

# Validity And Practicality of Experiment Integrated Guided Inquiry-Based Module on Topic of Colloidal Chemistry for Senior High School Learning

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**Abstract.** *This Research & Development study aims to produce a valid and practical experiment integrated guided inquiry based module on topic of colloidal chemistry. 4D instructional design model was selected in this study. Limited trial of the product was conducted at SMAN 7 Padang. Instruments used were validity and practicality questionnaires. Validity and practicality data were analyzed using Kappa moment. Analysis of the data shows that Kappa moment for validity was 0.88 indicating a very high degree of validity. Kappa moments for the practicality from students and teachers were 0.89 and 0.95 respectively indicating high degree of practicality. Analysis on the module filled in by students shows that 91.37% students could correctly answer critical thinking, exercise, prelab, postlab and worksheet questions asked in the module. These findings indicate that the integrated guided inquiry based module on topic of colloidal chemistry was valid and practical for chemistry learning in senior high school*

## 1. Introduction

Chemistry is developed through processes done in the laboratory to produce what is called scientific knowledge. As a science, chemistry is formed through interrelation among attitude and scientific processes, investigations of natural phenomena, and scientific products [1]. At school, chemistry is more frequently taught in class than in laboratory. As students rarely do experiment and discover concepts in the laboratory, they often consider chemistry as a knowledge of memorization and thus is difficult and unpopular. Students are not either actively involved in learning or given chances to develop thinking process, and thus do not experience the discovery of concepts [2]. Teachers on the other hand do not always engage affective and psychomotoric aspects in learning, so what is taught is easily forgotten by students [3]. To involve the affective, psychomotoric and cognitive aspects, chemistry is best taught through laboratory or experient-based approach. The experiment activities can provide direct experience for meaningful learning [4].



Colloidal system is one of chemistry matters taught in grade XI senior high school (SMA) [5]. The matter consists of factual, conceptual and procedural knowledge dimensions that must be accomplished by students. Fortunately colloidal system is applicative in everyday lives. To help students learn the concepts, direct experiential learning with scientific process skill integrated can be implemented. This is in line with the command of ministry of education (permendikbud) that emphasizes science learning on the employment of scientific process skill <sup>[6]</sup>. Scientific process skill involves the advance of intellectual, social, physical skills derived from basic skills that already exist in students [7]. In addition to learning science concepts and principles through memorization and being familiar with formulas and terms through verbal exercises, students are asked to have direct experience through the processes of experiment.

Experiment method gives chances to students to be involved in discovering the concepts and developing cognitive, affective and psychomotor abilities. Experiment in the laboratory can be done by emphasizing concepts' discovery and scientific process skill <sup>[8]</sup>. Experiment activities that emphasize on discovery can be integrated in learning process (experiment integrated). Students can actively learn, investigate, collect data, analyze data, self discover the concepts, and solve problems under teacher's supervision. Learning can then be meaningful and thus is not easily forgotten by students. Studies done by Hofstein& Lunetta (2003) and Hofstein&Mamlok-Naaman (2007) show that laboratory experiences (experiment) entirely support the achievement of science education's objectives <sup>[9][10]</sup>.

Observation and questionnaire data obtained from teachers and students in several schools in West Sumatra show that (1) Learning material that integrates experiment in classroom learning was not available, (2) Learning materials used could not encourage students to find the concepts by themselves, so they inclined to only memorize and do mathematics, (3) Learning materials used could not lead students to have scientific process skill, (4) Experiment activities were done after matters are taught just to confirm concepts, (5) Learning materials used could not attract students' attention and motivation to learn.

To deal with these problems, it is suggested that teachers integrate experiment in learning activities (experiment integrated) by emphasizing concept inquiry process, so students can actively learn, investigate, collect data, analyze data, find concepts by themselves, and solve problems under teacher's supervision (guided inquiry) [11]. Guided-Inquiry learning is students-centred one where students carrying their own role study in a small group while teacher's role is to make sure that all of the students are involved in learning process [12]. This type of learning can improve students' understanding and scientific process skill. To implement learning process that integrates experiment in classroom learning, an appropriate learning material is needed.

