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Development of a Deep Learning-Based E-Worksheet Integrated with Multiple Intelligences for Teaching the Fundamental Laws of Chemistry

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Abstrak

Penelitian ini bertujuan untuk mengembangkan dan mengetahui kelayakan E-LKPD berbasis Deep Learning terintegrasi Multiple Intelligences pada materi Hukum Dasar Kimia. Penelitian menggunakan metode Research and Development (R&D) dengan model ADDIE yang dibatasi pada tahap Analysis, Design, dan Development. Analisis kebutuhan dilakukan melalui observasi pembelajaran, wawancara guru, analisis kurikulum, dan studi literatur. Produk yang dikembangkan berupa E-LKPD digital interaktif yang mengintegrasikan prinsip Deep Learning (mindful, meaningful, dan joyful learning) dengan Multiple Intelligences. Kelayakan produk dinilai oleh dua dosen ahli dan satu guru kimia menggunakan lembar validasi ahli. Hasil validasi menunjukkan nilai Aiken's V sebesar 0,921 pada aspek materi dan 0,909 pada aspek media dengan kategori tinggi. Karakteristik E-LKPD yang dihasilkan meliputi integrasi prinsip Deep Learning, pengakomodasian berbagai kecerdasan majemuk, tampilan interaktif, serta aktivitas yang mendukung keterampilan berpikir kreatif. Berdasarkan hasil validasi, E-LKPD dinyatakan layak digunakan sebagai bahan ajar pada materi Hukum Dasar Kimia.

Kata Kunci: E-Worksheet, Deep Learning, Multiple Intelligences, Fundamental Laws of Chemistry, Educational Development.

Abstract

This study aimed to develop and evaluate the feasibility of an electronic student worksheet (E-Worksheet) designed by integrating Deep Learning principles and Multiple Intelligences theory into the teaching of the Fundamental Laws of Chemistry. The research employed a Research and Development (R&D) approach using the ADDIE model, focusing on the analysis, design, and development stages. A needs assessment was conducted through curriculum analysis, classroom observations, teacher interviews, and a review of relevant literature. The resulting product was an interactive digital worksheet that incorporated the principles of mindful, meaningful, and joyful learning while accommodating students' diverse intelligence profiles. The feasibility of the product was assessed by two chemistry education experts and one chemistry teacher using expert validation instruments. The findings revealed validity scores of 0.921 for the content aspect and 0.909 for the media aspect, both of which fall within the high validity category. These results indicate that the developed E-Worksheet meets the required standards in terms of content quality, presentation, language use, and visual design. The product is characterized by an engaging visual interface, the integration of Deep Learning activities, the accommodation of various intelligence types, and learning tasks designed to foster creative thinking skills. Based on the validation results, the developed E-Worksheet is considered suitable for use in chemistry learning.

Keywords: ***E-Worksheet*, *Deep Learning*, *Multiple Intelligences*, *Fundamental Laws of Chemistry*, *Educational Development*..**

INTRODUCTION

In the implementation of Merdeka Curriculum, it is important to pay attention to the development of the competency of students through the meaningful and relevant learning experiences. In accordance with this principle, the Indonesian Ministry of Education has adopted Deep Learning as a way to conduct learning process that is mindful, meaningful and joyful. In comparison with traditional learning style that means memorizing of information, Deep Learning focuses on the acquisition of the knowledge

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by the students who should connect new concepts with their previous experience and apply their knowledge in practice. It is especially important to use Deep Learning approach in the teaching of chemistry as some chemical concepts are abstract, hierarchical and interrelated. It is necessary for the students to know and comprehend the phenomena at the macroscopic, submicroscopic and symbolic levels. For this reason, meaningful learning is a must for students to acquire conceptual knowledge.

One of the chemistry topics that may cause problems for students is the Fundamental Laws of Chemistry. The topic is necessary for comprehending stoichiometry and other quantitative parts of chemistry. In this part of studying, students should be able to interpret numerical relations between substances, make conclusions based on the analysis of experimental data, and use mathematics to explain chemical processes. The studies showed that it is quite common for students to face misconceptions and problems regarding the understanding of the relations between mass, composition, and volume in chemical reactions. As a result, the connection between theory and practice is difficult to establish for many learners.

