Development of story of atom enrichment book apply four steps teaching material development (4S TMD)

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Abstract. The purpose of this research is to develop the story of atom enrichment book using Four Steps Teaching Material Development (4S TMD) method. In addition to providing detailed information about the development of atomic theory and to minimize misconceptions, making story of atom enrichment books aim is to describe concrete examples of applying critical thinking and scientific approach. 4S TMD method consisting of selection, structuring, characteristics, and reduction stages. The selection stage was conducted by gathering and selecting various information to identify problems, determine the theoretical background for strengthening products, and various materials in the product. The structuring phase was carried out by developing the product draft. The characterization stage was performed so that the products are made accordingly. The finished product was reviewed by experts and revised based on the review's results. At the reduction stage, the product was reviewed by students as the product user target mainly from the aspect of language and readable to improve the product suitability. After the product had been revised, the product was strengthened by a product quality assessment to show that the product fits as a learning resource.

1. Introduction
Education for sustainable development (ESD) is a part of Agenda 21 to promote sustainable development, increase human capacity to save the environment, change the way thinking on the issue, increase the value of caring, build habits that are corresponding with sustainable development, and build effective participation in the decision-making process [1]. The focus of ESD is to prepare the young generation to take responsibility both for themselves and for future generations based on the concept of sustainable development [2]. To take responsibility, they must be aware of what it does this time will have an impact on the future. This awareness can be obtained through history lessons. Studying history allows us to feel the great impact of the past on our lives today. Knowledge of the past for the present is important to build identity self, how becomes citizens, and understand the human condition. The relationship between the past, present, and future in the classroom can be built by using historical knowledge to assess and explain developments in the present then make a possible future development picture that might make sense and make an anticipate [3].

To combine science learning with ESD, learning especially chemistry should not just focus on abstract matter and restricted knowledge but also enters a broader view from various perspectives [4]. Studying the history of science makes this possible. Science education must have a central position in influencing or fostering students in shaping a responsible society in an increasingly complex world and to adapt to the changing world that is happening [5]. The history of science needs to be studied to show...
that science has a connection with one another in influencing the world. One of the science developments in the past that very influential in life today is the development of atomic theory. Technology and knowledge which developed at this time were preceded by discovery invention about the atom. The history of developing atomic theory also has many values that can be learned, such as how scientists think, take scientific approaches, and scientific methods.

The relevance of science teaching and learning is based on three dimensions (individual, social and vocational relevance); internal and external components; and the time scale from now to the future [6]. Relevant science learning occurs if learning has a positive impact on students now or in the future. Studying the development of atoms from a historical perspective allows students to observe and study science development from the past to the present. It leads students to discuss the applications and impacts of chemistry and technology intensively. After realizing how great the development of atomic theory in the past for the present, students will realize the current development of science will also greatly affect the future and make students continue to question what types of knowledge can be useful for future citizens. This approach can be called an external perspective on science to increase the relevance of teaching and learning science [7]. Through the development of atomic theory, students can learn scientific methods and scientific approaches that researchers use to solve problems, so by teaching them students are expected to be motivated to apply them. Teaching social-scientific problems in chemical education can use social-critical approaches and problem-oriented approaches [8].

In reality, learning about theory atom in high school often does not explain the background of scientific thought in formulating these atomic theories, but directly deliver the contents of the theory. This makes the discussion of atomic theory less meaningful and can trigger misunderstanding. On the other side, doing meaningful learning in class is not easy. Process of learning in the class is always hampered by time and because the teacher cannot discuss a material broadly and deeply. Because of this, students must undertake an independent learning process if they want to know a material more deeply and more broadly. These activities can be carried out by students outside of class by utilizing the various learning resources available like an enrichment book.

Based on the various explanations above, then needed enrichment books containing material development of the atomic theory that tells how the way scientists think, find problems, and what ideas that underlie their experiments to produce a theory. In addition to providing detailed information about the development of atomic theory and to minimize misconceptions, developing atomic enrichment storybooks is also expected to increase students' motivation and awareness of the importance of sustainable development.

2. Methods
This research design applied procedural development design. Before being delivered to students, teaching materials, including books, should pass four stages as recognized as qualified. This stage refers to 4S TMD (Four Steps Teaching Material Development), which consists of the process of selection, structuring, characteristics, and reduction [9]. The selection stage was conducted by gathering and selecting various information needed to identify problems, determine theoretical foundations for strengthening products, determine basic competencies (KD), and various materials needed in the product.