Based on the explanation above, learning material which is based on guided inquiry learning is needed to help teacher solve the problems in learning. A learning material called module is one of the appropriate one for this situation. Module consists of series of complete and various materials that allows students to learn independently, self-evaluate their achievement, determine their phase of learning to achieve learning goals with minimum help from teacher [13]-[15]. Module is a complete learning material consisting of matters, exercises, and evaluation designed systematically in certain format for students to learn and understand the concepts.

In this research, a learning material called module was developed. The module was designed by following the syntax of guided inquiry learning proposed by Lawson & Abraham (1979) and Hanson (2005). According to Lawson & Abraham (1979), the cycle of guided inquiry learning consists of exploration, concept formation, and application. According to Hanson (2005) guided inquiry learning's syntax comprises of orientation, exploration, concept formation, application, and conclusion [16][17]. To discover the concept, students are guided with a series of critical thinking questions starting from simple question to complex ones designed with indicators of scientific process skill. Students answer these questions after they observe and analyze model or do experiment on exploration stage. Experiment activities are designed by denoting to components of the laboratory

investigation by The Collage Board containing title, information, learning goals, tools and materials, procedure, safety precaution, prelab questions, microscopic activities, and postlab questions [16].

Researches on scientific process skill were done previously. Hesbon (2014) concluded that learning with scientific process skill integrated can significantly improve students' learning achievement<sup>[18]</sup>. Nworgu dan Otum (2013) concluded that guided inquiry has effect on the achievement of scientific process skill on students and give chances for students to use various source of information and ideas in understanding and solving various problems [19]. Research related to experiment integrated activities was done by Andromeda et. al (2015) who concluded that learning with experiment activities integrated can effectively increase students' achievement in cognitive aspect [20]. Sodikun (2015) concluded that learning that integrates experiment activities increases students' motivation and trains their scientific process skill [21]. Researches in developing valid and practical guided inquiry based worksheet for SMA learning were also done by Iryani et. al (2014), Andromeda et. al (2015, a), Andromeda et. al (2015, b) [22]-[24]. However, the worksheet did not integrate experiment in learning nor aimed to make students get scientific process skill.

In regard to the necessity of learning materials that have orientation on concepts formation and to fulfill curriculum demand and execute higher education's contribution in building and developing the Information, Technology, Science- Social and culture (IPTEKS-SOSBUD) aspect, research on developing learning material was taken. This research aims to developed guided inquiry based module that integrates experiment in learning process in order to increase scientific process skill of senior high school students.

## 2. Research Method

The aim of this research is to produce a valid and practical module that is based experiment integrated guided inquiry-based module on colloidal topic. The module is intended to improve scientific process skill of SMA students. The method is Research and Development (R & D) using 4D instructional design model developed by Thiagarajan, Semmel & Semmel (1974). The model consists of 4 phases called Define, Design, Develop, dan Disseminate<sup>[25]</sup>. Research in the first year was limited to validity and practicality tests. Limited trial was done at SMAN 7 Padang. The result became the basis for revising the product developed.

Define is a phase to set and define learning prerequisites. It begins with analysis of core competencies, basic competencies, and learning materials based on the content standard of curriculum 2013. This phase consists of five main steps named (1) front-end analysis, (2) students analysis, (3) task analysis, (4) concept analysis, and (5) learning goals formulation.

Design is a phase to define skills, formulate the goals, and determine the sequence of learning and small scale test that can be implemented. The focus of this phase is to design the module that is based on guided inquiry model and integrated with experiment activities. The steps of this phase includes: a) understanding basic competencies and specifying the indicators and learning goals that students must achieve after learning colloidal topic, b) determining concepts on colloidal topic, c) designing module with guided inquiry syntax developed by Hanson (2005) and experiment activities by The Collage Board and modifying it according to the needs of students, d) choosing appropriate format as described by module design guideline<sup>[26]</sup>.

