



Development of Guided Inquiry Lesson Based on Ethnoscience E-Modules to Improve Students' Problem-solving Ability in Chemistry Class

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Abstract: The limitations of teaching materials in the implementation of distance learning coupled with students' low problem-solving ability led to the need to develop teaching materials in the form of guided inquiry to improve students' ability to solve problems. This development research aims to determine the validity, practicality, and effectiveness of the Guided Inquiry Lesson Based on Ethnoscience (GILBE) e-module. This development research employs the Research and Development (R&D) approach with a 4D development model, meaning define, design, develop, and disseminate. GILBE e-module on colloid material was piloted on 16 students SMA at Central Kalimantan in the limited trial and 30 students SMA at South Kalimantan in the broad trial. The validity test was measured using a validation sheet. The practicality test was measured using a readability questionnaire, student and teacher responses, and the effectiveness test was measured using a problem-solving ability test instrument in the form of ten essay questions. Descriptive and inferential statistical analysis was used to analyze the data. The findings revealed that the designed e-module matched valid, practical, and effective. The effectiveness is based on the p-value <0.05 in the limited and broad trial of the N-gain of students' problem-solving abilities in the high category and can be used in the chemistry learning process. Further research will develop teaching materials for higher-order thinking that apply the GILBE model, which is of higher quality.

Keywords: e-module GILBE; colloid; problem-solving ability; chemistry learning

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INTRODUCTION

Humans need 21st-century life skills to make decisions in solving problems related to everyday life. Students are expected to be able to provide solutions to various problems that occur in learning at school and in the world of work. It is essential to instill problem-solving abilities (PSA), so students can easily solve problems based on their knowledge and experience in the world of education. The inquiry learning model is one of the science learning models suitable for twenty-first-century learning (Scott, 2015), involving thinking processes and activities (Kidman & Casinader, 2017). Inquiry-based learning can increase student engagement, academic achievement, and scientific process skills (Abdi, 2014; Kaya & Yilmaz, 2016; Murphy, Smith & Broderick, 2019) and improve environmental attitude and higher order thinking skills such as PSA (Cabalang & Cabalang, 2022; Şimşek & Kabapınar, 2010).

Along with the times, the world of education in the era of the Industrial Revolution 4.0 is required to be able to equip students with developing skills needed in the 21st century (Becker & Park, 2011; Oktavia, 2019) such as technology, communication, and problem-solving ability (Bell, 2010; Kholifah et al., 2018). An effort done is using teaching materials (Haspen & Festiyed, 2019). Teaching materials that can be used according to the Industrial Revolution 4.0 era and during the COVID-19 period Zhang et al. (2020) are online teaching materials to help students learn online using virtual classes from anywhere in the world (Tsegay et al., 2022).

The phenomenon occurred at SMA in South and Center Kalimantan, where chemistry teachers have not trained students in solving problems related to local wisdom. Hence, students find it difficult to apply chemical concepts in everyday life, especially in the culture around them. Teaching materials are difficult to learn independently by students. They need help from various sources such as material summaries or solutions to these problems on the internet or YouTube. Based on that, innovation is required that combines culture, and local potential as a source of contextual science/chemistry learning (Betaubun, 2019; Hermino, 2016; Mayasari, 2017), to practice problem-solving ability.

Teaching materials are designed to support educators and students in the learning activity, making learning more effective (Asrizal et al., 2018). These teaching materials can be meaningful during distance

learning because they can be accessed via mobile phones. According to [Herawati and Muhtadi \(2018\)](#), e-modules, also known as electronic modules, are educational materials that can be used in the classroom that are presented in digital form and contain simulations along with text, images, or both. One learning unit with a variety of components is included in the e-module so that students can complete their learning objectives on their own.