The structuring phase was carried out by preparing the product design and material framework, then developing the product draft. Product quality criteria, along with product assessment instruments, were also prepared to oversee the product in order to produce products with functional categories. Each teaching material has a different character. The characterization stage was performed so that the products are made accordingly. The finished product was reviewed by experts and revised based on the review's results. Products were reviewed and revised in two stages to obtaining more suitable products. At the reduction stage, the product was reviewed by students as the product user target mainly from the aspect of language and readable. The results were utilized to improve the product suitability. After the product had been revised, the product was strengthened by a product quality assessment by chemistry teachers.
with more than ten years of teaching experience. The quality assessment uses a questionnaire that includes material/content feasibility, presentation, and language and drawings criteria.

3. Result and Discussion
The development results of the story of the atom enrichment book using the 4S TMD method are as follows:

3.1. selection
At this selection stage, various information is collected and selected. Starting from information regarding various problems that arise, information regarding solution design that will be done, to product support material. Every topic or problem that is believed to be relevant enough to be taught in formal education must have personal relevance or meaning for students for present and futures and can develop the potential to increase student capacity so they can decide the fate, doing participation in society, and doing solidarity [10]. Studying history can support ESD because it allows students to be able to live a more purposeful life [11].

Observation results indicate that the delivery of atomic material in the class most of all only limited to the delivery of atomic theory without accompanied by experiments that underlie and the rationale of scientists in formulating the theory. This makes the discussion of atomic theory less meaningful because the values that can be taken from the story of the development of atomic theory are not conveyed. In addition, it can also trigger student misconceptions and makes students confused in representing the atomic model and connecting between atomic models with one another. Although realizing that atoms are very small, some students in the learning process think that scientists can observe atoms through a microscope and scientists have seen a single atom and its constituents. The belief that scientists have seen atoms shows that students sometimes misinterpret images of the atomic model. Therefore, it is very important for the teacher to explain that the model is just an analogy of atoms and not a real picture of them [12]. Students confuse in determining the atomic model and understanding the relationship between the atomic model with one another is caused by exposure in the textbook not sustainable at every grade level. A textbook that does not discuss the background to the formulation of atomic theory and the relationship between theories with one another triggers the emergence of misconceptions [13].

In explaining changes in the atomic model students need to be given an explanation of how a model is replaced by another model due to a reason that can be presented explicitly and concretely with arguments that are closely related to experimental evidence. Otherwise, students will have difficulty visualizing atoms [14].

Conveying atomic theory without a background also makes critical thinking of students less honed. The values contained in the story cannot be conveyed. On the other hand, educators state that studying the development of atomic theory requires a lot of time, but school hours are so limited that it is impossible to convey this material structurally and deeply. Independent learning is one-way students can broaden their horizons regarding the development of atomic theory. Books can be a source of learning. However, the school books used by students mostly separate discussions of atomic theory with invention atomic constituent particles or not explain the flow of the discovery coherently, and do not explore thoroughly how atomic theory is formulated. Even though the chemical concept presented in textbooks greatly affects the understanding and misunderstanding that occurs in students. Textbooks also influence how students choose and form atomic models [13]. Therefore, so that independent learning takes place effectively then it must be prepared learning resources corresponding which can lead students in self-learning [15].

As a solution to the various problems that arise, then the story of the atom enrichment book needs to be compiled. This enrichment book is a non-textbook with a type of knowledge enrichment book. Knowledge enrichment books have a function to increase knowledge, add insight, and experience of the reader [16]. Enrichment book that is packaged in a storybook can give a big influence on science concept comprehension students regardless of the student's curiosity [17]. Basically, in the process of preparing enrichment books do not have to be tied to the curriculum directly, but still must be under the objectives
of national education. So that enrichment books are suitable to be used as a source of learning support for students in school, then basic competencies in the curriculum syllabus need to be studied. The basic competence associated with the atomic theory is KD 2.3, which understands the atomic model of Dalton, Thomson, Rutherford, Bohr, and quantum mechanics. The material in KD 2.3 should be included in all enrichment books, supported by a variety of other studies that support it. This stage is continued by gathering references about related material to develop the product through various university books, journals, and trusted websites.

