

Karakteristik pengembangan *e-book* interaktif berbasis *science, environment, technology, and society* (SETS)

Characteristics of the development of science, environment, technology, and society-based (SETS) interactive e-book

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Abstrak

Penelitian ini bertujuan untuk mengetahui karakteristik bahan ajar berupa *e-book* interaktif berbasis *science, environment, technology, and society* (SETS) pada materi termokimia yang dikembangkan untuk siswa SMA. Tahapan pengembangan dimulai dari tahapan seleksi, karakterisasi, penataan, dan reduksi didaktis sehingga sesuai dengan kebutuhan siswa. *Storyboard* disusun sebagai acuan untuk mengembangkan *e-book* interaktif. Aspek interaktif dari bahan ajar ini antara lain video terkait materi, soal latihan pada setiap indikator, dan soal uji kompetensi diakhir pembelajaran dilengkapi dengan kunci jawaban dan skor yang diperoleh siswa. *E-book* interaktif ini mencakup aspek *science, environment, technology, and society* sebagai pendekatan yang menyajikan kasus-kasus kontekstual dalam materi termokimia. *E-book* interaktif ini divalidasi oleh masing-masing dua ahli materi (isi) dan ahli media. Angket validasi merupakan instrumen yang digunakan dalam penelitian ini. Angket validasi isi terdiri dari aspek ketepatan subjek, kebaharuan, dan komunikasi. Angket validasi media terdiri dari desain media dan navigasi/pengoperasian. *E-book* interaktif ini dinyatakan valid.

Kata kunci: bahan ajar; metode pengembangan 4-STMD; termokimia

Abstract

This study aimed to determine the characteristics of teaching materials in the form of interactive e-books based on science, environment, technology, and society (SETS) on the subject of thermochemistry developed for high school students. The development stages start from the selection, characterization, structuring, and didactic reduction stages so that they follow the needs of students. Storyboard was prepared as a reference for developing the interactive e-books. Interactive aspects of this teaching material include videos of the subject, practice questions on each indicator, and competency test questions at the end of the lesson equipped with answer keys and scores obtained by students. This interactive e-book covers aspects of science, environment, technology, and society as an approach that presents contextual cases in the subject of thermochemistry. This interactive e-book was validated by content and media experts. Validation questionnaire was the instrument used in this study. The content validation questionnaire consists of aspects of subject accuracy, novelty, and communication. The media validation questionnaire consists of media design and navigation/operations. This e-book interactive is valid.

Keywords: learning material; 4-STMD development method; thermochemistry

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Introduction

In the learning process, several important aspects are interrelated so that a learning goal can be appropriately achieved by teachers, students, and teaching materials (Anwar, 2014). In an interaction between teachers and students, a teacher must develop

teaching materials by the competencies that must meet in each subject matter. Teaching materials are one of the most important aspects of being a guide for a subject written and compiled by an expert in a related field, in this case, a teacher (Arifin & Kusrianto, 2008). Students expect to get and improve their knowledge with suitable teaching materials or learning resources. Therefore,

teaching materials that are easy to understand and efficient in their use are needed. In addition, research conducted by Ormanci & Cepni (2020) states that teaching materials prepared by teachers are based on current curriculum requirements.

Books are one of the most frequently used types of teaching materials. Teaching materials present knowledge composed of bound sheets and leather (Depdiknas, 2008). Through the current development of science and technology, printed books can be converted into electronic forms to be more effective and efficient in their use. Through these teaching materials, the teacher is expected to be no longer the only source of learning designers. Teachers are required to be able to design learning by utilizing various types of appropriate media so that the learning process takes place effectively and efficiently (Sanjaya, 2012).

The development and use of knowledge in information and communication technology to improve students' understanding of chemical representations has been carried out (Kozma & Russell, 1997). This development of technology can provide a positive learning experience in enhancing active learning through peer interaction and understanding multiple representations of molecular structures using technology (Lawrie & Appleton, 2011). Chemistry teaching materials prepared using a chemical representation approach have a high level of validity and reliability based on teacher and student assessments (Rosilawati, Wulandari, & Setyarini, 2022; Tania & Fadiawati, 2015).

