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Development of Electronic Student Worksheets Based on The Theory of Conceptual Change in Thermodynamics

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ABSTRACT

The development of valid and practical electronic student worksheets based on the theory of conceptual change in thermodynamics material has been completed. This development research uses the Rowntree development model which consists of three stages, namely the planning stage, the development stage, and the evaluation stage. At the evaluation stage, the researcher used Tessmer's formative evaluation in the form of self-evaluation, expert review, one-to-one evaluation, and small group evaluation. Data collection instruments used expert validation sheets and questionnaires. The results of data analysis at the expert review stage obtained an average expert validation of 4.4 with a very valid category. The average of the student questionnaire sheets in the one-on-one evaluation and small group evaluation phases was 4.4 and 4.5, respectively, with a very practical category. Thus, an electronic student worksheet based on the theory of conceptual change has been successfully developed on valid and practical thermodynamic material. This electronic student worksheet can be used to clarify conceptual understanding and correct thermodynamics misconceptions.

Keywords: Development of Electronic Student Worksheets, Overcoming Misconceptions, Physics

INTRODUCTION

Thermodynamics is one of the sciences that studies the process of energy transfer as heat and work between the system and the environment. In terms of concepts, many think that the concept of thermodynamics is very easy to understand. But in reality, this material is one of the materials that is quite difficult for students at the high school level to master at the university level (Syuhendri S, 2016). Many students have problems understanding concepts caused by the thoughts they build based on previous daily life experiences that provide their understanding of their environment. The difference between the initial conception that students have with the correct concept is what is called a misconception (Paramitha & Darmaji, 2021). The abstract concept of thermodynamics makes students often experience misconceptions when studying so students have misconceptions about the study (Eda et al., 2020).

According to (Yaqin et al., 2017) the percentage level of students' conceptual understanding of the subject of Thermodynamics at SMAN Pakusari is dominated by Don't Know the Concept (TTK) with an average percentage level of understanding of the concept of 55.48%. and the smallest percentage of concept understanding at the Concept Understanding but Not Sure enough level with an average percentage of 2.58%, while the average percentage of students at the Concept Understanding (PK) and Misconception (M) levels is 9.03% and 32.90% The items that have the highest percentage of misconceptions are found in the sub-topic "Efforts and Processes in Thermodynamics". Furthermore, in research conducted by (Handayani et al., 2018) on the law of thermodynamics which was carried out in 3 high schools in Bondowoso, the overall misconception experienced by students on the subject of the Law of Thermodynamics in 3 Bondowoso high schools was 28.04% so that this misconception was classified as low level.

Misconceptions or misunderstandings can occur due to incorrectly connecting a concept with other concepts and there are differences

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in understanding caused by a misunderstanding of the concept. (Nurulwati & Rahmadani, 2019), Between new concepts and existing concepts with the interaction of students and the natural surroundings a wrong concept is formed and an idea that does not follow the scientific understanding accepted by experts Samara et al., (2020); Rahmawati & Syuhendri, (2014); (Triastutik et al., 2021). Misconceptions have a stable nature and last for a long time will result in the low ability of students to build concepts and not achieve complete learning (Rahma et al., 2018) So that the next learning process does not encounter obstacles, misconceptions need to be eliminated (Sania et al., 2021).

Conceptual change or restructuring of existing knowledge is learning that involves changing students' concepts by adding new knowledge to their existing knowledge (Posner dkk., 1982). It has been widely studied in science education where students often have misconceptions about physics, contrary to what students learn in school. For decades, the focus of research on conceptual change has been the cognitive and developmental factors that influence changes in students' knowledge (Nadelson et al., 2018). Therefore, a specific teaching approach is needed to support conceptual change and dispel misconceptions. Teaching that is carried out explicitly aims to help students experience conceptual change and follow the guidelines of the conceptual change model as teaching (Syuhendri, 2017).

When learning problems occur in students, it is necessary to know the causes of these problems to determine the appropriate steps to overcome them (Maison et al., 2020). Various efforts can be made to improve students' understanding of concepts, namely by using various methods, techniques, and strategies in learning, as well as by developing teaching material. The development of teaching materials can answer or solve problems or difficulties in learning such as misconceptions (Departemen Pendidikan Nasional, 2008).

