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Development of Chemistry Worksheets Learners Based on Technological Pedagogical and Content Knowledge Using the Problem Based Learning Model on Hydrocarbon Topics

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Abstract: Development of Chemistry Worksheet Learners Based on Technological Pedagogical and Content Knowledge Using the Problem Based Learning Model on Hydrocarbon Topics. The purpose of this study to develop TPACK-based LKPD using PBL model to see the extent to which the use of LKPD and practicum can improve student learning outcomes on hydrocarbon materials. The research method used is Research & Development (R & D) with 4D models (define, design, develop and desseminate) with a limited trial. On liveworksheet assisted e-LKPD conducted feasibility validation test and praktiklaitas test by 2 teachers chemistry and 27 learners. The result is an interactive e-LKPD with almost the same characteristics as the printed LKPD, based on everyday phenomena and equipped with video shows. Based on expert validation, the percentage of material aspects, learning, e-LKPD validation, and e-LKPD validation by education practitioners were 97.9%, 100%, 95% and 81.25%, respectively. The percentage of student response in the field trial was 93.22% with problem solving skills of 86.92%.

Keywords: Hydrocarbons, Worksheet Learners, Technological Pedagogical and Content Knowledge, Problem Based Learning Model.

Abstrak: Pengembangan LKPD Kimia Berbasis Technological Pedagogical and Content Knowledge Menggunakan Model Problem BasedLearning pada Materi Hidrokarbon. *Tujuan penelitian ini untuk mengembangkan LKPD berbasis TPACK menggunakan model PBL untuk melihat sejauh mana penggunaan LKPD dan Praktikum dapat meningkatkan hasil belajar siswa pada materi hidrokarbon. Metode penelitian yang digunakan adalah Research & Development (R&D) dengan model 4D (define, design, develop and desseminate) dengan uji coba terbatas. Padae-LKPD berbantuan liveworksheet dilakukan uji validasi kelayakan dan uji praktiklaitas oleh 2 guru kimia dan 27 peserta didik.. Hasilnya berupa e-LKPD interaktif dengan karakteristik hampir sama dengan LKPD cetak, berbasis fenomena sehari-hari dan dilengkapi dengan tayangan video. Berdasarkan validasi ahli, persentase pada aspek materi, pembelajaran, validasi e-LKPD, dan validasi e-LKPD oleh praktisi pendidikan secara berturut-turut adalah 97,9%, 100%, 95% dan 81,25%. Persentase respon siswa pada uji coba lapangan adalah 93,22% dengan keterampilan pemecahan masalah sejumlah 86,92%.*

Kata kunci: Hidrokarbon, Lembar Kerja Peserta Didik, Technological Pedagogical and Content Knowledge, Model *Problem Based Learning.*

▪ INTRODUCTION

The 21st century is called the century of knowledge, the century of knowledge-based economy, the century of information technology, globalization, the industrial revolution 4.0, and so on. In this century, there have been very rapid and unpredictable changes in all aspects of life including the economy, transportation, technology, communication, information, and others. These very rapid changes can provide opportunities if they can be utilized properly, but can also be a disaster if not anticipated systematically, structured, and measurably. One example of this very rapid change is in the field of information technology, especially social media. Recently, this social media has been used by irresponsible people to spread hate speech and fake news (hoaxes). Critical thinking is one effort to counter false information spread on social media (Redhana, 2019).

The right learning Model must focus on students as a learned man, the problems presented are real-world problems, and using a scientific approachin its learning activities. Activities like this help students to be able to develop critical thinking skills in explore the material from the side different and thorough, so that students can make decisions, develop skills, and solve specific problems accordingly by necessity. This activity will achieve one of them if using the model problem-based learning (PBL) (Lumbu., dkk. 2018).

Ability Technological Pedagogical Content Knowledge (TPaCK). This ability consists of components Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), educational Content Knowledge (PCK), Technological Content Knowledge (TCK), Technical Knowledge (TPK) and Technological Pedagogical Content Knowledge (TPaCK), each capability has integration different types and main components of These tpacks are CK, PK and TK. Technological Pedagogical Content Knowledge (TPaCK) is a technology integration into the content of pedagogy and content material or more simply knowledge about the integration of technology into appropriate learning strategies/methods with the characteristics of the material to facilitate students in learning.Technological Pedagogical Content Knowledge (TPacK) is the ability which requires teachers to master 3 the main component of the TPaCK. Nah, what happens when a teacher can't integrate these components into learning so that you can't facilitate students in learning (Kaharuddin & Arsyad, 2023).

Chemistry is a branch of science that focuses on studying matter, its properties, changes in compounds, and energy. The abstract nature of chemistry has a major influence on how well students understand the content of the material they are studying. This is due to the high level of difficulty faced by students. The reason behind the challenges faced by students is the educational process in schools that fails to attract interest and focus on learning from students (Ulya et al., 2017).

One of the emical materials is hydrocarbons. Hydrocarbons are a fairly abstract material but are also widely found in everyday life. Hydrocarbons are widely found in everyday life, one of which is gasoline. In addition, hydrocarbons are also widely found in items used in everyday life, such as plastic, charcoal, gas and others (Herlina, 2020).

LKPD is a type of learning resource that contains text, summaries, and learning exercises in the form of homework that must be completed by students. Teachers can utilize this learning tool so that students are more enthusiastic about learning and meet learning achievement indicators. Here, LKPD is not only available in printed form, but also electronically (LKPD). LKPD refers to teaching materials that are methodically developed using internet technology and delivered electronically. Videos, images, texts, and questions with automatic assessment capabilities can all be seen in LKPD. With the interaction between teachers and students and between students and other students in solving existing problems, the use of LKPD certainly facilitates learning activities (Kholifahtus, 2021).