Based on identifying these problems, the authors also feel the need for efforts to improve the innovative learning process, one of which is through guided inquiry learning integrated with ethnoscience. Ethnoscience integrates knowledge in local culture (local wisdom), objects (local potential), and natural events that can be practiced by the community in everyday life ([Abonyi, 2002](#)). It is recently rare to find learning by integrating learning chemistry that contains ethnoscience, learning methods, learning materials, and learning assessments ([Sudarmin & Sumarni, 2018](#)). In ethnoscience learning, activities and learning materials are designed based on the students' original culture, which students relate to science concepts. Several previous studies found that local wisdom or ethnoscience can improve students' learning outcomes ([Risianto et al., 2020](#); [Sudarmin et al., 2018](#)), students' understanding of concepts ([Atmojo, 2015](#); [Dwianto et al., 2017](#); [Fasasi, 2017](#); [Ultay & Ultay, 2015](#)), and effectively build concepts of the student's long term memory ([Budiarti et al., 2020](#); [Budiarti & Winarti, 2022](#)).

Learning inquiry and PSA cannot be separated because the understanding of chemical concepts is obtained from PSA, and vice versa PSA is trained through learning chemistry using inquiry strategies. Moreover, learning chemistry that contains ethnoscience will increase the interest of students. Characteristics of chemical materials containing ethnoscience, one of which is colloidal material whose concepts can be applied in everyday life. [Wenning \(2011\)](#) divides the inquiry model into several levels based on the level of students' intellectual sophistication and the learning control center called the Level of Inquiry (LOI). The distribution of LOI is presented in [Table 1](#).

Table 1. The basic hierarchy of practice level of inquiry

Discovery Learning	Interactive Demonstration	Inquiry Lesson	Inquiry Lab	Real-world Application	Hypothetical Inquiry
Low		Intellectual Sophistication			High
Teacher		Locus of Control			Student

Inquiry lessons are part of the LOI developed by [Wenning \(2011\)](#). This approach will help students better understand the inquiry process. This Inquiry Lesson is essential to bridge the gap between interactive demonstration and Inquiry Lab. It happens because it is unreasonable to assume that students can use more sophisticated experimental approaches before they are familiar with them. In inquiry lessons, students are introduced to scientific experimental activities, and the teacher acts as a facilitator. Students learning activities get guidance from the teacher in the form of questions that lead to the concept's discovery. This matters according to the scaffolding learning theory that helps students discover new concepts. Someone's help is needed at the beginning of the activity ([Reiser & Tabak, 2014](#)). This study uses a guided inquiry lesson based on the ethnoscience (GILBE) model, where students solve authentic problems in groups. The GILBE syntax refers to inquiry model lessons, including 1) orientation, 2) manipulation, 3) generalizations, 4) verification, and 5) applications and evaluation (Adapted from [Wenning, 2011](#)). Applying a guided inquiry could improve students' science process skills, cognitive abilities, and understanding of the content of chemistry learning ([Tauhidah & Suciati, 2015](#)). It is consistent with the constructivism theory that learners construct and create a solution (their knowledge) to learning problems ([Bada, 2016](#); [Bhattacharjee, 2015](#); [Fernando & Marikar, 2017](#)).

Technology integration in learning affects the learning process and student outcomes ([Wai & Seng, 2013](#); [Chauhan, 2017](#)). One of the efforts made is through the development of the GILBE e-module on colloid material. This research is considered vital because it is an alternative to enable students to learn and develop PSA through learning. As suggested, learning experiences that activate students during the learning process can improve PSA ([Klegeris et al., 2013](#); [Shieh & Chang, 2014](#); [Suparno & Supriyanto, 2018](#); [Surya et al., 2017](#)). Therefore, this research aims to evaluate the feasibility of the GILBE e-module to increase PSA. The essential findings of this research are expected to provide consideration for teachers to use GILBE as learning alternatives to improve PSA and student learning outcomes.

METHODS

This research is a Research & Development using the 4D model of [Thiagarajan and Semmel \(1974\)](#). The 4D development steps can be seen in [Table 2](#). This research evaluates the validity, practicality, and

effectiveness of using the GILBE e-module on colloidal materials to improve students' PSA.

Table 2. Steps for developing 4D model

Step	Sample Task	Sample Output
Define	Examinations of the front end, the learner, the task, and the educational goals	Describe the problem statement, learner profile, instructional content, and what needs to be learned.
Design	Construction of a criterion referenced test, format selection, and preliminary design	Measurable objectives, guidelines for the teaching aids, and an e-module design draft.
Development	Evaluation by expert and developmental testing (individual and small group testing)	E-module prototype, professional feedback, and the outcome of developmental testing.
Disseminate	Validating packaging, publication, and real-world testing (limited and extensive trials)	Data evaluation and student response. revised package report and the e-module. Seminar and research gate publications

Design

Learning activities conducted in the class lasted 90 minutes for each meeting. The learning steps of the GILBE model can be seen in [Table 3](#).

