

PAPER • OPEN ACCESS

## Development of guided discovery learning based module on colloidal system topic for senior high school

To cite this article: Yerimadesi *et al* 2018 *J. Phys.: Conf. Ser.* **1116** 042044

View the [article online](#) for updates and enhancements.



**IOP | ebooks™**

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the [collection](#) - download the first chapter of every title for free.

# Development of guided discovery learning based module on colloidal system topic for senior high school

Yerimadesi<sup>1\*</sup>, Y Kiram<sup>2</sup>, Lufri<sup>3</sup>, and Festiyed<sup>4</sup>

<sup>1</sup> Department of Chemistry, Faculty of Mathematics and Science, Universitas Negeri Padang, Indonesia

<sup>2</sup> Department of Sport Coaching Education, Faculty of Sport Science, Universitas Negeri Padang, Indonesia

<sup>3</sup> Department of Biology, Faculty of Mathematics and Science, Universitas Negeri Padang, Indonesia

<sup>4</sup> Department of Physics, Faculty of Mathematics and Science, Universitas Negeri Padang, Indonesia

\*E-mail: yeri@fmipa.unp.ac.id

**Abstract.** This paper is the result of research and development that developed guided discovery based module on colloidal system topic for senior high school. Product developments reverred to the 4D model (define, design, develop, and disseminate). Research instruments used were of questionnaires and learning outcomes test. The product was validated by experts and tested to a number of students in one of Senior High School in Padang, Indonesia. Data were analyzed qualitatively and quantitatively with descriptive technique and the statistical tests were done with the help of the Statistical Package for Social Science 16 Software. The result of validity and practicality analyzed by using kappa Cohen's formula showed that developed module has very high validity category ( $\kappa = 0.89$ ), very high category of the practicality on teacher response ( $\kappa = 0.87$ ) and high category of the practicality on student response ( $\kappa = 0.71$ ). The results of field trials obtained that the students' learning outcomes in experiment class is higher significantly than the control class. The research findings showed that the guided discovery learning based module developed was valid, practical and effective to use in chemistry learning in senior high school.

## 1. Introduction

Chemistry is needed in daily life because it provides an important and significant contribution to the development of other applied sciences, such as agricultural sciences, health, fisheries, and technology. Therefore, chemistry becomes one of the compulsory subjects in senior high school in Indonesia. Chemistry learned composition, structure, properties, changes, dynamics and energy of matter that involved skills and reasoning [1]. Students' skills and reasoning can be trained through guided discovery learning (GDL).

GDL is one of the active learning models that can improve student learning achievement and critical thinking skills. Through GDL teachers act as motivators, students' learning guide and helper to solve the difficulties that they find in learning [2]. Student performance in chemistry learning is greatly improved through guided discovery, if compared to student-centered demonstration and the



expository instructional strategies. Expository instructional strategies are the least effective among the three [3]. The same results obtained by Akinbobola, A.O. and Afolabib. F, guided discovery is the most effective in facilitating student achievement in Physics learning after being given a pictorial organizer, that followed by demonstration, while expository is considered least effective. GDL is the most effective followed by student center implementation, since learning becomes meaningful when students are actively involved in the process of acquiring knowledge [3]. From the results Akanbi, A.A. and Kolawole, C.B. research, the improvement of student learning result using guided discovery strategy ( $x = 14.20$ ), self-learning ( $x = 14.59$ ) and traditional ( $x = 12.53$ ) [4]. Self-learning and guided discovery improve student learning outcomes for high school in biology subject. Similar results were obtained from the research of Lasisi, N., et al, that the GDL is the most effective learning strategy in improving student retention in chemistry learning in Nigeria, compared to conventional learning and problem solving methods [5].

