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Development of Project-Based Learning Modules on the Subject of Chemical Equilibrium

Jamalum Purba[1*] and Bilham Aditia Sembiring[2]

[1,2]*Chemistry Education Study Program, Universitas Negeri Medan, Medan*

**Email: jamalum@unimed.ac.id*

Abstract: *Education is a serious concern for the Indonesian people considering the important role of education in the progress of the nation. The problems in education need serious attention from the government. The main objective of this study is to find out the feasibility of project-based learning modules on the subject of chemical equilibrium and determine student responses to project-based learning modules on the subject of chemical equilibrium. This study was created utilizing the ADDIE development paradigm and the Research & Development (R&D) approach. This research was conducted at Universitas Negeri Medan and SMA Negeri 6 Binjai. The results of this study indicate that through the development of project-based learning modules on the subject of chemical equilibrium: (1) Average content eligibility by lecturers is 3.7 and by teachers 3.8., (2) Average eligibility presentation by lecturers is 3, 6 and by the teacher 3.7., (3) The average of language proficiency by the lecturer is 3.5 and by the teacher 3.7., (4) The average graphic proficiency by the lecturer is 3.9 and by the teacher 3.8. And the average result of student responses is 3.73. This means that the learning module that has been developed is feasible and does not need to be revised.*

Keywords: *Module; Project Based Learning; Feasibility; Chemical Equilibrium*

INTRODUCTION

Education is a serious concern for the Indonesian people considering the important role of education in the progress of the nation. The problems in education need serious attention from the government. The aim of overcoming problems in education is to improve the quality of education which includes various fields such as the quality of curriculum, infrastructure, teaching and learning processes, improving the quality of teachers, and other efforts included in the education component (Karina, 2019).

The application of the Curriculum (2013) is a follow-up to the Kurikulum Berbasis Kompetensi (KBK) which was initiated in 2004 and Kurikulum Tingkat Satuan Pendidikan (KTSP) in 2006. Receipt of results learn from cognitive, affective, and competency. This psychomotor illustrates the quality of stable between acceptance of hard skills and soft skills. The advantages of the 2013 Curriculum include the activity is compulsory of all students, creative and innovative in problem solving, assessments are obtained from all aspects, student grades are not only obtained from exam scores but also from politeness, religion, practice, and

attitude values, there is character development and character education that has been integrated into all study programs and in accordance with national education requirements (Amin, 2013).

Chemistry's understanding of chemical equilibrium is complicated because it takes into consideration the reciprocal reactions that take place between reactants and products. Chemical equilibrium material frequently confuses students, especially when it comes to the number of moles of reactants, the number of moles when they react, the number of moles when they decompose, the number of moles when equilibrium is reached, and the residue from the reaction, making it one of the most challenging topics in chemistry learning. The instructional materials' presentation of the chemical equilibrium concept must be completed (Situmorang, 2015).

Students can actively engage in cognitive, psychomotor, and scientific attitudes by using a teaching resource in the form of learning modules. Learning through the use of modules can give students the chance to study in accordance with how each student might approach an issue. Creating modules with the needs of students in mind has the objective of providing instructional resources that meet curriculum requirements. Teachers can choose a theme using the teaching resources for a module. Themes that take into account pupils' cognitive development and their immediate environment in order to help them absorb the lessons being taught methodically (Anisa, 2018).

The project-based learning model is one of the suggested learning models. By integrating the project-based learning model syntax and experimental activities in this module, it can help teachers in the learning process. Learning activities that apply the project-based learning model consist of 8 stages, namely project costs, gathering information, drafting project plans, compiling activity schedules, project completion, reporting and reporting, assessment and evaluation (Dinda & Sukma, 2021).

According to findings from observations done at SMA Negeri 6 Binjai, the instructional materials were insufficient. Students entirely use the contents of the teacher's summary. Teachers use textbook sources in the form of modules and chemistry textbooks which emphasize the content dimension rather than the process and context dimensions. The teaching material presented in the textbooks is only in the form of concept definitions, a set of formulas and practice questions as a summary material given to students.

