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Development of E-Worksheet Based on Flipped-Guided Inquiry Learning (FGIL) in Thermochemistry for Phase F

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ABSTRAK

Termokimia memiliki materi yang bersifat abstrak dan matematis yang menyebabkan siswa sulit untuk memahami materi ini. Siswa diharuskan membahas materi ini secara mendalam sehingga dibutuhkan bahan ajar yang mendukung pembelajaran siswa secara fleksibel. Dengan demikian, penelitian ini memiliki tujuan untuk mengembangkan suatu e-worksheet termokimia berbasis FGIL untuk siswa SMA pada fase F. Jenis penelitian ini adalah R&D dengan model ADDIE yang dibatasi pada tahap Development. Validitas isi dilakukan dengan empat orang validator dan praktikalitas didapatkan dari 36 siswa SMA fase F. Instrumen penelitian berupa lembar validasi dan angket respon siswa. Nilai validitas ditentukan dengan uji V Aiken's, jika nilai V > 0,40 maka suatu aspek dinyatakan valid. Hasil penelitian menunjukkan rata-rata penilaian pada aspek materi 0,92 (sangat valid); aspek media 0,96 (sangat valid); dan aspek bahasa 0,83 (sangat valid), sedangkan rata-rata persentase respon siswa 96% (sangat praktis). Jadi, dapat disimpulkan bahwa e-worksheet termokimia berbasis FGIL yang dikembangkan valid dan praktis untuk digunakan.

ABSTRACT

Thermochemistry has abstract and mathematical material which makes it difficult for students to understand this material. Students are required to discuss this material in depth so teaching materials are needed that support student learning flexibly. Thus, the research purpose is to develop a thermochemistry e-worksheet based on FGIL for high school students in phase F. The research type is R&D with the ADDIE model which is limited to the Development stage. Content validity was carried out with four validators and practicality was obtained from 36 phases F high school students. The research instruments were validation sheets and student response questionnaires. The validity value is determined by Aiken's V test, if the V value is > 0.40 then an aspect is declared valid. The research findings demonstrated that the average assessment on the material aspect was 0.92 (very valid); the media aspect 0.96 (very valid); and the language aspect was 0.83 (very valid), while the average percentage of student responses was 96% (very practical). So, it can be said that the developed thermochemistry e-worksheet based on FGIL is valid and practical to use.

1. INTRODUCTION

Chemistry is one of the basic sciences, a part of science that focuses on the structure, characteristics, alterations, and accompanying energy changes of matter (Jespersen et al., 2012). Chemistry can be viewed as both a process and a product. As a process, it can be interpreted as a scientific activity to perfect knowledge or to discover new knowledge, while as a product it is defined as the result of a process in the form of facts, concepts, principles, and laws as well as theories discovered by chemical scientists (Hemayanti et al., 2020). Chemistry is a difficult subject because it is rich in abstract concepts covering macroscopic, symbolic, and microscopic levels (Priliyanti et al., 2021; Aliifah et al., 2023).

One of the chemistry materials is thermochemistry. Thermochemistry is class XI material or in the Merdeka curriculum it is called phase F. Thermochemistry is part of a broad discussion called thermodynamics, which is the science that studies changes between heat and other forms of energy (Biya et al., 2023). Thermochemistry material studies the energy released or absorbed in a chemical reaction, energy units, and energy changes. Students who study are expected to understand thermochemical equations and be able to determine various heats of reactions (Aswita et al., 2017). This material also contains concepts about enthalpy changes, exothermic and endothermic reactions, as well as determining

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the value of enthalpy changes using the calorimetry method, Hess's law, and binding energy (Chen et al., 2017; Zakiyah et al., 2018). The concept of thermochemistry is abstract, making it difficult to learn (Biya et al., 2023).

Previous research by Irawati (2015) identified students' learning difficulties in thermochemistry material namely, students struggled to distinguish temperature and heat, students struggled to distinguish between exothermic and endothermic reactions, as well as the system and environment in a reaction that was still in progress. Aswita et al. (2017) these difficulties can be caused by internal factors, namely students forgetting how to solve questions that have been studied previously, students not paying attention when the teacher gives an explanation, and students also have difficulty understanding algorithmic material, while external factors are students needing tools to help them calculate and the lack of laboratory facilities causes students cannot obtain correct results.