During preliminary observations made in the research site, it was noted that the chemistry lessons devoted to the Fundamental Laws of Chemistry were mostly teacher-centered. Lessons were carried out through lectures with the help of textbooks and Powerpoint presentations. Though the material was important for students, it did not give learners an opportunity to actively take part in the learning process. Instead, learners just got the information, solved usual tasks, and had teacher explanations. Thus, there was little chance for creative thinking and problem-solving.

In addition, one of the challenges found in the process of learning is that each student has different characteristics when learning. Each student has his own strengths, learning styles, and methods of processing information. The Multiple Intelligences theory by Gardner states that there are multiple intelligences rather than one intelligence in humans, which consist of linguistic, logical-mathematical, visual-spatial, interpersonal, intrapersonal, and naturalistic intelligences. Differences in intelligences will affect the way each student learns, comprehends, and even shows his understanding of concepts. Therefore, instructional materials must also be created in accordance with those different types of intelligence so that students can learn accordingly. Although the concept of Deep Learning and Multiple Intelligences has attracted the attention of many researchers recently, there is still a lack of instructional materials which incorporate these two concepts. Digital learning tools often include learning processes which only emphasize delivering and assessing the content to the students. In addition, most of the research on E-Worksheet creation emphasizes problem-based learning, project-based learning, and critical thinking skills but ignores the integration of Deep Learning principles and Multiple Intelligences into the instructional material.

The improvement of educational technology may be considered as the basis for solving the mentioned problems by means of creating interactive computer-assisted learning materials. The concept of electronic student worksheets (E-Worksheets) is quite versatile and may include not only text but also images, video, animations, and interactive tasks in one package. All these elements could increase students' involvement, promote independent learning, and help introduce new forms of education. By combining Deep Learning concepts with Multiple Intelligences Theory, E-Worksheets could offer a more personalized experience and promote creative thinking of students through various learning activities. Considering all the above, the current study has been designed to create an E-Worksheet based on the concepts of Deep Learning and Multiple Intelligences for studying the Fundamental Laws of Chemistry. In particular, the following goals have to be achieved within the framework of this research work.

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METHODS

The methodology used in the current research is Research and Development (R&D), which follows the ADDIE model of instruction design. While the ADDIE model involves five steps - Analysis, Design, Development, Implementation, and Evaluation, the current study only included the three steps necessary for the development and evaluation of the feasibility of the product – Analysis, Design, and Development.

The analysis step was done to determine the learning needs and characteristics of the students. The tasks in this step include the curriculum analysis, classroom observation, interviewing the chemistry teachers and the review of the literature involving Deep Learning and Multiple Intelligences theory.

The design stage involves planning the structure and contents of the E-Worksheet. At this stage, the product development includes the creation of the product framework, the design of learning activities, incorporation of the concept of Deep Learning and Multiple Intelligences, preparation of research tools and storyboard creation. It should be noted that the learning activities are deliberately designed in such a way as to ensure mindful, meaningful and joyful learning taking into consideration various student intelligences.

At the development stage, an interactive digital E-Worksheet is developed on the Liveworksheets platform. It combines learning materials, illustrations, video clips, interactive learning tasks, reflective activities and exercises to promote creative thinking skills. After completion of the first product prototype, it was put to expert analysis to assess its quality and suitability for learning. Product validation was performed by three experts including two chemistry education lecturers and one chemistry teacher. The following four major areas were validated: content validity, presentation, language and readability, and graphic design. Suggestions and recommendations of the validators were used as the grounds for further revision of the product.

The E-Worksheet was then subjected to trial to test its readability, usability, and initial perception of the material among students. The data gathered from this trial were utilized to improve several aspects of the product such as instruction, navigation, appearance, and learning activities. Another trial was performed using students who had previously studied about the topic of Fundamental Laws of Chemistry in order to determine the practicality and feasibility of the created E-Worksheet.

Data were obtained through expert validation sheet, readability questionnaire, and student questionnaire. The validity of the product was measured through Aiken's V coefficient, whereas the readability and responses of the students were measured descriptively using percentage scores. The overall feasibility of the E-Worksheet was determined based on the validation and trial of the product. A product with a high validity and favorable responses among the students is deemed ready for use in chemistry learning.