Based on the aforementioned facts, insufficient learning resources, such as books or learning modules, are the reason for students' lack of interest in the ongoing learning process activities. Based on some previous research, the development of learning media is needed in order to go beyond problems in one form of developing media that is attractive to students, for example learning media in the form of modules that are integrated with the application of learning models and approaches.

Learning modules must be able to bridge learning so that the competencies that have been set are systematic, and complete in teaching materials, easy to understand, interesting, encourage independent learning, and have material. Additionally, they must be able to present lesson plans that adhere to curriculum requirements, monitor scientific advancements, stay up with IPTEK, and be able to connect learning. The construction of a module learning system involves a number of regular steps called "module development." Building modules requires a procedure that is in line with the objectives you want to accomplish, a transparent learning framework, and the capacity to satisfy requirements (Sihombing, 2022).

The integration of a project-based learning model and developed teaching materials showed that there was a higher

increase in chemistry learning outcomes when using project-based modules than when not using project-based module teaching materials, with a difference of increase of 15.594% according to Rumarhonos (2017).

As for what will be used in this study is to determine the appropriateness of project-based learning modules that will be used using the BSNP (Badan Standar Nasional Pendidikan), in order to determine student responses to learning modules on the subject of chemical equilibrium.

LITERATURE REVIEW

A. Module

In order to develop the desired competences, modules are learning tools or facilities that include materials, techniques, constraints of learning resources, directions for learning activities, exercises, and ways of evaluation. They are systematically and attractively created and can be used independently (Aditia & Muspara, 2013). A printed educational resource known as a module is made for independent study by students. Because they contain self-study instructions, modules are often known as media for self-study (Susilo, 2016). The tasks connected to materials and media, as well as evaluation, are typically organized into modules. The notion of independent learning is one feature of the module as one of the teaching materials (Lasmiyati & Harta 2014).

The module serves the following purposes in the learning process: 1) Unbiased educational resources. In other words, the usage of modules in the learning process helps students get better at studying on their own or independently without relying on the presence of teachers; 2) Replace the role of educators. In other words, modules must be able to clearly convey subject matter and be simple enough for students of varying knowledge and ages to understand. Educators are also associated with something's explaining role. Consequently, the utilization of modules can serve as a replacement for the job or duty of the facilitator or educator; 3) As a tool for evaluation. Students must be able to evaluate their own skills and degree of knowledge of the subject they have learned in order to pass the module. The module is thus also a tool for evaluation; 4) As a source of information for students. In other words, the module selects a function as a reference material to collect content for students since it comprises a variety of items that students must study (Wahyuni & Puspita Sari, 2017).

B. Project Based Learning

Project-based learning (PjBL) is a learning model that offers teachers the opportunity to conduct face-to-face classes through project work. This project-based learning is based on constructivist learning theory, based on the idea that students construct their own knowledge in the context of their own experiences. Building knowledge means giving freedom to students to explore knowledge and make efforts to build from the experience gained. This PjBL can make students more active and motivated to participate in the learning process (Bhawayani, 2018).

The PjBL model and its effects on student learning show that it improves the growth of both students' knowledge and abilities. Additionally, students believe that the PjBL paradigm fosters group collaboration and bargaining. Some students, however, claimed to be unmotivated. In contrast to project-based learning, which is centered on active learning of science constructs, problem-based learning places more emphasis on the application of information. emphasizes how knowledge is built. With the freedom to test and implement their ideas whenever they see fit, this innovative method of knowledge creation fosters students' capacity for invention. With the freedom to test and implement their ideas whenever they see fit, this innovative method of knowledge creation fosters students' capacity for invention (Nasution & Lubis, 2022).

The characteristics of the project-based learning model according to what is stated (Natty, 2019) are as follows (1)

Learning begins with questions, (2) Planning projects, (3) Arranging schedules (4) Supervising project progress, (5) Product evaluation, (6) Evaluation (Natty, 2019). The advantages of the Project based learning (PjBL) model are that it provides experience to students learning and practicing organizing projects, providing learning experiences that engage students in a complex manner and are designed to develop in the real world, making the learning atmosphere enjoyable. While the weaknesses of the Project based learning (PjBL) model are that it requires a lot of time to solve problems, the amount of equipment that must be provided, there is a possibility that students are less active in group work, and requires quite a lot of money (Setyowati, 2021).

