Development of work and energy encyclopedia based on science technology society

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Abstract. This study aims to develop work and energy encyclopedias based on Science Technology Society (STS), that is suitable for use as a source of learning. The method that used in this research is Research and Development (R&D) with ADDIE model. The steps are analysis, design, development, implementation, and evaluation. This encyclopedia is developed based on Science Technology Society, consists of introduction, concept development, application in real life, concept reinforcement, and evaluation. This encyclopedia has been validated by instructional methods experts, instructional media experts, and content experts. Overall, this encyclopedia is feasible to be used as a learning resource for students.

1. Introduction

Twenty first century education is expected to shape students to be ready to face globalization era, environmental issues, and information technology progress, which is one of important foundations in nation building. One of science education goals is to prepare students to have ability in understanding science in their daily life. The curriculum should give understanding of science based on individual needs, besides giving chance to students to get involved in social problems either in local, national, or global scales [1]. Students, that are also as citizens, should have good competence to well participate in society they live in [2].

One of instructional principle is a learning based on various learning resources [3]. Based on analysis of high school students needs in Bekasi region with total respondents of 118, obtained information that 81.5% of the students claimed that limited learning resources caused less understanding in physics material. 90.8% of students claimed that new additional learning resources in physics is needed. The additional learning resource that can be used in physics is encyclopedia, but 58% of the students have not known about encyclopedia and only 10.1% of students have used it as a learning resource.

Encyclopedia is a reference that provides complete fundamental information about various problems in various fields or branches of science [4]. The purpose of encyclopedia publication is to summarize and organize knowledge accumulation and to attract readers. Reference utilization is very helpful and even indispensable for students to achieve their educational outcomes. Reference
utilization is one of the most important parts in an academic practice process [5]. In this decade, many researchers have developed research on encyclopedias, among others are the Development of Digital Encyclopedia of Electrical Technology Based on Contextual Teaching and Learning (CTL) by Nurhatmi, Rusdi & Kamid in 2015, Development of Physics Measurement Encyclopedia as Independent Learning Resources for First Grade Senior High School by Widiana & Hasanah in 2014, and Development of Wave Encyclopedia Based on Scientific Approach by Nuraffifah in 2017, but development studies encyclopedia designed based on Science Technology Society are not yet available.

Instructional model that can improve understanding in science and scientific literacy is Science Technology Society [6]. Science Technology Society (STS) instructional model connects science and technology with their benefits in society [7]. By connecting the instruction of science and technology with their benefits and need in society, it is expected that the concepts that have been learned and understood can be beneficial for the learners and can be used to solve the problems they face or to overcome social environment issues. Instructional activity of Science Technology Society conducted continually may realize scientific instructional goal, that is developing scientifically literate students [8]. Abu Alrob and Shah stated in their report that development of scientific instructional material should be based on the development of Science Technology Society (STS) to ensure that the students obtain benefit from the scientific content [9]. Science, Technology, and Society helps students to develop concepts, creativity, attitude toward science, and knowledge and basic competence in science, including problem solving and skill to explore self-knowledge [10]. Klahan and Yuenyong concluded that the strength of science learning through Science, Technology, and Society (STS) are (1) science learning regarding the nature of science, (2) awareness about connection between science, technology, and society, (3) improving students’ independent learning, and (4) scientific attitude toward physics learning [11].

Based on respondents’ ability test that was performed on twelfth grade students in Laboratorium Percontohan UPI Senior High School [12], known that the students have difficulty in understanding about energy and kinetic energy concepts. The result of analysis of needs with high school teachers in Bekasi region, obtained information that students have difficulty in understanding about work and energy concept and one of the causes is limited learning resources. Based on the description above, it is considered to develop work and energy encyclopedia based on Science Technology Society.

2. Research Method

Research method used was Research & Development (R&D) with ADDIE development model. ADDIE is an acronym of Analysis, Design, Development, Implementation, dan Evaluation [13]. In the step of analysis, it was analyzed the gap between expectation and reality. The procedures were conducted by performing analysis of needs by giving questionnaire to students and teachers; determining the intended students; and identifying the required resources.