E-books play an essential role in learning because they can increase learning productivity and streamline learning time. In addition, e-books as teaching materials also have an essential role in shaping students to learn independently (Fatah, 2015). Although e-books have several advantages compared to printed books until now, most e-books are presented in text and images only, so it is necessary to develop e-books that can show videos, simulations, and animations for the material given. An interactive e-book is a form of e-learning. In simple terms, an e-book is a printed book that is transferred into an electronic form that is displayed on computer media (Putera, 2011). Based on research results from Munawwarah et al. (2017), interactive e-books do not only consist of text but contain assignments, animations, and quizzes that can invite students to interact directly.

Interactive e-books are very suitable for chemistry because the chemistry presented includes three levels of representation, namely macroscopic, sub-microscopic, and symbolic aspects (Pietzner, 2014). The displayed pictures, videos, and animations can clarify the presented concepts (Suryani & Sukarmin, 2012). Information obtained verbally and visually from interactive e-books will be stored in long-term memory. In addition, exercises that provide feedback can teach

students and entertain or encourage students to continue learning (Razek & Modayan, 2012). Therefore, through interactive e-books, students' understanding and interest in learning chemistry can be increased (Yulianti, Fidiawati, & Tania, 2015). Interactive e-books can also improve students' higher-order thinking skills (HOTS) if the book is developed with a scientific approach (Suyatna et al., 2019). In addition, the use of interactive e-books in the learning process can also increase student self-efficacy and learning achievement (Gwo-Jen & Chiu-Lin, 2017).

The most important aspect of designing teaching materials development is paying attention to the demands of the curriculum (Depdiknas, 2008). This important aspect means that the prepared teaching materials must comply with the curriculum. In the 2013 curriculum, the government has determined main competence (MC) and basic competence (BC) and applied them to all schools with the same level in Indonesia. Meanwhile, BC is a competency that students learn for a subject in a certain grade (Kemendikbud, 2012). Therefore, the development of teaching materials must be based on the needs of students. Widodo & Jasmadi (2008) developed a flow of teaching materials development which states that after the development of teaching materials, student guidelines and teaching guidelines must be provided by the teaching and learning activity plan.

Suitable teaching materials are materials that can be used by all students with different backgrounds and according to development. Three necessary levels must be included in teaching material: macroscopic, submicroscopic and symbolic. The macroscopic level is related to changes in the color of a substance, the form of a new substance, and other chemical phenomena that the five senses can feel (seeing, touching, smelling, hearing, and feeling). The submicroscopic level involves the arrangement and movement of particles such as electrons, atoms, ions, and molecules. The symbolic is related to symbols (atomic names, atomic numbers, structures, models, formulas, calculations, etc.).

The preparation of e-books can differ even though they are on the same subject, depending on the objectives and approach used. One approach that can be applied in teaching material is the science, environment, technology, and society (SETS) approach. This is done because presenting concepts thematically and close to everyday life in e-books can make students understand science more in an integrated manner (Widodo & Jasmadi, 2008). Basically, this approach was developed to connect science, technology and its impact on society. (Pudjiadi, 2007). SETS is an interdisciplinary knowledge involving science as natural knowledge that produces a technological product expected to benefit the environment and people's lives.

Based on this description, in preparing teaching materials in the form of interactive e-books, a development research method with the DDE model is used, which begins with designing, developing and evaluating the resulting teaching materials. The development model is combined the 4STMD method. Teaching materials are obtained that are by demands of curriculum, explanations of chemistry materials, and needs of students. Therefore, this study aimed to determine the characteristics of the development of teaching materials in the form of interactive e-books based on SETS on thermochemistry subjects developed for high school students.

Method

The research method used was Developmental Research by Richey, Klein, and Nelson (2004). The development model is the design, development, and evaluation (DDE) and combined with the 4 steps teaching material development (4STMD) method by Anwar (2014). The overall research activity can be seen in Figure 1.

The teaching materials were validated by two content and media experts, respectively. In this research there are two instruments were used. Open questionnaire in the form of material presented in teaching materials was used for content validation and open questionnaire in the form of e-book display and its ease of operation was used for media validation. Two media experts carried out validation.

Result and Discussion

The development of SETS-based interactive e-book on thermochemistry subject is using the 4STMD method, which consists of four stages namely selection, structuring, characterization, and didactic reduction stages. The method is combined with the development research model by Richey, Klein, and Nelson (2004).