Most chemistry teachers were still struggling to apply the GDL model. Based on the questionnaire given to 33 chemistry teachers of public and private high schools in West Sumatera, Indonesia in the semester of January-June 2016 was obtained data: (1) 66.7% teachers believe that middle students could find facts, concepts, principles or procedures contained in learning chemistry with teacher guidance. (2) 33.4% of teachers have tried to apply the learning model suggested by the 2013 curriculum. (3) 87.9% of teachers had difficulty applying discovery learning model in chemical learning process, therefore teachers were still teaching traditionally. One of the causes of problems faced by teachers was the lack of availability of learning materials that can assist teachers in guiding students in finding concepts. Meanwhile, to support the use of GDL model, it is needed a learning material to guide student learning either independent or by group and teachers act as facilitators and mentors [3]. One of characteristics of GDL is focus thinking (convergent thinking), therefore through learning material teacher is required to provide some statement or question that guides students, using a logical step, and make some discoveries leading to one determination [4]. Smitha, V. P. explains that students' understanding is actively built through individual and social processes and actions of teacher [6]. What students learned is greatly influenced by how they are taught. This is in line with the demands of the 2013 curriculum, which states that teachers need to prepare learning materials that can assist students in the learning process. In preparing learning materials, it is recommended that teachers use the GDL model [4].

Some researchers report that the using of guided discovery learning materials is effective in learning, such as in geometry and measurement topic for math [7], Calculus II [8]; and chemistry learning [9]. One of the learning materials that can be developed by teachers is module. Module is printed material that has the most complete components compared to other learning materials, such as worksheet, and handout. Module contains all the essential components of learning materials, namely: title, study guide, basic competence (KD), supporting information, exercises, task and assessment [10]. In addition, the module also comes with activity, work sheet and evaluation answer keys, so that students can measure their own ability. Students also can learn based on their learning speed.

The module is the learning material which is in accordance with guided discovery learning model, that guide students learn independently. The use of module in chemistry learning can improve student learning outcomes, such as electrochemical analysis [11], hydrocarbon compounds and their derivatives [2], and chemical equilibrium [13], acid-base [14]. Using of module can also stimulate the intrinsic motivation of students to learn chemistry. It is significantly higher than conventional learning [15]. Based on the above background, this research aims to develop guided discovery learning based module for chemistry learning in senior high school. The learning stages designed in the module are expected to develop students' critical thinking skills. Students are guided to understand and find the concept independently or by group.

## 2. Methods

This Research and Development (R&D) used the model four D (4-D model) [16]. The development procedure consists of four stages, namely define, design, develop, and disseminate. The product has

been developed in the form of colloidal system module based on guided discovery learning for chemistry learning. The steps taken at each stage of development were outlined as follows.

In the define stage, five needs analysis were performed: front-end analysis, learner analysis, task analysis, concept analysis and specifying instructional objectives. Front-end analysis and learner analysis, conducted through literature study and using the instrument in the form of a questionnaire given to 33 chemistry teachers of senior high school in West Sumatera, Indonesia. Task analysis, conducted by analyzing syllabus of senior high school chemistry in accordance with the 2013 curriculum which is used in Indonesia. This study selected a subject matter of chemistry, the colloidal system. Concept analysis was done by arranging the concept of colloidal system in a hierarchy, ranging from general to specific according to Ausubel learning theory. Specifying instructional objectives were performed by analyzing Basic Competence and Core Competence of colloidal system material in the 2013 curriculum syllabus. The results of this analysis became a basis for constructing module that developed was design process of to improve student learning outcomes and critical thinking skills of high school students.

The modules were designed based on guided discovery learning syntax for chemistry learning [17]. The syntax of this model is modified from the GDL model syntax found by Carin, A. A [18], Smitha, V.P [6] and Ministry of Education Rule No. 59 in 2014 [19]. The module format was modified from the instructional material guidance by the national education department of the directorate general of basic education management and the middle directorate of high school coaching [20] and creative guides to create innovative teaching materials [21].

The development stage performs the validity, practicality, and effectiveness of the developed modules. Instrument used were in the form of questionnaire, observation sheet, and learning outcome test. The colloid module was assessed by experts (lecturers and teachers). The practicality of the module was assessed by the teachers and students in the pilot schools. The field test was conducted through quasi experiment research with the randomized control-group pretest-posttest design. Sample consists of two classes, namely experiment class and control class.

The data obtained from this research are quantitative and qualitative data. Quantitative data were obtained from questionnaires and learning outcome test. Qualitative data were obtained from suggestions provided by validators and practitioners. The questionnaire data were analyzed using Kappa Cohen's formula and decision category based on kappa moment ( $\kappa$ ) can be seen in **Table 1**. The data of student learning outcomes were analyzed by quantitative statistics sequentially, starting from the difference data of experiment class and control class, normality test, homogeneity test and hypothesis test. The statistic test was done with Statistical Package for Social Science (SPSS) 16 software.

