Developing Wave Encyclopaedia based on Scientific Approach

A Nuraffifah, A S Budi and B Z Siahaan
Program Studi Magister Pendidikan Fisika, Universitas Negeri Jakarta, Jl. Rawamangun Muka, Jakarta Timur, Indonesia 13220
‘agus_sb@unj.ac.id

Abstract. Students have many difficulties in understanding to wave propagation. Such difficulties lead to misconceptions also in understanding sound, light, and electromagnetic wave. Meanwhile, students only use the text book as the learning resources. Whereas students need a more varied and interesting learning resources. This study aims to develop a wave encyclopaedia based on scientific approach as the learning resources that tested the feasibility and superiority. The method used is research by design. The steps are (1) analysing learner characteristic, (2) state objective, (3) select media and materials, (4) utilize materials, (5) requires learner participation, (6) evaluation and revision. The wave encyclopaedia is developed by applying the 5 components of a scientific approach that is, observing, questioning, experimenting, associating, and communicating. In this encyclopaedia also includes fun science activities and exciting recommended websites. The encyclopaedia has been validated by material experts, media experts, and learning experts. And then field trials are conducted to assess an impact on use. Overall the development of encyclopaedia based on scientific approach can enhance learning outcomes of students in high school.

1. Introduction
Physics will be meaningful if studied contextually. Physics class now applying students’ centre which is students as information centre and teachers as a facilitator. However, in some schools teachers are still the centre of information. It’s because of limited learning resources that support students to gain more knowledge. The text book is the only one learning resource used in the classroom. Learning is always synonymous with reading activities because reading will increase knowledge, attitude and skills. The low reading power of these students can be attributed to the limited source of interesting reading, especially reading sources that support student learning in schools.

A teaching and learning process will be done well if supported by a comprehensive learning resources. One of learning resources that has comprehensive information is the encyclopaedia. The use of encyclopaedias as an enrichment learning resource is still very limited as evidenced by the results of the questionnaire showing only 5.6% of students who often use the encyclopaedia to support the learning process. The observations made on the existence of the encyclopaedia in the school library show that first, the encyclopaedia is still limited, secondly, the encyclopaedia owned by most schools for early childhood so that the depth of the material is not appropriate for high school students. In addition, the size of the encyclopaedia that is too big and heavy makes it difficult for students to bring and read it. Electromagnetic wave material has abstract characteristics so that students have difficulties in understanding this material. Studying electromagnetic waves would be easier if students had already understood vibrations and wave propagation.
Based on the above description, to improve student learning outcomes, it is necessary to develop a book of knowledge and skill enrichment that contains additional information about learning materials. The knowledge and skills enrichment book developed in this research is a wave encyclopaedia based on scientific approach. The encyclopaedia is developed based on a scientific approach so that it is equipped with hands-on activity that utilizes local potentials so that it can be used anywhere. The encyclopaedia is expected to be an additional reference book for students to learn physics so as to improve student learning outcomes.

2. Experimental Method
This research was conducted in November 2016 - May 2017. The encyclopaedia development was carried out at State University of Jakarta and field test at senior high school. Data was collected by analysing questionnaires about teachers’ needs, students’ needs, and validation of expert.

Research by design is a process used to develop and validate educational products. The steps of this process are usually referred to as the R & D cycle, which consists of studying the research findings related to the product to be developed, developing the product based on these findings, the testing field in the setting where it will be used eventually, and revising it to correct deficiencies Which was found in the stage of filing the test. In a more rigorous program of R & D, this cycle is repeated until field-test data indicates that the product meets defined behavioral goals[1].

The research by design of this encyclopaedia aims to produce a learning resources that can improve students’ learning outcome and test the effectiveness of the product. Design this research by design uses ASSURE model design. The ASSURE model is a class-oriented model. This model can be used to create a successful, effective, efficient, and interesting learning. This model is an abbreviation of the components or important steps contained in it, namely, analyse learner characteristic; state performance objectives; select methods, media, and materials; utilize materials; requires learner participation; evaluation and revision.

![Figure 1. Research stages based on the ASSURE model](image-url)
3. Result and Discussion

3.1. Preliminary Research

Preliminary research is the first step that must be done to assess the real condition with the expected conditions. This process uses questionnaires to obtain the encyclopaedia usage data requirement as an ideal learning resource compared to existing encyclopaedia conditions. The method used in the preliminary study is the descriptive method used to collect data from existing product conditions and user conditions and supporting and inhibiting factors.

The encyclopaedia initially contains only a more profound explanation than the dictionary. Along with the development of the times, the encyclopaedia was developed by adding images to achieve its main goal of reference resources with comprehensive, actual and accurate information. Encyclopaedia, also spelled encyclopedia, reference work that contains information on all branches of knowledge or that treats a particular branch of knowledge in a comprehensive manner. Of the various types of reference works—who’s dictionaries, atlases, gazetteers, directories, and so forth—the encyclopaedia is the only one that can be termed self-contained [2].