C. Chemical equilibrium

As the concentration of a gas in a space will affect its pressure, the equilibrium constant for processes involving gases can be calculated from the value of each gas's partial pressure at equilibrium. The equilibrium constant based on concentration is currently represented by the sign Kc, while the equilibrium constant based on pressure is represented by the symbol Kp. This enables us to differentiate between the equilibrium constant value for a balanced reaction obtained from the concentration value and from the partial pressure value:

$$mA(g) + Nb(g) \rightleftharpoons xC(g) + yD(g).$$

A system in an equilibrium state tends to keep itself in equilibrium, so if there is an outside effect, the system will adapt in a way that allows it to swiftly return to an equilibrium state. Le Chatelier's principle argues that if an equilibrium system is subjected to an action, it will change in a way that lessens the effect of that action. Concentration changes, volume changes, pressure changes, and temperature changes are a few acts that might alter an equilibrium system. As long as there is no external influence, the concentration of the chemicals involved in an equilibrium reaction remains constant (Sudarmo, 2016).

D. Relevant Research

According to research conducted by Hardjo, F. N entitled Development of Project-Based Teaching Materials on Energy Materials to Improve Student Science Literacy. This research has the goal of producing project-based learning modules that can increase students' scientific literacy in energy matters. In this study, where the results were obtained in the form of making modules using several stages, namely needs analysis, design and development, implementation, evaluation. In the validation results on the eligibility of the contents, presentation feasibility and language eligibility components the average was 88% (very good) and the validation results by 2 science teachers obtained an average score of 95% (very good). Project-based teaching materials can increase student interest where students get a score of 90% (very good) and can facilitate teachers in learning and developing project-based teaching materials on energy materials can increase students' scientific literacy (Hardjo, 2018).

Development of a Project-based learning-based Statistics Module, in this study the aim was to develop a PjBL-based statistics module. The Plomp model is employed as the development model. The study's findings show that the average proportion of instructional materials prepared according to the didactic, content, linguistic, and display aspects has extremely valid standards. Therefore, it can be said that the instructional resources created as part of this study are reliable (Delyana, 2021).

The study, “Development of Project-Based Review Text Teaching Materials for Class VIII Students of SMP Negeri 2 Bululawang” aims to create a model for creating teaching resources in the form of project-based review textbooks, specifically activity-oriented textbooks or special work that has a firmness in the time of achievement, starting from the firmness in determining the source of data, information, or facts, deciding the method of collecting and analyzing data, to the firmness in the time of reporting or communicating the results, in this research

data analysis. The conclusion is that instructional resources serve as review texts. This project-based method is eligible for use/utilization by teachers who will teach project-based review texts at least once throughout one academic year since it satisfies eligibility requirements in terms of content, presentation, language, and graphics. Students can use instructional materials to increase their proficiency in creating review texts (Jamilah, 2017).

METHODS

This research will be conducted in Class XI MIPA SMA Negeri 6 Binjai on Jl. A. R. Hakim No. 66 A, Jackfruit, Kec. North Binjai, Binjai City, North Sumatra 20742 in the odd semester 2022/2023 academic year. The type of research applied in this study is research and development (R&D). The development model applied to the implementation of this research is the ADDIE model. This model performs 3 stages namely analysis, design, development:

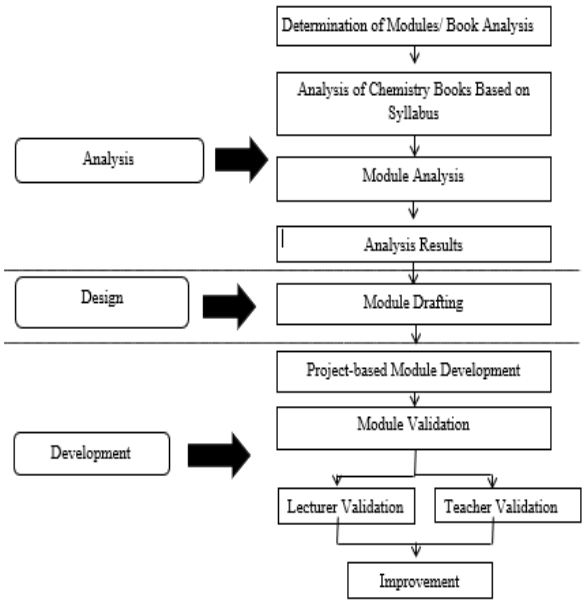

Figure 1. ADDIE's research procedure

The subjects of this research are experienced education and learning validators received by three chemistry lecturers from Univesitas Negeri Medan, two chemistry teachers from SMAN 6 Binjai and one teacher from SMAN 4 Binjai and 20 students from class XI. Class at SMAN 6 Binjai. Despite the fact that the study's focus is a project-based module on chemical equilibrium.

The instrument used in this study is a non-test instrument. The non-test is in the form of a questionnaire to confirm the feasibility of BSNP-based teaching materials/modules and a student feedback survey for project-based chemical equilibrium modules. For data analysis to analyze the feasibility of validating BSNP-based teaching materials/modules when the questionnaire is shown in Table 1 below:

Table 1. Module eligibility category

Average	Eligibility Criteria
3.26 – 4.00	Decent
2.51 – 3.25	Decent enough
1.76 – 2.50	Inadequate
1.00 – 1.75	Not feasible

Data analysis of student responses, the results of percentage of student response questionnaires can be observed using the categories in Table 2 as follows.

Table 2. Student satisfaction with module categories

Satisfaction Level	Category
31 - 45%	Not satisfactory
46 - 60%	Less satisfactory
61 - 75%	Good enough
76 - 85%	Satisfying
86 - 100%	Very satisfactory

Use formulas to find percentage scores for faculty and teacher responses

$$\textit{Average}: \frac{\sum \textit{score x number of respondents}}{\textit{score maximum}}$$

Aspects of the questionnaire are content feasibility, language feasibility, presentation and graphics feasibility. Results use Likert scale with categories.

4 : Very Agree
3 : Agree
2 : Disagree
1 : Strongly disagree

On the survey scale, 1 means bad/disagree and 4 means very good/strongly agree. The criteria included in Table 3 are:

Table 3. Validation criteria for learning modules.

Average	Validation Criteria
3.26 - 4.00	Valid and no modification required
3.25 – 2.51	It is completely valid and does not need to be modified
2.50 – 1.76	Less valuable, because a learning module needs to be modified
1.75 – 1.00	Invalid and requires a full overhaul

RESULT AND DISCUSSION

A. Syllabus and Curriculum Analysis

Examining the features of the curriculum used in schools allows for the analysis of the curriculum and syllabus. This is done in order to coordinate the creation of the module. utilizing current curricula and curricula. The curriculum approved by RI training in accordance with Kurikulum 2013 is the curriculum that has been applied in SMAN 6 Binjai. Researchers also looked at his KD, AI, and subsequent learning measures. Researchers included into modules.

B. Analysis of Chemistry Books Based on Syllabus

At this stage, the researcher conducts a document needs analysis in 3 selected books. This analysis aims to become a reference for researchers in compiling project-based teaching modules on the topic of stoichiometry. The needs analysis was guided by the 2013 program-by-use program, in which this study analyzes three books specifically conducted on stoichiometry to see the pros and cons of the three books. The analysis is carried out according to the content of the book and the subject being treated.

