Electronic thermodynamics teaching materials based on authentic learning to practice students’ problem-solving skills: Aspects of validity

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Abstract. The purpose of this study was to describe the validity of authentic learning-based electronic thermodynamic teaching materials to train students' problem-solving skills during the COVID-19 pandemic. The model used in this study was the ASSURE development model, which only reached the third stage, namely Selection of Media and Materials. The validation of teaching materials was assessed by three validators consisting of two physics education academics and one practitioner. Based on the validation results, it was found that the authentic learning-based electronic thermodynamic teaching material for training students' problem-solving skills was declared valid with a value of 3.14. Appropriate teaching materials can then be used in schools' teaching and learning processes and tested for practicality and effectiveness.

1. Introduction
National education standards in Indonesia are expected to improve students' skills, one of which is problem-solving skills. Schools are expected to be able to create students who have good problem-solving skills [1,2]. This skill is essential to train students because it is beneficial for students in dealing with problems, both in physics problems and in real-world issues [3,4].

The results of an interview with one of the physics teachers at a high school in the city of Banjarmasin explained that the learning resources during the COVID-19 pandemic were student worksheets and videos on YouTube. The existing learning media have not been optimized in facilitating students to learn independently. The material in the student worksheets tends to display general concepts and abstract concepts but cannot be applied to learning in the real world. Teaching materials used in schools are also less helpful for students to solve analytical problems. Because of this, students tend to have less problem-solving skills when viewed from the problem-solving skill indicators. This can be seen after the researchers test students by giving physics questions in essays that practice problem-solving skills. As a result, students answer questions by describing the problem or what is known about the issue without telling or visualizing the problem encountered.

The problems above need exceptional innovations so that the ordinary skills of students are not lost. One solution is to develop authentic learning-based thermodynamic electronic teaching materials to train students' problem-solving skills during the COVID-19 pandemic. Authentic Learning focuses on real-world situations, problem-based activities, complex problems and solutions, case studies, and individual
and group practice [5]. Authentic learning is learning that can provide a real learning experience [6–8]. Authentic learning is designed to connect students' issues, problems, and applications in the real world [9–11]. Submission of material in the teaching and learning process, in physics learning, will be more meaningful if it is associated with the surrounding environment [12–14]. The surrounding environment is closely related to the concepts of physics lessons [15–17]. Authentic learning is more inclined to a constructivist learning model that can create meaning for students [18]. Authentic learning can develop students' skills for the better [19]. Authentic learning allows learners to engage in practical tasks using real-world resources and tools and provides opportunities for learners to learn with intention by thinking and acting like professionals as they tackle real problems [20]. Authentic learning can improve understanding, comparing, proving, suggesting, and reflecting on the problem-solving process [21].

The subject used in the development of authentic learning-based electronic teaching materials is the subject of thermodynamics. Thermodynamics material is relatively difficult to complete by students, especially in an online learning system like this. It will complicate material that is already relatively difficult. The application of thermodynamics is also relatively often encountered by students in everyday life or the real world. This thermodynamic material is easier to relate to real-world problems that can provide more value in the learning process. Examples of materials in thermodynamics that can be loaded in authentic learning are thermodynamic processes, heat engines, and cooling engines. In addition, it can also be applied to the toy boat game; to make the toy boat move, there is a thermodynamic process in it, it takes oil in the body of the boat which will be given fire in it, with the heat from the fire that remains burning as long as the oil is still hot it will rotate propeller under the boat that causes the ship to move. Thermodynamics teaching materials are expected to help and facilitate students in solving complex problems.

The results of previous studies stated that authentic learning-based teaching materials could improve student learning outcomes and improve students' problem-solving skills [22–24]. However, the weakness is that students still struggle to remember the sequence of problem-solving skills [25]. Previous research still uses printed teaching materials in the teaching and learning process with the face-to-face method. As for this study, teaching materials are made in such a way as to adapt to the conditions that occurred in Indonesia, namely COVID-19. These teaching materials are made in the electronic form to make it easier for students to access anywhere and anytime. This electronic teaching material also adapts to the needs of students who have difficulty getting access to textbooks. Authentic learning must also adapt to students' circumstances, for example, by adjusting online learning to meet the needs of students well [26].

This research produced a learning product, namely authentic learning-based thermodynamic electronic teaching materials, to train students' problem-solving skills during the covid-19 pandemic. The focus of this research was to describe the validity of original learning-based thermodynamics electronic teaching materials to teach students problem-solving skills.

