although it succeeded in obtaining a grating diffraction pattern using tools and materials that can be easily found around the school, it is difficult to measure the distance between the bright center and other points due to the inaccuracy of the objects used. The data should have been analyzed using the diffraction grating formula to calculate the diameter of the object and obtained the data of the distance between the laser to the central bright spot and the distance between the central bright spot and the other bright spots. Because the distance between one point and another was too close, the researcher could

not measure it so they only analyzed based on the scattering results only. This needs to be a consideration for further research to find more appropriate objects to improve the accuracy of measurement results.

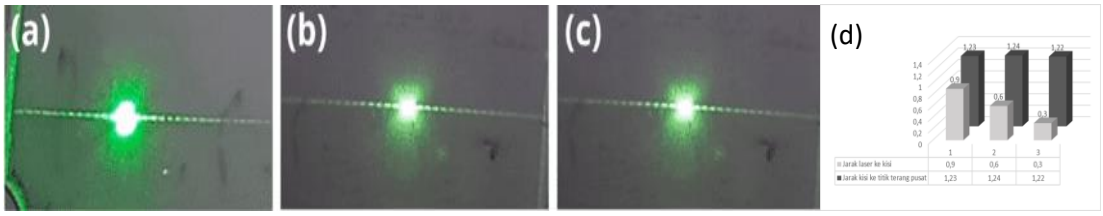

Figure 4. (a-c) Image of Diffraction Pattern Results (d) Diagram of Results Based on Three Experiment (The Data: Distance from Laser to Grating and Distance from Grating to Central Bright Spot) with a Hair Object

Photo Source: Documentation During the Experiment

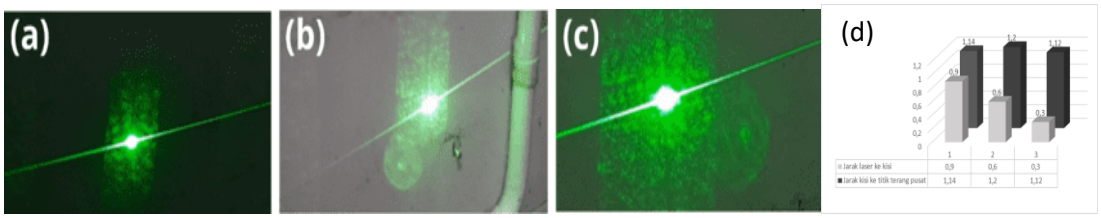

Figure 5. (a-c) Image of Diffraction Pattern Results (d) Diagram of Results Based on Three Experiment (The Data: Distance from Laser to Grating and Distance from Grating to Central Bright Spot) with a Broom Palm Fiber Broom Object

Photo Source: Documentation During the Experiment

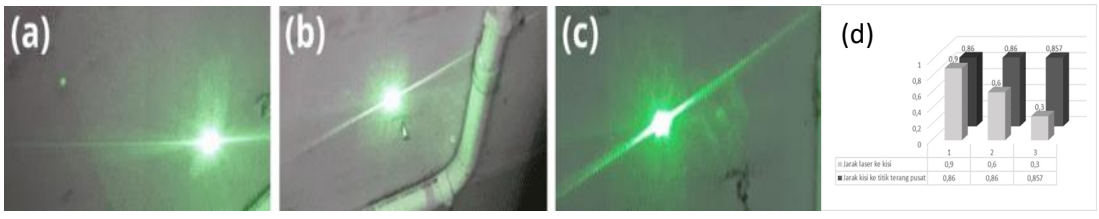

Figure 6. (a-c) Image of Diffraction Pattern Results (d) Diagram of Results Based on Three Experiment (The Data: Distance from Laser to Grating and Distance from Grating to Central Bright Spot) with a Plastic Broom Object

Photo Source: Documentation During the Experiment

CONCLUSION AND ADVICE

In an effort to overcome the limitations of laboratory equipment in schools, an experiment on diffraction using broom fibers and a strand of hair as substitutes for banana leaves has been conducted. The experimental results indicate the occurrence of Fraunhofer diffraction, where the farthest distance from the grating to the central bright spot is a hair strand with an average distance of 1.23 meters. Although the experiment successfully generated diffraction grating patterns using readily available tools and materials, the challenge of measuring the distance between bright spots necessitates a reevaluation of the experimental setup. This consideration is crucial for further research aimed at improving measurement accuracy and enhancing the overall quality of the experiment. Additionally, ensure that the experiment is conducted in a dark environment, and the observation area is free from distractions (no other objects) to ensure clearer observation results. These conclusions can serve as a basis for the development of more effective and accurate laboratory methods in schools with limited facilities.

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