3.2. structuring
This stage began by developing an instrument of book quality criteria and validating them logically. This is intended to control product development in order to be in accordance with established criteria. The material framework that is presented in the book was compiled based on information that had been obtained in the previous stage. The material tells how one model is replaced by another because of a reason that can be presented explicitly and concretely supported with arguments that are closely related to experimental evidence [14]. Some models that can be used in studying science are scientific models and historical models. The scientific historical model is about how to teach friction using historical scientific models and theories as sources [18].

The book was arranged in a coherent plot like a storybook, so students are expected to understand the course of the development of atomic theory and can take the value. Excellent reading skills are fundamental to learn science concepts. For students, science texts are often considered more challenging to understand than other types of texts. Many school texts are difficult to understand because they often omit important information such as background and fail to make connections between concepts in explicit texts [19]. Also, to explain changes in the atomic model, students need an explanation of how another model replaces one model due to a reason that can be presented explicitly and concretely. Difficulties in visualizing atoms can also be minimized by convincing students to use arguments closely related to experimental evidence [14].

The first chapter of the product explains atomic philosophy. This section explains how philosophers came up with ideas to think about and find the basic material making up the universe. This way of thinking of philosophers is accompanied by the refutation of other philosophers to produce new ideas about the basic material making up the universe. Thales observe natural phenomena and concluded that water is the basis of matter because the shape of water can change and all living things need water. That thought was refuted by Anaximander who stated that the basis of matter should be in everything and there are no substances that contradict water like fire and think that all substances come from the air. The connection between one knowledge and another knowledge was also revealed. As an explanation of the invention, basic law chemistry was presented before the invention of Dalton’s atomic theory. It is intended that students also know the basic theories that underlie and support thinking the scientist in formulating the thinker.

Author much focus on building the model and the reasons behind the model. The phenomenon observed from the experiments carried out is explained as a basis in drawing conclusions or formulating theories. Experiments carried out by Rutherford produced sense phenomenon like most of the particle alpha is continued, so it can be concluded that a large part of the atom is empty space. From the various phenomenon observed and conclusions obtained, only then is an atomic model formulated. The discussion is complemented by pictures that support making it easier for students to understand. Limitations of the previous model are always discussed before moving on to the next model. Models are compared and contrasted, and the strengths and limitations of each model are discussed. The explanation in the book is also accompanied by years to show that knowledge develops hand in hand and is sustainable. Misconceptions that often occur in students are also taken into account in the preparation of books. As misconceptions of writing electron configurations that often occur, the author inserts a table along with an explanation of the orbital energy diagram based on the atomic number.

The book completed with a summary, keywords, questions to refresh students’ memories about the subjects they have learned, and questions to challenge students’ skills in applying and motivate students
to study deeper at the end of each chapter. The connection between the historical development of the atomic theory and its impact or influence on life today is also inserted in the discussion, such as usability of cathode ray tube, and are presented with a specific theme at the end of each chapter such as the explanation that living things emit light or the benefits of quantum mechanics for life. The development of the topic and sub-matter can be seen in Table 1.

Table 1. Development of the topic and sub-matter.

| Chapter                | Topic                      | Sub-Matter                                | Experiment |
|------------------------|----------------------------|-------------------------------------------|------------|
| Philosophy of Atom     | First philosophy           | Thales & Anaximander                      |            |
|                        |                            | Heraclitus                                |            |
|                        |                            | Empedocles                                |            |
|                        | Thinking about atom        | Leucippus & Democritus                    |            |
|                        |                            | Aristoteles                               |            |
|                        |                            | Jabir bin Hayyan                          |            |
|                        |                            | Abul Hasan Al Asy’ary                     |            |
| Dalton                 | Basic concept of chemistry | Lavoisier's mass mobility law             | V          |
| Atomic Theory          | Birth of Dalton's atomic theory | Dalaton's relative atomic weight          | V          |
|                        |                            | Dalaton's multiple comparison law         | V          |
|                        |                            | Basic Dalton's Atomic Theory              |            |
| Thompson               | Electric discovery         | The discovery of electricity              | V          |
| Atomic Theory          |                            | Discovery of the cathode ray tube         | V          |
|                        |                            | Discovery of electrons                     | V          |
|                        | Thompson atomic model      | Discovery of Thompson atomic model        | V          |
|                        |                            | Discovery of the electron mass            | V          |
| Proton discovery       |                            | Proof of protons                          | V          |
|                        | Determination of proton mass |                                                      |            |
| Rutherford             | Radiation beam             | The discovery of the radiation beam       | V          |
| Atomic Theory          | Rutherford atomic model    | Discovery of Rutherford atomic model      | V          |
|                        | Neutron discovery          | Neutron discovery                         | V          |
| Bohr                   | The properties of light    | Light as particles                        | V          |
| Atomic Theory          |                            | Light as wave                             | V          |
|                        | Basic theory of Bohr's atom | Max Planck's energy quantization theory   | V          |
|                        |                            | Einstein's photoelectric effect            |            |
|                        | Bohr's atomic theory       | Discovery of Bohr's atomic theory         | V          |
| Quantum Mechanics      | Basic theory of quantum mechanics | Particle dualism theory of de Broglie's | V          |
| Theory                 |                            | Heinsberg's uncertainty principle         | V          |
|                        | Theory of quantum mechanics | Quantum mechanics basic theory             | V          |
|                        |                            | Quantum numbers                           | V          |
|                        |                            | Electron Configuration                     | V          |