2. Method

This research was part of the development research with the ASSURE model. However, this article was only up to the fourth stage, namely the Utilization of instructional materials. The following are the stages of the ASSURE model.

The first step is student analysis, the characteristics in one of the senior high schools in Banjarmasin class XI range from 16 to 17 years old. Based on Piaget's theory of cognitive development level, the age of senior high school students in Banjarmasin belongs to the formal operational category. At this age, students are considered capable of communicating socially with their friends, applying concepts, solving problems, and assessing work. Learning activities must emphasize abstract and analytical thinking processes to find answers to a pain in the learning process. However, students still do not understand how to relate learning to everyday life, so problem-solving skills are still lacking.

The second step is to formulate learning objectives. The teaching material used in the research was thermodynamics for the high school of class XI. Learning objectives were taken based on essential competencies in the revised 2013 (K-13) curriculum.
The third step is choosing media, and learning packages, the material used was thermodynamics based on authentic learning. The fourth step is using learning materials; at this stage, validation will be carried out.

Validity measures a teaching material that can or cannot be used to measure what should be measured [27]. According to Ridho [22], validity is an activity to validate a device based on the suitability of the criteria needed in electronic teaching materials. Approval, in this case, is approved by the validator, namely from academics and practitioners. The requirements for the validity of teaching materials are listed in Table 1. Meanwhile, the reliability is calculated using the Cronbach's Alpha equation.

| No | Mean Score | Category   |
|----|------------|------------|
| 1  | $x > 3.4$  | Very Valid |
| 2  | $2.8 < x \leq 3.4$ | Valid |
| 3  | $2.2 < x \leq 2.8$ | Adequately Valid |
| 4  | $1.6 < x \leq 2.2$ | Less Valid |
| 5  | $x \leq 1.6$ | Very Less Valid |

3. Result and Discussion

The result of this research was electronic thermodynamics teaching material based on authentic learning. There are eight characteristics of authentic learning [28], which some of them are contained in the making of this teaching material, including (1) learning is centered on authentic tasks that are interesting to the learner, (2) students are encouraged to explore the world around them and inquire, (3) students become motivated in more complex tasks, and higher-order thinking, (4) the teacher as a facilitator who helps in learning, and (5) students carry out the basic framework of techniques.

Electronic teaching materials that authentic learning included teaching materials that contained life problems, such as the inclusion of specific regional game objects and nearby tools into teaching materials. This is expected to increase students' motivation to learn so that it is easy to understand the material presented by the teacher. In addition, students can understand the relationship between physics material in everyday life. This electronic teaching material is also equipped with pictures and videos to make it easier for students to understand electronic teaching materials individually. The electronic teaching materials produced have gone through various stages, one of which was validation by two academic validators and one practitioner validator. Two validators are physics education lecturers and one practitioner from a state high school in Banjarmasin. The following suggestions given by the three validators can be seen in Table 2.

| No | Validator's Recommendation on Electronic Thermodynamics Teaching Materials |
|----|--------------------------------------------------------------------------------|
| 1  | This teaching material is in accordance with current conditions and helps students learn online independently. Improvements to the table of contents, concept definitions that must use university standard books, science corners must be consistent; learning objectives are replaced with learning indicators, italicized sentences are only for foreign languages, sample questions must be given hands, formula numbers should not be blocked, image forms must be proportional, add a glossary, and pay attention to writing at the beginning of each meeting. Pay attention to the writing aspects of teaching materials such as punctuation, spaces, italics, formula writing, etc. |
| 2  | Electronic teaching materials are also expected to increase students' motivation to learn. Clarify authentic learning indicators in the teaching materials. |
presented are adjusted to the syllabus multiply practice questions related to problem-solving.

The following display of electronic teaching materials before and after being validated can be seen in Table 3.

Table 3. Electronic teaching materials before and after being validated

| Before | After |
|--------|-------|
| Cover  | None  |
|  Preliminary of authentic learning |  Example questions with steps to solve the problem |

The validity of electronic teaching materials consists of aspects of format, language, content, presentation, and usability. After being assessed by the validator and then analyzed by the author, the validation results were obtained. The results of the validity of electronic teaching materials for each aspect can be seen in Table 4.
The advantages of authentic learning are that students will gain new understanding and experience a level of change in making perceptions, questions, and summaries. This also shows that the contents of electronic teaching materials are in accordance with national standards or competency standards that should be adapted to the curriculum currently circulating during the COVID-19 pandemic. The aspect of presenting the material is categorized as valid. It also shows that the presentation delivered in electronic teaching materials is good enough to be used in the teaching and learning process in the classroom. Finally, the aspects of the benefits and uses of electronic teaching materials are categorized as valid. This also shows that the developed teaching materials will have good benefits and uses for their users later during the teaching and learning process.

