LEARNING MEDIA SIMULATION OF SIGNAL PROCESSING USING JAVASCRIPT PROGRAMMING LANGUAGE AS ALTERNATIVE TO DISTANCE LEARNING

APRENDIENDO LA SIMULACIÓN EN LOS MEDIOS DEL PROCESAMIENTO DE SEÑALES USANDO LA PROGRAMACIÓN EN EL LENGUAJE JAVASCRIPT COMO UNA ALTERNATIVA DE LA ENSEÑANZA A DISTANCIA

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The main objective of this research is to create a signal processing simulation using Javascript programming language on acoustic waves. Signal processing uses Fourier Transform to convert signals from the time domain to the frequency domain. Acoustic wave samples were obtained from a Javanese musical instrument called Gamelan. Acoustic wave signals from Gamelan are chosen because there is still little research on Gamelan signal processing. This research has successfully created a simulation using Javascript programming language. The simulation can show the waveform in function of time and its wave spectrum. The convenience of this tools for distant learning is substantiated.

El objetivo principal de esta investigación es crear una simulación de procesamiento de señales usando el lenguaje de programación Javascript. El procesamiento de señales usa la transformada de Fourier para convertir señales del dominio del tiempo al dominio de la frecuencia. Se obtuvieron muestras de señales acústicas de un instrumento musical típico de Java llamado Gamelan. Se escogieron las señales acústicas del Gamelan porque aún existe poca investigación en su procesamiento. Hemos logrado crear una simulación usando el lenguaje de programación Javascript. La simulación es capaz de mostrar la forma de onda en el tiempo, y si espectro. Se argumenta la conveniencia de esta herramienta para la enseñanza a distancia.

PACS: Physics education (enseñanza de la física), 01.40.-d; Physics teaching methods (métodos de enseñanza de la fisica), 01.40.gb; Educational aids (ayudas educativas), 01.50.–i; Computers in experimental physics (computadores en física experimental), 05.07.-t; Simulation (simulacion), 52.65.-y; Audiovisual means (medios audiovisuales), 01.50.F-; Use of computers in physics education (uso de computadoras en la enseñanza de Física) 01.50.ht; Using computers in the laboratory (uso de computadoras en el laboratorio), 01.50.Lc.

I. INTRODUCTION

The study of acoustic waves is a classic problem that is often discussed in physics textbooks at university. Almost every physics laboratory at the undergraduate level includes acoustic wave experiments. For some students, acoustic waves are one of the most difficult materials because they are classified as abstract so that learning is needed through direct observation and investigation [1]. This is due to the understanding of science, especially physics, based on giving meaning to abstract or intangible material [2]. In recent years, the benefits of technology in the science learning process have been widely practiced [3–9]. This shows that in the 21st century the use of technology is increasingly important. The use of technology in learning includes animated videos, programming simulations, and similar technological tools [2].

21st century skills require students to master the use of technology to face global competition. The 21st century skills that must be mastered include information and communications technology literacy, contextual learning skills, information and media literacy skills [10]. Technology has been widely used to assist the learning process, one of which is to help students know the relationship between theory and experiment [9]. However, technology is actually not to replace the role of teachers because education is not only to make them academically smart but also have character [11].

One of the important things in learning is achieving learning objectives. Many learning models can be chosen in the classroom, but not all learning models are applied according to the characteristics of the material and students [5]. This is in accordance with previous researchers' statements that no learning model is suitable for all concepts, therefore the model must be adjusted to the material being taught [5,12,13]. One of the models, namely simulation, will be used in this study. This simulation-based learning media research is only limited to

acoustic wave material. Simulation is used in research because it has many advantages including being able to facilitate students to learn independently so that positive cognitive changes occur [6,14,15].

The use of simulation media has been widely used by previous researchers. Research conducted by [16] showed that simulation media had a positive influence on school students. The application of simulation media has advantages and attractiveness to foster active learning in school students. However, it has disadvantages such as limited multimedia space in secondary schools [16]. The application of virtual simulations was also carried out by [17] in distance learning during Covid-19. The results of the research analysis showed that the learning outcomes and motivation of students showed a significant increase. The results of this study indicate that virtual simulation media can be used as an alternative to the limitations of teaching aids for practicum. This is also in accordance with the findings of [18] who revealed that the experimental group in his research through computer simulation was more successful than the control group conducted face-to-face. In addition, research conducted by [19] showed that PheT-based simulation media can be used to provide students with an understanding of the general form of waves. Increased student understanding occurs due to interactive discussions between lecturers and students. However, the Phet-based simulation only determines the general shape of the propagating wave, not yet using the Fourier Transformation to see the spectrum. The creation of Phet-based simulations also uses the Javascript programming language. This shows that the use of simulation has an important role in the learning process.