The procedures conducted in the step of design were determining the goals that would be achieved by students after performing the instructions; determining proper strategies, methods, and instructional media. In the step of development, the design was realized to become a real product, that was product of encyclopedia with the contents of work and energy. The encyclopedia was validated by instructional media experts, content experts, and instructional method experts. After the validation, the encyclopedia was revised based on experts’ suggestion and assessment, and then a field test was conducted on students. The target of the field test of the encyclopedia was high school students. In the step of implementation, the encyclopedia was used by students as a learning resource. The procedure conducted in the step of evaluation was evaluating students who had used the encyclopedia.

3. Result and Discussion

3.1. Product
The encyclopedia was developed based on Science, Technology, and Society (STS) with the steps of introduction, concept development, real life application, concept reinforcement, and evaluation. This was confirmed by Abu Alrob and Shah who stated in their report that development of scientific instructional material should be based on the development of Science, Technology, and Society (STS) to ensure that the students obtain benefit from the scientific content [9]. Science, Technology, and Society helps students to develop concepts, creativity, attitude toward science, and knowledge and basic competence in science, including problem solving and skill to explore self-knowledge [10]. In accordance with the study by Klahan and Yuenyong that concluded that the strength of science learning through Science, Technology, and Society (STS) are (1) science learning regarding the nature of science, (2) awareness about connection between science, technology, and society, (3) improving students’ independent learning, and (4) scientific attitude toward physics learning [11].

The step of STS consists of introduction, concept development, real life application, concept reinforcement, and evaluation. The introduction can be referred to as initiation or beginning, and can also be referred to as invitation, that is an invitation for students to pay attention to the instruction. Real life apperception also can be done, that is by relating events that have been known by students with the material that will be discussed, so that a knowledge correlation is noticeable because it begins with the things that have been known by students that is emphasized on the daily life circumstances. Concept development can be performed by various methods. In the end of the concept development, students are expected to understand whether analysis of issues or problem solving described in the beginning of the instruction have applied concepts followed by scientists. With a good conceptual understanding, students perform analysis of issues or problem solving that is referred to as real life concept application. Then, concept reinforcement needs to be performed by reinforcing important key concepts that should be known in certain learning material. And the last is students’ evaluation [7].

The encyclopedia contains materials of Work and Energy. The sections are work, potential energy, kinetic energy, work-energy theorem, power, and energy sources. Components of the encyclopedia are cover, instructions of use, content, and index (Figures 1).

![Image](image.png)

**Figure 1.** Front and back cover display of the encyclopedia.

3.2. **Validity**

Validation test performed by media experts with the aspects of content, presentation, language, and usefulness resulted in average percentage of 91.35% (Figure 2). Validation test performed by content experts with the aspects of content and presentation resulted in average percentage of 85.16% (Figure 3). Validation test performed by instructional method experts with the aspects of content, presentation, instruction of Science, Technology, and Society, and language resulted in average percentage of 95.11% (Figure 4).
Figure 2. Validation Test by Instructional Media Experts.

Validation Test Result by Instructional Media Experts

- Simplicity of use: 100%
- Serve as an independent learning resource: 100%
- Writing language appropriacy: 84.4%
- Compatibility of bibliography: 50.0%
- Line spacing consistency: 87.5%
- Compatibility between figures and texts: 98.8%
- Suitability of font type, size, and color: 87.5%
- Suitability of colors combination and composition: 93.3%
- Compatibility between content and encyclopedia components: 90.0%
- Compatibility between cover and content: 100%

Figure 3. Validation Test by Content Experts.

Validation Test Result by Content Experts

- Compatibility between bibliography and content: 88.9%
- Compatibility between figures and texts: 87.5%
- Accuracy of concept presentation order: 87.5%
- Relevance of bibliography: 75.0%
- Relevance of the material toward advancement of science: 75.0%
- Writing accuracy: 87.5%
- Compatibility of content: 87.5%
- Compatibility between content and level of thinking: 87.5%
- Compatibility between content and basic competency: 87.5%

Figure 4. Validation Test by Instructional Method Experts.