3.3. characteristic

The characterization stage was performed so that the products are made accordingly, which include the eligibility of material or content, presentation components, and linguistic components and images. Material coverage must be appropriate, the concept must be right and up to date. Book presentation must complete, logical, systematic, interesting, and can stimulate curiosity. The language and graphics used are precise and readable. The printed book was then reviewed and given constructive advice from the supervisor and five peer reviewers so that the product can meet the criteria. Revisions based on input were related to writing, graphics, book closing sentences, and book cover improvements. After the
revision was complete, a review was carried out by the media expert and instructor. Revisions were performed in regards to graphics, writing, adding matter, further explanation, and replacing or eliminating incorrect images.

3.4. reduction
At the reduction stage, the product was reviewed by students as the product user target. Ten grade X students from various schools had finished studying the atomic material at the school reviewing the product. The products reviewed were mainly from the aspect of language and readable. The results were then used to improve the product to make it more suitable. Sentences and graphics that are still difficult for students to understand are corrected.

After the product had been revised, the product was assessed by five chemistry teachers with more than ten years of teaching experience using instruments in the form of a questionnaire that had been prepared. The questionnaire was adjusted to the product criteria to be achieved. The questionnaire produced qualitative data, which was further processed into quantitative data to determine product quality assessment results. Product quality assessment consists of three components: the material/content feasibility component, the presentation component, and the language and image components, which are then broken down into 30 criteria.

The data shows that the most prominent advantages of this product lie in the truth of the concepts presented that are by the opinions of experts and reality. The most prominent weakness of this product is about the accuracy of the use of grammar, spelling, and terms used. It is possible because the references used in writing products are university reference books and not infrequently use a foreign language that influences the arrangement of sentences. Also, there are indeed several terms that are unfamiliar to students that affect the readability of a sentence. In summary, the overall evaluation is presented in Table 2.

| Components       | Average of Score | Highest Ideal Score | Average Score on max 5 scale | % Ideality | Category |
|------------------|------------------|---------------------|-----------------------------|------------|----------|
| Material / Content Feasibility | 50.8             | 55                  | 4.6                         | 92.4       | Good     |
| Presentation     | 49.2             | 55                  | 4.5                         | 89.5       | Good     |
| Language and Image | 34.6             | 40                  | 4.3                         | 86.5       | Good     |
| Total Score      | 134.6            | 150                 | 4.5                         | 89.7       | Good     |

Overall, the quality of the story of an atomic enrichment book for X grade high school obtained an average of 134.6 from an ideal high score of 150 so that it was in good category with a percentage of ideals of 89.7%. Thus, the story of an atomic chemistry enrichment book is applied correctly as a source of learning for high schools, especially for X grade students, but it can still be improved to obtain a better product.

4. Conclusion
A story of an atom enrichment book using the 4S TMD method had been successfully developed. The selection phase shows that the product developed is the following needs and innovation. This product complies with the curriculum, and the conceptual truth is guaranteed because it uses trusted references. The structuring phase shows that the product is structured. The characterization phase presents that the product is suitable for the concepts and is well organized. The reduction stage creates a product suitable for product targets. The product assessment shows that the product has the appropriate material coverage, right, and up to date. Book presentation adequate complete, logical, systematic, interesting,
and can stimulate curiosity. The language and graphics used are suitable and readable. It means that this book fits as a learning resource for secondary schools, mainly grade X, but it can still be improved to get a better product.

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