The four aspects in the validation show that this electronic teaching material is categorized as valid and ready to be used in authentic learning. This indicates that the developed teaching materials can be used for further trials. This electronic teaching material, after being validated, was then revised according to the validator's suggestions. This was done to obtain better electronic teaching materials than before. In addition, teaching materials that are declared valid indication that the teaching materials can measure precisely what will be measured, in this case, students' problem-solving abilities [29–31].

This electronic teaching material was designed to adapt to the current situation, making electronic teaching materials not in printed form to make it easier for students and teachers to access teaching materials anytime and anywhere. Electronic teaching materials are equipped with sample questions with problem-solving skill methods so that students can quickly obtain electronic teaching materials that can improve their problem-solving skills. Electronic teaching materials that are declared valid can be suitable and used in the learning process [22,32]. Appropriate teaching materials according to Prastowo [33], have several criteria such as: (1) titles or materials that are prepared based on essential competencies or basic materials that students must achieve; (2) the design is clear and attractive, the order of contents must be easy, the title is short, the cognitive structure is clear, and contains a table of contents, summaries, and student assignments; (3) language that is easy to understand, seen from the flowing vocabulary, clear sentences and relationships between sentences, and not long-winded sentences; (4) the content of the material that can be used to test understanding, meaning that teachers can assess students' understanding through teaching materials; (5) contains stimulants, this concerns the content of the material that encourages students to think; (6) easy to read, seen from the eye-friendly teaching materials, the letters are not too small and easy to read, and the order of the text is structured; and (7) instructional materials, meaning that the contents of the teaching materials contain clear instructions and instructions to make it easier for students to learn.

Suitable teaching materials must contain relevant facts, concepts, principles, and procedures and are written in points according to the formulation of the competency indicators [34]. Electronic teaching materials are developed to train students' problem-solving skills. This teaching material contains authentic learning knowledge, motivations, sample questions with problem-solving skills, practice questions, and summaries. The advantages of authentic learning are that students will gain new understanding and experience a level of change in making perceptions [35]. The benefits of Authentic Learning are included in education that can occur anywhere so that students do not feel bored with

Table 4. The results of the validation of teaching materials

| Aspect     | V1  | Category | V2  | Category | V3  | Category |
|------------|-----|----------|-----|----------|-----|----------|
| Format     | 3.17| Valid    | 3.33| Valid    | 3.08| Valid    |
| Language   | 3.26| Valid    | 3.21| Valid    | 2.95| Valid    |
| Content    | 3.00| Valid    | 3.30| Valid    | 3.00| Valid    |
| Delivery   | 3.17| Valid    | 3.29| Valid    | 2.83| Valid    |
| Usage      | 3.50| Very     | 3.00| Valid    | 3.00| Valid    |

Table 4 shows that the validation results of electronic teaching materials in all categories are reasonable or valid. First, the language aspect of the teaching material is categorized as accurate. It means that the language aspect used in the electronic teaching material is in accordance with the rules of good and correct Indonesian. Second, the aspect of the content of electronic teaching materials is categorized as valid. This also shows that the contents of electronic teaching materials are in accordance with national standards or competency standards that should be adapted to the curriculum currently circulating during the COVID-19 pandemic. The aspect of presenting the material is categorized as valid. It also shows that the presentation delivered in electronic teaching materials is good enough to be used in the teaching and learning process in the classroom. Finally, the aspects of the benefits and uses of electronic teaching materials are categorized as valid. This also shows that the developed teaching materials will have good benefits and uses for their users later during the teaching and learning process.

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learning; students have more extraordinary skills in analyzing problems that arise in real life, students get a qualified learning experience in interacting with the surrounding environment, learning is student-centered so that students can understand their material in depth [36].

In general, authentic learning-based thermodynamic electronic teaching materials are declared valid. It shows that these electronic teaching materials can be used to train students' problem-solving skills. In addition, this teaching material can be used as a reference during the COVID-19 pandemic. Furthermore, this teaching material needs to be implemented in the teaching and learning process to measure its practicality and effectiveness.

4. Conclusion
The authentic learning-based thermodynamic electronic teaching material developed is categorized as valid with an average value of 3.14. Teaching materials that are said to be helpful can then be used in the class trial stage. As for suggestions for further research, further research is needed to test the validated electronic teaching materials.

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