The Problem Based Learning Model is a learning model with a student learning approach to authentic problems so that students can construct their own knowledge, develop higher skills and inquiry, and make students independent to increase their self-confidence. In this learning, the teacher plays a role in raising problems or questions, providing encouragement, motivation, providing teaching materials and the necessary facilities. In addition, the teacher provides scaffolding in the form of support in an effort to reveal the inquiry skills and intellectual development of students (Meutia, 2020).

Characteristics of the Problem Based Learning model are (1) asking problem questions, (2) linking to other disciplines, (3) authentic investigation, (4) producing "work results" and exhibiting them, (5) collaboration Arends (in Ratumanan 2004:146). The main objective of the Problem Based Learning model is to help students develop their thinking processes; learning maturely through experiences that make students independent. There are 3 (three) objectives of the Problem Based Learning model according to Arends (2007), namely: (1) developing students' thinking skills and problem-solving skills, (2) maturing students through assessment, (3) making students independent (Meutia, 2020).

Based on the analysis of Triwahyudi's (2021) research data entitled "Development of TPACK-Based Learning Devices in High School Chemistry Materials", it was revealed that this study aims to obtain an overview of student characteristics and then use them as a basis for consideration in developing TPACK-based learning devices in chemistry learning. The survey results stated that 72.7% of students had difficulty solving the questions given, while 57.6% of students had difficulty understanding ideas. Based on the survey results, to achieve learning objectives, all students must create learning resources that use TPACK. Furthermore, according to the analysis of Yuliandriati's (2019) research data entitled "Development of Student Worksheets Based on Problem Based Learning in Class X Chemical Bonding Materials". The results of the data analysis show validity in the following areas: content, presentation, language, graphics, and problem-based learning features. These aspects produce validity percentages of 98.3%, 98.3%, 93.3%, 95.8%, and 100% respectively. Teachers and students who use LKPD have response test scores of 95.8% and 96.13% respectively. LKPD based on Problem Based Learning on chemical bonding material produced is considered valid and feasible to be used in learning activities, according to the results of data analysis.

Previous research on the development of TPACK-based E-LKPD using Problem-Based Learning (PBL) model has reached the development stage which shows great potential in improving the quality of learning. However, most of these studies only focused on the design and validation aspects of E-LKPD without conducting effectiveness tests on its implementation in the context of real learning. Therefore, in the study will be tested the effectiveness of E-LKPD that has been developed. It is important to know how

effective E-LKPD is in improving students ' understanding of hydrocarbon materials, as well as their impact on critical thinking and problem solving skills. By conducting a comprehensive evaluation, it is expected to provide a deeper insight into the benefits and challenges of using TPACK-based E-LKPD in Chemistry learning.

▪ METHOD

The type of research conducted is research and Development (R&D) which produces products in the form of e-LKPD based on Technological Pedagogical Content Knowledge (TPACK) using Problem Based learning (PBL) models on hydrocarbon subjects. The development Model conducted in this study is a 4D model by going through several stages, namely define (defining), design (design), develop (development), and disseminate (dissemination) (Octaviani et al.,2020).

1) Define (defined)
   At the define stage is divided into three stages of analysis, namely, initial analysis, Analysis, Analysis of concepts and tasks, and the formulation of learning objectives
2) Design(planning)
   The design stage is the stage of preparation of the initial draft of the e-LKPD, this stage is used to set the design of the e-module so that it can build the knowledge and skills needed by learners.
3) Development
   At the develop stage or the development stage, researchers validate materials and media against e-LKPD already. After that, the researcher perfected the e-LKPD in accordance with the assessment and suggestions of the validator with the aim that the e-lkpdl developed reached the validity criteria.
4) Disseminate
   After revision based on expert assessment, the initial prosuk is ready to be tested. The deployment phase with limited trials is carried out in one class, starting with the initial test implementation. Furthermore, students are given an e-LKPD that has been declared valid to be studied, followed by a final test to measure their understanding after using the e-LKPD. After that, the researchers continued with a practical test, which was conducted by collecting responses from students related to the use of e-LKPD.

Data Collection Techniques

Data collection techniques in this study is to conduct interviews with chemistry teachers and provide questionnaires including questionnaires the needs of teaching materials by students, and eligibility validation questionnaires to validators (1 lecturer of chemistry Medan State University and 1 chemistry teacher) and response questionnaires (1 chemistry teacher and 27 students of Class XII at SMAN 1 Percut Sei Tuan).

Research Instruments

The instruments used in this study are interviews with chemistry teachers, questionnaire needs of teaching materials, questionnaire analysis of teaching materials, feasibility validation questionnaire and questionnaire responses of chemistry teachers and students. Interviews were conducted with chemistry teachers directly and analysis of the needs of teaching materials by students was carried out using observation sheets containing 18 questions related to Learning Resources, Learning media, learning

outcomes, and interests. interview and analysis of the needs of teaching materials aims to get an overview of the problems that occur in the process of learning chemistry and the needs of teaching materials needed. Analysis of teaching materials conducted by researchers aims to be used as a reference for writing e-LKPD.