Based on the findings of SMAN 1 Lengayang's chemistry teachers' interviews, it is known that most students consider thermochemistry material to be difficult because it contains abstract and mathematical concepts. Several concepts in thermochemistry material require students to carry out calculations, for example in determining the value of enthalpy change using the calorimetry method. The mathematical skills possessed by students influence students when studying thermochemistry material (Purnomo et al., 2022). Most students have low mathematical skills so they have difficulty completing calculations. In thermochemistry material, students must have mathematical skills such as variable equations, multiplication and division of decimal numbers, conversion numbers, rounding numbers, and interpreting graphs (Silitonga & Sitepu, 2022). Apart from that, the teacher also said that students did not prepare themselves before studying thermochemistry material. Teachers hope that students understand the material first before studying it in class so that it will make it easier for students. However, teachers do not have teaching materials that support these activities.

Therefore, we need teaching materials that students can use flexibly both in terms of time and place. E-worksheets are among the instructional resources that are available flexibly. E-worksheets are electronic-based worksheets that contain tasks and work instructions for a particular task. E-worksheets are easy and effective to use because they can be accessed at any time and do not require a lot of space to store them (Mitasari & Hidayah, 2022). Using e-worksheets in the learning process has the benefit of facilitating the creation of engaging teaching materials by teachers through the addition of images, videos, and links; students are easy to use because they don't need to download an application; and students' answers can be filled in directly in the column provided and sent directly to the teacher (Anisah & Nasrudin, 2023). E-worksheets are also equipped with interactive assignments and questions that can be tested automatically, making the learning and evaluation process easier (Rumasoreng et al., 2023).

Teachers need to monitor students when working on e-worksheets, so a flipped classroom is needed. The flipped classroom is a technique in education that includes both computer-based, individual learning outside of the classroom and learning activities with interactive groups inside the classroom (Bishop & Verleger, 2013). Learning in a flipped classroom consists of two stages, namely the pre-meeting stage and the in-class stage (Wolff & Chan, 2016). Students are encouraged to think more critically by applying, analyzing, evaluating, and making in a flipped classroom, while understanding and remembering are carried out before learning in class (Paristiowati et al., 2017). Various studies related to the flipped classroom have been conducted previously, including its effect on cognitive learning outcomes by Jdaitawi (2019). The research results show that the flipped classroom succeeded in making significant improvements in learning outcomes among students who studied in the flipped classroom compared to their peers in the conventional group.

The flipped classroom pre-meeting stage was carried out via Google Classroom. One online tool for setting up a virtual classroom is Google Classroom. Assignments can be transferred, gathered, and graded using this platform (Shahroom & Hussin, 2018). For the in-class stage, a learning model is needed that can support student learning to be more systematic and focused. One sample model that can support this is guided inquiry learning. Guided inquiry learning is an inquiry led by a teaching team that gives students access to a range of knowledge sources and allows them to gain a profound understanding and a personal perspective (Kuhlthau et al., 2015). This model's benefit is that it enables students to move forward while also assisting them in mastering skills and cognitive processes (Arlianty, 2015).

Based on the description above, the model used in developing this e-worksheet is Flipped-Guided Inquiry Learning (FGIL). FGIL is a model that integrates guided inquiry learning into the flipped classroom syntax. The application of this model provides various advantages, for example, exploration in class is more in-depth because FGIL encourages students to study first from home and students can access learning materials as much as they like to repeat parts they don't understand through Google Classroom (Drake, 2016; Juniantari et al., 2018). However, in its implementation, this model also has weaknesses, namely the difficulty of controlling students' pre-meeting activities from home (Siga, 2023). To overcome this, students

answer several short questions on Google Classroom so the teacher can monitor them. Several models have been used in research related to the development of thermochemistry e-worksheets, but there has been no application of the FGIL learning model. Therefore, this study attempts to create a thermochemistry e-worksheet based on FGIL for students in high school.

2. METHOD

Using the ADDIE model, this research is Research and Development (R&D). The model of ADDIE comprises five distinct stages, which are Analysis, Design, Development, Implementation, and Evaluation. In this research, the ADDIE stage is limited to the Analyze, Design, and Development stages because this research only aims to develop valid teaching materials referring to validator assessments (Setiawan et al., 2021). In this research, an e-worksheet was developed by applying Flipped-Guied Inquiry Learning (FGIL) to determine its validity and practical values. E-worksheets are developed with the help of Liveworksheets. Liveworksheets is an educational resource that lets teachers make interactive worksheets or find ones that have been shared by global teacher communities (Le & Prabjandee, 2023).