**Table 1.** The category of decision based on Kappa moment ( $\kappa$  value) [22]

Interval of the $\kappa$ value	Category
0.81 to 1.00	Very high
0.61 to 0.80	High
0.41 to 0.60	Medium
0.21 to 0.40	Low
0.01 to 0.20	Very low
$\leq 0,00$	Invalid

### 3. Result

#### 3.1 Define Stage

Based on the questionnaire analysis filled by 33 high school chemistry teachers in West Sumatera, Indonesia in the semester of January-June 2016 obtained some problems in the study of chemistry. These problems were: (1) most teacher still taught conventionally, and only 27% of teachers used scientific approach. (2) Teacher had difficulty in applying scientific approach in teaching chemistry; (3) Only 12.6% teachers applied discovery learning model in teaching chemistry, the reason of teachers did not used it, because there were no material learning that guided student used discovery

learning need to solve this problem, discovery learning need can guide teacher and student in used scientific approach.

Analysis of the students showed the cognitive development of high school students between the ages of 15-17 years or in adolescence. According to Piaget 11-15 years of age into adulthood called formal operational period, and this stage is the final stage of cognitive development in quality. Adolescents think was more abstract, idealistic, and logical and was able to hold reasoning using abstract things. Reasoning that occur in cognitive structure has been able to use symbols, ideas, abstractions and generalizations. He has had the abilities to perform the operations that the relationship between the concepts and understand the concept [23]. However, not all students are in adolescence able to think abstractly as described by the Piaget. Piaget does not give sufficient attention to individual variation in adolescent thinking. Many teenagers who still think operationally concrete [24]. Therefore a child at the age of adolescence, need guidance from adults, such as parents and teachers. Model GDL is one model that can guide or lead students to think critically, draw conclusions, and develop hypotheses. This is a consideration in developing, designing and preparing teaching materials that will is developed in the module.

Based on the syllabus analysis of chemistry subjects of senior high school [25]. The topics to be studied in colloidal system materials include: (1) understanding of colloidal systems, (2) colloidal species, (3) colloidal properties, (4) lyophilic sol and lyophobic sol, (5) colloid manufacture, (6) colloids in daily life and industry. Based on these two KD, 6 learning indicators were obtained for this material. (1) Classify crude suspensions, true solutions, and colloids based on observational data. (2) Group colloid types based on the dispersed phase and dispersion phase. (3) describe the properties of colloids (optical, kinetic, adsorption, electrical and coagulation properties). (4) Explain the difference of lyophilic and lyophobic colloids. (5) Explain the process of colloid-making based on the experience of making several colloid types; and (6) describe the role of colloids in the cosmetics, food and pharmaceutical industries based on daily life experiences. These six indicators were used as guidance in preparing the learning materials in the module.

The concept analysis obtained the main concepts studied on the material colloidal system. The concepts obtained were made in a concept analysis table consisting of concept labels, concept definitions, concept types, concept attributes, concept positions, examples and non-examples [26]. The conceptual analysis table was used to create concept maps and guidelines in compiling the material content of the module. Concept maps on modules were designed to enable teachers to guide students in learning colloidal material systems and introduce new terms to the learning materials. The concept map was also structured to guide students find the relationship between one concept with another concept.

### *3.2 Design Stage*

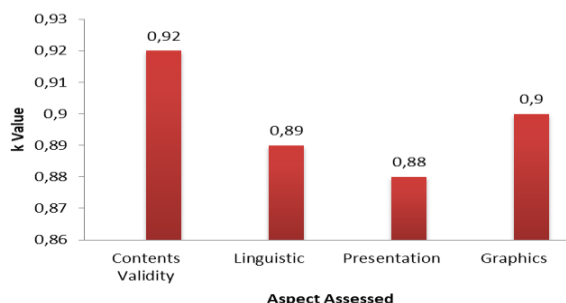
The guided discovery learning module consists of several components: instruction manual, student activity sheet, student worksheet, evaluation sheet and evaluation key. Usage manuals are used as guidelines for students in using modules in the learning process. The activity sheets contain the activities that the student will undertake during the learning process and some questions that the student should fill in the answer sheets provided separately. The student worksheet contains formative test questions and evaluation sheets containing summative test questions. The activity sheets of the modules are based on the syntax or stage of guided discovery learning (GDL) model for chemistry learning, which includes 5 stages: (1) motivation and problem presentation, (2) data collection, (3) data processing, (4) verification, and (5) closure. Some student experience of using modules designed is to discover concepts through laboratory or activity in class.