Data Analysis Techniques

Data analysis techniques in this study the results of validation e - LKPD by validators

and media experts and media experts as well as questionnaire responses of students, namely :

Validity Analysis

The scoring of the answers in the validation instrument is based on a Likert scale with a score of 1-4 which can be seen in

Table 1. Criteria a Likert Scale

Criteria	Criteria
strongly agree (SA)	very valid
Agree (A)	Valid
disagree (D)	less valid
Very Disagree (VD)	Invalid

Feasibility validation analysis was obtained from material and media expert validators analyzed using the following percentage formula:

$$\text{Scale range} = \frac{m\,(n-1)}{n}$$

Description :

m = number of indicators;

n = number of alternative answers

To analyze the percentage of validation value of media experts and material expertsby using the validation criteria presented in Table 2

Table 2. answer criteria item instrument validation with Likert Scale Percentage (%) Criteria

Percentage (%)	
ria 81-100 valid	Crite Very
61-80	Valid
41-60	Less valid
21-40	Invalid
0-20	Very invalid

Student Response Analysis

Scoring of answers in the validation instrument is based on a Likert scale with ascore of 1-4 which can be seen in Table 3.

Table 3. Likert scale criteria

No	Answers	Scor
1	Yes	1
2	No	0

Feasibility validation analysis obtained from the responses of students who wereanalyzed using the following percentage formula:

$$P=\frac{£}{N} X\ 100\%$$

(Sudijono, 2012)

Description:
P = percentage of category
F = number or frequency of answers (number of students who answered <yes=)N = number of respondents score availability

To analyze the percentage of validation value from media experts and materialexperts by using validation criteria according to presented in Table 4

Table 4. criteria for the percentage of LKPD validity indicators for Student

Percentage Interval	Criteria	Kualification
50% ≤ X ≤100%	Good	LKPD has been declared practical and can be used for the learning process/no revisioni
0% ≤ X ≤50%	Not Good	Product fails, revises a lot and fundamentally about the content of the product

▪ RESULT AND DISCUSSION

Initial analysis

At this stage, an analysis is carried out on the problems faced by teachers related to the needs of teaching materials to be used. The analysis was carried out through the use of a teacher needs analysis questionnaire which was distributed directly through a form sheet to two chemistry teachers at SMA Negeri 1 Percut Sei Tuan. The questionnaire contains questions related to chemistry learning, such as students' learning interests and difficulties in learning chemistry, the use of teaching materials and learning resources, the application of TPACK-based learning methods, and the use of electronic student activity sheets in learning.

Table 5. Results of the Initial Analysis

No	Preliminary Analysis Results
1	Hydrocarbon materials are interesting to learners
2	Never implemented a TPACK-based LKPD
3	The absence of electronic LKPD causes teachers to lack and difficulty in preparing the provision of teaching materials.
5	The need for TPACK-based E-LKPD

Based on the data collected through filling out questionnaires by teachers, it can beconcluded that the use of TPACK-based LKPD in learning, especially on hydrocarbon

materials that are closely related to daily life, has not been widely done. In addition, it was found that not all chemistry teachers at SMA Negeri 1 Percut Sei Tuan had ever usedE-LKPD as a teaching material. Generally, they still use printed LKPD that is already available. The printed LKPD used at SMA Negeri 1 Percut Sei Tuan has a less attractiveappearance and less varied questions, especially on hydrocarbon materials, so the two teachers agreed that the researcher should develop a TPACK-based LKPD on hydrocarbon materials. So, from the results of the initial analysis, it can be concluded that the teacher agreed to hold the development of a TPACK-based LKPD using a problem-based learning model on hydrocarbon materials.

Analysis of student characteristics

This stage aims to obtain information about the characteristics of students in the context of learning in school, including their interest in hydrocarbon materials, their interest in the learning process in the classroom, and the learning resources they often use. The results of this analysis provide additional information that is important in the development of E-LKPD so that it can be adjusted to the needs of students. At this stage, the questionnaire was filled out by 35 students from class XII Matlangraf at SMA Negeri 1 Percut Sei Tuan through filling out an interview sheet. The results of the student needs analysis questionnaire are presented in

Tabel 6. Results of student characteristics analysis

No	Analysis of Student Characteristics
4	Hydrocarbon combustion materials are interesting to students..
5	Hydrocarbon burning materials are considered difficult because they are memorized, methods, approaches, books used, and teachers lack detail when teaching.
6	Most students are not yet aware of TPACK and have never been taught TPACK-problem based learning
7	The average student does not like to read books about chemistry because the teaching materials are uninteresting and monotonous
8	Material presented is attractive, delivered concisely and concisely, easy to understand, equipped with practice questions that are diverse and relevant to dailylife, and supported by interesting animations or pictures.
9	The Internet (wifi and data packages), laptops, and smartphones, can supportstudents' learning independently..
10	The need for a TPACK-based LKPD

Based on the analysis of the characteristics of students at SMA Negeri 1 Percut Sei Tuan, the majority of students face difficulties in learning chemistry, especially in hydrocarbon materials. This difficulty is due to the teaching methods used and the less effective approach, as well as the material that focuses too much on memorization. The large number of formulas, names of chemical compounds, and complex explanations are also inhibiting factors. In the learning process, students are generally less motivated when doing practicum and lack understanding in pouring the results of the practicum. So, they will be more motivated if the practicum is presented with an interesting LKPD, and can

be accessed online. The researcher chose to develop a TPACK-based E-LKPD because by doing practicum it is easier for them to pour the results of the practicum through the use of LKPD. This is the main reason that encourages researchers to develop an electronic LKPD that can connect the concept of making acetylene gas using carbide with real situations in daily life. Thus, it is hoped that the use of E-LKPD can increase students' interest and understanding in chemistry learning and strengthen the connection between learning materials and their lives outside the classroom and can achieve learning goals.

