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# Validity and Practicality of Project-Based e-Student Worksheet on Thermochemical Materials to Improve Learning Outcomes

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**Abstract:** In the 21st century with the industrial era 4.0, teachers and students are required to be technology literate. Then, the Covid-19 that emerged at the end of 2019 greatly affected the education sector. One of the chemistry materials in class XI in exact fields that are quite difficult to understand is thermochemistry because it is abstract. Learning models that guide students to learn independently, such as the Project Based Learning (PjBL) model are needed. The purpose of this study was to develop electronic teaching materials in the form of project-based Electronic Student Worksheets (e-SW) on thermochemical materials and to test their validity and practicality. Project-based e-SW on thermochemical materials was developed using the Plomp development model. The results of the material and media validation analysis were calculated using the Aiken's V formula and the results of the practicality analysis were calculated using the percentage of practicality. The results of material and media validation are 0.88 and 0.89 with very valid categories. The results of the practicality of students in the small group were 89.86% in the very practical category, while the practical results of students and teachers in the field test were 87.21% and 89.03% in the very practical category.

**Keywords:** e-SW; PjBL; Thermochemistry; Flip PDF Professional

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## Introduction

The field of study that is required based on the 2013 curriculum in upper secondary education in the exact field is chemistry. Chemistry is a science that studies many things that are abstract and complex (Dayana et al., 2013). In class XI there is thermochemical material, where the material is quite difficult for students to understand because the teaching materials used are inadequate, there are no worksheets to do assignments, and practicum is needed (Andriyani et al., 2018). So, to understand the material, teaching materials are needed that can guide students to understand the concept.

The use of appropriate teaching materials can increase the effectiveness of the learning process (Sari & Wulanda, 2019). One of the teaching materials needed is the student worksheet. SW is a book that has worksheets for learning, usually, the SW components consist of titles, Core Competencies (CC), Basic Competencies (BC), Competency Achievement Indicators (GPA), time, tools/materials, information, learning stages, exercises, and reports on results (Depdiknas, 2008).

In the 21st century with the industrial era 4.0, information can be accessed easily because of increasingly sophisticated technology. This does not escape the field of education, where 2013 curriculum requires teachers and students to master technology in learning (Reski et al., 2019). Then the Covid-19 emerged at the end of 2019 ended up becoming a pandemic because it had an impact around the world and caused a new health crisis that threatened the world (Singhal, 2020). The Covid-19 pandemic affects various sectors, such as the economy, tourism, industry, and the education sector is no exception (Wahyono et al., 2020).

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The impact of this pandemic causes learning to be carried out in two shifts, namely shifts that study face-to-face and study at home and reduce learning hours to minimize the impact of contracting Covid-19 (Kemendikbud, 2020). This causes learning not to run optimally. Thus, learning using electronic teaching materials is one solution to these two problems, such as the use of e-SW. e-SW can be accessed easily using smartphones, laptops, and others.

To create interesting and fun chemistry learning as well as active and effective, the selection of learning models in making e-SW is very necessary. The selection of this learning model is useful for students to find a concept through activities or real learning that is carried out, both independently and in groups. The learning model is PjBL. Learning with the PjBL model is contextual and requires the activeness of students (Mulyana, 2022). This model also guides students to work on projects that vary in their activities, for example making works in the form of videos, recordings, posters, pictures, and concept maps (Pujiasih, 2020). There are 6 learning steps (syntax) of the PjBL model developed by The George Lucas Educational Foundation (2005), namely: 1) Start with the essential question, 2) Design a plan for the project, 3) Create a schedule, 4) Monitor the students and the progress of the project, 5) Assess the outcome, and 6) Evaluate the experience.

The application used in developing project-based e-SW is Flip PDF Professional. This application is equipped with various multimedia features, such as video, audio, and animation. The use of multimedia in the Flip PDF Professional application is effective for practicing science process skills, such as observing, classifying, interpreting, predicting, asking questions, hypothesizing, planning research/experiments, using tools/materials, apply the concept (Watin & Kustijono, 2017). Teaching materials developed using this application help students to be more active in learning (Febrianti, 2021).