Table 3. Learning steps of the GILBE model in the online class

Phase	Step	Aspects of problem-solving abilities involved	Duration (min)
Orientation	Students in groups observe and identify phenomena from the material they have read	Understanding the problems	10
Manipulation	Students collect information/data about an event they see or experience and plan strategies to solve the problem.	Devising the plan (planning)	20
Generalization	Students are asked to make hypotheses	Devising the plan (planning)	15
Verification	Students in groups collect and analyze data and provide several options to solve the problem.	Carrying out the plan (monitoring)	25
Application and evaluation	Students convey the results of their evaluations to all students so that conclusions can be drawn from classical	Looking back (reflection)	20

[Table 3](#) shows that the learning process carried out using the GILBE model steps has the same duration for each meeting. Learning activities facilitate students to be active in learning to identify problems and solve them in groups. Through these activities, students are expected to acquire problem-solving ability needed in everyday life.

Participants

The participants in this study were 46 students of class XI, which consist of two classes at SMA Negeri Central Kalimantan (in a limited trial, N = 16) and South Kalimantan (in a broad trial, N = 30). They were taught using e-modules with guided inquiry learning based on ethnoscience to learn chemical concepts related to colloids.

Instrument

The instrument used in this research was a problem-solving ability test (PSAT) using ten essay questions. Each question employed 0-3 assessment rubrics resulting in a score of 0-100. The PSAT determines the level of students' PSA in different stages: understanding the problem, devising the plan, carrying out the plan, and looking back ([Polya, 2004](#)). Analysis of students' PSA after participating in learning activities referring to the rubric scoring guidelines for PSA ([Ariani et al., 2017](#); [Syahmani et al., 2020](#)) is presented in [Table 4](#).

Table 4. Assessment rubric for measuring students' PSA

Aspect	Response to questions or problems	Score
Understanding the problems	Misunderstand the question/no answer	0
	Write known/asked/sketch or model but wrong	1
	Fulfilling information/problems with inaccurate/incomplete	2
	Successfully understand the problem thoroughly	3
Devising the plan (planning)	There is no settlement strategy plan	0
	The planned strategy is not precise/unclear and incomplete	1
	Strategy exists, but it is not complete and not clear	2
	Strategies/steps of completion leading to the correct answer	3
Carrying out the plan (monitoring)	No solution at all	0
	There is a solution, but the procedure is not clear/wrong	1
	Using specific procedures that are correct but incomplete	2
	Using specific strategies/procedures appropriately and correctly	3
Looking back (evaluation)	No answer / no writing conclusions	0
	Examination of the results of incorrect answers / writing wrong conclusions	1
	Examination of answers that are not correct / conclusions are not correct	2
	Check the results of the correct answer / write the conclusion correctly	3

Data Collection Technique

The procedure of research is through four stages. The first stage is Define. A front-end analysis is carried out to study the possibility of effective and alternative teaching materials. An analysis of the problems experienced by students shows that teaching materials are less attractive during distance learning. Therefore, the importance of special teaching colloid materials to attract students' attention and concept analysis related to ethnoscience is presented in Table 5. The second stage is Design. This stage composes the media and makes an e-module on colloidal material, both text preparation and format selection. The researcher uses the Canva application as the e-module design and the fliphtml5 website as a place to access the e-module.

Table 5. Colloidal material containing ethnoscience

Meeting	Material Subject	Ethnoscience
First	Types of colloids	Dayak traditional food such as Kelumpe and Juhu Umbut Rattan Ink for Dayak Tattoos
Second	Colloidal Properties	Sap from the rubber tree Handicrafts from <i>nyatu</i> tree sap Water treatment in wetlands
Third	Making Colloids	Ink for Dayak Tattoos Making jelly-brown sugar, coconut milk, and <i>bingka</i> Making VCO or coconut oil for treatment and " <i>Tapung Tawar</i> " rituals

The third stage is Development. This stage carries out the implementation of the e-module product design that has been validated by experts to determine the feasibility of the e-module. Revise based on expert feedback, so it can be carried out to the next stage, namely product testing. This trial lasted for three meetings, and each meeting consisted of two hours of lessons. The first and second meetings were conducted online using the Zoom application and WhatsApp group, while the third meeting was conducted offline in class. This trial design uses a one-group pretest-posttest method.