After the Define Stage, the next step is the Design Stage. In the Design stage, there are several steps that are taken, namely the preparation of instruments, the selection of media, the selection of formats, and the initial design. The first step is to prepare instruments, where the instruments used in this study are validity instruments in this casein the form of design expert validation questionnaires and material expert validation questionnaires, compile practicality instruments which in this case are in the form of

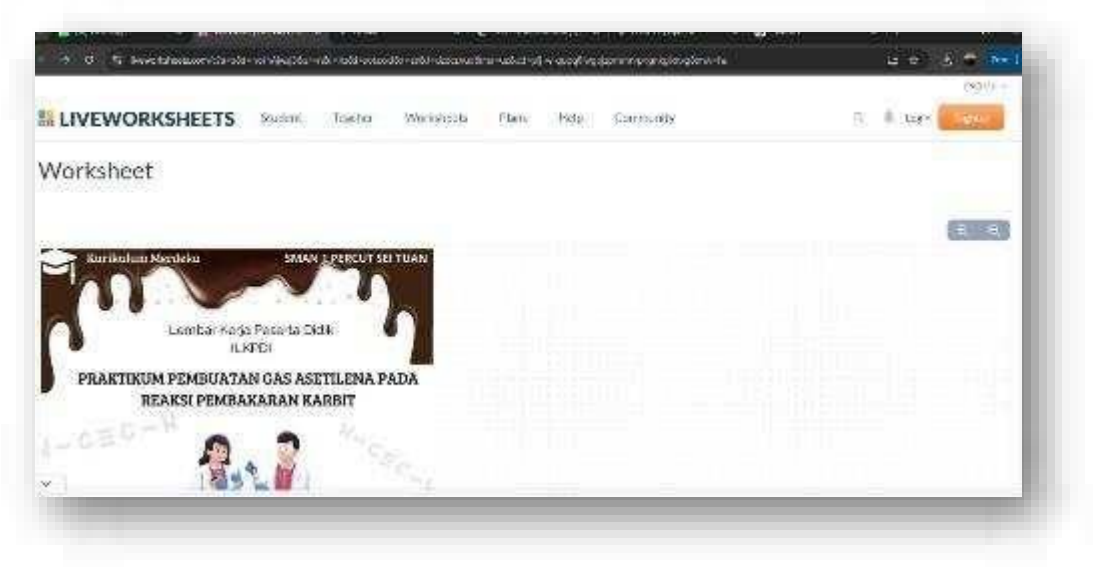

Figure 1. E-LKPD display on Liveworksheets

teacher and student response questionnaires, and compile effectiveness instruments which in this case test the ability to understand mathematical concepts and student effectiveness questionnaires. Furthermore, the selection of media was carried out, namely e-LKPD which was designed using Liveworksheep with Hydrocarbon material presented in the form of real problems with the stages of the approach used in learning, namely the TPACK Approach. Then the selection of the e-LKPD format containing the Cover, Pets for the use of LKPD, Work Instructions, Learning Objectives, Problem Orientation, Word Search, Investigation, Data Collection, and Data Analysis were selected.

The purpose of using the PBL model is so that students can more easily understand the material and gain a deeper understanding through the presentation of material related to contextual problems in daily life. This is in accordance with several opinions that state that by using the PBL model, students will also understand the concept more deeply. Where students are given the opportunity to think freely and find solutions with strategies, methods and approaches that are in accordance with the student's understanding to solve the problem (Salamah & Amelia, 2019; Kadarisma, 2018).

Development

Results of the Validation Test

1) E-LKPD Validation by Material Experts

Validation of E-LKPD by materials experts in table 2 below

Table 7. Material Expert Validation Results

No	Assessment Aspects	Average Assessment Score Each Aspect	Percentage	Category
1	Fill	4,00	100%	Highly Valid
2	Linguistics	3,75	93,75%	Highly Valid
Average overall assessment score		**3,88**	**97,9%**	**Highly Valid**

Based on the results of the assessment of the material experts above, namely the quality of the e-LKPD based on the results of the assessment by the material expert lecturers, it proves that the average score is 3.88 out of the average maximum score of 4.00 or with an assessment percentage of 97.9%, thus *the e-LKPD* shows a very valid category.

2) E-LKPD Validation by Learning Experts

The results of validation by learning experts are shown in table 3 below

Table 8. Data Validation Results by Learning Experts

No.	**Assessment Aspects**	**Average Assessment Score for Each Aspect**	**Percentage**	**Category**
1.	Didactive Requirements	4	100%	Highly Worthy
2.	Construction Requirements	4	100%	Highly Worthy
3.	Technical Requirements	4	100%	Highly Worthy
4.	Learning Components of Problem *Based Learning* (PBL)	4	100%	Highly Worthy
Average overall assessment score		**4**	**100%**	**Highly Worthy**

Based on the results of the assessment of the learning experts above, the quality of the e-LKPD proves that the average score is 4.00 out of the average maximum score of 4.00 orwith an assessment percentage of 100%, thus the e-LKPD shows a very feasible category.