Student Worksheets (LKPD) are learning resources in the form of task sheets, instructions for carrying out tasks, and evaluation of learning that must be done by students (Alfi Rahayu, 2019). LKPD that is following the material can be developed and designed by the teacher himself as a supporter in the process of learning and teaching activities so that it can help students independently explore the material and achieve learning goals (Prastowo, 2015). According to Purnawati et al (2020) So far, the Student Worksheets used in learning are still in the form of printed materials. The disadvantages of using LKPD from printed materials are impractical, more complicated to carry anywhere, and require more space when carried (Hidayah et al., 2020). LKPD can also train students to be able to express concepts, clarify and present cognitive conflicts so that students are more open to the next conception, and restructure concepts into scientific concepts. The LKPD is a conceptual change-based LKPD.

Based on the description above, it appears that the use of electronic student worksheets based on conceptual change is very good in the learning process. Besides being able to improve understanding of concepts, worksheets like this can also help in remediating misconceptions experienced by students. However, until now, there are very limited LKPD based on conceptual changes for physics material. Therefore, this study developed a student worksheet based on the theory of conceptual change for thermodynamics material that can be used by teachers in the learning process. The purpose of this project was to provide electronic student worksheets based on the notion of conceptual change in authentic and practical Thermodynamics content.

RESEARCH METHODS

Based on the theory of conceptual change in thermodynamic material, the research methodology used aims to produce electronic worksheets teaching (LKPD)

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materials. The development model used to develop teaching materials in research is the Rowntree model. Rowntree model is a product-oriented development model, which in this case is teaching materials.

The Rowntree development model consists of three stages, namely the planning stage, the development stage, and the evaluation stage (Prawiladilaga, 2008). At the planning stage, the researcher conducted a needs analysis and formulated the learning objectives. The development stage is carried out for developing topics, drafting, and producing prototypes. The format or systematic writing of the Theory of Conceptual Change used follows that developed by Syuhendri (2017).

Finally, at the evaluation stage, the researcher used Tessmer's formative evaluation model, namely: (1) self-evaluation; (2) expert review; (3) one-to-one evaluation; and (4) small group evaluation.

In the self-evaluation stage, the researcher did his checking of the LKPD draft that would be developed and revised according to the weaknesses found. Revisions were made to the format and content of the developed product. The revised results are referred to as LKPD based on conceptual changes to the thermodynamics draft 1 material, which will be reviewed by experts (expert review) and tested on a limited basis for users at the one-to-one evaluation stage. Various inputs from this stage are used to improve teaching materials, the results of which are referred to as LKPD based on conceptual changes to draft 2 thermodynamics material.

Furthermore, in the small group evaluation stage, the LKPD based on conceptual changes to the thermodynamics draft 2 material was tested on users on a wider scale. The results of this trial are also used as material to revise the product. The final result of this stage is the obtaining of the final version of the LKPD based on conceptual changes in thermodynamic material. Because this stage is following the research objectives to be achieved, namely to produce valid and practical teaching material products, the field-test evaluation stage is not carried out which aims to see the potential effects of using teaching materials.

The research was conducted at SMA Negeri 1 Lembak. Participants in the study were students of class XI science. The instruments used are 1) Expert Validation Sheets given to experts to validate the product being developed, 2) Questionnaires used to find out the opinions of students and teachers about the teaching materials being developed. The expert validation sheet is used to determine the validation of the developed product. From the expert validation sheet, you will get an assessment and advice, and recommendations from experts to improve the product. Based on the analysis of the expert validation sheet, the validity of the teaching materials was determined. Meanwhile, the usefulness of the teaching materials is assessed during the one-on-one evaluation and small group evaluation phases.

Following the research problem, the data analysis to answer the problem is to conduct a qualitative analysis of the results of existing instruments, namely Expert Validation Sheet, Questionnaire 1, and Questionnaire 2, with descriptive statistical analysis. Data obtained through a questionnaire in the form of a qualitative scale was converted into a quantitative scale. For positive statements, the SS (Strongly Agree) category is given the highest score and STS (Strongly Disagree) is given the lowest score. Between the two is given a score by considering the number of choices and the range of scores given. The final result is the average of the results of the assessments of the experts and participants involved in the research.

RESULTS AND DISCUSSION

Following Syuhendri's systematics and using the Rowntree development stage and Tessmer evaluation, electronic student worksheets based on the theory of conceptual change in thermodynamics are established. The use of the Rowntree model is because the

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model produces products, including teaching materials. The Rowntree model has three stages, namely the planning stage, the development stage, and the evaluation stage.

The Tessmer evaluation was applied in this research during the evaluation stage. This is because Tessmer's evaluation is more structured than Rowntree's evaluation. Tessmer's evaluation stage consisted of self-evaluation, expert review, one-to-one evaluation, and small group evaluation. The research results are described for each research stage, Specifically, the stages of planning, developing, and evaluating. The evaluation stage is further broken down into small group, one-on-one, expert review, and self-evaluations.