Initial observations that have been made in three different high schools in West Pasaman Regency, namely SMAN 1 Pasaman, SMAN 1 Kinali, and SMAN 2 Kinali, the results show that: 1) Teachers have implemented 2013 curriculum in schools, such as using the discovery learning model in the classroom and have never used the PjBL learning model in teaching, 2) The teaching materials used are generally in the form of printed books and have not used electronic teaching materials, such as e-SW or e-modules, and 3) Students are relatively difficult in learning thermochemistry because several materials must carry out practicum but is not carried out due to time constraints, inadequate teaching materials such as the unavailability of worksheets so that this affects the learning outcomes obtained to be relatively low.

Based on the observations from the three schools, the researchers chose SMAN 1 Kinali as a place to research because the teacher had carried out practical work in the laboratory on exothermic, endothermic, electrolyte solutions, and nonelectrolytes and the teacher had also carried out projects on acid-base materials so that this will help students in working on projects. The purpose of this research is to develop electronic teaching materials, namely e-SW based on projects on thermochemical materials. The developed e-SW is tested for validity and practicality so that it can be used in learning.

## Method

The type of research conducted is educational design research and the development model used is the plomp model developed by Tjeerd Plomp. There are three stages of development in the plomp model, namely: 1) Preliminary research, namely observation activities in several schools by conducting needs analysis, curriculum analysis, concept analysis, student analysis, and literature study, 2) Prototyping phase, namely the stage of making prototypes (teaching materials) which will be developed by establishing design guidelines and optimizing prototypes through a small cycle of formative research and revision, as shown in Figures 1, and 3) Assessment phase, namely the evaluation phase used in drawing related conclusions, whether the prototype produced is under that have been determined (Plomp, 2010).

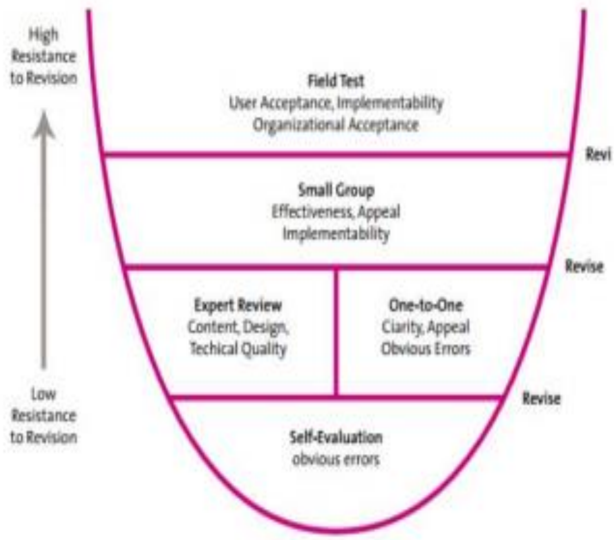



**Figure 1.** Tessmer's Formative Evaluation (Plomp, 2010)

The study was conducted at SMAN 1 Kinali from October 4 to November 4, 2021. Research data were obtained from research subjects, research objects, and data collection instruments. The subjects in this study were lecturers in the chemistry department of FMIPA UNP, lecturers of learning media at FT UNP, lecturers of educational technology at FIP UNP, chemistry teachers, and students at several high schools in West Pasaman Regency. The object of this research is a project-based e-SW on thermochemical material. The instruments used in collecting data are: 1) Chemistry teacher interview sheet, 2) Student questionnaires, 3) e-SW Validation Test Questionnaire, and 4) e-SW Practicality Test Questionnaire.