The development of the interactive e-book was carried out twice, namely after the characterization and didactic reduction stages. The e-book produced after the characterization stage is first draft of teaching materials.

Planning

At this stage, the researcher collects information on the effective of teaching materials to be developed. Based on this information, teaching materials in the form of interactive e-books were made. An interactive e-book is one type of teaching material that can be used as a source of independent learning for students. The e-book display text and images, and provide features that invite students to interact with the teaching materials.

The e-books provide learning experiences for learners in two ways. First, the valuable features featured in the e-book can directly improve their learning outcomes. Second, it can increase knowledge about information and communication technology. In addition, technology can provide a positive learning experience in increasing active learning through peer interaction and understanding of various representations of molecular structures using technology (Lawrie & Appleton, 2011). In this stage determining the type of material, the appropriate approach, and the length of time needed to develop this teaching material are arranged.

Development

The development of teaching materials refers to MC and BC of chemistry in the Indonesian Republic's curriculum of 2013. There are two BCs in MC of thermochemistry subjects in syllabus of the curriculum of 2013. The content on the thermochemistry subject is collected from several trusted textbooks. Therefore, these concepts, theories, and laws are used in achieving the indicators.

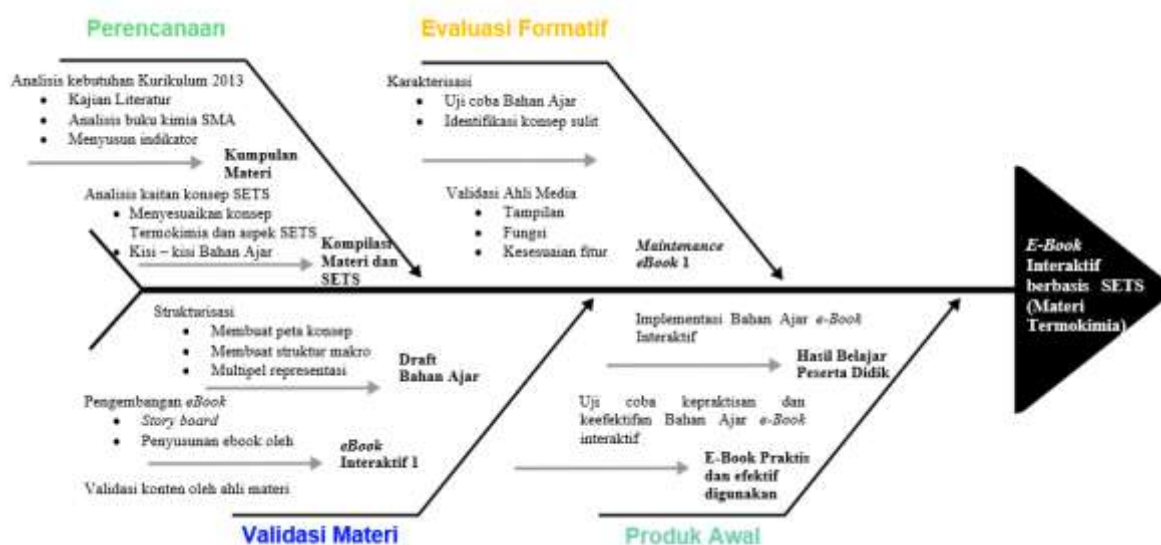


Figure 1. Overall development flow stage

Table 1
BCs and indicators of MC in thermochemistry

BCs	Indicators
Distinguish between exothermic and endothermic reactions based on experimental results and energy level diagrams.	Explain the types of systems based on the characteristics of the transfer of energy and matter that occur
	Able to distinguish exothermic and endothermic reactions based on the value of ΔH of a reaction equation
	Analyze the difference between exothermic and endothermic reactions based on experimental results and energy level diagrams
Determine the ΔH of the reaction based on Hess's law, standard enthalpy change data of formation, and bond energy data	Explain the types of enthalpy changes
	Be able to determine ΔH by applying Hess's law
	Able to determine ΔH using standard enthalpy change data of formation
	Able to determine ΔH using data and bond energy equations

The first stage in developing the interactive e-book is the selection stage. The selection stage is divided into two, namely the selection of the first part, which consists of content standards in the curriculum related to the development of material indicators, material sources related to the identification of the suitability of concepts with indicators, and value education related to chemistry. Value education related to electrochemical material is replaced with the suitability of SETS aspects with electrochemical material. The second selection stage consists of material analysis with SETS aspects, teaching materials compilation, and teaching materials review. This selection stage is more specific to the material presented in the teaching materials, related to the grid on the teaching materials, the collection of materials, and the linkages between MC, BC, and indicators to be achieved.