RESULTS AND DISCUSSION

Needs Analysis

There is a needs assessment done through curriculum analysis, classroom observation, interview with teachers, and review of literature. As found out during the process of curriculum analysis, Fundamental Laws of Chemistry is one of the topics in senior high school chemistry and it is a pre-requisite topic for Stoichiometry and other quantitative concepts of chemistry. Based on the Merdeka Curriculum Learning Outcomes, students are supposed not only to understand the fundamental laws but also use these concepts in solving contextual and quantitative problem solving questions.

Additionally, it has been noted that Fundamental Laws of Chemistry involves concepts that are complex and quantitatively difficult for students to understand. It means that the understanding of the

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concept involves the interpretation of numbers, relationships between chemical substances and explanation of scientific phenomenon through scientific reasoning. It shows the importance of adopting learning strategies that put emphasis on the understanding of the concept and not just memorizing.

From classroom observations, it was evident that the method of teaching chemistry was mostly teacher-centered. Majority of the learning activities involved lecture delivery, use of textbooks and PowerPoint slides as main sources of instructions. Even though such learning materials offered necessary content to the students, they lacked elements of involvement in activities by the students. Consequently, most students became passive learners who engaged themselves in doing only exercises.

Information gathered from interviews with the teachers highlighted other difficulties experienced during the learning process. According to the teachers, most students had problems comprehending the quantitative aspects of the Fundamental Laws of Chemistry and depended on memorizing rather than analyzing concepts. In addition, the current learning materials did not cater for student-centered learning. The current worksheets only involved procedural activities with little room for exploration and reflection.

In addition, the analysis indicated the heterogeneity of students' intelligence. As noted by teachers, there were variations in learners' proficiency in acquiring chemistry knowledge; some learners were able to acquire knowledge through visualizing objects better than other learners, who learned faster using numbers, discussion groups, and learning through experience. Nevertheless, all the educational materials used a common method of instruction, which did not fully meet the needs of the learners. Such situation necessitates the development of learning resources, which should take into account various types of intelligence described in the concept of Multiple Intelligences.

As was found out during literature review, educational materials based on principles of Deep Learning along with Multiple Intelligences remain underrepresented. Despite the great number of studies devoted to the development of E-Worksheets to promote critical and creative thinking, problem solving and learning effectiveness, there are very few resources developed according to the principles of mindful, meaningful, and joyful learning and taking into account learners' multiple intelligences. With respect to the results obtained from the needs analysis, the necessity of developing an E-Worksheet using Deep Learning that incorporates Multiple Intelligences became necessary. This learning tool will foster meaningful and interesting learning situations, active involvement, consideration of student individuality, and creativity development when learning the Fundamental Laws of Chemistry.

E-Worksheet Design

The E-Worksheet was created using the concept of Deep Learning and Multiple Intelligences to develop a learning material that promotes meaningful learning and addresses the different learning needs of the students. At this point, the entire design of the product was formulated, which included the arrangement of the learning materials, the formulation of learning activities, the creation of learning assessment tools, and the inclusion of media elements in order to facilitate learning.

The design of the learning activities was guided by the three basic components of Deep Learning: mindful learning, meaningful learning, and joyful learning. Mindful learning was facilitated using learning activities that encourage students to set learning goals, relate the new concepts learned to previous knowledge, and check their understanding of the concepts. Meaningful learning was provided through activities that present contextual problems and real-life applications of the Fundamental Laws of Chemistry, allowing students to build knowledge through problem solving. On the other hand, joyful learning was facilitated through interactive activities, appealing visual presentations, multimedia, and diversified learning activities that would keep the students motivated.