3) E-LKPD Validation by LKPD Validators

The results of the validation of e-LKPD by LKPD validators are shown in table below :

Table 9. Data on the Results of E-LKPD Validation by LKPD Validators

No.	Assessment Aspects	Average Assessment Score for Each Aspect	Percentage	Categories
1	Penyajian	4	100%	Highly Worthy
2	Language	3	80%	Proper
3	Fill	4	100%	Proper
4	LKPD Design	4	100%	Proper
Average overall assessment		**3,75**	**95%**	**Highly Worthy**

The results of the assessment of media experts in the final stage, the number of scores obtained in the aspect of presentation was 12 with an average of 4. The linguistic aspect of the total score obtained was 16 with an average of 3. The Contents aspect obtained a total score of 16 with an average of 4, and the LKPD design aspect obtained atotal score of 24 with an average of 4. Based on the quantitative and qualitative data conversion guidelines, the products developed are assessed from the media aspect to be included in the category of very feasible.

4) E-LKPD Validation by Education Practitioners

The results of the validation of e-LKPD by education practitioners are shown in table 10

Table 10. Data Validated by Education Practitioners

No.	Assessment Aspects	Average Assessment Score for Each Aspect	Percentage	Categories
1	LKPD Display	4	100%	Highly Worthy
2	Presentation of LKPD	3	75%	Proper
3	Linguistics	3	75%	Proper
4	Implementation of TPACK-based LKPD Learning (PBL)	3	75%	Proper
Average overall assessment		3,25	**81,25%**	Proper

Based on the results of the assessment by the Education Practitioners above, the quality of *the e-LKPD* proves that the average score is 3.25 out of the average maximum score of 4.00 or with an assessment percentage of 81.25%, thus *the e-LKPD* shows a decent category.

Student Response Analysis Data

The field trial was carried out on October 21, 2024. This limited trial involved as many as 27 students in grade XII of Maklangraf State High School 1 Percut Sei Tuan. Respondents were asked to use teaching materials in the form of LKPD developed by researchers by participating in learning activities. After finishing using the teaching material product, the respondent filled out the questionnaire that had been provided by the researcher.

In the results of the student response questionnaire in the field trial, the average score was 93.22. Based on the guidelines of the LKPD Validity Indicator Criteria, the development of teaching materials carried out by researchers is included in the Good category, where the LKPD has been declared practical and can be used in the learning process/does not need revision.

Product Revision

1. Revision of Materials Experts

Revisions made based on material experts' suggestions for improvement of printedteaching materials can be seen in the following table.

Table 11. Material Expert Improvement Suggestions

No	Suggestions for Improvement	Form of Revision
1	Ineffective sentences	Using effective sentences and miswriting is neat

Before the Revision

After the Revision

Figure 2. Changing sentences to be effective

2. Revision of E-LKPD

Table 12. LKPD Improvement Suggestions

It	Suggestions for Improvement	Form of Revision
1	LKPD cover repair	Designing a simpler cover
2	Improvement of work instructions	Work hazards are more emphasized

Before the Revision

After the Revision

Figure 3. Page cover changes

Before the Revision After the Revision

Figure 4. Changes to the attention layout

Disseminate

The last stage is dissemination, where the e-LKPD developed should be widely disseminated and applied. However, in this study, the dissemination stage was only carried out in a limited manner at SMP Negeri 1 Percut Sei Tuan school. The distribution was carried out to class XII Matklangraf of SMA Negeri 1 Percut Sei Tuan and teachers of Chemistry at SMP Negeri 1 Percut Sei Tuan. This is supported by several studies that disseminate the final product in a limited way to the schools where the research is carried out, but the final product can be widely used in the software where the e-LKPD is disseminated (Adoe et al., 2022; Asmara et al., 2022).

1) Quality of TPACK-Based LKPD Development Using Problem Based Learning (PBL) Model on Hydrocarbon Materials

The quality of TPACK-based e-LKPD using the PBL model on chemical bonding materials in grade XII of high school can be obtained by meeting the criteria of validity, practicality and effectiveness. The validity criteria are measured through a material and design validation questionnaire from a team of experts. The practicality criteria were measured by a questionnaire on the practicality of teacher and student responses. The effectiveness criteria were measured by a test of the ability to understand chemical concepts and a questionnaire on the effectiveness of student responses. The first stage carried out by the researcher was to validate the instrument first to the instrument experts, namely Zahairiah Nasution validated the design validation instrument,the practicality of e-LKPD (teacher response), the practicality of e-LKPD (student response) and effectiveness (student response), and Helprida Sinaga validatedthe material validation instrument and the student's concept comprehension ability test.

a. Validity of e-LKPD based on PBL Model

e-LKPD is said to be valid judging from the material validation questionnaireand design validation assessed by the validator on the e-LKPD based on the TPACK Approach using the Liveworksheet that has been developed. The material validation questionnaire and design validation questionnaire were assessed by the validator Zuhairiah Nasution.

The validation of e-LKPD materials based on the TPACK Approach using *Liveworksheet* is assessed from several aspects, namely the quality of content and objectives as well as the quality of learning. Based on the results of the material validation, from the aspect of the quality of the content and objectives, it was found that the material presented in the e-LKPD was in accordance with the curriculum, learning objectives and learning flow, the exercises or examples presented were clearand did not cause confusion according to the class XII hydrocarbon material, the material presented in the e-LKPD was continuous, clear, complete and in-depth, the e-LKPD used good and correct Indonesian according to PUEBI (General Guidelines for Indonesian Spelling), The language used is also communicative and interactive, the sentences used in the media are interesting, clear, and easy to understand, the material and sample questions presented emphasize the indicators of concept comprehension ability, and the presentation of images/animations in the learning media is interesting and in accordance with the material.