Simulation-based media research on acoustic wave material will use waves with Gamelan sound sources. Gamelan is one of the Indonesian artworks with a distinctive sound. Gamelan is a result of art that can be used as a medium for learning physics, namely on acoustic wave material. Javanese Gamelan research has been used by several researchers, one of which investigates the frequency of gamelan measured using Audacity software [20]. Gamelan sounds have also been analyzed for their frequency values using Visual Analyser software [21]. Previous research shows that Gamelan sound processing has been done using several software, but no one has used the Javascript programming language.

This research will use Javascript programming language to to create signal processing simulations on acoustic waves. Research using Javascript programming language for Gamelan acoustic wave processing has never been done by previous researchers, which constitutes a novelty in this research. This is a novelty in research. Javascript programming language is usually only used in making websites [22]. The Javascript programming language was chosen by researchers because users do not need to buy software because access can easily use existing browsers. Therefore, this research aims to create a simulation using Javascript programming language on gamelan acoustic waves.

II. METHODS

We aim at producing simulation media using Javascript. The development uses Borg & Gall's Research and Development (R&D) development steps which consist of 10 stages. However, in this study only up to stage 3, namely product design development. Systematically the flow of development research is as follows (1) preliminary study (research and information collecting), (2) planning, (3) product design development (developing preliminary form of product), (4) limited trial (preliminary field testing), (5) main product revision, (6) wider trial (main field testing), (7) operational product revision (operational product revision), (8) final product trial (operational field testing), (9) final product revision, and (10) dissemination and implementation. The following R&D model can be seen in Fig. 1 below.

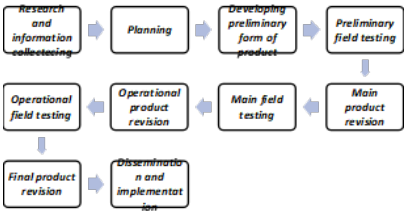

Figure 1. Research Flow Chart.

Research and Information Collection

This first step includes a needs analysis, as well as a literature study.

Planning

Developing a research plan, including the skills needed in conducting the research, formulating the objectives to be achieved by the research, design or research steps.

Developing Preliminary Form of Product

This step includes determining the design of the product to be developed (hypothetical design), determining the research facilities and infrastructure needed during the research and development process. At this stage, researchers began designing simulation media and supporting components in the preparation of learning media.

Preliminary Field Testing

The field trial stage is an activity to conduct a validation stage on the draft product developed.

Main Product Revision

This step is a product improvement based on the test of suggestions and advice from experts which aims to improve the developed product.

Main Field Testing

At this stage the activity carried out is a field trial conducted on students.

Operational Product Revision

This step is a product improvement on the results of the field test based on input and the results of the main field test.

Operational Field Testing

Products that have been revised based on input and suggestions at the small-scale test stage are then tested to test the experimental and control classes.

Final Product Revision

Product refinement of field implementation test results is the final revision of simulation media.

Dissemination and Implementation

The last step in the process of developing this learning model is dissemination to the community by socializing the product in the form of dissemination or online through the web or research seminars and journal publications.

III. RESULTS AND DISCUSSION

Research and Information Collection

This first step includes needs analysis, as well as literature studies. The needs analysis begins with several criteria including the product being developed is important for the world of education, product development is possible to be developed, literature study. The literature study is aimed at collecting research findings and other information related to the planned product.

Planning

After conducting a preliminary study, then plan the research. Planning includes: formulating the purpose of the research, formulating the form of participation in the research.

Developing Preliminary Form of Product

Simulation Creation Process

This research uses a simulation using the Javascript programming language as shown in Figure 2. This research uses Fourier Transform analysis on the signal. Fourier Transform was chosen because it has been successfully used by many researchers with satisfactory results [23–25].

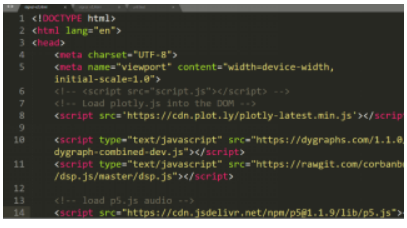

Figure 2. Javascript Coding.