Develop is a phase to develop draft of the module. This phase consists of two stages named validity and practicality testings. Validity testing in this research was done by giving validity questionnaire to experts (four chemistry lecturers, two chemistry teachers at SMAN 7 Padang, and two chemistry teachers at SMAN 1 2 X 11 Kayu Tanam). The evaluation on validity testing were on the content, presentation, linguistics, and graphics aspects. The result was used as a basis for product revision. Furthermore, limited trial to see the practicality of the module was done. This trial was done at SMAN 7 Padang. The result was used to revise the product for further effectiveness testing of the module developed.

Disseminate is the final phase which aims to distribute the product in scholarly seminars that involve teachers and experts of chemistry, professional association and scientific journal. The quality assurance of the product must be done by standardizing it to the accepted criteria.

The instruments used to collect data in this research were validity and practicality questionnaires and the module itself. To determine validity and practicality levels, data were analysed with Kappa Cohen formula (equation 1). The interpretation of Kappa moment can be seen in Table 1[27]. For the module, it was analyzed with percentage technique.

$$Kappamoment (k) = \frac{\rho_0 - \rho_e}{1 - \rho_e} \quad (1)$$

**Table 1.** Decision category based on *Kappa moment (k)*

Interval	Category
0,81 – 1,00	Very high
0,61 – 0,80	High
0,41 – 0,60	Middle
0,21 – 0,40	Low
0,01 – 0,20	Very low
<0,00	Invalid

### 3. Result and discussion

#### 3.1. Result

Experiment integrated guided inquiry-based module to improve scientific process skill was developed using 4D instructional design model. The result is as follow Some text.

*3.1.1. Define phase.* In this phase, front-end, students, task, and concept analyses and learning goals formulation were done. In front-end analysis, problems faced by teachers and students in chemistry learning were studied. Data obtained from interview and questionnaire given to 30 teachers in West Sumatra show that (1) Learning materials that integrate experiment activities in classroom learning were not available, (2) Learning materials used could not make students find the concepts by themselves and students were only asked to calculate and memorize, (3) Learning materials used did not aim to get students have scientific process skill, (4) Experiments were done after classroom learning and had role to confirm concepts, (5) Tools and materials were available, but the experiments were not done due to insufficient time. Data obtained from questionnaire given to 50 students show that (1) 73 % students perceived chemistry as a difficult subject, 2) 88 % students explained that colloidal topic is full of memorization, 3) 70 % students explained that learning materials used were not interesting and motivating students to learn. These facts show that learning process has not fulfilled the demand of curriculum 2013. Based on the analysis, it was determined to design learning material that motivates students to learn, guides students to find concepts through direct experience using scientific process skill, and provides meaningful learning for students [6]. It also became researchers' consideration to develop experiment integrated guided inquiry-based module on topic of colloidal system to enhance scientific process skill of SMA students.

Students analysis was done through interview and questionnaire given to teachers and students. The analysis showed that guided inquiry is suitable for senior high school learning as it can improve students' motivation to learn independently and find the concept by themselves. Participant students were grade XI students whose ages range from 15 to 17 years old. According to Piaget developmental theory, teenagers (in this case age 15-17) have formal operational thinking. In this stage, they can think logically, can interpret and draw conclusion. The analysis of students' characteristics became the basis for developing experiment integrated guided inquiry-based module.

Task analysis was done by referring to current curriculum 2013. In this curriculum, colloidal topic is included in basic competency 3.15 (categorize various types of colloidal system, explain colloidal