Planning Stage

The development of teaching materials goes through various processes consisting of literature studies and field studies. In the literature study, the researcher reads a lot of journals that discuss misconceptions that are often found in thermodynamics. Next, the researcher made observations by distributing questionnaires to students to analyze the needs of the teaching materials to be developed.

According to the findings of the needs analysis, 75.8% of students found it quite difficult to learn physics. Physics is difficult to learn because 65.2 percent of students struggle. After all, the material is too challenging to understand. After all, it is taken from a reference book, 89.4% of students need understandable references so that learning is easier and more practical to implement and 27.3% of students need additional references in the form of LKPD. Furthermore, based on literature studies, many forms of misconceptions in thermodynamic material and the high need for students for learning references are needed, and a special approach is needed based on conceptual change learning. the work of electronic students based on the theory of conceptual change in thermodynamic material. The development of electronic student worksheets is done by making an Outline of Teaching Material Contents (GBIBA) on thermodynamic material. GBIBA aims to facilitate researchers in developing draft teaching materials. The drafting of student worksheets based on the theory of conceptual change in thermodynamics consists of (1) cover; (2) Preface; (3) table of contents; (4) introduction; (5) core competencies and Basic Competencies; (6) material map; (7) student worksheets on thermodynamic material; (8) practice questions; (9) Glossary; (10) bibliography.

Development Stage

At the development stage, the topics of the teaching materials developed must be following the thermodynamics syllabus. After developing topics on teaching materials. Furthermore, the outline of the contents of the teaching materials (GBIBA) was made as a reference for drafting teaching materials. Then at the production stage, prototypes are prepared and tools are compiled for evaluation. The evaluation tool is used to assess the teaching materials that have been made by looking at the teaching materials in terms of content, language, and design of teaching materials. These evaluation tools are in the form of content/material validation sheets, linguistic validation sheets, teaching material designs, as well as student responses questionnaire sheets.

Evaluation Stage

The evaluation stages used are following Tessmer's evaluation stages. First, the researchers conducted a self-evaluation stage which resulted in prototype 1. Suggestions and comments were used to improve electronic student worksheets based on the theory of conceptual changes in thermodynamic material. At the evaluation stage, the teaching materials that have been designed as prototype 1. For the next step in prototype 1, the self-evaluation stage is carried out.

Self Evaluation Result

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The self-evaluation stage is an assessment carried out by researchers on teaching materials that have been developed by checking the content of the material, language, and design. Then the researchers revised the teaching materials according to the results of the self-evaluation. Self-evaluation and revision are carried out several times until the teaching materials are good according to the syllabus and characteristics of prospective users.

Expert Review Result

After the self-evaluation stage then enters the expert review stage, this stage is carried out on teaching materials that have been developed (prototype 1) by asking for review and evaluation assistance from experts as validators. This stage is carried out to measure the validity of the electronic LKPD that has been developed by the researcher. The validation tests carried out were the validity of the content (material), language, and design of teaching materials. The validation results in the form of responses/comments and suggestions on the validation sheet are used as the basis for revising teaching materials (prototype 1). The results of the validation carried out by experts are presented in Table 1.

Table 1. Recapitulation of Validation Assessment Results

No	Electronic LKPD Validation	Score
1	Content Validation	4,3
2	Language Validation	4,5
3	Design Validation	4,5
4	Conceptual Change validation	4,4
	Average	4,4
	Category	Highly valid

Validation was carried out by three different validators. The results of content validation given by the three validators were averaged so that a value of 4.30 was obtained with a very valid category. Furthermore, the results of the linguistic validation of the three validators are averaged so that the results are 4.50 with a very valid category and the results from design validation and conceptual change validation are 4.50 and 4.40 with very valid categories, respectively. From the three aspects assessed by the validator, an average of 4.40 was obtained and the electronic LKPD could be declared very valid. In addition to providing grades, the validator also provides suggestions and comments on the validation sheet. Suggestions and comments from validators are used to improve prototype 1. All validators state that electronic worksheets based on the theory of conceptual change in thermodynamics are worthy of testing with revisions according to suggestions. Furthermore, the results of the expert review are also a very important input for improving teaching materials.