Fig. 2 shows the coding for making simulations using Sublime Text software. Coding in Fig. 2 starts with creating HTML, HTML starts with an opening tag <> and ends with a closing tag < / >. In general, HTML is a framework while Javascript is a programming language. HTML contains head and body. The head section contains <title> and the source that will be used in making simulations. In this study using several plugins including unpkg.com and cdnjs.cloudflare.com. The next step is between the opening tag <body> and the closing tag < /body> signal processing coding is made. First create a heading with the script <h4> Select an WAV File< /h4>. Then to create the input file, write the script ¡input type=”file” id=”file-input”/¿ with the file extension .wav or audio with the script <audio id=”audio”><source id=”source” src=”” type=”audio/wav” / >< /audio>. Before being transformed, a windowing process is carried out first in order to reduce noise. Next, the Fast Fourier Transform is used to transform the signal from the time domain to the frequency domain.

Stages of signal processing using simulation

The first stage is recording the Gamelan sound. The gamelan used in signal processing is owned by one of the craftsmen in the Panggungharjo area, Sewon, Bantul. After getting the gamelan sound recording convert the Gamelan signal file into a .wav or audio extension. Next, enter the file in the software by clicking browse. Then a signal display of the Gamelan sound in the time domain and its spectrum in the frequency domain will appear as shown in Fig. 3.

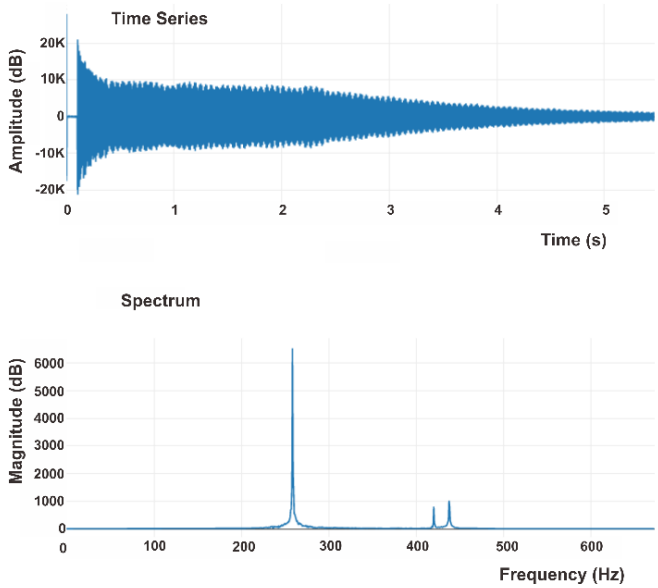

Figure 3. Signal Processing Results Using Javascript Programming Language.

In Fig. 3, the signal is first obtained in the time domain after which it is processed using a windowing process. There are various types of windowing functions such as Rectangular window, Hanning window, Hamming window, and Gaussian. In this research, rectangular window is used. After that, the FFT (Fast Fourier Transform) process is performed on each window. From each window then averaged and get the spectrum of the signal processing.

By using the Fourier Transform, the signal is obtained from the time domain (time series) changing to the frequency domain or what we often refer to as the spectrum. The flowchart of

signal processing is further explained in Fig. 4.

Figure 4. Signal processing flow chart.

There are 3 types of Gamelan basic materials namely Iron, Brass, and Bronze. According to the results of an interview with one of the Gamelan craftsmen, among the three types of basic materials, the best is Bronze. Bronze has a longer tone than other types, so this type is the most in demand. The composition of making a bronze Gamelan is 3 kg of white tin and 10 kg of copper. The material is then melted together to be used as a Gamelan instrument. In this study, a small gong sound recording called Bende was used. Bende display is shown in Fig. 5. Sound recording was done 3 times to get accurate results.

Figure 5. Bronze Material Type Bende.

The first stage carried out in this study was the recording of the bende which was measured 3 times. However, this research was carried out recording when it was raining so it was possible that the sound of rain was also included in the recording. Bende recording results on software created using Javascript are shown in Fig. 6.

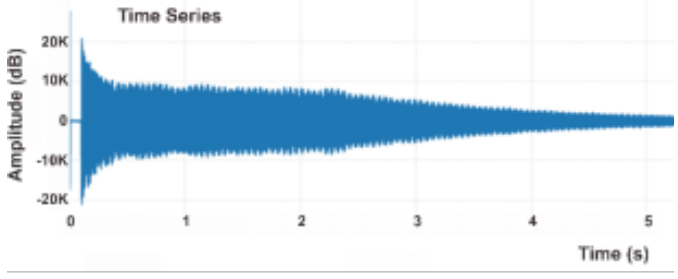

Figure 6. Sound Recording of Bende in the First Measurement.