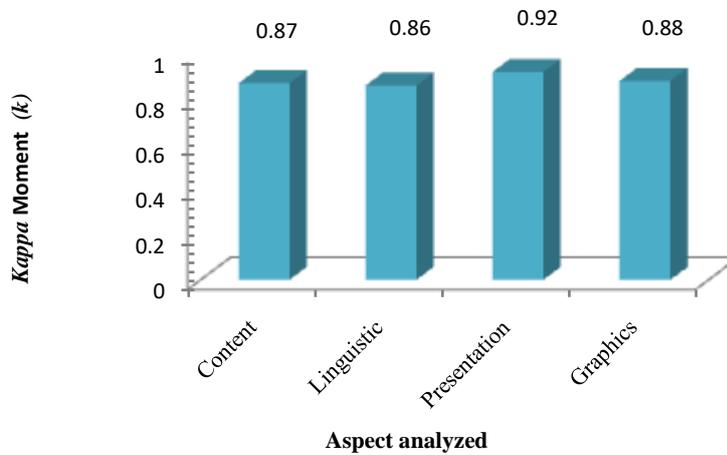
properties and applications in daily lives) and basic competency 4.15 (make colloidal food and other products using colloidal principles). From these basic competencies, the derived indicators in this research were 1) classify solution, colloid and suspension, 2) categorize colloid based on dispersed phase and dispersing medium, 3) explain collidal properties (optical, kinetics, adsorption, coagulation, and dialysis), 4) differentiate liofil and liofob colloids, 5) explain the syntesis of colloid in laboratorium, 6) analyze the application of colloid in daily lives and industry, 7) prepare colloid in daily lives. Furthermore, concept analysis was done to determine the main concepts included in the topic. They include solution, colloid, and suspension; types of colloid; colloidal properties; liofil and liofob colloids; colloid synthesis; and the application of colloid in daily lives.

Learning goal analysis was done by specifying the indicators. Learning goals in this topic were 1) Students can explain the definition of solution, colloid, and suspension based on experimental data correctly, 2) Students can categorize types of colloid based on dispersing medium and dispersed phase correctly, 3) Students can explain the properties of colloid; the optical, kinetics, adsorption, electric, coagulation, and dialysis properties based on experimental data correctly, 4) Students can differentiate liofil and liofob colloids based on the interaction of dispersing medium and dispersed phase using model correctly, 6) Students can explain the synthesis of colloid based on dispersion and condensation ways through experimental data correctly, 7) Students can analyze the applications of colloid in daily lives and industry correctly, 8) Students can make product of colloid using its principles in daily lives through experiment activities correctly.

*3.1.2. Design phase.* The define phase was followed by the design of experiment integrated guided inquiry-based module on topic of colloidal system to enhacescientif process skill of SMA students. Learning material was designed with Microsoft Word with font Times New Roman, Comic Sans MS, Calibri (Body), Chitter, Ravie, Tempus Sans ITC font-styles. Background of the cover was blue, black, and white in color, while the content was white in color.

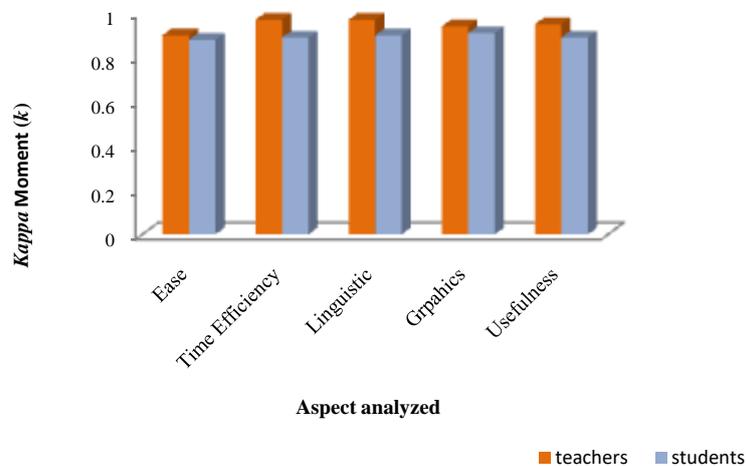
Module was designed with the syntax of guided inquiry which consists of orientation, exploration, concept formation, application, and conclusion. In exploration stage, laboratory activities ia done by denoting to thecomponents of the laboratory investigation by The Collage Board which consists of title, information, learning goals, tools and materials, procedures, safety precaution, prelab questions, microscopic activities, and postlab questions. In concept foramtion stage, students were guided to correlate facts obtained in the experiment (macroscopic) with the submicroscopic illustrations shown in the module. They were also guided with critical thinking questions to find the concepts. The module's format was following the instrcutional design guidelines by Suryosubroto. The format of the module concluded: 1) guidelines for teachers, 2) students' activities sheet, 3) worksheet, 4) the key of the activities sheet, 5) test, 6) key of the test[26].