The first meeting includes a pre-test and learning activities using an e-module on dispersion system material and types of colloids. The second meeting carried out learning activities on the material properties of colloids. The third meeting carried out learning activities on the material of making colloids, filling out response questionnaires by students and teachers, and doing post-test. The data collection technique was based on interviews, questionnaires, test instruments, and documentation. The last stage is Disseminate. This stage is the publication of the results obtained in the previous stage. Links and e-module files were given to teachers and students SMA Negeri 1 Benua Lima in the limited trial and students SMA Negeri 1 Banjarmasin in the broad trial. Disseminate is done by socializing teaching materials through distribution to teachers and students.

Data analysis

The data analysis technique used is descriptive statistics and inferential statistics. The validity of the GILBE e-module was measured through a validation sheet. Practicality was measured through a readability questionnaire and student responses to individual and small group trials, while the student and teacher response questionnaires were conducted in a limited trial. The effectiveness of learning is measured through a PSAT instrument. Tests of normality and homogeneity indicated that the PSA pre-test and post-test were all normally distributed and homogeneous. Detailed results can be seen in [Table 6](#) and [Table 7](#).

Table 6. Test results of normality Kolmogorov-Smirnova

Class	Test	Statistic	df	Sig.	Criteria	Conclusion
Experiment 1 (Limited Trial)	Pretest_PSA	.187	16	.136*	0.05	Normal
	Posttest_PSA	.199	16	.091*	0.05	Normal
Experiment 2 (Broad Trial)	Pretest_PSA	.143	30	.121*	0.05	Normal
	Posttest_PSA	.142	30	.125*	0.05	Normal

^aLilliefors Significance Correction (* p -value ≥ 0.05)

Table 7. Test results of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.	Criteria	Conclusion
Based on Mean	1.891	1	30	.179*	0.05	Homogeneous
Based on Median	1.386	1	30	.248*	0.05	Homogeneous

* p -value ≥ 0.05 (Significant)

The effectiveness of students' PSA was measured using N-gain. The average N-gain of students' scientific literacy competence is interpreted according to the categories: $g > 0.7$ (high), $0.3 < g \leq 0.7$ (moderate), and $g \leq 0.3$ (low) ([Hake, 1998](#)). The e-module is effective if it can achieve a minimum N-gain in the medium category. To show a significant increase in the pre-test and post-test PSA, the researchers strengthened the data using paired sample t-test (if the data were following the assumption of normality). The tested hypotheses null (H_0) are presented below: there is no significant increase in students' PSA before and after participating in learning using the e-module. In testing the hypothesis using a significant level $\alpha = 5\%$ (two-tailed). The rejection criterion for H_0 is based on the p -value below: If the p -value $< \alpha$, then H_0 is rejected.

RESULT AND DISCUSSION

The results obtained in the validation, practicality, and effectiveness tests of the developed e-module will be presented based on the research objectives. The results obtained in this study are.

Development Results

The advantage of this product is the e-module which is designed with GILBE steps used during learning activities. This e-module also contains the original science of the local community, especially the Maanyan Dayak. This technologically advanced development product makes use of the ease with which various computers, laptops, and mobile phones can access this e-module. There are four pages total in this e-module on colloidal material: a cover page, an introduction page, a content page, and a closing page ([Figure 1](#)). The cover page consists of the author's identity, the supervisor's identity, the development product's identity, the subject's title, the class's identity, and images relevant to the material. The introduction page consists of the initial page, introduction, table of contents, e-module concept framework, e-module completeness, e-module usage instructions, and core competencies. The contents page consists of concept maps and learning activities, including the introduction, core, and closing sections. The introductory part of each learning activity consists of basic competencies, achievement indicators, learning objectives, required initial knowledge, source materials, time, and discourse containing indigenous science from the community.