The validity test of electronic teaching materials was analyzed using Aiken's V formula. The Aiken's V formula was formulated as follows:

$$V = \frac{\Sigma s}{n(c-1)} \quad (1)$$

where,

s : r – Io
r : the number given by validator
Io : the lowest value of the validity assessment
c : the highest value of the validity assessment
n : number of validator

**Table 1.** Decision Category of Validation Value based on Aiken's V

| Criterion V | Interpretation |
|---|---|
| V < 0.4 | Less valid |
| 0.4 ≤ V ≤ 0.8 | Valid |
| V > 0.8 | Very valid |

(Retnawati, 2016)

The practicality test of electronic teaching materials was analyzed using the following formula:

$$\% \text{ Practicality} = \frac{\text{Total score}}{\text{Maximum score}} \times 100\% \quad (2)$$

**Table 2.** Decisions Category of Practical Value

| Value (%) | Category |
|---|---|
| 81 – 100 | Very practical |
| 61 – 80 | Practical |
| 41 – 60 | Quite practical |
| 21 – 40 | Less practical |
| 0 – 20 | Not practical |

(Yanto, 2019)

## Result and Discussion

*Development or prototype stage*

This stage discusses the making of the prototype. Four prototypes were made and revised through a small cycle of research using the Tessmer Formative Evaluation stage before being used in learning. This is explained as follows:

1. Prototype I

Based on initial observations that have been made in several SMAN Kab. Pasaman Barat, as explained in the introduction. So, the prototype I was designed in the form of an e-SW based on a project on thermochemical material. The components of the project-based e-SW designed are as follows:

a. Cover

Cover contains information in the form of project-based e-SW titles, materials, classes, and names of researchers. The cover is made according to the content of the material and is as attractive as possible.


**Figure 2.** Cover of Project-Based e-SW

b. BC and GPA

BC contains cognitive and psychomotor aspects that will be achieved by students during the learning process. This is based on the 2013 curriculum. GPA is formulated based on cognitive and psychomotor BC by taking into account the operational verbs contained in BC.

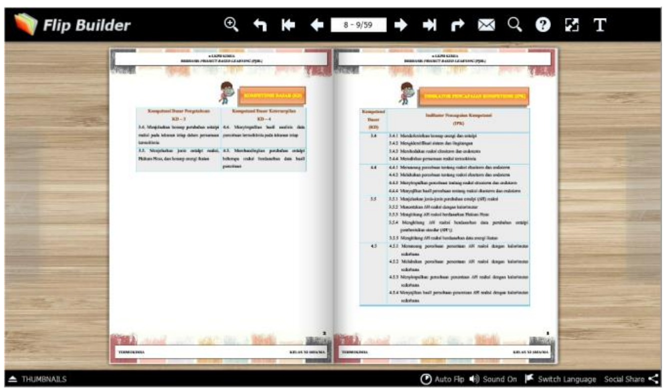



**Figure 3.** BC and GPA

c. Instructions for Use

Instructions for using project-based e-SW were created to guide teachers and students in using them.

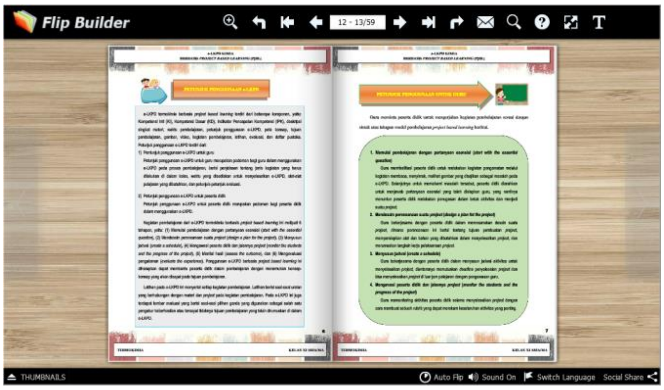
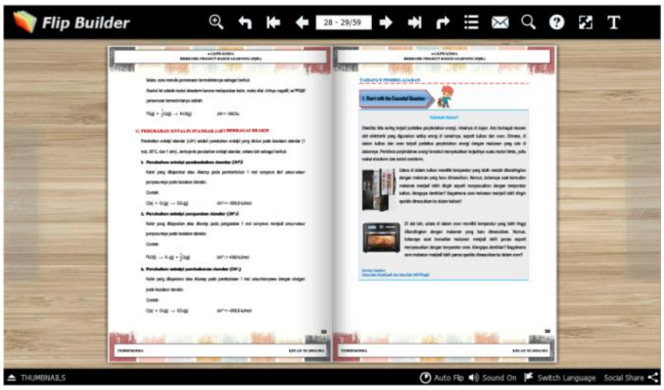