C. Design

After analyzing the book, the next step is to design and develop the learning modules. The design of the learning module is based on the syllabus. At the design stage, learning modules developed from the three books were analyzed. In addition to using books, the researcher also uses a number of references on the Internet related to the topic of the module. From the results of the analysis of the three books, the strengths found were used in the design and development of the learning modules. An outline of the initial design for completing PBL modules on the topic of stoichiometry is shown in Table 4:

Table 4. Module design draft

Draft	Material description
Cover	Introduction Equilibrium Effects 1. Effect of Temperature Pressure Concentration 2. Writing the formulas for Kp and Kc 3. Problems example 4. Exercise Project 1 5. The effect of shifting the equilibrium 6. Material Tools Project 3 7. Effects of Shifting Equilibrium 8. Factors Affecting Equilibrium Project 3 9. Summary 10. Answer key 11. Glossary

D. Development

The learning module is built on the basis of the arrangement of learning materials, concept diagrams, course details including learning materials, sample questions, complete applications in daily life, images that can increase excitement. students' interest to clarify each learning material and simple, easy-to-implement projects found in everyday life to create favorable conditions for students to practice experiments as well as increase interest and arouse curiosity. students and stimulate students' critical spirit. Constructive learning modules include topics about real-world stoichiometric problems to broaden students' perspectives, sample questions, discussions, and some links to videos on the subject. There are also several projects, a glossary, summary questions, and practical questions with an answer.

E. Leaning Module Validation

Once the development of the stoichiometry module is completed, the validation process will proceed. A validator uses the BSNP tool during validation to acquire evaluation results and suggestions for improvement. The findings of the lecturers' and teachers' course evaluation are as follows.

Table 5. Results of Learning Module Validation by Lecturers.

Assessment Component	Mean	Criteria
Content	3.7	Valid
Presentation	3.6	Valid
Language	3.5	Valid
Graphic	3.9	Valid
Total	**3.7**	**Valid**

Table 5 also display on graph below:

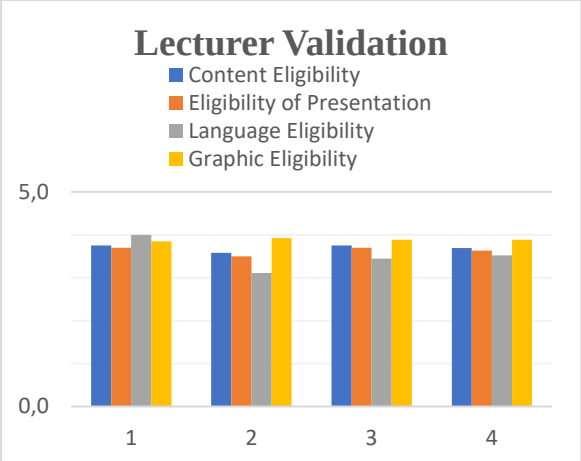

Figure 2. Lecturer validation graphs.

Table 6. Results of Learning Module Validation by teacher.

Assessment Component	Mean	Criteria
Content	3.8	Valid
Presentation	3.7	Valid
Language	3.7	Valid
Graphic	3.8	Valid
Total	**3.7**	**Valid**

Based on the above tables, we can conclude that we have received positive feedback from instructors or teachers. And for lecturers the average value is 3.7 and for lecturers it is also similar, namely 3.7. This means that a project-based learning module on the topic of stoichiometry is built and can be used as a learning module. To see more clearly the assessment of the teaching materials developed by the respondents who are teachers and teachers, we can see in the image below.

Table 6 also display on graph below:

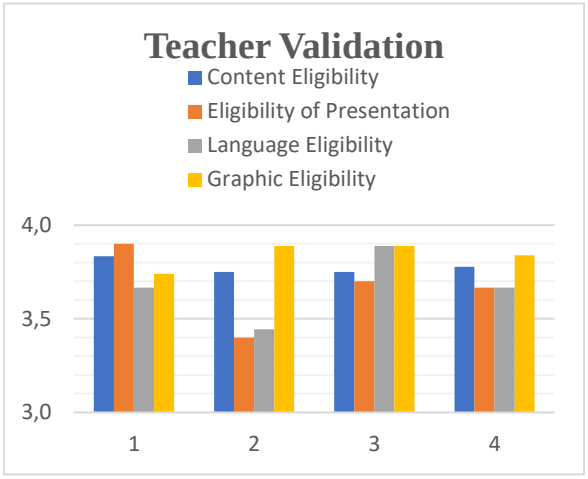

Figure 3. Teacher validation graphs.