The encyclopaedia can be defined as a scientific work containing vast information, in various fields of knowledge, and usually alphabetically arranged in the subject or name. [3] According to Feather the encyclopaedia is a database or reference book containing information on all fields of science or limited to specialized fields, arranged systematically (usually alphabetically).[4] The encyclopaedia is defined as the most systematic summary of knowledge that is most significant to human beings, its function is very different between encyclopaedias and dictionaries. The dictionary functions to define, while the encyclopaedia defines and interprets. In some ways an encyclopaedia begins with a dictionary. A dictionary says "what", the encyclopaedia says "what, when, how, where and why". [5] Based on input from teachers and students who have already used the encyclopaedia, the encyclopaedia is expected to add graphic content, tables, research-related data and simple experiments to achieve the ultimate encyclopaedia's goals. The results of an existing encyclopaedia evaluation found that there is no encyclopaedia that is entirely based on a scientific approach.

The scientific approach includes several activities including; Observing, asking, trying, reasoning and communicating. Researchers see that what students and governments expect in this respect is evident from the 2013 curriculum there are similarities. Therefore, to support learning activities and add learning resources to student enrichment of encyclopaedias based on a scientific approach will be very interesting to develop.

The basic of scientific approach consists of determining hypotheses, hypothesis testing, deductive or inductive logic, experimenting, and associating data and theory [6]. The scientific approach is intended to provide an understanding to learners in knowing, understanding various materials using a scientific approach, that information can come from anywhere, anytime, regardless of teacher's in-line information. Therefore, the expected learning conditions are created to encourage learners to find out from various sources through observation, not just to be notified [7].

The inquiry scientific approach in learning has stages consisting of students conducting investigations, students determining problems, students identifying problems in investigation and students speculating on how to solve problems [8]. Based on the theory of Dyer, scientific approaches can be developed in learning that have learning process components such as: 1) observing; 2) questioning; 3) try/collect information; 4) reasoning / association; 5) networking (communicating). Stages of learning activities conducted with scientific learning should not be followed following a rigid procedure, but can be adapted to the knowledge to be studied [9]. Based on the opinion of some experts it can be synthesized that the scientific approach is a learning approach consisting of observing activities, asking, trying, reasoning, and communicating that aims to improve the ability of knowledge, attitude and skills of students at once.

Students have many difficulties in understanding to wave propagation. Such difficulties lead to misconceptions also in understanding sound, light, and electromagnetic wave. A single frequency traveling wave will take the form of a sine wave. A snapshot of the wave in space at an instant of time
can be used to show the relationship of the wave properties frequency, wavelength and propagation velocity. The motion relationship "distance = velocity x time" is the key to the basic wave relationship. With the wavelength as distance, this relationship becomes \( \lambda = vT \). Then using \( f = 1/T \) gives the standard wave relationship.

Actually, there are many technological advances based on wave. The ability to transmit light via optical fibers has led to many technological advances in fields ranging from telecommunications to medicine. In telecommunications, for example, single fibers can transmit quantities of data equivalent to over 30000 voices speaking simultaneously.[10] The rainbow is a natural phenomenon that inspires the curiosity of every student. This study is innovative in terms of utilizing the colors of a rainbow as a shared visual experience for students and teachers by transforming it into a playground of minds-on experiences. The materials used in this experimental activity are easily accessible in a school.[11] When a sound wave passes through a medium and meets a boundary, the energy of the wave splits up—some of it is transmitted into the next material and some of it is reflected back. The amount of energy in the reflected wave is determined by the acoustic impedance of the two mediums. The point here is that the acoustic impedance of air in an open space is different to the acoustic impedance of trapped air (i.e. the air in the pipe). This difference in acoustic impedance is the reason why energy is reflected back down the tube from the open end’[12].

3.2. Validity
Validation in the study was conducted by material experts, media experts, and professional physics teachers to assess and provide opinions about the encyclopaedia that has been developed based on scientific approach. Assessment is conducted to determine the effectiveness of the encyclopaedia to be re-evaluated before a limited trial. The procedures include: a) making an expert judgment instrument based on methods and research objects; b) presenting the encyclopaedia in order to be tested to the expert so that it can be assessed; c) revise the results of the assessment and expert opinion.

Validation media experts include aspects of content, presentation, language, and graphics. Expert judgments include material achievements on the basic competencies selected under the 2013 curriculum. And expert validation of learning includes aspects of content, strategy, evaluation.

![Figure 2. Graphs validation by Media and Material Experts](image-url)
3.3. Field Test

Trial of encyclopaedia on small group with target of high school students of class XI semester 2. The trial was conducted to 5 students senior high school which was chosen by random. The learners will use an encyclopaedia based on a scientific approach to learning activities that have previously been reviewed by experts and then revised according to conclusions. Learners will then provide advice and opinions after using the encyclopaedia. Then a feasibility test is performed on a physics teacher who aims to know that the encyclopaedia is appropriate or not used as a learning resource. Based on input from this small group trial the module will be revised again.