*3.1.3. Develop phase.* Develop phase aimed to produce a valid and practical experiment integrated guided inquiry-based module on topic of colloidal system. Based on the analysis of validity data from eight validators, the value of Kappa moment was 0,88 indicating very high degree of validity. The result of analysis per aspect from eight validators is seen in Figure 1.



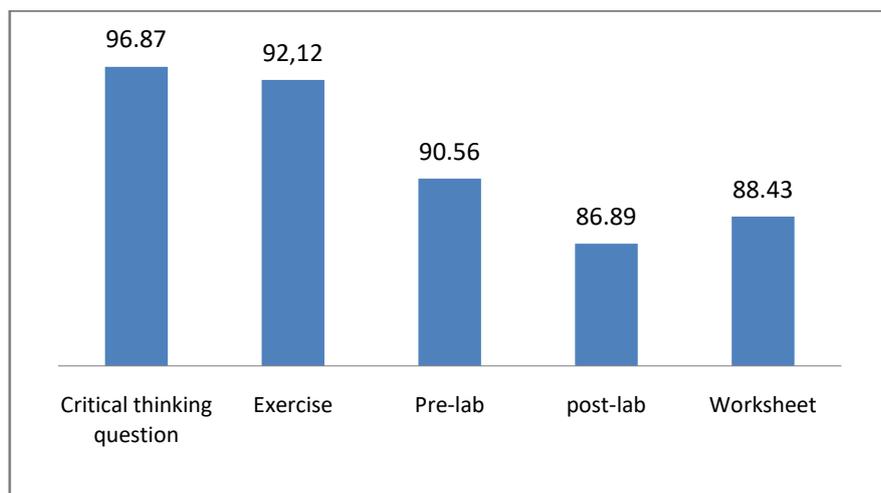
**Figure 1.** Analysis per aspect on validity level from validators

Although validity of the module was very high, there were several things to revise for the perfection of the module developed. Analysis on practicality data done by four teachers resulted that the average Kappa moment was 0.95 and analysis on practicality data obtained from 27 grade XI MIPA 5 students at SMAN 7 Padang revealed that the value was 0.89 indicating very high degree of practicality. The result of analysis per aspect of practicality done by students and teachers is seen in Figure 2.



**Figure 2.** Analysis per aspect on practicality level from teachers and students

The result of analysis on the module filled in by students in answering critical thinking, prelab, and postlab, exercise, and worksheet questions can be seen in Figure 3.



**Figure 3.** The percentage of student in answering the question in module

### 3.2. Discussion

**3.2.1. Validity of the module.** Analysis of validity data from eight validators on content component of the module revealed that the average of Kappa moment was 0.87 having a very high degree of validity. In other words, module developed was fulfilling the demand of basic competency 3.15 and 4.15 [6]. The module's content could make students improve their skill of scientific process using of scientific process skill indicators. This is consistent with researches done by Andromeda (2015) and Sodikun (2015) which concluded that learning which is integrated with experiment activities can improve learning outcomes, motivation to learn and practice scientific process skill of high school students<sup>[20][21]</sup>. Module provides the opportunity for students to learn continuously so their insight will be constantly increasing. Module can be said to be adaptive if it is flexible to be used and can be adapted to the development of science and technology [14].

Analysis of validity data on presentation component revealed the average Kappa moment of 0.92 indicating a very high degree of validity. In other words, the module developed was valid from presentation aspect. Colloidal system module was systematically developed and arranged accordingly to guided inquiry learning syntax consisting of orientation, exploration, concept formation, applications, and conclusion [17]. Evaluation on the writing's systematic of the module proved that the experiment integrated guided inquiry-based module on topics of colloidal system was presented in accordance with the instructional design guideline by Suryosubroto[26].

Analysis of validity data on the linguistic component revealed an average Kappa moment of 0.86 with very high degree of validity in category. This shows that the experiment integrated guided inquiry-based module on colloidal topic developed was communicative and unambiguous. The critical questions posed were clear and it provided symbols presented in consistent manner. A good module is one that is user friendly. The use of language that is simple, clear, familiar, and easy to understand is one kind of user friendliness[14].