The product developed was validated by two chemistry department lecturers and two chemistry subject teachers. Quantitative and qualitative information is provided through validator comments and recommendations to improve the product. Quantitative information is obtained to evaluate all criterion points for all argumentation using previously validated instruments. The assessment of each criterion uses a Likert scale, a Likert scale consisting of scores of 4 (very agree), 3 (agree), 2 (disagree), and 1 (very disagree). An assessment rubric is included with the e-worksheet validation test instrument so that experts can assign appropriate scores. There isn't currently an assessment rubric available for the student response questionnaire instrument. Quantitative analysis techniques were employed to analyze the data derived from the assessment results. The Aiken's V was used to determine the validity of the research data (Aiken, 1985).

$$V = \frac{\sum s}{n(c-1)} \qquad (1)$$

Information:
V = factor of content quality
s = r-l_0
r = the validator provided a score
l_0 = smallest rating score
n = validator total
c = biggest qualification score

The results of the data analysis are classified according to Table 1.

Table 1. Aiken's V Interpretation Results (Istiyono, 2020)

Average Result	Classification
V ≥ 0.80	Very valid
0.40 < V < 0.80	Valid
V ≤ 0.40	Not valid

If the FGIL e-worksheet satisfies the valid criteria, it is used and if not, it is revised again based on the validator's recommendations.

To determine the e-worksheet based on FGIL practicality, research practicality was carried out. Using quantitative equations (Sudjana, 2005), a practicality analysis was carried out. Table 2 presents the findings categorized according to the categories adapted by Riduwan (2015).

Table 2. Practicality Analysis Category

Average Result	Classification
0-20	Very Impractical
21-40	Impractical
41-60	Pretty Practical
61-80	Practical
81-100	Very Practical

3. RESULT AND DISCUSSION

Result

The research begins with the analysis stage. The analysis carried out was in the form of an analysis of students' learning difficulties, especially in thermochemistry material. Analysis was carried out using interview techniques with one of the chemistry teachers at SMAN 1 Lengayang. The results of the interviews indicate that because thermochemistry involves abstract and mathematical concepts, it is an example of the kinds of subjects that students find difficult. The ability to distinguish between exothermic and endothermic reactions is typically lacking in students. Apart from that, students have difficulty determining the formula used to solve the problem of determining enthalpy changes using the calorimetry method.

After the problems regarding thermochemistry material have been analyzed, the e-worksheet design stage is then carried out. The e-worksheet is designed according to the problems found at the analysis stage. The e-worksheet components that have been designed are shown in Table 3.

Table 3. E-worksheet Components

Number	Section	Components
1	Front cover	The title, name of the author, the origin of the author's institution, the image relevant to the material, curriculum
2	Preface	Foreword for preparing e-worksheet
3	List of contents	Information about the contents of each page in the e-worksheet
4	Introduction	Instructions for use, concept maps, learning indicators
5	Gain attention and explain the inquiry process	Explanation of the learning process that will be carried out
6	Present the inquiry problem	Presentation of problems in the learning process
7	Formulation of hypothesis	Direct students to ask questions related to the problem presented and formulate a hypothesis
8	Data collection and hypothesis testing	Data is collected to test hypotheses
9	Formulation of conclusions	Conclusion of the learning process
10	Reflection	Reflection on the inquiry process that has been carried out
11	Glossary	Definitions of chemical terms found in the e-worksheet
12	Bibliography	References used in making e-worksheet

The design that has been created is then developed in the third stage, namely the development stage. At this stage, the e-worksheet component is developed. The e-worksheet is prepared using FGIL syntax for thermochemistry material. Figure 1 presents the e-worksheet design.

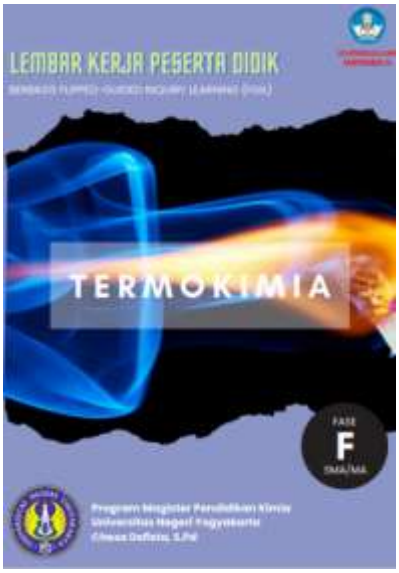

Figure 1. E-worksheet components

The results of the e-worksheet design then determine its validity and practicality values. The validity determined was content validity by four validators, namely two lecturers in Chemistry Education, FMIPA, Universitas Negeri Yogyakarta and two chemistry teachers. Table 4 shows that all aspects of content validity received a very valid assessment category. Data from the results for validation of the FGIL-based thermochemistry e-worksheet are shown in Table 4.

