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Development of Guided Discovery Based Stoichiometry E-Modules to Improve Students' Science Literacy

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Abstract: This research aims to create e-modules based on guided discovery learning that are effective, practical, and support student learning. The research type uses research and development (R&D) using a 4-D model with four steps: definition, design, development, and dissemination. This tool is in the form of a questionnaire on effectiveness and feasibility. Elastic modulus is verified by her 6 validators. Data were analyzed according to the Aikens V formula and percent utility. In the analysis of content validity and technical rating, the average V of Aikens with high valid categories was 0.85 and 0.83. Teacher and student ratings of the practicality questionnaire data were 82% and 83% in the highly practical category. Data analysis shows that young's modulus has high validity and practicality. Therefore, it can be concluded that e-modules based on guided discovery learning are effective, practical, and categorized as teaching materials that improve students' scientific literacy.

Keywords: e-module, stoichiometry, guided discovery learning, science literacy.

Abstrak: *Penelitian ini bertujuan untuk menghasilkan E-Modul berbasis guided discovery learning yang valid dan praktis dan mampu membantu proses belajar siswa. Jenis penelitian ini menggunakan research and development (R&D) dengan model 4-D yang terdiri dari empat langkah yaitu define, design, develop, dan disseminate. penelitian ini dibatasi pada tahap develop. Intrumen yang digunakan pada penelitian berupa angket validitas dan kepraktisan. E-Modul divalidasi oleh 6 validator. Data dianalisis dengan rumus Aikens'V, dan persentase kepraktisan. Analisis untuk validitas konten dan teknikal skor rata-rata Aikens' V 0.85 dan 0.83 dengan katagori valid tinggi. Analisis data angket kepraktisan guru dan siswa adalah 82% dan 83% dengan kategori sangat praktis.Analisis data yang didapat menunjukkan bahwa E-Modul memiliki tingkat validitas dan kepraktisan yang tinggi. Oleh karena itu, dapat disimpulkan bahwa E-Modul berbasis guided discovery learning merupakan bahan ajar yang dikategorikan valid dan praktis sehingga dapat digunakan dalam proses pembelajaran kimia agar dapat meningkatkan kemampuan literasi sains siswa.*

Kata kunci: *e-modul, stoikiometri, guided discovery learning, literasi sains.*

▪ INTRODUCTION

Chemical science has its own characteristics. A chemistry characterization by Kean and Middlecamp, 1985 in Palisoa (2008) is: 1) Some chemistry concepts are abstract. 2) Chemistry terminology is generally a simplification of the actual situation. 3) The concept of chemistry is continuous and stepwise. 4) Chemistry is not just about solving problems. In chemistry there are two kinds of understanding that students must acquire: conceptual understanding and algorithmic understanding. Conceptual understanding is understanding what is associated with a concept. Algorithmic understanding is understanding the procedure or set of rules containing the mathematical calculations to solve Mustofa's problem (Zidny, et al, 2010).

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One of his chemistry learning materials is stoichiometry. Stoichiometry is taught in grade X with even terms. Current Curriculum 2013 teaches basic skills in stoichiometry KD 3.10 Basic Laws of Chemistry, the concept of relative molecular mass, chemical equations, the concept of moles, and quantities of matter to perform chemical calculations. Stoichiometric substances are abstract substances. Stoichiometry is also one of the basic materials for studying some advanced chemicals. If students have difficulty understanding the reaction equation concept and the molar concept, they will most likely have difficulty learning the following material as well. For this reason, teachers must be able to design interesting, learning, comprehensible students according to the 2013 Curriculum Principles, the student-centered principle, so that students do not have difficulty in the next level.

Based on observations made by the authors with several class X science students at SMAN 1 Rambatan. They showed that stoichiometric substances are classified as substances that are not very interesting to students and are very difficult to understand. , failing to arouse the interest and curiosity of students who actively participate in learning. Further interviews with school teachers revealed that teachers still used printed books for some learning activities, that teachers focused on the content of the teaching materials, and that the 2013 curriculum stipulated that students It became clear that we were not using the stage to teach the.

Apart from being based on the results of observations and interviews, there are also previous studies that explain the problems faced by students in stoichiometry material. Some of the results of the study are: (1) Zidny, et al (2013) in the results of their study said that 76.67% of students said stoichiometry is material that is difficult to learn. The difficulty of stoichiometry material according to students because this material applies a lot of counting questions, is difficult to apply and complicated because of many formulas. Zidny, et al argue that this indicates that students are crammed with calculation skills by applying certain formulas without being equipped with understanding concepts, (2) Delhita & Suyono (2012) said that stoichiometry is considered difficult by 60% of high school students in Surabaya, (3) Zakiyah (2018) said that stoichiometry is considered difficult for most students. Concepts in stoichiometry that are difficult for students to understand are the concept of moles, algorithmic formulas and reaction equations.