The recorded sound of the bende was converted into wav format so that it could be displayed and analysed for frequency. In Fig. 6, the x-axis is the time component while the y-axis is the amplitude component. Furthermore, the frequency analysis of 3 bende sound recordings using the Fourier Transform. Software created using Javascript can be used to process the Fourier Transform, the results of which are shown in Fig. 7.

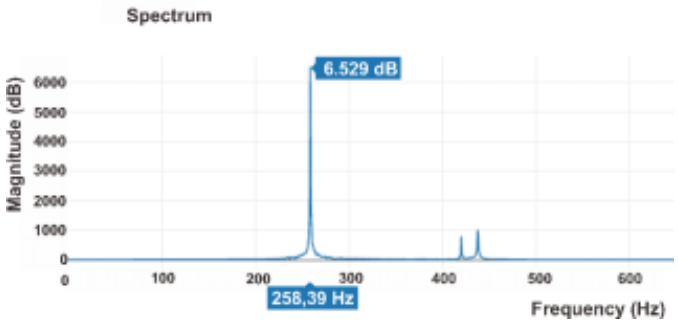

Figure 7. Results of frequency analysis on Bende first measurement.

In Fig. 7, the x-axis is the frequency component while the y-axis is the amplitude. Fourier Transformation is used in this article. The result of the Fourier Transform is a complex number consisting of the Real number and its Imaginary number. Then the transformation result is converted to absolute number form. Mathematically from complex numbers to absolute numbers, namely $|z| = |x + yi| = \sqrt{x^2 + y^2} = \sqrt{[Re(z)]^2 + [Im(z)]^2}$.

Real numbers are shown in Re while imaginary numbers are shown in Im. The first Bende measurement obtained an amplitude value of 6.529 dB while the base frequency or fundamental frequency was 258,39 Hz. The second Bende measurement obtained an amplitude value of 6.529 dB while the base frequency or fundamental frequency was 258,39 Hz. The third Bende measurement obtained an amplitude value of 6.529 dB while the base frequency or fundamental frequency was 258,39 Hz. These repeated measurements show that the results of frequency analysis are the same at a frequency of 258,39 Hz for Bende type Gamelan.

Signal Processing Theory

Acoustics is a physical science that studies wave motion in the form of gas, liquid or solid and the effects of wave motion [26]. The wave equation in one dimension is shown in eq. (1).

$$\frac{\partial^2 p}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2 p}{\partial t^2} \tag{1}$$

Signals and Sampling

In general, there are two types of signals: analog and digital. Analog signals are commonly referred to as continuous signals and digital signals are derived from analog signals that are sampled according to their sampling frequency (sampling rate). According to the Nyquist criterion, the minimum

sampling frequency (fs) is 2 times the frequency of the analog signal to be converted. If this criterion is not met there will be an aliasing effect shown in eq. (2).

$$2f_{max} < f_s \tag{2}$$

Fourier Transformation

One of the mathematical methods used to analyze and decompose signals in the frequency domain is the Fourier Transform [27]. A signal in the time domain will be transformed into the frequency domain to be analyzed. One of the transformations that can be used to convert signals in the time domain into the frequency domain is the Fourier Transform. Mathematically the Fourier Transform is shown in eq. (3).

$$X(F) = \int_{-\infty}^{\infty} x(t) \exp(-2t\pi ft)dt \tag{3}$$

Eq. (3) defines $X(f)$ in the frequency domain as the Fourier Transform of the signal function x(t) in the time domain. The variables t is time and f is frequency, while is the kernel function, and The output of the Fourier Transform is a complex number shown in eq. 4.

$$X(f) = R(f) + i(f) = |X(f)| \exp(i\theta(f)) \tag{4}$$

R(f) is the real part of the Fourier Transform, while I(f) is the imaginary part of the Fourier Transform. While is the Fourier Spectrum obtained from and is the phase angle of the Fourier Transform obtained using . The Fourier Transform plays an important role in many fields such as computer graphics, image processing and physics.