Analysis of validity data on graphics component revealed an average Kappa moment of 0.88 indicating a very high degree of validity. Images, font-style and font-size provided in the module were clearly observed. The layout and design of the module were interesting. Therefore, module can be said user-friendly. In line with previous research, instruction and information provided should be able to assist students in understanding the content of the modules [14].

As a whole, experiment integrated guided inquiry-based module on colloidal topic had an average Kappa moment of 0.88 indicating very high degree of validity. A product is said to be valid if it can create a condition that fulfills the content and construct of the determined one<sup>[28]</sup>. Content validity shows that a model / prototype developed is based on a strong theoretical rationale while construct

validity shows the fitness of components contained in the module with the defined indicators <sup>[29]</sup>. In general, module developed had a very high degree of validity, but there were some parts of the module's components needed to be fixed as suggested the validators.

### 3.2.2 Practicality of the module

#### *Teachers practicality.*

The average Kappa moment of ease of use of the module was 0.90 belonging to very high practicality category. This indicates that the instructions of use, the materials, the critical thinking questions, and the sequence of learning provided in the module could help teachers in learning process and enhance teacher's role as learning facilitator. The module helped students to learn independently without being fully dependent on others. That is why a module must be self-instructional [14].

The developed module had very high degree of practicality on efficiency and linguistic components (the average Kappa moment of both components = 0.97). With module, teachers could teach efficient manner. Module provided communicative, unambiguous, grammatically correct language, and clear questions. Indeed, a good module must use clear and communicative language <sup>[13]</sup>.

The developed module also had very high degree of practicality on graphics and usefulness components. Analysis on graphics and usefulness components data obtained from four chemistry teachers showed Kappa moments of 0.94 and 0.95 indicating very high degree of practicality. This indicates that letters, drawings, and sub microscopic illustrations in the modules were clearly readable and understandable for students. The layout was organized; the design and appearance of module were attractive; and module was easy to carry because its size was practical. In the usefulness component, module could help students find the concept by themselves independently; it allowed teachers to increase students' interest, activities, and scientific process skills in learning.

#### *Students Practicality*

Analysis of students' practicality data on ease of use component revealed an average Kappa moment of 0.88. This value belongs to a very high degree of practicality. This indicates that the instructions of use, the materials, the critical thinking questions, and the sequence of learning activities were straightforward and understandable for students. Analysis of students' practicality data on efficiency component revealed an average kappa moment of 0.89 showing a very high degree of practicality. It means that students could learn accordingly to their learning pace. Module could be used anytime and anywhere they needed because it was not restricted to particular time or places. Flexible learning can cultivate students' interest in learning. The use of the module can surmount the limitations of time, space, and senses on both students and teachers. Module can increase students' motivation, develop their prior capabilities, and thus encourage them to learn independently [14].

The average Kappa moments of the module on linguistic and graphics components were 0.90 and 0.91 respectively. It means that the module had very high degree of practicality on both of these components. The experiment integrated guided inquiry-based module on colloidal system topic used communicative language; it was unambiguous; and the questions asked were understandable. Letters and images used were clear and easy to read. The layout of the module was organized and neat, and it had attractive appearance. Therefore, module could attract students' interest to learn.

In terms of usefulness, the module gained an average Kappa moment of 0.89 with very high degree of practicality category. This indicates that the module developed could help students understand the concepts appropriately. Students could independently find the concept by themselves, and their scientific process skills were enhanced. This is proven by the results of analysis on sheets answered by students. In overall, student could correctly answer 96.87% of critical thinking questions, 92.12% of exercises questions, 90, 56% of prelab questions, 86.89% of post-lab questions, 88.43% of activity sheets' questions asked.

To sum up, as a whole experiment integrated guided inquiry-based module on colloidal topic increased student interest to independently learn and find the concepts by themselves. It was practical

to be used by teachers and students in learning activities. The module is a printed learning material that can be used by students with or without teachers' guidance [15].

#### 4. Conclusion

Based on the results of research and data analysis done, it can be concluded that 1) The experiment integrated guided inquiry-based module on colloidal topic was successfully developed using 4D developmental model, 2) The experiment integrated guided inquiry-based module on colloidal topic had very high degree of validity and practicality.

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