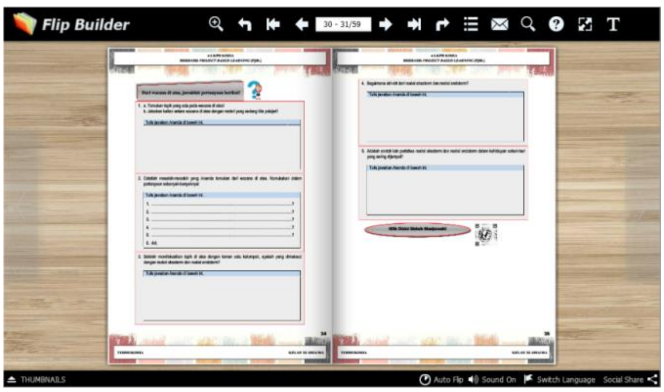

**Figure 4.** Instructions for Using Project-Based e-SW

d. Student Worksheet

SW contains the PjBL model syntax. This is so that learning becomes sequential because it follows the steps of learning. In the following, the PjBL model syntax is presented in e-SW.




(a). Problem introduction




(b). Essential question

**Figure 5.** (a) and (b). First Syntax of PjBL Model on e-SW

The first syntax of the learning process begins by introducing problems and providing essential questions related to everyday life, as shown in Figures 5 (a) and (b) above. In this study, students read and understand the problems presented. Next, they answer essential questions based on the problem, which will direct students to create a project.


**Figure 6.** Second Syntax of PjBL Model on e-SW

The second syntax of the learning process begins with designing a project plan by paying attention to the videos that have been prepared, as shown in Figure 6 above. In this study, students watched and observed videos. Next, they design a project plan which includes the following: 1) Formulating the purpose of making the project, 2) Determining the tools and materials for making the project, and 3) Determining the work steps for making the project.

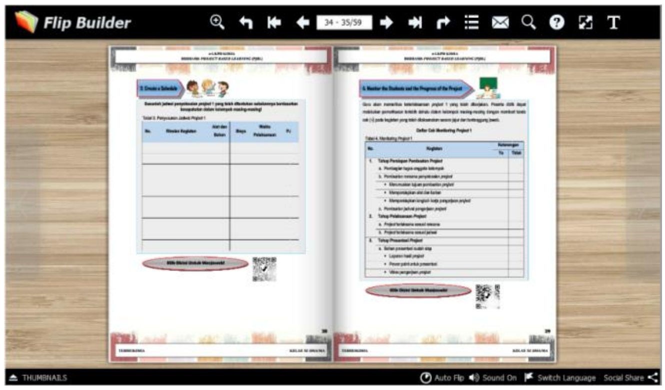



**Figure 7.** Third and Fourth Syntax of PjBL Model on e-SW

The third syntax of the learning processes begins with compiling a project schedule, as shown in Figure 7 above. In this study, students discuss and decide together when to complete a project. They determine the details of the activities carried out, the tools and materials used, the costs required, the implementation time, and the person in charge of the activities.

The fourth syntax of the learning process begins by checking every activity carried out by students by the teacher, as shown in Figure 7 above. In this study, the teacher monitors by checking projects that have or have not been carried out by students. Next, the teacher gives a checkmark at each stage of making the project they have done.