Teacher-designed learning must be capable of independent comprehension of what is learned. One way is to use technology development, one of which is the use of e-modules. E-modules are electronic modules. E-modules allow students to learn independently. E-modules are systematically edited sets of digital or non-print educational media to be used for independent learning purposes in electronic form (Danang, 2015). E-modules are part of electronics-based learning that uses information and communication technology, especially electronic devices, in the learning process. This means that it affects not just the Internet, but all electronic devices such as films, videocassettes, OHPs, slides, LCD projectors (Jaenudin, 2017).

Teachers must not only be proficient with technology, but also be able to use learning models/methods that enable students to understand the material in order to achieve the learning objectives set in the 2013 curriculum. Learning can be better optimized by using technology and learning models together. Adhering to the principles of the 2013 Curriculum, according to the author, one of the learning models that can be used simultaneously with the e-modules created by Sigil is the Guided Discovery learning model.

The discovery model is his one of the learning models developed by Jerome Brunner. Brunner developed his discovery model based on constructivist and cognitive learning theory views. Brunner believes that seeking knowledge through human activity yields the best results (Trianto, 2009). This guided discovery learning model employs the scientific method, where questions and experiences are presented to students, allowing them to discover concepts for themselves. This is definitely guided by a teacher. Also, students are encouraged to think based on the materials provided by the teacher and students can discover principles/concepts/theories from the materials provided. (Muntari et al., 2021).

Based on research previously conducted by Bamiro (2015), the use of Guided Discovery can develop and improve the quality of cognitive abilities of students, and teachers are particularly encouraged to use Guided Discovery in science learning in the classroom. found to be recommended. (Ulumi, Diana Fatihatul., 2015), based on their findings, also found that using a guided discovery learning model can improve student learning outcomes in the areas of knowledge, attitudes, and skills. According to research (Yerimadesi, Bayharti., S. M. Jannah., Lufri., Festiyed., 2018), using modules based on Guided Discovery Learning in six learning units made students more active and motivated to learn. improve. Guided Discovery Learning can also inspire students to use critical thinking in the learning process.

A skill whose development is currently the subject of much debate is literacy. When it comes to learning science, there is also reading comprehension, or scientific literacy. Scientific literacy is the ability to understand scientific processes and obtain meaningful scientific information that can be used in everyday life. Developing scientific skills is very important in today's digital age. There are many issues related to knowledge and technology to enable people to make personal decisions and participate in shaping public policies that affect their lives (Izzatunnisa, 2019).

Against the background of the above, the author describes the development of his E-Modules using the Sigil application, based on guided discovery learning on stoichiometric materials to improve science literacy in high school/master's courses. I am interested in a research paper with the title.

▪ METHOD

The type of applied research is research and development (R&D). According to Sugishirono (2013), "Research and development methods, or in English, research and development methods, are research methods used to create specific products and test the effectiveness of products." was conducted using the 4D development model. According to Semmel (in Subamia, 2020), the 4-D model consists of four phases: definition (definition), design (design), development (development), and dissemination (deployment). The Define phase (Define) is front-end analysis, student analysis, task analysis, concept analysis, and learning goal analysis. Design phase, design of young's modulus media based on guided discovery learning of chemical learning media for stoichiometric materials. The development phase (development) produces young's modules based on guided discovery learning to valid and practical stoichiometric materials. During this phase, effectiveness and practicality tests are performed.

The study subjects used as sources for data collection consisted of 5 lecturers, 3 chemistry teachers and student X from SMAN 1 Rambatan. The populations used in the study are the experimental and control classes. The instruments used are interview questionnaires, validation questionnaires (in the form of content and technical tests), and utility questionnaires. The content and technology validation analysis methodology is based on category scores, and the content and technology validation sheet consists of multiple statements that are scored against the statements. The verifier makes decisions based on the results of the evaluation of the expanded modulus of elasticity.

The method used to analyze the obtained validation data uses the Aikens-V formula:

$$V = \frac{\Sigma(r_i - l_0)}{n(c-1)}$$

Where: r = number assigned by rater, lo = number with lowest plausibility score, c = number with highest plausibility score, n = number of experts and practitioners conducting the assessment, i = 1, 2, month number from 3 to n, where n = number of reviewers. Aikens`v validation with V scale ≤ 0.4, with few categories, 0.4 < V ≤ 0.8, moderate categories, 0.8 <; V with valid categories (Nugroho, 2017).