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Also, in response to the variation in learners' preferred mode of learning and areas of intelligence, the E-Worksheet was developed using Gardner's theory of Multiple Intelligences. The learning exercises included various types of intelligence such as linguistic, logical-mathematical, visual-spatial, interpersonal, intrapersonal and naturalistic intelligence. Linguistic intelligence was supported by means of activities involving reading and writing while logical-mathematical intelligence was stimulated by inclusion of numerical and analysis-related activities. Visual spatial intelligence was promoted by use of pictures and diagrams while interpersonal and intrapersonal intelligence was developed by facilitating discussion and independent learning exercises. Naturalistic intelligence was integrated through incorporation of the relevance of chemistry concepts to environmental issues and life experience. In order to have consistency between the approach to learning and the learner characteristics, an integration map was systematically developed where Deep Learning dimensions were matched to various types of intelligence.

The E-Worksheet was designed using the Liveworksheets platform that provides a number of interactive features appropriate for online learning environment. With the help of this platform, different multimedia tools such as texts, images, video clips, links, and interactive exercises were combined in one educational resource. These tools helped students have flexible access to information resources and immediate feedback during educational activities. The content of the E-Worksheet was organized logically and sequentially. The introductory part comprised learning objectives, instructions, concept maps, and motivation activities meant to activate previous knowledge of students. The major part of the worksheet was devoted to contextual problem situations, exploring of concepts, investigations, interpreting data, guided discussion, and problem solving. In its concluding part there was space for reflection, assessment, and application of learned concepts to real life.

Moreover, the activities designed to develop creative thinking were included in the E-Worksheet. The students were expected to develop many ideas and alternatives, justify them, and give explanations based on evidence. By using Deep Learning approach and theory of Multiple Intelligences, the developed E-Worksheet should help students better understand the learned concepts, become more engaged in learning process, and develop their creative thinking skills.

Characteristics of the Developed E-Worksheet

There are a number of distinctive features of the developed E-Worksheet, which make it different from regular instructional tools used in education. These features were introduced intentionally to make certain the effectiveness of Deep Learning strategy, account for different types of student intelligence, and foster creative thinking in chemistry. One of the distinguishing features of the product is its interactive and attractive design. The E-Worksheet was created using the principles of an efficient layout, user-accessible interface, relevant color scheme and good typography, which would increase convenience of studying. The variety of visual aids such as pictures, diagrams, and representations of concepts were added in order to simplify understanding of abstract and quantitative chemistry notions.

The other notable attribute of the E-Worksheet is the use of Deep Learning principles in all the learning processes. The design of the E-Worksheet was based on the principles of mindful, meaningful, and joyful learning. Mindful learning activities allowed the students to identify learning goals, associate the newly acquired information with what they already know and to assess their understanding. Meaningful learning was made possible through the introduction of realistic situations and problems that would relate the concepts of chemistry to real-life situations. On the other hand, joyful learning was encouraged through interactive activities, use of multimedia and diversified learning experiences that would motivate the students to participate actively.

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Also, the application of Multiple Intelligences Theory is another distinctive feature of the E-Worksheet. Various kinds of learning activities provided opportunities for developing various intelligence types and different styles of learning. Reading, writing, and expression of ideas fostered linguistic intelligence, while logical analysis and calculations promoted logical-mathematical one. Activities that involved graphical representation, concept maps, and illustrations catered to visual-spatial intelligence, interpersonal intelligence was developed through cooperation and discussion activities, and intrapersonal intelligence was fostered through reflective exercises and self-assessment. Moreover, naturalistic intelligence was developed through association of chemistry concepts with environmental and real-life situations. Such a wide variety of activities ensured engagement of students in the study of learning material based on their strengths and preferences.

Moreover, the E-Worksheet was aimed at promoting creative thinking skills of students. Instead of offering creative thinking activities only in the final stage of learning process, creative thinking was integrated into the whole instructional process. Students had to generate several ideas, offer alternative solutions, justify their arguments, and explain them using scientific evidence. All the mentioned activities corresponded to the basic aspects of creativity such as fluency, flexibility, originality, and elaboration.

Another characteristic feature of the product is that it uses a specific sequence of learning activities. The E-Worksheet contains a number of activities that are interrelated and go from identifying problems in a certain context through exploring and investigating the related concepts and interpreting the obtained information to discussing, reflecting on, and evaluating the results. In other words, the sequence of learning activities promotes an active construction of knowledge and steady progress of the understanding of chemistry concepts. It is in line with both the ideas of Deep Learning and learning outcomes provided in the Merdeka Curriculum. In general, the E-Worksheet combines such characteristics as digital interaction, Deep Learning, Multiple Intelligences, and creative thinking activities. Thus, the product becomes not only a tool of learning but also an instrument of promoting active participation and meaning-making in the modern context of education.