### *3.3. Develop Stage*

#### *The Results of Validity test*

**Figure 1** shows by 12 experts, the result of validity test of colloidal system module based on guided discovery learning. It can be seen that the developed product is valid with very high level of

expression content, presentation, language, and graphics. However, these module need to be revised from the product before a practicality test is performed, validator suggested some revision. Some of the revised sections are cover, layout, and module usage instructions.



**Figure 1.** Results of the module validity by validators

### *The Results of Practicality Test*

**Table 2** shows the results of practicality module testing by practitioners in one of the public high schools in Padang City, Indonesia. It can be seen that the modules developed are practical according to the teacher and student ratings. The test results of the practicality of the module given by the teachers are higher than that given by the student. From the teacher's appraisal, the average value of kappa moment,  $k = 0.87$  with the very high degree of practicality and the students' scoring obtained the average value of kappa moment,  $k = 0.71$  with high practicality category.

**Table 2.** Practical test results module by practitioner (teacher and student)

No	Aspect Assessed	$\kappa$ value	
		Teachers	Student
1	Ease of Use	0.89	0.71
2	Time Learning Efficiency	0.86	0.65
3	Benefits	0.86	0.76
Average of $\kappa$ value		0.87	0.71
category		Very high	High

### *The Results of Effectiveness Test*

The module effectiveness was obtained through quasi-experimental at Senior High School 10 in Padang, Indonesia. The sample of research is the students of XI Science class 2 as the experimental class and Science class 3 as control class. Assessment of student learning outcomes derived from the test scores conducted on learning in both classes by providing pretest and posttest. The test problem consists of 25 items at objective test with 5 answers choices that was taken from 40 questions that have been tested. **Table 3** presented the pretest and posttest results obtained student learning outcomes.

**Table 3.** Student results data of grade XI senior high school 10 in Padang, Indonesia based on n-gain obtained by students

Sample	N	Average Value		N-Gain	Category
		Pretest	Posttest		
Experiment Class	32	41	96	0.93	High
Control Class	32	33	84	0.76	High

This **Table 3** shows that the difference in mean values of N-Gain experimental class (0.93) is higher than that at control class (0.77), but the N-Gain category of both sample classes is high. To prove whether the value of these values differ significantly or not, a statistical test is performed using the Statistical Package for Social Science (SPSS) 16 Software. Before the first hypothesis test is done the

normality and homogeneity that of data variance of both groups. Testing normality and homogeneity of data in this study was conducted by using Kolmogorov-Smirnov test with the help of SPSS 16 software program. The normality test result of the sample class is shown in **Table 4** and it appears that the two sample classes are not normally distributed.

**Table 4.** Normality test of sample class

	Class	Kolmogorov- Smirnov <sup>a</sup>			Conclusion
		Statistic	df	Sig.	
N-Gain	Experiment	.251	32	.000	Not normally distributed
	Control	.166	32	.025	Not normally distributed

a. Lilliefors Significance Correction

On **Table 4**, we can see that the two sample classes are not normally distributed, then the homogeneity test is done. From the homogeneity test results obtained significance value  $0.045 < 0.05$  ( $H_0$  is rejected), meaning that the two sample classes are not homogeneous. Therefore, the hypothesis of the study was tested using Mann-Whitney Test (**Table 5**)

**Table 5.** Hypothesis test results with Mann-Whitney Test

	Class	N	Mean Rank	Sum of Ranks
N-Gain	Experiment	32	45.38	1452.00
	Control	32	19.62	628.00
	Total	64		

Test Statistics <sup>a</sup>	
	N-Gain
Mann-Whitney U	100.000
Wilcoxon W	628.000
Z	-5.574
Asymp. Sig. (2-tailed)	.000