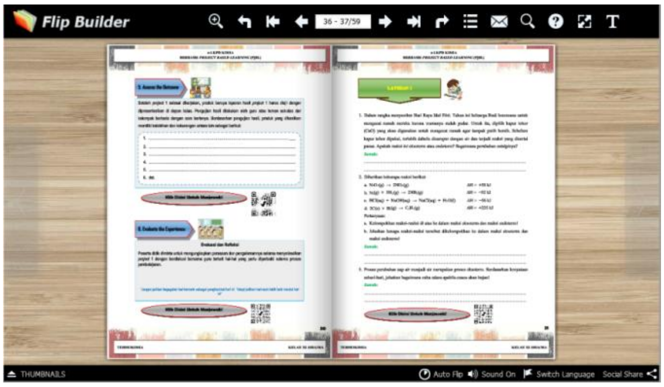


**Figure 8.** Fifth and Sixth Syntax of PjBL Model on e-SW

The fifth syntax of the learning process begins with presenting the project results in the form of products, namely reports, power points for presentations, and video projects. In this study, students presented the results of their group projects intending to test these results. The results were tested by teachers and classmates from different groups by asking questions. If the advantages and disadvantages are found in the results of the project, then they are written on the prepared sheet, as shown in Figure 8 above.

The sixth syntax of the learning process begins by asking students to convey the things they experienced while working on the project. Furthermore, their responses were written on the prepared sheet, as shown in Figure 8 above. Then the responses are collected to improve work in making the next project.

e. Evaluation

The evaluation contains questions related to thermochemical material. This aims to see the extent to which students abilities in mastering thermochemical material are presented in the form of project-based e-SW.

f. Bibliography

The bibliography contains the sources used as literature in developing project-based e-SW.

The project-based e-SW design includes content, construct, language, and graphic components. The project-based e-SW design on thermochemical materials is a prototype I.

2. Prototype II

The prototype I produced began to enter the Tessmer formative evaluation stage in the form of a self-evaluation carried out by the researcher. In this study, researchers checked the e-SW components according to the standards of the Education Office and corrected typing errors. If the revision has been made, a prototype II will be produced.

3. Prototype III

The resulting prototype II entered the second stage of Tessmer's formative evaluation in the form of an expert review and one-to-one evaluation with the following results:

a. Expert Review

Expert reviews are carried out by experts, they are commonly referred to as validators. The validator validates the materials and media on prototype II by filling out a material and media validation questionnaire to see the validity of the developed e-SW. In this study, material expert validators were 3 chemistry lecturers at FMIPA UNP and 3 chemistry teachers at SMAN 1 Kinali West Pasaman Regency. While the media expert validators are 2 lecturers of learning media at FT UNP and 1 lecturer of educational technology at FIP UNP. The material and media validation questionnaire that has been filled out by the validator is analyzed using the Aiken's V formula and the suggestions given by the validator are used as a reference in improving prototype II.

The results of material validation by material expert validators are presented in table 3 below:

**Table 3.** Analysis of Project-Based e-SW Material Validation

| Aspects Assessed | V | Validity Category |
|---|---|---|
| Content Component | 0.88 | Very Valid |
| Construct Components | 0.89 | Very Valid |
| Language Components | 0.89 | Very Valid |
| Graphical Components | 0.86 | Very Valid |
| Average | 0.88 | Very Valid |

Based on table 3 above, it can be seen that the assessed aspects consist of four aspects, namely the content component, the construct component, the linguistic component, and the graphic component. The component aspect of the content of the e-SW has a validation value of 0.88 with a very valid category. This means that the project-based e-SW on thermochemical material is developed based on the curriculum (Rochmad, 2012). The construct component aspect of the e-SW has a validation value of 0.89 with a very valid category. This means that the project-based e-SW on thermochemical materials developed has clear learning objectives, complete information, teaching materials are presented sequentially, and interesting motivation is given. The Directorate of High School Development (2017) in Yani (2022) states that this shows that the developed e-SW has been systematically arranged according to the components contained in the e-SW (Puspita et al., 2022). The linguistic component aspect of the e-SW has a validation value of 0.89 with a very valid category. This means that the project-based e-SW on thermochemical materials was developed using good and correct Indonesian rules (Majid, 2012). The graphic component aspect of the e-SW has a validation value of 0.86 with a very valid category. This means that the project-based e-SW on thermochemical materials was developed using a clear layout, type of writing, writing size, and images. Students' learning interest increases due to the use of teaching materials that have multimedia features in them, such as video, audio, and animation (Hartini et al., 2017) (Istyadji et al., 2022). So, the overall material validation is considered very valid.