Utility data is collected from teachers and students who complete declarations on utility sheets. For utility data, we specifically use utility percentages (Rinduan, 2009).

$$\text{Practicality score} = \frac{score\ obtained}{maximum\ score} \text{ x } 100\%$$

Table 1. Practical product categories

No	Category	Criterion
1.	80% < X ≤ 100%	Very Practical
2.	60% < X ≤ 79%	Practical
3.	40% < X ≤ 59%	Pretty Practical
4.	20% < X ≤ 39%	Less Practical
5.	X ≤ 19%	Impractical

Efficacy is determined from the results of pre-test and post-test evaluations and analyzed with the N-Gain equation to determine the effectiveness of e-modules based on guided discovery learning. Efficacy tests, or essay questions with science literacy, are used to ensure that students improve their scientific literacy. Science literacy draws on the context of scientific problems that arise in everyday life (Eijck, 2010). Learning with emphasis on aspects of science literacy can improve the science literacy of learners (Deboer, 2000). Liu (2009) defines scientific literacy as the process from the beginning of life to death, so it is a long process.

▪ RESULT AND DISSCUSSION

In the define phase (define) the frontend, students, tasks, concepts and learning objectives are analyzed. First, examine the syllabus and issues in this area. So I need a solution to the problem at hand. The problem is, according to interviews with teachers, there is no stoichiometry module based on guided discovery learning that helps students improve their basic science knowledge. The E-module developed in this way. According to Suryadie (in Herawati & Muhtadi, 2018), electronic modules are an innovative medium that can increase students' interest in learning. The characteristics of the students were also analyzed by distributing questionnaires, and the questionnaire results showed that 60% of the students still had difficulties with stoichiometric materials. The results of the analysis serve as a reference for researchers to develop modulus of elasticity. Student X subjects aged 15-16. Students of this age are already at a formal working stage where they can think abstractly (Omrod, 2014). Core competencies are also detailed during this phase as indicators of competence attainment and used as learning objectives. Basic capabilities for stoichiometric materials are found in 3.10. Apply basic laws of chemistry, the concept of relative molecular mass, chemical equations, the concept of moles, and levels of matter to perform chemical calculations (Permendikbud, 2018). performance indicators, namely 1) explanation of the meaning of moles, 2) determination of molar masses of known elements and compounds of Ar/Mrnya, 3) calculation of molar volume values of gases based on known molar values, 4) determination of molecular weights. Formula of compound using experimental data, 5) Determine formula if formula is known, 6) Write down reaction formula, 7) Balance reaction formula, 8) Apply reaction factor to determine limiting reagent do. After the learning goal is recognized in the indicators, the learning goal is achieved through a guided discovery learning model by discovering different knowledge from different sources. Encourage students to be actively involved in the learning process, to express curious, conscientious and responsible opinions, to answer questions, to make suggestions and to criticize, and to enable students to understand stoichiometric material. is desired. In this phase, concepts must be identified to create a concept map. Concepts are analyzed using college chemistry textbooks and high school chemistry.

The design phase will be carried out according to the observations made by the students of SMAN 1 Rambatan School. The e-modules are intended to arouse students' interest in learning. The e-module should consist of a cover page, preface, table of contents, information about the e-module, a guide on how to use the e-module, core competencies, basic competencies and indicators of competency achievement, concept map, introduction. Designed to Activity worksheets, assessment questions, and references.