Validation Test Result by Instructional Method Experts

- Writing language appropriacy: 81.3%
- Compatibility between content and steps of STS: 95.2%
- Simplicity of material comprehension: 100%
- Display design attractiveness: 100%
- Compatibility between figures and content: 100%
- Compatibility between figures and texts: 95.8%
- Suitability of font type, size, and color: 100%
- Compatibility between content and encyclopedia components: 100%
- Compatibility between content and level of thinking: 100%
- Compatibility between content and basic competency: 100%
Average score of validation test results performed by instructional media experts, content experts, and instructional method experts is of 90.54% that was interpreted as “very good”.

3.3. Field Test
Field test performed on 5 high school students with the aspects of content, presentation, language, and usefulness resulted in average of 90.31%. This result is interpreted as “very good”. In accordance with the study conducted by Nurafifah, reported that the encyclopedia developed based on scientific approach can improve high school students’ learning outcomes [14].

![Figure 5. Field Test Result on Students.](image)

4. Conclusion
Percentage of validation test performed by media experts is 91.35%, percentage of validation test performed by content experts is 85.16%, and percentage of validation test performed by instructional method experts is 95.11%. Based on the result and discussion, it is concluded that the work and energy encyclopedia that was developed based on Science Technology Society (STS) is feasible to be used as a learning resource in physics subject.

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References
[1] Liversidge T, Cochrane M, Kerfoot B, & Thomas J 2010 Teaching Science (Los Angeles: SAGE Publications)
[2] Soobard R, Rannikmae M 2011 Assessing Student’s Level of Scientific Literacy Using Interdisciplinary Scenarios Science Education Int. 22 133-144
[3] Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia 2013 Standar Proses Pendidikan Dasar dan Menengah
[4] Saleh A R, Sujana J G 2009 Pengantar Kepustakaan (Jakarta: Sagung Seto)
[5] Iroaganachi M A, Ilogho J E 2012 Utilization of Reference Books by Students: A Case Study of Covenant University, Nigeria Chinese Librarianship: an Int. Electronic Jl 34 48-56 Retrieved from http://www.iecl.us/cliej/cl34II.pdf
[6] Akgul M E 2004 Teaching Scientific Literacy Through a Science Technology and Society Course: Prospective Elementary Science Teacher's Case The Turkish Online J. of
Education Technology 3(4).

[7] Poedjiadi A 2010 Sains Teknologi Masyarakat, Model Pembelajaran Kontekstual Bermuatan Nilai (Bandung: PT Remaja Rosdakarya Offset).

[8] Rahayuni G 2016 Hubungan Keterampilan Berpikir Kritis dan Literasi Sains Pada Pembelajaran IPA Terpadu dengan Model PBM dan STM Jurnal Penelitian dan Pembelajaran IPA 2 131-146.

[9] Abualrob M M, Shah M 2012 Science Technology and Society Modules Development Process and Testing on Its Effectiveness Social and Behavioral Sciences 46 811-816.

[10] Chantaranima T, Yuenyong C 2014 The Outcomes of Teaching and Learning About Sound Based on Science Technology and Society (STS) Approach Social and Behavioral Sciences 116 2286–92.

[11] Klahan T, Yuenyong C 2012 An Analysis of Grade 12 Students’ Technological Capability in Learning About Electromagnetics Through Science Technology and Society Approach (STS Approach) Social and Behavioral Sciences 46 5085–93.

[12] Rusnayati H, Stefani R, Wijaya A F 2015 Desain Didaktis Pembelajaran Konsep Energi dan Energi Kinetik Berdasarkan Kesulitan Belajar Siswa pada Sekolah Menengah Atas Jurnal Penelitian & Pengembangan Pendidikan Fisika 69-76.

[13] Branch R M 2009 The Instructional Design: The ADDIE Approach (New York: Springer)

[14] Nurafifah A, Budi A S, Siahaan B Z 2017 Developing Wave Encyclopaedia based on Scientific Approach J. of Phys. Conf. Ser. 895 012018.