The results of media validation by media expert validators are presented in table 4 below:

**Table 4.** Analysis of Project-Based e-SW Media Validation

| Aspects Assessed V | V | Validity Category |
|---|---|---|
| Display Aspect | 0.87 | Very Valid |
| Programming Aspects | 0.89 | Very Valid |
| Aspects of Utilization | 0.90 | Very Valid |
| Average | 0.89 | Very Valid |

Based on table 4 above, it can be seen that the assessed aspects consist of three aspects, namely the display aspect, the programming aspect, and the utilization aspect. The display aspect of the e-SW has a validation value of 0.87 with a very valid category. This means that the project-based e-SW on the thermochemical material developed has precise and clear letters, pictures, and videos. The programming aspect of e-SW has a validation value of 0.89 with a very valid category. This means that the project-based e-SW on the developed thermochemical material shows the efficiency of the developed e-SW media is correct. The utilization aspect of e-SW has a validation value of 0.90 with a very valid category. This means that the project-based e-SW on thermochemical materials developed shows that users are very easy to use the e-SW. Thus, the overall media validation is considered very valid.

b. One-to-one Evaluation

A one-to-one evaluation was carried out on 3 students of class XII MIPA 1 SMAN 1 Kinali with different cognitive abilities, namely students with low, medium, and high cognitive abilities. This evaluation was carried out by interviewing 3 students as described previously. The evaluated aspects are the appearance, attractiveness, clarity, presentation, language, and errors contained in the project-based e-SW developed.

Prototype II which has been validated by material and media expert validators provides a very valid validation result overall. The interview results from the one-to-one evaluation showed the students' interest in project-based e-SW. After making revisions, a valid prototype III was produced.

4. Prototype IV

The resulting prototype III entered the third stage of Tessmer's formative evaluation in the form of a small group trial. Small group trials were conducted on 6 students of class XII MIPA 1 SMAN 1 Kinali with various cognitive abilities, namely low, medium, and high. Students fill out an instrument in the form of a practicality questionnaire to find out the practicality of the project-based e-SW developed. The results of the practicality questionnaire analysis from the small group test are presented in Table 5.

**Table 5.** Analysis of Project-Based e-SW Practical

| Aspects Assessed | % Practicality | Category Practicality |
|---|---|---|
| Attraction | 93.33 | Very Practical |
| Ease of Use | 90.00 | Very Practical |
| Benefits | 91.11 | Very Practical |
| Learning Time Efficiency | 85.00 | Very Practical |
| Average | 89.86 | Very Practical |

Based on table 5 above, it can be seen that the results of the practical analysis of project-based e-SW in small groups have an average practicality percentage value of 89.86% with a very practical category. After making revisions to prototype III and being declared practical, prototype IV was obtained which was ready to enter the field test stage.

*Assessment phase*

At this stage, an assessment of the prototype IV is carried out by conducting field trials to see its practicality and effectiveness of the prototype IV. The practicality test carried out on the field test is a practical test on a larger scale. Practical trials in the field test were carried out on: 1) 1 large class that had studied thermochemical material, namely class XII MIPA 2 SMAN 1 Kinali with 32 students and 2) 3 chemistry teachers at SMAN 1 Kinali West Pasaman Regency.

Practicality is carried out on chemistry students and teachers by filling out a practicality questionnaire to see the practicality of the developed e-SW. The practical value of the e-SW is presented in tables 6 and 7 below:

**Table 6.** Practical Analysis of Project-Based e-SW by Students

| Aspects Assessed | % Practicality | Category Practicality |
|---|---|---|
| Attraction | 84.38 | Very Practical |
| Ease of Use | 86.25 | Very Practical |
| Benefits | 89.79 | Very Practical |
| Learning Time Efficiency | 88.44 | Very Practical |
| Average | 87.21 | Very Practical |