Learning (arranging, forming, understanding) by mobilizing all the intelligence and organ of the body goes from the knowledge of concrete aspects to its abstract understanding [13]. In general, learning can be understood as the stages of change in the overall behaviour of individuals who relativity settled as a result of experience and interaction with the environment that involves cognitive processes [14]. Sudjana defines that the students' learning outcomes are essentially behavioural changes and as feedback in an effort to improve the teaching and learning process. Behaviour as a result of learning in the broadest sense includes the fields of cognitive, affective, and psychomotor [15]. So Bloom's Taxonomy has revised cognitive domains by Anderson and Krathwohl: remember, comprehend, apply, analyse, evaluate, and create.[16]

In large group trials the revised encyclopaedia of small group trial results will be used by high school students in the second semester of class XI but who direct not from researchers but teachers who come from the school, it is useful to keep the objectivity of the conclusions generated for Furthermore the evaluation material for the product perfected. Students get an encyclopaedia-guided learning. Previously, students did a pre-test to determine the initial level of understanding of wave matter. At the end of the learning students do post-test, so through large-scale trials obtained information on the
large increase in student cognitive learning outcomes. The instruments used in the pre-test and post-test have been tested for their validity and reliability. According to Savinainen & Scott to see the increase in student learning outcomes used gain test [17].

**Tabel 1.** N-gain <g> test results

| Class    | Average pre-test score | Average post-test score | <g> | Criteria |
|----------|------------------------|-------------------------|-----|----------|
| Experiment | 54                     | 80                      | 0.56| Moderate |

Based on the data analysis, the average score of all aspects based on large group trials is 81.08%. This indicates that the developed wave encyclopaedia is considered "excellent". And the average score of pre-test and post-test obtained value of gain <g> of 0.56. The value is interpreted on moderate criteria. So it can be concluded that there is an increase in learning outcomes of learners using wave-based encyclopaedia of scientific approach.

4. Conclusion

Based on result and discussion, it can be concluded that encyclopaedia have been developed based on scientific approach. The wave encyclopaedia is developed by applying the 5 components of a scientific approach that is, observing, questioning, experimenting, associating, and communicating. In this encyclopaedia also includes fun science activities and exciting recommended websites. Overall the development of encyclopaedia based on scientific approach can enhance learning outcomes of students in high school.

Acknowledgments

We gratefully thank to all experts for comments that greatly improved the manuscript.

References

[1] Gall, B. a. 2007. Educational Research, An Introduction (New York and London: Longman Inc)
[2] Collison, R., & Preece, W 2016 *Encyclopædia Britannica Online* (USA:Encyclopædia Britannica)
[3] Lestari, I 2013 *Bahan Ajar Berbasis Kompetensi* (Jakarta: Rineka Cipta) p 28
[4] Feather, J., & Sturges, P. 2003 International Encyclopedia of Information and Library Science. New York: Routledge.
[5] Allen Kent, H. L. 1978 *Encyclopedia of Library and Information Science: Volume 25*. New York: CRC Press
[6] Gauch, H. G 2003 *Scientific Method in Practice* (United Kingdom: Cambridge University Press)
[7] Maryani, I., & Fatmawati, L. 2015 *Pendekatan Scientific dalam Pembelajaran di Sekolah Dasar: Teori dan Praktik* (Yogyakarta: Deepublish) p 56
[8] Joyce, B. 2009. Models of Teaching. Boston: Pearson Education.
[9] Sani, R. A 2014 *Pembelajaran Sains untuk Implementasi Kurikulum 2013* (Jakarta: Bumi Aksara) p 53
[10] Anderson, M. et al. Activities to investigate wavelength-shifting optical fiber *Phys. Educ.* 52 (2017) 043003 (3pp)
[11] Yurumezoglu, K. 2015 Teaching the absorption of light colours using an artificial rainbow *Phys. Educ*. 50 402
[12] OCR 2015 AS and A Level Delivery Guide H156/ H556, Physics A, Theme: Waves (Cambridge: Oxford Cambridge and RSA) p 15
[13] Sanusi, A 2014 *Pembaharuan Strategi Pendidikan* (Bandung: Nuansa Cendekia) p 43
[14] Syah, M 2010 *Psikologi Pendidikan* (Bandung: Remaja Rosda Karya) p 51
[15] Sudjana, N 2009 *Penilaian Hasil Proses Belajar Mengajar* (Bandung: Remaja Rosda Karya) p 23

[16] Anderson, L., & Krathwohl, D. 2001 A Taxonomy For Learning, Teaching, and Assessing (A Revision Of Bloom's Taxonomy Of an Educational Objective). New York: Addison Wesley Longman.

[17] Wiyanto 2008 *Menyiapkan Guru Sains Mengembangkan Kompetensi Laboratorium* (Semarang: Universitas Negeri Semarang Press) p 86