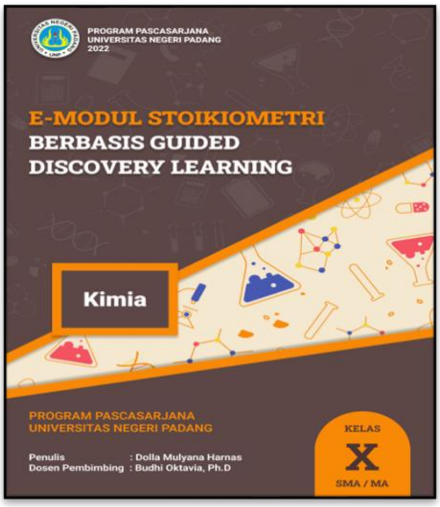
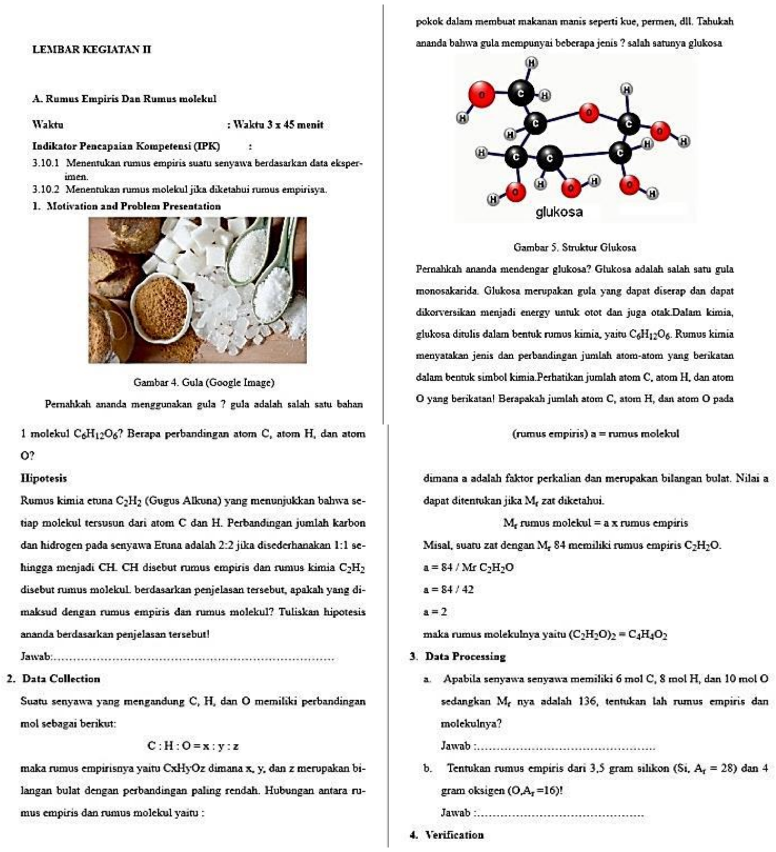


Figure 1. Cover



LEMBAR KEGIATAN II

A. Rumus Empiris Dan Rumus molekul

Waktu : **Waktu 3 x 45 menit**

Indikator Pencapaian Kompetensi (IPK) :

3.10.1 Menentukan rumus empiris suatu senyawa berdasarkan data eksperimen.

3.10.2 Menentukan rumus molekul jika diketahui rumus empirisya.

1. Motivation and Problem Presentation

Gambar 4. Gula (Google Image)

Pernahkah ananda menggunakan gula ? gula adalah salah satu bahan pokok dalam membuat makanan manis seperti kue, permen, dll. Tahukah ananda bahwa gula mempunyai beberapa jenis ? salah satunya glukosa

Gambar 5. Struktur Glukosa

Pernahkah ananda mendengar glukosa? Glukosa adalah salah satu gula monosakarida. Glukosa merupakan gula yang dapat diserap dan dapat dikorversikan menjadi energy untuk otot dan juga otak.Dalam kimia, glukosa ditulis dalam bentuk rumus kimia, yaitu $C_6H_{12}O_6$. Rumus kimia menyatakan jenis dan perbandingan jumlah atom-atom yang berikatan dalam bentuk simbol kimia.Perhatikan jumlah atom C, atom H, dan atom O yang berikatan! Berapakah jumlah atom C, atom H, dan atom O pada 1 molekul $C_6H_{12}O_6$? Berapa perbandingan atom C, atom H, dan atom O?

Hipotesis

Rumus kimia etuna C_2H_2 (Gugus Alkuna) yang menunjukkan bahwa setiap molekul tersusun dari atom C dan H. Perbandingan jumlah karbon dan hidrogen pada senyawa Etuna adalah 2:2 jika disederhanakan 1:1 sehingga menjadi CH. CH disebut rumus empiris dan rumus kimia C_2H_2 disebut rumus molekul. berdasarkan penjelasan tersebut, apakah yang dimaksud dengan rumus empiris dan rumus molekul? Tuliskan hipotesis ananda berdasarkan penjelasan tersebut!

Jawab:...

2. Data Collection

Suatu senyawa yang mengandung C, H, dan O memiliki perbandingan mol sebagai berikut:

C : H : O = x : y : z

maka rumus empirisnya yaitu CxHyOz dimana x, y, dan z merupakan bilangan bulat dengan perbandingan paling rendah. Hubungan antara rumus empiris dan rumus molekul yaitu :

(rumus empiris) a = rumus molekul

dimana a adalah faktor perkalian dan merupakan bilangan bulat. Nilai a dapat ditentukan jika M_r zat diketahui.