The core activities in each learning activity include the syntax of the GILBE model. The community column is presented to provide knowledge about the community's original science, which has something to do with scientific science on colloidal materials. The closing page consists of a summary of each subject matter, the final evaluation link to the google form, a glossary, and a bibliography. According to [Utari et al. \(2020\)](#), the display of e-modules is a significant part so that students do not feel bored and bored when studying.



Figure 1. E-module display design

Validation Test Results

Before testing the e-module product, it is validated first by the validator to determine the feasibility of the e-module. The validator consists of three ULM chemistry education lecturers, one ULM educational technology lecturer, and one chemistry teacher at SMAN 1 Tamiang Layang. The interpretation of the validity of the e-module was determined as follows: $85 < x \leq 100$ (very valid), $70 < x \leq 85$ (valid), $50 < x \leq 70$ (less valid), and $x \leq 50$ (not valid) (Yunita et al., 2021). The feasibility of the e-module can be determined through the assessment given by the validator using a validation sheet that includes four components: content, presentation, language, and media.

Table 8. Validation results

Aspects of assessment	Validation Score	Description
Contents	96.00	Very Valid
Presentation	95,80	Very Valid
Language	93.33	Very Valid
Media	95.43	Very Valid
Average amount	95.14	Very Valid

Based on Table 8, the percentage results get a very good category so that the e-module GILBE on colloid material can be feasible to be used. However, the aspect of language assessment has the lowest score among other aspects because this e-module dialogue does not contain motivational words or aphorisms that inspire students' learning enthusiasm. The e-module was revised so that it can be used at a later stage. This e-module is good teaching material because it has the characteristics of an e-module, i.e., self-contained, self-instruction, and self-explanatory power. E-modules can also support interactive learning and challenge students to use active learning strategies where students can control their learning and offer control over learning, learning speed, and learning time and place (Ikram, 2012).

The material in this e-module is complete such as a dispersion system, the properties of colloids and types of colloids, and the manufacture and use of colloids based on self-contained characteristics so that students complete learning the material. With the presence of ethnoscience supplements in each material, this e-module has the advantage. Moreover, the e-module that uses guided inquiry, according to Syahmani et al. (2021), will make students more quickly master the material related to everyday life as a guide to learning

independence. It aims to shape students' creative character and make it easier for students to study independently at home (Budhiharti & Suyitno, 2017).

The e-module does not require supporting tools because this e-module already has learning videos and practice questions that go directly to youtube and google forms which can be directly accessed from the e-module. It is based on the characteristics of Stand Alone. This e-module requires the internet to be able to access it. It can be opened anytime and anywhere to follow the development of science and technology because current learning must adapt to technology, namely Adaptive. The following is the display of the e-module in the form of a laptop and Handphone in Figure 2. This e-module has user-friendly characteristics. According to the results of the validity of the e-module on the language aspect, the average value is 93.33, meaning that this e-module uses language that is easy for students to understand. Accessible teaching materials and easy-to-understand language make it easier for students to understand (Nufus et al., 2020).