Feasibility of the E-Worksheet

The feasibility of the designed E-Worksheet was assessed through the expert validation stage, conducted by two lecturers specializing in Chemistry Education and one chemistry teacher. The main purpose of the assessment was to evaluate the quality of the produced product regarding its content, presentation, language, readability, and design attractiveness before it would be used in the teaching process.

In particular, the results of the content validation demonstrated that the E-Worksheet had Aiken's V values of 0.944 and 0.889 related to the appropriateness of content and presentation respectively, providing the average score of 0.921, which is defined as highly valid. Hence, the conclusion may be drawn about the scientific accuracy of the content, activities, examples, and concepts provided in the E-Worksheet. Furthermore, the content is consistent with the learning objectives and corresponds to the goals of the Merdeka Curriculum.

Table 1. Material Expert Validation Results

Aspect	Aiken's V	Category
Content Feasibility	0.944	High
Presentation Feasibility	0.889	High
Average	0.921	High

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Another positive finding came from the media validation process. The score that the graphical design received is 0.944, whereas the language and readability scored 0.867. Overall, the average score of 0.909 shows that the E-Worksheet is highly valid from the point of view of media. As the validators say, the visual look, layout, typography, color scheme and multimedia elements are suitable for senior high school learners. In addition, the language used in the E-Worksheet is understandable and appropriate for the cognitive level of students so that they can understand instructions and content.

Table 2. Media Expert Validation Results

Aspect	Aiken's V	Category
Graphic Design	0.944	High
Language and Readability	0.867	High
Average	0.909	High

Apart from giving validation scores, the experts gave constructive criticism to ensure the quality of the product. Various changes were made in terms of refining learning instructions, making page designs that are more readable and consistent in terms of visual design, and strengthening the connection of the Deep Learning approach and Multiple Intelligences in specific learning tasks. All the changes were included in the revised version of the E-Worksheet.

After revising the product, the E-Worksheet went through various product trials to test its practicality and acceptability by the students. Readability tests and student response questionnaires proved to be positive. Students found the E-Worksheet to be very easy to use and understand. In addition, the students liked its appearance and felt that the E-Worksheet helped them in comprehending the Fundamental Laws of Chemistry.

Overall, it can be said that the results from the validation and pilot testing clearly reveal that the designed E-Worksheet corresponds to the requirements related to both the content and the design of the learning materials. The experts noted that the E-Worksheet is well aligned with the principles of Deep Learning and provides for a development of creative thinking skills for people with different kinds of intelligence.

CONCLUSION

Based on this research work, an E-Worksheet that utilizes deep learning along with multiple intelligences has been developed for the Fundamental Laws of Chemistry topic. This product has been developed according to the three components of the ADDIE Model namely analysis, design, and development phases in order to create an innovative learning product that can help in implementing the Merdeka Curriculum. There are a number of vital features possessed by the developed E-Worksheet such as visually attractive design, incorporation of mindful, meaningful, and joyful learning concepts, theory of multiple intelligences, and activities designed to help in developing creative thinking abilities of the learners. The use of contextual learning, reflective learning, multimedia, and learning activities has helped in engaging the students in their learning process.

As a result, it was revealed that the product was developed in accordance with the requirements of high-level validity. The average Aiken's V scores for content were 0.921 while those for media were 0.909. Both of these values belong to the category of highly valid scores. Moreover, it was possible to conclude from the tests carried out among students that they found the developed product to be useful, legible, applicable, attractive, and helpful in their educational process. It means that the product is valid in terms of its instructional and media components.

In conclusion, it should be noted that the E-Worksheet developed based on the principles of Deep Learning with Multiple Intelligences is a valid and realistic educational tool for chemistry lessons,

including those on Fundamental Laws of Chemistry. This combination of two theories is a good strategy for taking into account individual differences of students, making learning active and developing creativity. Thus, it is possible to use E-Worksheet as an educational resource for chemistry in senior high school.

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