M_r rumus molekul = a x rumus empiris

Misal, suatu zat dengan M_r 84 memiliki rumus empiris C_2H_2O.

a = 84 / Mr C_2H_2O

a = 84 / 42

a = 2

maka rumus molekulnya yaitu $(C_2H_2O)_2 = C_4H_4O_2$

3. Data Processing

a. Apabila senyawa senyawa memiliki 6 mol C, 8 mol H, dan 10 mol O sedangkan M_r nya adalah 136, tentukan lah rumus empiris dan molekulnya?

Jawab :...

b. Tentukan rumus empiris dari 3,5 gram silikon (Si, A_r = 28) dan 4 gram oksigen (O,A_r =16)!

Jawab :...

4. Verification

Figure 2. Activity sheet according to syntactic guided discovery learning

The development phase (Develop) is seen as a result of practical fitness and effectiveness testing. Validation tests are performed to verify the effectiveness of the product by the verifier. This eModule assessment will be conducted by her 4 instructors and her 2 teachers at SMAN. Validity results are shown in Tables 2 and 3.

Table 2. Stoichiometry e-module content validity results by validators

No	Category	V	Categories vality
1	Component Contents	0.83	Valid
2	Linguistic Components	0.85	Valid
3	Serving Components	0.85	Valid
4	Graphic Components	0.88	Valid
	Average	**0.85**	**Valid**

In the effects of content material validity, there are four additives, specifically the additives of content material, language, presentation, and graphics (Depdiknas, 2018). The validator evaluation for the 4 additives is with Aiken`V. The common validity of the content material is 0.85 with legitimate categories. Technical validity results have three dimensions: presentation, programming, and usage. The Aiken`v formula is used, with an average validity of 0.83 for valid categories.

Table 3. Technical validity results of stoichiometry e-module by validator

No	Category	V	Categories vality
1	Display Aspects	0.87	Valid
2	Programming Aspects	0.75	Keep
3	Utilization Aspects	0.87	Valid
	Average	**0.83**	**Valid**

A hands-on test conducted by teachers and students on stoichiometric materials using guided discovery learning. In teacher practice results based on a practicality questionnaire completed by the teacher, the teacher got her usability score of 86%, learning time efficiency of 80%, and learning utility of 80%, which is very practical as an overall average. 82% of the category. The teacher gave a good answer to the developed stoichiometric Young's modulus based on guided discovery learning. Developed based on guided discovery learning, Stoichiometric Young's Modulus helps students master stoichiometric materials, according to teachers. Guided discovery learning can enhance students' cognitive learning during learning (Bamiro, 2015). Students achieved an average of 81% actual fitness results for E module stoichiometry, with an ease-of-use value of 83%, an efficiency of learning time of 80%, and an advantage of 81%. This is because the stoichiometry module of Guided Discovery Learning is actually used in learning, i.e. the stoichiometry module of Guided Discovery Learning is easy to learn and supports the learning process of students to improve reading comprehension. indicates that you can student skills. E-modules based on guided discovery learning can improve students' scientific literacy (Darwis, 2019).

Efficacy studies are derived from pre- and post-tests. Before learning begins, a pre-test is given to determine the student's initial ability, followed by a post-test with the same questions. After receiving the overall pre- and post-test results, the N-gain test, normality test, and uniformity test are performed. After both classes are normally distributed and uniform, a hypothesis test is performed. Normality, homogeneity, and t-tests using SPSS as follows:

Table 4. Hypothesis test results

Class	N		Sig.(2-ekor)	Information
Experiment	36	0,05	0,000	Tolak H_0
Control	35			

Based on Table 4, it is determined that H0 can be interpreted to mean that there is a stoichiometric Young's modulus effect based on guided discovery learning on students' scientific literacy. In this case, a hypothesis test (a t-test sample independent test) can show that the significant test value is less than the significant value of 0.000 < 0.000. 0.05.

▪ CONCLUSION

Based on the results of the conducted research and data processing, a stoichiometry e-module for guided discovery learning was effectively and practically developed using a 4-D development model. The average e-module content effectiveness is 0.85 for valid categories and the average technical effectiveness is 0.83 for valid categories. The practicality of modulus of elasticity is evaluated by distributing questionnaire to students and teachers. Average teacher practicality is 82% in the very practical category and student practicality is 81% in the very practical category.

The developed elastic modulus can be used to support students' learning process to improve their basic scientific knowledge about stoichiometric substances. The disadvantage of this Young's modulus is that it is limited only to stoichiometric materials. Other researchers have to redesign Young's modulus if they want to use it to study materials other than stoichiometry.

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