Implementation in Learning

This learning media using Javascript programming language is used as a visual aid that can provide real experience for students. This paper shows that Javascript is a tool that can be used for innovative learning. This technology is suitable for distance learning. Distance learning methods are required to be effective because of the importance of knowledge transfer to students [9]. Easy-to-use media for distance learning can be done with simulation-based media. This paper has successfully used Javascript programming language in simulating the shape of acoustic wave signals in the time domain and its spectrum. Javascript also helps in improving critical thinking skills and concept understanding [28, 29]. This paper has also successfully integrated several fields of science including from a physics point of view on acoustic wave material. Learning using other disciplines and being connected will add insight to students in the application of physics concepts. It appears that physics material can be integrated with other fields of science such as mathematics, engineering and art or often called STEM. Learning using other disciplines can help students learn with relevant contexts. Based on the relationship between these sciences, an integrated approach is possible.

This also shows that local wisdom in Indonesia also supports innovative learning. Learning using current technology is also important especially in today's technological era.

IV. CONCLUSIONS

This paper has successfully produced a product, namely making a signal processing simulation using the Javascript programming language on acoustic waves. This paper also shows that the use of Javascript programming language can be implemented in learning, especially in the field of physics. Students gain insight into signal processing from the time domain to the frequency domain using the Fourier Transform. The frequency has been obtained for one type of the musical instrument called Gamelian.

REFERENCES

[1] D. P. Anggraeni, Sukarmin, and F. Nurosyid, J. Phys. Conf. Ser. **1153**, (2019).
[2] B. Pekdağ, J. Turkish Sci. Educ. **7**, 79 (2010).
[3] M. M. Hafid, J. Turk. Sci. Educ. **19**, 1119 (2022).
[4] R. Jantrasee, J. Turk. Sci. Educ. **19**, 1155 (2022).
[5] S. Rahayu, J. Pendidik. Fis. dan Teknol. **1**, 118 (2017).
[6] D. R. Rizaldi, A. W. Jufri, and J. Jamaluddin, J. Ilm. Profesi Pendidik. **5**, 10 (2020).
[7] A. P. Sasmito and P. Sekarsari, J. Turk. Sci. Educ. **19**, 180 (2022).
[8] M. Sosa, Rev. Mex. Fis. **51**, 102 (2005).
[9] A. Yoga Purnama, H. Kuswanto, S. Ayunisa Rani, and H. Putranta, Rev. Mex. Fis. **19**, 1 (2022).
[10] A. Jayadi, D. H. Putri, and H. Johan, J. Kumparan Fis. **3**, (2020)
[11] A. Fatwa, J. Mhs. Teknol. Pendidik. **1**, 0 (2021).
[12] A. Arseven, Univers. J. Educ. Res. **3**, 973 (2015).
[13] D. V and Y. A, Arts Soc. Sci. J. **7**, 66 (2016).
[14] E. H. Au and J. J. Lee, Int. J. Innov. Educ. **4**, 215 (2017).
[15] M. S. Khine, Int. Trends Educ. Assess., 1 (2019).
[16] E. Putriani and Sarwi, Unnes Phys. Educ. J. **3**, 34 (2014).
[17] I. P. Y. Setia Permana and E. Purwaningsih, J. Pendidik. Fis. **10**, 17 (2022).
[18] C. Bayrak, Turkish Online J. Distance Educ. **9**, 62 (2008).
[19] K. Kusumaningtyas, Tecnoscienza **1**, 39 (2017).
[20] Y. Pramudya, L. Widayanti, and F. Melliagrina, J. Phys. Conf. Ser., 1075 (2018).
[21] Mitrayana and V. J. Cytasari, J. Fis. Indones. **18**, (2015).
[22] F. C. Andika, I. D. Kurniawati, and S. Nita, Pros. Semin. Nas. Teknol. Inf. dan Komun. **2**, 135 (2019).
[23] A. Ripai, Z. Abdullah, and M. Syafwan, J. Fis. Unand **8**, 171 (2019).
[24] D. R. Suryandari and F. A. Yulianto, "Dekomposisi Nilai Singular Dan Discrete Fourier Transform" (2009).
[25] S. Veerasingam et al., Crit. Rev. Environ. Sci. Technol. **51**, 2681 (2021).
[26] S. Sugiyanto, J. D. Setiawan, F. Nugraha, and R. W. Yuwana, Rotasi **21**, 115, (2019).

[27] N. H. Wibowo, S. Musdalifah, and R. Resnawati, J. Ilm. Mat. Dan Terap. **16**, 1 (2019).
[28] D. Apriandi and R. K. Setyansah, Aksioma J. Pendidik. Mat. **6**, 159 (2017).
[29] L. Herayanti and H. Habibi, J. Pendidik. Fis. dan Teknol. **1**, 61 (2017).

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