Based on the aspect of learning quality, it is said that the e-LKPD presented can help students easily understand the material in learning, the e-LKPD can be used independently, and the e-LKPD presented triggers students to learn other materials. This is in accordance with research that states that the use of e-LKPD mediacontributes to facilitating the learning process, and the material presented in the LKPDis an attraction for students. This makes it easier for students to understand the material being taught, as well as making it easier for teachers to deliver material more effectively. Another advantage is that the e-LKPD can be repeated many times, allowing students who have difficulty understanding the material to repeat the material independently (Susanti & Damayanti, 2022; Dewi & Handayani, 2021).

The validation of the e-LKPD design based on the TPACK Approach using *Liveworksheet* was assessed from several aspects of assessment, namely simplicity, integration, balance, shape, color, and emphasis. After the e-LKPD is seen by the validator, then the validator fills out a design validation questionnaire and there are several comments and suggestions including improving the size of the storage or dataon the e-LKPD, setting the color appropriately so that it is not too boring, and addinga video to the e-LKPD.

Based on the results of the design validation, judging from the aspect of simplicity, it was found that the messages/information contained in the LKPD were easy to capture and understand, the images/animations in the LKPD were in accordance with the characteristics of the students, the e-LKPD could be used easilyby the students, and the sentences used in the e-LKPD were easy to understand. Furthermore, from the aspect of integration, it was found that the order between the slides in the LKPD was in accordance with the steps of the TPACK Approach, and the images/animations and writings in the LKPD were appropriate and sealed. Then seen from the balance aspect, it was found that the size of the images and text on eachvideo slide was balanced, and the layout of the text and images on each video was balanced.

Judging from the aspect of shape, it was found that the images/animations used in the e-LKPD were interesting and the letter shapes used in the LKPD were easy to read.

In addition, judging from the color aspect, it was found that the color intensity of each LKPD slide could attract attention and the color of each LKPD slide was appropriate. The purpose of the e-LKPD is designed with attractive pictures andbright colors, namely to make students able to focus on the objects displayed. So thatthe development of e-LKPD can change the learning atmosphere to be more enjoyable, and enable students to be further motivated in the learning process (Asmaraet al., 2022; From & Rahmayani, 2023).

After being assessed by material and design experts, the next revision stage is carried out based on the comments and suggestions given. The results obtained from validation by material experts are with a percentage of 97.9% which means very validand the results obtained from validation by design experts are with a percentage of 95%, and learning experts with a percentage of 100% which means very valid whichmeans valid based on the criteria of the validity percentage of e-LKPD. So that the average percentage of validation from material experts, learning and design experts was obtained which was 97.50% with the criteria that e-LKPD was valid and could be used with a slight revision.

b. Practicality of e-LKPD based on PBL Model

e-LKPD is said to be practical judging from the practicality questionnaire by teachers and students. The practicality questionnaire by teachers was carried out at the individual trial stage, namely by Mrs. Helprida Sinaga, S.Pd and the practicality questionnaire by students was carried out at the small group trial stage, namely by 27 students with low, medium and high abilities. The feasibility aspect of practicality is explained according to Lestari (2013) which includes the feasibility of content, language, graphic presentation and product components.

Based on the results of practicality by teachers, it is known that from the aspectof the feasibility of the content, it is obtained that the material in the e-LKPD is in accordance with the curriculum, and the learning objectives developed, the problems raised in the e-LKPD are very relevant according to real-life situations, the e-LKPD developed can make it easier for students to understand the subject matter, the material presented in the LKPD is developed completely, and the e-LKPD developedis able to improve comprehension skills concept and meet the indicators of understanding chemical concepts, as well as the learning sequence in the e-LKPD adjusting the steps of the PBL Model. This is in accordance with research conductedby Cahyati et al., (2020) which stated that the use of the PBL model in learning is ableto improve students' ability to understand chemical concepts as seen from learning activities with the PBL model continues to improve. In addition, the assessment from the linguistic aspect obtained that the language used in the e-LKPD is easy to understand.

Judging from the aspect of graphic presentation, it is obtained that the selection of backgrounds, fonts, animations and colors is appropriate, the e-LKPD developed is presented can attract attention, and the material in the e-LKPD is presented sequentially and completely. Furthermore, seen from the aspect of productcomponents, it was found that e-LKPD contains a component of a description of one-variable linear inequality material that is presented completely, e_LKPD contains a component of sample problem solving and practice questions that are presented in complete and e-LKPD contains a reinforcement component in the form of a summaryof the material.

After being assessed by the teacher, the revision stage is then carried out basedon the comments and suggestions given. The results of individual trials of e-LKPD based on the PBL model using *Liveworksheet* obtained a percentage of 93.22%, which means that it is practical based on the percentage criteria of e-LKPD practicality.

While the assessment of the student response questionnaire, students gave assessments in a limited trial directly. So the assessment is based on student opinionsand assessments after students actually use e-LKPD in learning activities, withassessment aspects in accordance with the questionnaire grid prepared based on the appearance of LKPD, LKPD Presentation, PBL learning components.

Based on the results of the practicality assessment by students, it is known that judging from the aspect of the appearance of the LKPD, it is found that the display ofthe e-LKPD presented is interesting, the use of e-LKPD makes learning moreenjoyable, this is supported by relevant research that states that the learning process using LKPD makes students more active, happy and interested during the learning process because the LKPD is designed with a clear background, colors, transitions and the right animations (Oktavia & Zanil, 2022; Sabilla et al., 2020). The results of the practicality assessment by other students are known that the practice questions contained in the e-LKPD are in accordance with the material, the overall concepts inlearning are in accordance with the learning objectives to be achieved, the existence of e-LKPD is important for students to master the material, e-LKPD with animation supports students to easily understand Hydrocarbon material, and the e-LKPD presented is able to adjust the steps of the PBL model.