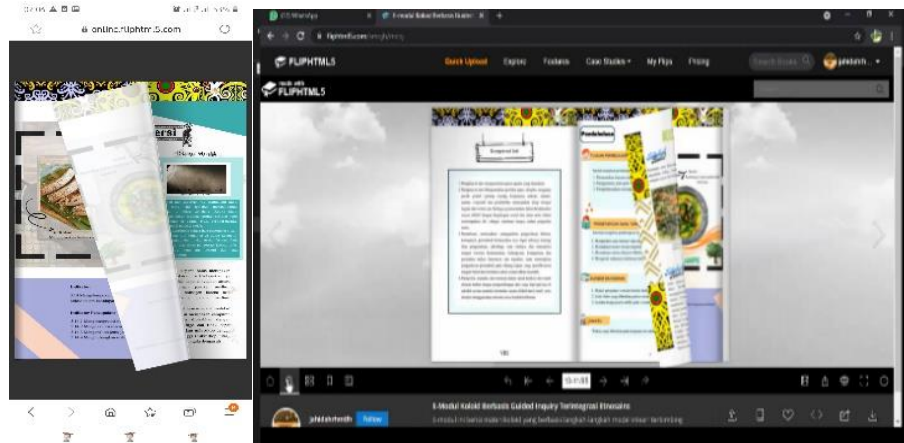


Figure 2. E-modules in the form of laptops and handphones

Practicality Test Results

The practicality test is carried out by giving questionnaires to teachers and students to know the practicality of e-modules in learning activities. The analysis of the practicality of the e-module was measured through three questionnaires, namely readability in individual and small group tests, and student and teacher responses to the use of the e-module are presented in Figure 3. The teacher and student response questionnaires were given at the end of the lesson, which contained statements regarding using e-modules in the learning process. Student responses were lower than the readability results of the small group test conducted in the previous stage because some students in the limited trial were not accustomed to using e-modules but often used textbooks. Hence, students needed to adapt more by using e-module teaching materials.

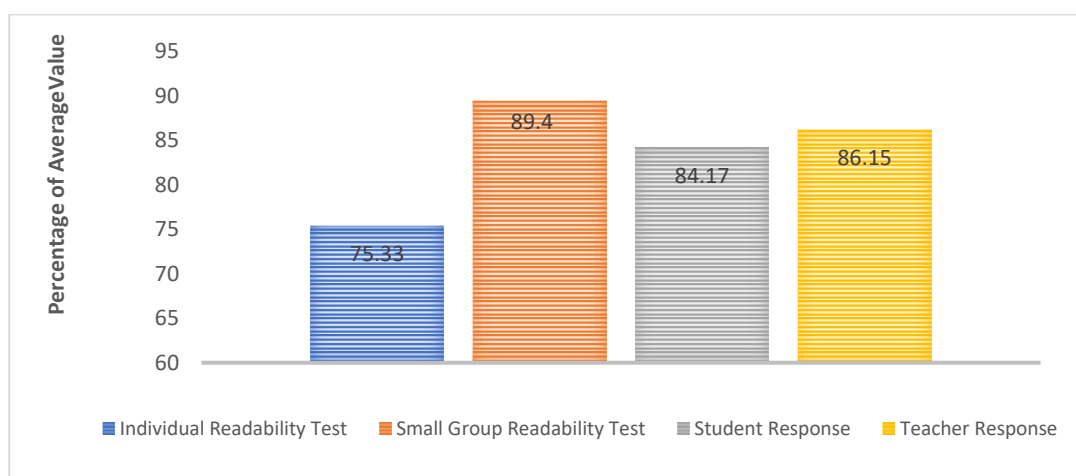


Figure 3. Practicality test results

Students establish empirical laws based on the measurement of variables (collaborative work used to

construct more detailed knowledge).

Effectiveness Test Results

This trial was carried out using an e-module that had passed the individual and small group trial stages and was previously revised. Then a limited trial was conducted to test the effectiveness of the developed e-module. Learning begins with giving pre-test questions to students to determine students' PSA before using an e-module on colloid material. At the end of learning, students are given a post-test to find out the level of PSA of students after participating in learning using e-modules. The average results of the ability to solve chemical problems from a limited and broad trial conducted in class are presented in Table 9.

Table 9. Percentage of average students' problem-solving ability

Indicator of PSA	Limited trial ^a				Broad trial ^b			
	PSA*(%)		N-gain	N-gain Categor	PSA*(%)		N-gain	N-gain Category
	Pre-	Posttes			Pre-	Posttes		
Understanding the problem	25.69	93.05	0.91	High	43.70	95.56	0.92	High
Devising the plan	15.63	80.21	0.77	High	29.26	89.26	0.85	High
Carrying out the plan	15.63	92.29	0.91	High	20.28	79.72	0.75	High
Looking back at the finished	14.58	61.80	0.55	Moderate	14.14	56.11	0.48	Moderate
Average	18.33	78.96	0.74	High	26.83	80.16	0.73	High

Note: ^aLimited trial with N = 16; ^bBroad trial with N = 30

*PSA achievement categories: 80-100 = very good, 66-79 = good, 56-65 = sufficient, <56 = less.