One-to-One Evaluation Result

After the electronic LKPD was declared valid at the expert review stage, a one-to-one evaluation trial was carried out on 3 students of class XI randomly. The students were asked to use the revised prototype 1, then the students were asked to fill out a questionnaire that had been prepared to find out the students' responses to see the practicality of the teaching materials from the students' point of view. The data on the results of the student response questionnaires can be seen in Table 2.

Table 2. Recapitulation of Student Questionnaire Data in the One-to-One Stage

No	Indicator	Value Recapitulation	Value Category
1	Learning materials	4,3	Very Practical
2	Giving Motivation	4,4	Very Practical
3	Languag e	4,5	Very Practical
4	Design	4,5	Very Practical
	Total	4,4	Very Practical

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The results of the one-to-one evaluation stage as a whole given by the three students obtained an average of 4.4 with a very practical category. In addition to providing grades, these three students provided suggestions and comments for the improvement of the electronic LKPD. Based on the results of the expert review and one-to-one evaluation, revisions were made to the electronic LKPD based on the theory of conceptual change that was developed. The results of this revision are referred to as prototype 2 electronic LKPD of thermodynamic materials. After the researchers made improvements according to the suggestions at the one-to-one evaluation stage, the electronic LKPD made by the researchers produced prototype 2 which would then be used to go to the small group evaluation stage.

Small-Group Evaluation Result

At the Small Group Evaluation stage, the student worksheets based on the theory of conceptual change prototype 2. Prototype 2 was tested on a small group of class XI students consisting of 9 randomly selected students. The students were asked to understand the revised prototype 2. At the end of the lesson, students are asked to fill out the questionnaire that has been given to find out the students' responses to prototype 2 used in learning. The instrument used in this stage is the same as the one-to-one evaluation questionnaire instrument. The goal is to test the level of practicality or the level of usability of the prototype. The results of student responses to the use of electronic LKPD based on the theory of conceptual change can be seen in Table 3.

Table 3. Recapitulation of Student Assessment Results in the Small Group Evaluation Stage

No	Indicator	Value Recapitulation	Value Category
1	Learning materials	4,5	Very Practical
2	Giving Motivation	4,5	Very Practical
3	Language	4,6	Very Practical
4	Design	4,5	Very Practical
Total		4,5	Very Practical

The results of the small group evaluation stage as a whole from the questionnaire filled out by students obtained an average of 4.5 with a very practical category. In addition to providing an assessment of prototype 2, students also provide suggestions and comments for improving prototype 2. The results of the questionnaire analysis describe the level of practicality of the teaching materials developed. Thus, it can be concluded that the electronic worksheet based on the theory of conceptual change in thermodynamic material is valid and practical.

The results of this study are in line with the results of research conducted by several other researchers such as (Badiro et al., 2019) who produce learning media for android applications based on the theory of conceptual changes in the material of the solar system and moon phases for IPBA courses that are valid and practical, (Yani et al., 2018) generate worksheets based on conceptual changes in electrolyte and non-electrolyte solution materials get teacher responses to aspects of content suitability, readability, and construction are categorized as very high.

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CONCLUSION

Based on the results of the research that has been carried out, teaching materials have been produced in the form of electronic student worksheets based on the theory of conceptual change in thermodynamic material which is categorized as valid and practical. This shows that the Electronic LKPD based on the theory of conceptual change is feasible to use. Furthermore, it is recommended that further research be conducted to measure the potential effects of teaching materials in improving students' understanding of concepts and their effectiveness in reducing misconceptions experienced by students.

REFERENCES

Badiro, D., Syuhendri, S., & Fathurohman, A. (2019). Pengembangan Media Pembelajaran Aplikasi Android Berbasis Teori Perubahan Konseptual Materi Tata Surya dan Fase Bulan Mata Kuliah IPBA. *Jurnal Inovasi Dan Pembelajaran Fisika*, *6*(1), 103–112.

Departemen Pendidikan Nasional. (2008). *Panduan Pengembangan Bahan Ajar*.

Eda, P., Purwaningsih, E., & Sutopo, S. (2020). *Conceptual Problem Solving (CPS) dalam Latihan Memecahkan Masalah untuk Meningkatkan Penguasaan Konsep Mahasiswa pada Topik Termodinamika*. *5*(1), 1–11.

Handayani, N. D., Astutik, S., & Lesmono, A. D. (2018). Identifikasi Miskonsepsi Siswa Menggunakan Four-Tier Diagnostic Test Pada Materi Hukum Termodinamika Di SMA Bondowoso. *Jurnal Pembelajaran Fisika*, *7*(2), 189–195.