Judging from the aspect of language use, it is found that the language used inthe e-LKPD is easy to understand. In addition, judging from the aspect of using video,it was found that the music and sounds used in the e-LKD were heard clearly, and thelearning videos conveyed the learning material clearly. The assessment on the last aspect is that the function of the media is obtained that e-LKPD can be used for independent learning at home, the hydrocarbon material delivered using e-LKPD is easier to understand, and the use of e-LKPD makes students happy in learning chemistry.

The results of the small group trial of TPACK-based e-LKPD using the PBL model with *Liveworksheet* obtained a percentage of 93.22%. which means that it is practical based on the percentage criteria of e-LKPD practicality. This is supported by the results of previous relevant research which states that the PBL model-based chemical e-LKPD has gone through an assessment by experts and product trials, obtaining excellent qualifications. Therefore, this LKPD is suitable to be used as a medium in learning (Sistadewi & Agustika, 2021).

c. The effectiveness of learning videos based on the Open Ended Approach The learning videos are said to be effective judging from the effectiveness questionnaire (student response) and the chemical concept comprehension test instrument (evaluation). The effectiveness questionnaire (student response) and the chemical concept understanding test instrument were used at the large group trial stage (field trial), namely to one class XII of SMA Negeri 1 Percut Sei Tuan.

Assessment of the effectiveness of e-LKPD based on TPACK Using the PBL model with *LiveworkSheet* is assessed from several aspects of assessment, namely the feasibility of content, language and function of e-LKPD. After the e-LKPD is used by students during the large group test, then students fill out an effectiveness questionnaire. The results of the assessment of the effectiveness of e-LKPD by students are 93.22%, which means "very good".

Based on the results of the effectiveness questionnaire assessment by students,from the aspect of the feasibility of the content, it was found that the hydrocarbon material presented in the e-LKPD made students interested, animation and problems in the students' LKPD in understanding the learning material, this is in accordance with the

opinion (Asmara et al., 2022) which stated that the use of learning media in the form of animated videos has a significant and important impact on the learning process, Because it is able to attract the interest of students so that mathematics learning becomes more interesting and not boring.

The results of the effectiveness questionnaire assessment by students, from the aspect of content feasibility, also found that the problems displayed in the e-LKPDwere clearly developed, and the e-LKPD with the PBL model made students better understand chemical materials and concepts. On the other hand, the assessment fromthe linguistic aspect was obtained that the use of language in the e-LKPD was easy tounderstand or understand. From the aspect of the function of e-LKPD, it was found that the e-LKPD developed was very helpful for students in understanding and mastering the material and the e-LKPD developed could make students more active in learning.

During the large-group trial using the PBL model, there were several evaluations that the researcher found, including that at the stage of presenting the student's open problem, there were several students who were constrained in writingwhat was known about the problem and relating it to the chemical form, so that the researcher gave a few examples of how to understand the problem and change the chemical form. On the other hand, at the stage of understanding the problem, there are still some students who are confused because they do not understand the problemwell, so that some students have quite difficulty in solving the given problem. However, the researcher helps by providing a little explanation and direction that refers to how to solve the given problem and instructs students to be able to see and follow the next stages so that they can know the solution.

Another evaluation that the researcher found was during the stage ofdiscussing together, where students were less conducive in paying attention to otherstudents who wrote their answers on the board, this was because there weredifferences in answers and steps to solve problems. In this case, the researcher directsthat students can listen well first and then discuss gradually one by one until finallygetting solutions and answers that can be accepted by all students. In the last stage,after the students and the researcher discussed the problems that had been solved,there were no obstacles in concluding, this was because many students had a goodenough understanding of problem solving through learning steps with the PBL model.Furthermore, the e-LKPD assessment based on the PBL Model uses *a Liveworksheet* with a concept comprehension test to see the improvement of students'abilities before and after learning using the developed e-LKPD. The questions givenwere 5 questions that contained indicators of the ability to understand chemicalconcepts, and tests were given to 27 grade XII students of SMA Negeri 1 Percut Sei Tuan.

In the e-LKPD effectiveness test, by using both tests from both the effectiveness questionnaire (student response) and the ability to understand chemicalconcepts test, they received a good response (positive) from teachers and students. This is in line with the statement of Nieveen et al. (2010) who said that a teaching material is said to be effective to use if it receives a good response from teachers and students in the learning process and can achieve the applicable competencies. Therefore, TPACK- based e-LKPD Using the PBL model with *Liveworksheet* is effective in improving the ability to understand chemical concepts of grade XII high school students on hydrocarbon materials.

▪ CONCLUSION

This study produces LKPD PBL-based hydrocarbons forClass XII high school, using the 4D method (Define, Design, Development, Disseminate).e-LKPD has been

validated by material, language, media, and teacher experts, with an average rating of 95%, indicating a very decent category. Trials in SMA Negeri 1 PercutSei Tuan showed good results with a percentage of 93.22%. this e-LKPD can be used toincrease physical activity of learners through easy-to-understand experiments, as well as develop cognitive, affective, and psychomotor abilities. Thus, TPACK-based LKPD andPBL models are valid as an alternative to teaching materials in high school.

▪ REFERENCES

Adoe, W., Amali, L. N., Salim, S., & Katili, M. R. (2022). Pengembangan Video Animasi Menggunakan Model 4D Untuk Pembelajaran Anak Usia Dini. *Prosiding Seminar Nasional Penelitian LPTKN*I, 29.