**Table 7.** Practical Analysis of Project-Based e-SW by Teachers

| Aspects Assessed | % Practicality | Category Practicality |
|---|---|---|
| Attraction | 86.67 | Very Practical |
| Ease of Use | 97.78 | Very Practical |
| Benefits | 83.33 | Very Practical |
| Learning Time Efficiency | 88.33 | Very Practical |
| Average | 89.03 | Very Practical |

From tables 6 and 7 above, it can be seen that the average value of the practicality percentage of 32 students of class XII MIPA 2 SMAN 1 Kinali is 87.21% with a very practical category. While the average value of the practicality percentage of 3 chemistry teachers at SMAN 1 Kinali is 89.03% with a very practical category. This means that the project-based e-SW developed is easy to use, learning time is more efficient, and able to attract students' interest in learning (Sukardi, 2010) (Rochmad, 2012) and can help students find the concept of chemistry subject matter (Hardeli et al., 2021). From these practical results, the developed e-SW has been practical and can be used in learning thermochemical material by both teachers and students.

In this study, the teaching materials used were e-SW. e-SW was chosen because one of the reasons is the teacher's effort in guiding students in a structured manner. The learning activities are carried out to provide opportunities for students to learn meaningfully and they can develop their science process skills (Wazni & Fatmawati, 2022). e-SW is also needed by teachers as teaching materials that attract students' interest in learning. The e-SW can also be used by students not only at school, for example in this study students carried out projects in the e-SW at home in groups. This can help students understand the concept better (Manalu et al., 2022). The use of student worksheets during the Covid-19 pandemic is needed to achieve optimal learning outcomes (Sujarwo et al., 2022).

In this study, the Flip PDF Professional application was used. The multimedia features used in developing project-based e-SW on thermochemical materials are video, audio, and animation. This helps students learn because they are interested in the presence of video, audio, and animation in the teaching materials they use. Especially during the Covid-19 pandemic, learning using videos can improve student learning outcomes (Sujarwo et al., 2022). Misbah, et al (2021) in Annisa (2022) state that e-modules developed with Flip PDF Professional can help students improve learning outcomes (Aulia & Hardeli, 2022).

In this study, students worked on projects related to everyday life, namely, they did simple projects regarding exothermic reactions, endothermic reactions, and simple calorimeters using tools and materials that are easily found in the environment. Real learning and engaging in outdoor learning during online learning using electronics during the Covid-19 pandemic helps students learn science directly and motivates and builds close relationships between teachers and students during difficult circumstances (Haeften et al., 2021). One way to make students active and think critically is through direct learning experiences, such as doing practicum (Hardeli et al., 2022). The project results obtained from this research are in the form of reports, power points, and learning videos. Students learn in groups, they are active, and are required to be independent by looking for learning resources other than books provided by the school. The PjBL model used can make learning time more effective and efficient because learning with the PjBL model can be done at home, so at school is the time to present and discuss material after students do projects at home in groups.

The PjBL model helps students work on projects using knowledge from multidisciplinary sciences, offers opportunities for students to apply theoretical knowledge in direct practice, and trains students to manage projects independently or in groups (Yang et al., 2019). The PjBL model is useful for students' science, technology, engineering, and math skills, this is useful for their future (Beier et al., 2018). The PjBL model that is integrated with 21st century skills (creative thinking, critical thinking, communication, and collaboration) can improve students' higher-order thinking skills, this is under the demands of skills in the 21st century (Hujjatusnaini et al., 2022).

Electronic teaching materials developed in the form of project-based e-SW on thermochemical materials following the demands of 2013 curriculum. Then with the existence of these electronic teaching materials, it is very helpful for distance learning during Covid-19. So, this developed electronic teaching material is one of the alternative teaching materials in the 21st century in the industrial era 4.0 and at the time of Covid-19.

## Conclusion

Electronic teaching materials developed in the form of project-based e-SW on thermochemical materials have been tested for validity and practicality tests by validators. The results obtained indicate that project-based e-SW on thermochemical material can be used in the learning process because it is categorized as valid and practical. These electronic teaching materials are one of the alternative teaching materials that can be used in the 21st century in the industrial era 4.0 and during Covid-19.

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