The PSA of students has increased with an average N-gain value for limited and broad are 0.74 and 0.73, respectively, in the high category. This increase is due to the e-module using guided inquiry steps that direct students to chemical problems. According to Winarti et al. (2019) and (Syahmani et al., 2021), students become accustomed to solving problems actively and independently through inquiry learning steps to practice PSA. The ability to solve problems based on Polya (2004) is divided into four, namely 1) understand the problem, the ability of students to apply concepts that have been known, 2) make a plan by being faced with a problem, students try to find a solution, 3) carry out a plan, students learn how to make discoveries by going through the process of solving problems, and 4) look back at the completed solution, becoming more skilled students in making decisions. The increase in PSA is obtained from the average of the four problem-solving indicators. Based on Table 8, it can be seen that the level of achievement of each competency in PSA gets a good score. The indicator of *understanding* has the highest value because students are often given problems and then find out what problems occur to make them think critically and creatively about problems related to their environment. Activities carried out in stages can help students develop their ability to understand the problems that occur (Zubaidah, 2017).

The indicator of *looking back at the finished* has the lowest score among other indicators because students are not appreciated or given rewards for the presentation of the results of their discussions. Giving rewards can make students feel happy and motivated because they feel appreciated for their learning outcomes. The indicator of *devising and carrying out the plan* have the highest scores of the indicator of *looking back at the finished* because students are more enthusiastic in planning and implementing problem-solving. Hence, they feel it is not too important because they are too lazy to read over and over again to understand the problems. According to Ijirana et al. (2020), students think it unnecessary to know the problem, so they focus more on stage planning and problem-solving. The results of the n-gain analysis are reinforced by parametric inferential statistical analysis using paired t-tests presented in Table 10. The paired sample t-test on the data of students' PSA in two pairs showed that Sig. (2-tailed) with a p -value <0.05, there was a significant increase in students' PSA before and after learning by using the e-module GILBE on colloid material. It is in line with the research findings that ethnoscience-based contextual learning significantly affects student learning outcomes and activity (Rahmawati et al., 2020).

Table 10. Paired samples t-test

Experimental		Paired Differences					t	df	p-value Sig. (2-tailed)	
		N	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower				Upper
Group 1	Pretest_PSA Posttest_PSA	16	-60.63813	18.07846	4.15962	-70.27146	-51.00479	-13.417	15	0.000
Group 2	Pretest_PSA Posttest_PSA	30	-54.81567	7.75155	1.41523	-57.71014	-57.71014	-38.733	29	0.000

The results showed that the two experimental groups 1 and 2 were significantly different from pretest to posttest [Experimental group 1: $t = -13,417$, $p = .000$; Experimental group 2: $t = -38,733$, $p = .000$]. Applying the module GILBE on colloidal material can improve students' PSA in chemistry learning.

GILBE E-module in Empowering PSA

This e-module is structured based on the phase and learning activity of GILBE and can be explained as follows:

a) **Orientation.** An inquiry model to investigate and explain problem phenomena (Joyce et al., 2011). In this phase, problems are presented in situations that make students curious and explain the research procedures to provide students' experience in constructing new knowledge (Gurses et al., 2015). In the first meeting, students observed the phenomenon of fog in the morning. The second meeting was the phenomenon of blue skies in the morning and orange at sunset, small particles moving in the car's light at night, and the clumping process of sap from liquid to solid. The third meeting presents the product phenomenon using the colloidal principle. Each phenomenon displayed by the teacher asks questions about the phenomenon to stimulate students to wonder why this can happen.

b) **Manipulation.** The teacher gives each problem related to daily life. Students gather information about an event they have seen or experienced by collecting data to solve problems and develop new ideas (Wenning, 2011). These questions stimulate students to do and plan what strategies to solve the problem. The first meeting deals with distinguishing the various and categorizing the mixture: a solution, suspension, and colloid. The second meeting was given two problems related to the material properties of colloids. The first problem is the presence of small particles scattered in the light of the car, while the second problem is the process of coagulating liquid latex into rubber sats. Students relate the problem to the properties of colloids. At the third meeting, questions were given on whether the solution or suspension was converted to colloid. These changes will be associated with the daily use of colloids.