Arends, R. I. (2007). *Learning to Teach Seventh Editio*n. New York: The McGraw Hill Companies.

Asmara, R., dan W.R.Kusumaningrum. (2020). Pendampingan Penulisan Karya Ilmiah Remaja BerstandarLKIR LIPIBagi Guru Dan Siswa SMAIslam Terpadu Ihsanul Fikri Kabupaten Magelang. *Jurnal Widya Laksana*, 9(1), 98-110.

Dewi, F. F., & Handayani, S. L. (2021). Pengembangan Media Pembelajaran Video Animasi En-Alter Sources Berbasis Aplikasi Powtoon Materi Sumber Energi Alternatif Sekolah Dasar. *Jurnal Basicedu*, 5(4), 2530–2540.

Herlina, H. (2020). Penerapan Problem Based Learning Untuk Meningkatkan Hasil Belajar Kimia Pada Materi Hidrokarbon. *PENDIPA Journal of Science Education*, 4(3), 7-13.

Kaharuddin, A., & Arsyad, N. (2023, November). Kemampuan Technological Pedagogical Content Knowledge (TPaCK) Guru Matematika Menggunakan Media Hologram 3D. *In Prosiding Seminar Nasional Ilmu Pendidikan* (Vol. 2, No. 1).

Kholifahtus, Y. F., Agustiningsih., & Wardoyo, A. A. (2021). Pengembangan: Lembar Kerja Peserta Didik Elektronik (LKPD) Berbasis Higher Order Thinking Skill (HOTS). *Edustream: Jurnal Pendidikan Dasar*. Vol 5, No 2.

Lumbu, M. A., Fadiawati, N., & Diawati, C. (2018). Efektivitas Pembelajaran Berbasis Masalah Pencemaran Limbah Pemutih dalam Meningkatkan Keterampilan Berpikir Kritis. *Jurnal Pendidikan dan Pembelajaran Kimia*, 7(2), 1-15.

Meutia, M. (2020). Penerapan Model Pembelajaran Problem Based Learning (PBL) pada Materi Pokok Senyawa Hidrokarbon untuk Meningkatkan Hasil Belajar Peserta Didik Di Kelas X TKR SMK Muhammadiyah I Banda Aceh. *Jurnal Serambi Akademica*, 8(5), 731-745.

Nieveen, N. (2010*). Pendidikan Penelitian Desain*. Belanda: SLO

Oktaviani, dkk. (2020). Identifikasi Faktor Penyebab Rendahnya Hasil Belajar Matematika Peserta Didik di SMK Negeri 1 Tonjong. *Jurnal Riset dan Inovasi Pendidikan Matematika*, 1 (2).

Oktavia, N., & Zainil, M. (2022). Pengembangan Media Video Animasi Menggunakan Animaker Pada Topik Pecahan. *Journal of Basic Education Studies*, 5(2), 1714–1721.

Rahmayani, D. (2023). Pengaruh Penerapan Strategi Means Ends Analysis (MEA) Terhadap Kemampuan Pemecahan Masalah Peserta Didik Di SMA Negeri 9 Pontianak. Karst*: Jurnal Pendidikan Fisika dan Terapannya*, 6(2), 70-79.

Ratumanan, T.W. (2004). *Belajar dan Pembelajaran*. UNESA University: Prees,

Surabaya.

Redhana, I. W. (2019). Mengembangkan Keterampilan Abad Ke-21 Dalam PembelajaranKimia. *Jurnal Inovasi Pendidikan Kimia*, 13(1).

Sabila, A. F., Sony I., & Badarudin. (2020). Pengembangan Media Pembelajaran Matematika Materi Keliling dan Luas Bangun Datar Menggunakan Animasi Powtoon di Kelas IV SD Universitas Muhammadiyah Purwokerto. *Jurnal Ilmiah Wahana Pendidikan*, 6(3), 354-364

Sheldon, R. A., Arends, I., & Hanefeld, U. (2007). *Green Chemistry And Catalysis*. John Wiley & Sons.

Sistadewi, K., & Agustika, G. N. S. (2022). Pengembangan Video Pembelajaran Matematika Berbasis Open Ended Materi Pecahan Senilai Untuk Kelas IV Di SD No. 1 Mengwi. *Jurnal Pendidikan dan Konseling (JPDK)*, 4(3), 769-777.

Sudijono, A. (2012). *Pengantar Statistik Pendidikan*. Jakarta: Raja Grafindo Persada. Susanti, V. D., & Damayanti, A. (2022). Pengembangan Video Pembelajaran Animasi

Berbasis Animaker Materi Garis Dan Sudut Untuk Meningkatkan Minat Belajar Siswa Smpn 1 Geger Di Masa Pandemi Covid-19. *Prima Magistra: Jurnal Ilmiah KePendidikan*, 3(3), 331–341.

Triwahyudi, T., Sutrisno., & Yusnaidar. (2021). Pengembangan Perangkat Pembelajaran Berbasis TPACK pada Materi Kimia SMA. *Chempublish Journal*. 6(1), 46-53. https://doi.org/10.22437/chp.xxx.xxx

Ulya, H., Rudibyani, R. B., & Efkar, T. (2018). Pengembangan Modul Kimia Berbasis Problem Solving pada Materi Asam Basa Arrhenius. *Jurnal Pendidikan dan Pembelajaran Kimia*. 7(1), 129-141.