Table 4. Result of Validity Test of Thermochemistry E-worksheet Based on FGIL with Validator

Aspects	Value (Average)	Category
Material	0.92	Very valid
Media	0.96	Very valid
Language	0.83	Very valid
Total Average	0.90	Very valid

After validity was determined, the practicality test of the e-worksheet was then carried out with 36 students of SMAN 1 Lengayang in West Sumatra. Several aspects must be assessed by students. Table 5 presents aspects and results of e-worksheet practicality testing with students.

Table 5. Results of Practicality Test of Thermochemistry E-worksheet Based on FGIL with Students

Number	Practical Aspects	Percentage
1	The design of the thermochemistry e-worksheet based on FGIL is interesting	98
2	The font used for the thermochemistry e-worksheet based on FGIL is correct	100
3	The language used in the thermochemistry e-worksheet based on FGIL is communicative	95
4	The material is presented clearly in the thermochemistry e-worksheet based on FGIL	90
5	The illustrations presented in the thermochemistry e-worksheet based on FGIL have good resolution	97
6	The illustrations presented in the thermochemistry e-worksheet based on FGIL correspond to the material	88
7	The FGIL syntax makes it easier for me to understand and find thermochemistry material	95
8	The e-worksheet is equipped with examples and thermochemistry practice questions to evaluate my understanding	93
9	Instructions for using the thermochemistry e-worksheet based on FGIL explain how to use the e-worksheet	99
10	Accessing the thermochemistry e-worksheet based on FGIL on a smartphone is easy	100
	Total Percentage	96

Discussion

The research purpose is to develop a thermochemistry e-worksheet based on Flipped-Guided Inquiry Learning (FGIL). The development stage was conducted using the model of ADDIE which was limited to the analysis, design, and development stages. Reviewing the e-worksheet development process is based on the practicality and validity of test results. Content validity is the validity test used in this study. To find out how well an instrument can measure a desired variable, content validity analysis is performed (Mohamad et al., 2015; Lau et al., 2019). Content validity can show the suitability of the draft e-worksheet with the materials, media, language, and FGIL learning model used with review from chemists and chemistry educators (Rasmawan, 2022; Saslina et al., 2020).

The first stage is the analysis stage in the form of researchers defining the issue, identifying the source of the issue, and determining possible solutions. During this stage, particular research methodologies like needs, goals, and task analyses are used (Muruganantham, 2015). Analysis was carried out using interview techniques with one of the chemistry teachers at SMAN 1 Lengayang. According to the interview results, students find thermochemistry to be one of the more challenging subjects because it involves abstract and mathematical concepts. This is similar to research by Aswita et al. (2017) that thermochemistry material is considered difficult for students because the material is algorithmic. Apart from the material being considered difficult, the teacher stated that textbooks are still used as teaching tools while teaching thermochemistry. Teaching materials in the shape of textbooks reduces students' interest in learning because learning with textbooks is still general so students have difficulty learning the material (Pawestri et al., 2023). Apart from that, textbooks are less interesting because they are not equipped with media that can increase students' interest in learning (Bau et al., 2022).

These issues highlight the need for electronic teaching resources that can facilitate learning and spark students' curiosity in the subject matter. As a result, instructional materials based on FGIL on thermochemistry material were created as e-worksheets. One of the advantages of e-worksheets is that they facilitate the learning process thereby increasing student activity and learning achievement (Prastika & Masniladevi, 2021). E-worksheets can also be interesting teaching materials because they can be combined with various media such as video, audio, animation, and images (Indriani et al., 2022; Putri et al., 2021). The use of e-worksheets in the process of learning is also effective in increasing student learning outcomes, problem-solving skills, learning motivation of the student, and so on (Mispa et al., 2022; Eriana et al., 2023).