Hidayah, A. N., Winingsih, P. H., Amalia, A. F., Fisika, D., Pageflip, D., & Problem, B. (2020). Development Of Physics E-LKPD (Electronic Worksheets) Using 3D Pageflip Based on Problem Based Learning on Balancing And Rotation Dynamics. *Jurnal Ilmiah Pendidikan Fisika-COMPTON*, *7*(2), 36–43.

Maison, M., Lestari, N., & Widaningtyas, A. (2020). Identifikasi Miskonsepsi Siswa Pada Materi Usaha Dan Energi. *Jurnal Penelitian Pendidikan IPA*, *6*(1), 32–39.

Nadelson, L. S., Heddy, B. C., Jones, S., Taasoobshirazi, G., & Johnson, M. (2018). Conceptual change in science teaching and learning: Introducing the dynamic model of conceptual change. *International Journal of Educational Psychology*, *7*(2), 151–195. https://doi.org/10.17583/ijep.2018.3349

Nurulwati, & Rahmadani. (2019). Perbandinagn Hasil Diagnostik Miskonsepsi Menggunakan Three Tier Dan Four Tier Diagnostic Test Pada MAteri Gerak Lurus. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *7 (2)*(101–110).

Paramitha, D., & Darmaji, M. (2021). *Tes Diagnostik Four-Tier untuk Mengidentifikasi Miskonsepsi pada Materi Fisika Four-Tier Diagnostic Test to Identify Misconceptions in Physics Concepts*. *6*(2), 193–198. https://doi.org/10.36709/jipfi.v6i2.17366

Prastowo, A. (2015). *Panduan Kreatif Membuat Bahan Ajar Inovatif* (Cetakan VI). Diva Press.

Prawiladilaga. (2008). *Prinsip Desain Pembelajarane*. Kencana Prenada Media Group.

Purnawati, W., Maison, M., & Haryanto, H. (2020). E-LKPD Berbasis Technological Pedagogical Content Knowledge (TPACK): Sebuah Pengembangan Sumber Belajar Pembelajaran. *Tarbawi: Jurnal Ilmu Pendidikan, Vol. 16, No. 2, Desember 2020, 126 – 133*, *16*(2), 126–133.

Rahma, U., Fikria, A., Setyarini, M., & Tania, L. (2018). *Pengembangan Lembar Kerja*

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Siswa Berbasis Perubahan Konseptual Pada Materi Asam Basa. *1*, 1–13.

Rahmawati, D., & Syuhendri, K. W. (2014). *Analisis Pemahaman Konsep Termodinamika Mahasiswa Pendidikan Fisika Menggunakan Instrumen Survey Of Thermodynamic Processes And First And Second LawS (STPFaSL)*.

Samara, R. A., Syuhendri, & Muslim, M. (2020). Pengembangan Teks Perubahan Konseptual Handout Untuk Remediasi Miskonsepsi Materi Dinamika SMA/MA. *Jurnal Inovasi Dan Pembelajaran Fisika*, *7*(1), 55–63.

Sania, L., Syuhendri, S., & Akhsan, H. (2021). Pengembangan Bahan Ajar Teks Perubahan Konseptual (TPK) Materi Fisika Dasar Topik Kinematika. *Jurnal Kumparan Fisika*, *4*(1), 43–50.

Syuhendri, S. (2017). A learning process based on a conceptual change approach to foster conceptual change in Newtonian mechanics. *Journal of Baltic Science Education*, *16*(2), 228–240.

Syuhendri S. (2016). No Title. *Developing of Conceptual Change Texts (CCTs) Based on Conceptual Change Model to Increase Students' Conceptual Understanding and Remediate Misconceptions in Kinematics. In: The 2nd Sriwijaya University Learning and Education-International Conference (SU*, 1191–1205.

Triastutik, M., Budiyono, A., & Diraya, I. (2021). *IDENTIFIKASI MISKONSEPSI SISWA PADA MATERI GERAK LURUS*. *8*(1), 61–72.

Yani, T. D. A., Setyarini, M., & Tania, L. (2018). Pengembangan LKS Berbasis Perubahan Konseptual pada Materi Larutan Elektrolit dan Non Elektrolit. *Jurnal Pendidikan Dan Pembelajaran Kimia*, 1–13.

Yaqin, M. K., Prastowo, S. H. B., & Harijanto, A. (2017). Identifikasi Pemahaman Konsep Fisika Terhadap Pokok Bahasan Termodinamika Pada Siswa SMA. *Seminar Nasional Pendidikan Fisika 2017*, *2*(September), 1–8.