c) **Generalization.** Generate competition for alternative hypotheses and predictions about what might happen and why it might happen. Students are asked to make hypotheses about the dispersion system based on their observations of various mixtures, colloids' properties in the phenomenon of small particles in spotlights and juice accumulation, and how to make colloids in everyday life.

d) **Verification.** Methodically and systematically, students implement the plan. Students collect and analyze data and monitor the problem-solving process. At the first meeting, a place for data collection was presented so that students could search for any data needed. Students use the internet to find information or reference learning resources. So at the second and third meetings, students were directed to collect data independently with their own PSA. Learners can search for information or data with the help of an e-module on colloid material. Students discuss and exchange opinions about their respective observations about colloidal systems.

e) **Application and Evaluation.** Finally, in the phase of applying their research results (Joyce et al., 2011; Ong et al., 2020). Student representatives will present the results of their discussions and other students will pay attention and provide feedback. The teacher reinforces the answers to the final results of the discussion. At the end of the activity, the teacher explains the relationship between local cultures and colloid materials being taught so that it becomes a provision of new knowledge gained by students. This evaluation stage is usually not done well. However, this stage has the greatest potential for recognition of success and for enhancing our ability to solve problems. Included in this stage are managing the thrill (and positive stress) of successfully completing a task and taking time to look back; checking that the answers are reasonable, error-free, and meet the criteria and objectives; reflecting on what we learned about problem-solving; identify and remember "experience factors"; elaborating the situation by creating another problem that can be solved using the same subject matter basics; identify the "cues" linking these successful solutions, the subject knowledge used, and the problem statement, implement, communicate, and prevent the problem from reoccurring.

In each phase in the syntax of the GILBE model, students perform problem-solving under an instructional design with a well-built scaffold (She et al., 2012). The relationship between the GILBE model syntax, e-module, and PSA is presented in Table 11.

Table 11. Learning steps of the GILBE model, module, and PSA

Phase	Module	Aspects of PSA involved
Orientation	Presenting scientific phenomena and problems in daily life "Do you know"	Understanding the problems
Manipulation	Experiment planning activities. "Chemistry focus" and "Let's Plan an Investigation"	Devising the plan (planning)
Generalization	Presenting questions to answer the formulation of the problem and being asked to make a hypothesis. "Community Column" and "Let's Discuss"	Devising the plan (planning)
Verification	Directions for conducting investigations and monitoring settlement strategies. "Let's make a solution and check"	Carrying out the plan (monitoring)
Application and reflection	Practice questions or assignments, "Let's practice applying and reflecting"	Looking back (reflection)

Findings from each syntax GILBE contribute to students' PSA, making it essential for future research on the effectiveness of inquiry learning in developing students' PSA. This finding is in line with some research that the guided inquiry-based learning integrated local culture approach is effective in improving students' PSA (Simamora et al., 2018; Surya et al., 2017), student achievement, conceptual understanding, and science process (Seraphin, 2014). Problem-solving will enhance students' ability to efficiently organize and consolidate their knowledge into their long-term memory. It supports the notion of problem representation construction, in which certain problem features can activate and relate knowledge in memory (Wang et al., 2013). Schemas for specific types of problems can then be activated and reset. When they work on problem-solving tasks, they not only improve their problem-solving abilities; they also develop a better understanding of scientific knowledge and HOTS, including problem-solving (Irwanto et al., 2019; Saputro et al., 2019). In the GILBE e-module, the emphasis shifts subtly to the more complex forms of scientific experimentation. The teacher still plays the role of providing guidance, facilitating, and raising questions. Guidance is given indirectly by using the right question and answer strategy. The teacher facilitates students to plan, identify, and control variables in their experiments. Teachers explicitly guide the scientific process through guiding questions. This approach will further help students understand the inquiry process. Thus, this GILBE e-module can be used as a reference or enrichment material (Usman et al., 2019; Utami et al., 2020) to improve the quality of education.

CONCLUSION

The GILBE e-module on colloid material developed is very good, both practical and effective. The effectiveness based on the p -value <0.05 in the limited and broad trial of the N-gain of students' problem-solving abilities in the high category can be used in the chemistry learning process. Further research can improve the quality of student activities for each step of learning and develop higher-order thinking teaching materials that apply the GILBE model, which is of higher quality.

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