The application of FGIL on e-worksheets is a combination of the flipped classroom with the guided inquiry learning model. Flipped is applied to control student learning at home via e-worksheets so teachers can monitor how students learn outside the classroom. Learning outside of class increases students'

understanding so that when they are in class they can discuss things in more depth. While high-level thinking, such as applying, analyzing, evaluating, and creating, occurs inside the classroom, low-level thinking, such as remembering and understanding, occurs outside of it (Paristiowati et al., 2017).

The next stage is the design stage. Products are developed based on problems found at the analysis stage. Writing the target population's description, analyzing learning, making test items and objectives, choosing a delivery method, and organizing the lessons are all possible during the design stage (Muruganantham, 2015). The components of the e-worksheet are in Table 3. Thermochemistry material was selected based on the results of the interviews regarding material that students considered difficult. The e-worksheet was initially designed using Canva and then converted into an e-worksheet with the LiveWorksheets application. The advantage of the Liveworksheets application is that it can save paper and time, is interactive, and motivates students (Felitasari & Rusmini, 2022).

At the development stage, the product that has been designed at the design stage is developed further. This stage includes the use of software in the product development process (Muruganantham, 2015). In this research, the product developed is an e-worksheet which is prepared concerning the FGIL model. The software used in developing this e-worksheet is Canva and then converted into an e-worksheet with the help of the liveworksheet application. The paper size is A4 with Poppins font. The number of e-worksheet pages is 29 pages including the front cover and back cover. Research on the development of e-worksheets assisted by live worksheets was also carried out by Susilawati et al. (2023) on biodiversity material. Research shows that the e-worksheet built meets the category of being valid, practical, and effective.

The e-worksheet is then validated with a validator to improve product quality. The validation aspects assessed are material, media, and language. The validator provides an assessment by filling out a validation sheet. Indicators assessed in the material aspect consist of the depth of the material according to the student's abilities, the breadth of information presented in the material, the suitability of the material with the competencies achieved by students, and the relationship between the material and the problems presented. For the media aspect, the indicators assessed are the presentation format arranged systematically, the type of font used is easy to read, the presentation is pleasant for students, and the e-worksheet design is attractive. In the language aspect, the indicators assessed consist of the language used following EYD rules, the language used is communicative, and the sentences used are easy to understand and clear. From validation activities, suggestions and input are obtained from validators as considerations for product improvement. The sample of suggestions from the validator is on the language aspect. In the system and environment images, there are terms in English that are recommended to be changed to Indonesian. Suggestions can be taken into consideration to improve the product even though it is stated that revisions are not necessary (Bungawati & Rahmadani, 2023). The improvement results are shown in Figure 2.

Pre-revision

Post-revision

Figure 2. Product revision

Figure 2 shows the change in the terms "system" and "surroundings" to "*sistem*" and "*lingkungan*". Changes in terms were made to make it easier for students to understand the e-worksheet. The validation results are in Table 4. The results of the V'aiken validity test are as follows, an average of 0.92 on the material aspect, 0.96 on the media aspect, and 0.83 on the language aspect, all of which are in the very valid category. Similar research by Epinur & Minarni (2023) and Ramadani et al. (2023) shows that worksheets on the inquiry-flipped classroom have very valid validity criteria. So, it can be concluded that the thermochemistry e-worksheet based on FGIL is very valid in terms of material, media, and language aspects so it is suitable for use in teaching thermochemistry material.

After validity is determined, it continues with practicality testing. The practicality test was carried out on 36 students in phase F. The student assessment items are in Table 5. This test was carried out to see responses from e-worksheet users to minimize differences in expert and user assessments (Rasmawan, 2022). There are three aspects of practicality assessment coverage, namely appearance, ability of use, and language. The practicality test results of the thermochemistry e-worksheet based on FGIL show an average value of 96% making the category very practical. Based on research by Ayunda & Azhar (2023) it was found that e-worksheets developed using Liveworksheets are in the very practical category. This means that the e-worksheet presents the material in a clear, simple, and easy-to-understand manner. The choice of size and type of letters is appropriate and equipped with instructions for use (Lestari et al., 2018).

4. CONCLUSION

Students thermochemistry e-worksheet based on Flipped-Guided Inquiry Learning (FGIL) for phase F students that have been developed have fulfilled all aspects of validity assessment according to the validator's assessment. The average validity obtained in the material aspect was 0.92 (very valid), in the media aspect 0.96 (very valid), and in the language aspect 0.83 (very valid). In the practicality test carried out with students, the average student assessment was 96% (very practical), meaning that e-worksheets can be used in the process of thermochemistry learning.

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