Upon completion of the learning module, the next step is to validate the use of the tools according to the BNSP standards, the aspects assessed as (1) content feasibility, (2) presentation feasibility, (3) linguistic feasibility, (4) graphic feasibility. Authentication by authenticators includes: three chemistry professors at FMIPA UNIMED and two chemistry professors at SMA Negeri 6 Binjai and one chemistry professor at SMA Negeri 4 Binjai. The average score of the teacher's assessment is 3.7 for content feasibility, 3.6 for presentation feasibility, 3.5 for language feasibility, and 3.9 for graphics feasibility. These results come from testing the teaching module using project-based stoichiometry. The speaker's authenticity score is 3.70 on average.

The average results of the chemistry teacher certification assessment are content feasibility is 3.8, presentation feasibility is 3.7, language feasibility is 3.7, and graphics feasibility is 3.8. The results of this

validation lead to the conclusion that the developed learning modules are more suitable for use in terms of content feasibility, presentation, language and graphic feasibility. Therefore, the teacher's average score is 3.70.

According to research by Purba (2021) with research on building project-based chemistry teaching materials with multimedia on alkenes in high schools, there are average scores of verified lecturers, scores of 4 aspects edge of BNPP is content eligibility 3.45, language eligibility 3.64, presentation feasibility 3.57 and graphical feasibility 3.45 and has an average score of 3.52 and for teacher validation results, it is valid for 4 aspects as follows content eligibility 3.61, language eligibility 3.91, presentation qualification 3.87 and graphic feasibility 3.94. It can be concluded that the current researcher has a higher score than the previous researcher did, as expressed in 4 aspects of the BNSP, with the value of content validity being 3.7, presentation validity being 3.6, and visual feasibility being 3.9 for teachers of the 4-way evaluator. The content's feasibility element, which scored 3.8, was the only one that the researcher's teacher felt was superior to that of the previous researcher.

According to a study by Sigalingging published in 2021 titled "Development of Project-Based Learning (PjBL) Teaching Materials on Ionic and Covalent Bonds Material for Class X," the average validation result from the lecturer validator was 3.62, with content eligibility 3.75, presentation eligibility 3.56, language eligibility 3.59, and graphic feasibility 3.70, and the average validation result from the teacher validator was 3.68, with content feasibility 3. According to a comparison of the 4 features of the BNSP researchers' performance with earlier researchers, researchers had somewhat higher average scores than earlier researchers from lectures (Sigalingging, 2021).

The same is true of Dalimunthe's research (2022), Problem Based Learning Module Development with a Scientific Approach to Acid-Base Material, which has average results from lecturer and teacher validators with 4 aspects of the BNSP, namely the content feasibility aspect, which has an average of 3.16; the presentation feasibility aspect, which has an average of 3.45; the language feasibility, which has an average of 3.27; and the graphic feasibility, which has an average of 3.16; the average of these 4 BNSP Researchers have a larger aspect value than earlier researchers since the current researcher has gotten more value than the average earlier researcher did (Dalimunthe, 2022).

F. Student Response

After the learning module has been validated and changed by the researchers after taking the chemistry teacher validator's advice and input into consideration. The next step was to collect student responses using targeted sampling by collecting 20 students from SMA Negeri 6 Binjai who responded to project-based learning modules on the topic. chemical balance. Learning modules that have been pre-developed by researchers and validated by faculty and teachers will be distributed to respondents, namely, and obtained by respondents. Based on the assessment results, the learning module that has been built is valid and does not need to be modified. The project-based learning modules on the topic of stoichiometry are also evaluated and validated by specialists, allowing for academic use. Students are provided learning materials to observe how they respond to the created learning materials. 20 students in all were chosen for the study's student respondents by the purposive sample approach, and their evaluation score was 3.73.

CONCLUSION

Based on the findings, it can be concluded that the project-based learning module on chemical equilibrium that has been created satisfies the following BNSP criteria: content feasibility, presentation feasibility, language feasibility, and graphic

feasibility. The lecturer validator has given the module an average score of 3.70, and the teacher validator has given it a score of 3.70. Additionally, students' replies to project-based learning modules on chemical equilibrium are advantageous, have a favorable effect, and average 3.73 responses.

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