The thermochemistry subject consists of two BCs from the MC, namely (1) Based on experimental results and energy level diagrams, distinguish between exothermic and endothermic reactions, and (2) Determine the ΔH of the reaction based on Hess's law, standard enthalpy change data of formation, and bond energy data. The two BCs selected in the selection process were then developed into seven indicators which can be seen in Table 1.

The source material is a textbook that has been internationally recognized. The selection of recognized material sources is carried out so that the material presented in the teaching materials is guaranteed to be true in terms of concepts, theories, laws, and so on. This is by one of the objectives of the selection stage itself, namely that the teaching materials prepared must be scientifically correct. The use of textbooks can be used as a basis for development because these books have been circulated throughout the world and the truth is recognized by scientists (Anwar, 2014). The textbooks used as a source of material in the preparation of these teaching materials are Chemistry, seventh edition by

James Brady; Basic Chemistry; Volume 1 by Raymond Chang; Gammon-General Chemistry: 9th Edition by Darrell Ebbing; Conceptual Chemistry for 12th grade student by Jain and Jain; Principles of Modern Chemistry by David W. Oxtoby; and *Kimia Dasar 2* by Yayan Sunarya.

The second stage is compiling drafts of teaching materials that contain concepts, theories, and thermochemical materials. The draft teaching materials are also equipped with pictures, video links, practice questions, and competency tests. These aspects are the principal capital in developing teaching materials in the form of interactive e-book media. The third stage is storyboarding that contains the material in the draft of teaching materials and is equipped with information that becomes a reference in the preparation of an interactive e-book. The final stage is the preparation of an interactive e-book by working with a programmer. During the practice of interactive e-books, researchers always coordinate through storyboards that have been prepared in the previous stage. In general, the characteristics of this interactive e-book teaching material can be seen in Figure 2.

SETS was initially known as an innovation in science learning that was applied at the junior and high school. Basically, the model was developed to connect science, technology and its impact on society (Pudjiadi, 2007). SETS is an interdisciplinary knowledge involving science as natural knowledge that produces a technological product expected to benefit the environment and people's lives. The approach can be used in a variety of subjects, including chemistry for high school students. SETS-based learning can increase students' enthusiasm, an ability to express opinions and increase students' understanding of chemistry subjects (Afriawan, Binadja, & Latifah, 2012).

The SETS pattern used in developing the interactive e-book is by connecting science (concepts, theories, and laws) with SETS as a supplement to the



Figure 2. SETS approach in interactive e-book of thermochemistry subject

topic according to the indicators that have been developed (Pudjiadi, 2007). This shows that the material text presented in the interactive e-book is not directly related to the four aspects of SETS. One or two aspects of SETS are highlighted in a text-only text while the other aspects are implied.

Evaluation

In this step, the interactive e-book is validated. The validation process consists of content validation and media validation and conducts by two experts, respectively. This validation aims to determine and ensure that the teaching materials meet the predetermined criteria.

Several changes were made after content and media experts validated the interactive e-book. Among them are differences in the appearance and content of teaching materials. Some of the revisions made after content validation were revising the concept map, replacing some words in the text to improve the meaning of the sentence, adding the use of SETS in the presentation of the material, and improving sentences and typing on the competency test questions.

The validation results from media validation are improving some of the appearances of teaching materials. That validation makes e-books look more attractive, adding images to specific questions, changing the font type on certain features, and inserting interesting invitation sentences according to the age of the students.

Conclusion

The development of SETS-based interactive e-book on thermochemistry subject is carried out through three stages: planning, development, and evaluation. Each stage is combined with the steps in the 4STMD development method. One of the revisions made after

the evaluation stage is a concept map. The resulting teaching materials have several features that invite students to learn independently. The SETS-based interactive e-book is valid.

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