<sup>a</sup> Grouping Variable: **Class**

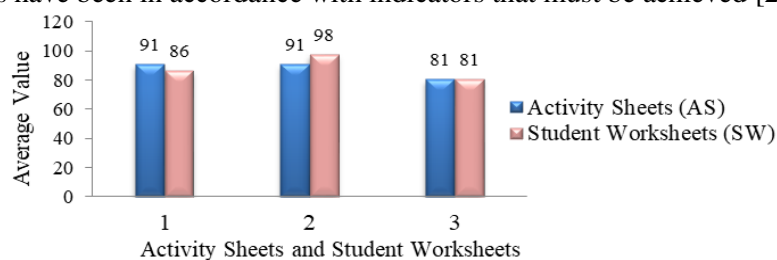
On **Table 5**, the significance value of  $0.000 < 0.05$  ( $H_0$  is rejected) and  $H_1$  (research hypothesis), N-Gain experiment class was significantly higher than the control class N-Gain. These data indicate that the learning outcomes of experimental class were significantly higher than the control class of Senior High School Chemistry Padang. Hypothesis test results showed that the module was very effective on improving student learning outcomes in Senior High School Chemistry Padang.

The effectiveness of the module on student learning outcomes is also evidenced from the results of the student's answer analysis whose using module. From the value obtained by the students by filling out and answering the questions that exist in the module obtained data on student learning outcomes as in Figure 2. Figure 2 shows the students are able to answer the questions that exist on the Activity Sheets (AS) and Student Worksheets (SW) that exist in the module and can already well understood by students. The value obtained by students in each LK and LKS is above the Minimum Criterion, which are 80. This data indicates that the module is very effectively applied in the pilot school that is senior high school chemistry Padang.

## 4. Discussion

### 4.1. Module Validity

**Figure 2**, shows that the developed colloidal system module is valid with a very high category of validity, in terms of content, presentation, language, and graphics. The validity of the content indicates that the learning material in the developed colloidal system module is compatible with senior high school curriculum and strong theoretical rationale [27] [28]. In addition, the components contained in the teaching materials have been in accordance with indicators that must be achieved [29] [30].



**Figure 2.** Average Value Activity Sheets (AS) dan Student Worksheets (SW)

The colloidal system module has a very high category of validity for the linguistic aspect. The colloidal system module is readable, the information presented is clear, in accordance with the Indonesian Language Spell is good and correct, and already utilize the language effectively and efficiently, and short. This is in accordance with Akbar that a good teaching material should be communicative, meaning that the content of the teaching materials is easy to digest, systematic, clear and contains no language errors. In addition, the shape and size of the letters used in the teaching materials are easy to read and the instructions and information presented are clear [31].

The validity aspect of graphics, The colloidal system module has a very high category of validity, with the average kappa moment ( $k = 0.90$ ). This data indicates that the colloidal system module already uses the type and size of the letters in accordance with the standard assessment of teaching materials, layout, illustrations, drawings and photographs and design a clear and attractive display in accordance with the guidelines for writing the material. This is in accordance with the standard of assessment put forward by the national standard education body [32], which is standard materials should use fonts, layouts, illustrations, images, photos and design a good view and according to user needs.

### 4.2. Module Practicality

**Table 2** shows that the module developed has been practical according to the teacher's assessment with very high practicality category, for the aspect of ease of use, the efficiency of learning time, and the benefit. The aspect of the ease of use of the product has a very high practicality category, meaning the module is easily understood by the teacher, the material on the module in accordance with the chemistry learning. The colloidal system module helps teachers organize the material from the learning objectives that have been formulated. The level of product practicality is seen from the explanation of whether teachers and other experts give consideration that the product is easy and can be used by teachers and students [33]. The model of development outcomes is concluded practically if (1) the practitioner states theoretically the model can be applied in the field and (2) the extent of the modeling is "good" or "high".

On the efficiency aspect of learning time, the module has a very high level of practicality with the average value of kappa moment  $k = 0.86$ . This data shows that module availability makes learning time more effective and efficient. The aspect of benefits, the product has a very high level of practicality ( $k = 0.86$ ). This data indicates that the product provides a high benefit for users, teachers and students. Teachers become helpful in carrying out the learning process, and teachers feel happy to teach.



Evaluation of the practicality given by this teacher indicates that the teacher can easily use the developed module. According to the teacher of learning with the module being more efficient, the role of the teacher as the facilitator becomes helpful. The colloidal system module helps teachers in guiding students to discover new concepts or knowledge on each learning topic. The results obtained are in accordance with those reported by Akinbobola, A.O. and Afolabib. F, that the teaching material provided on the GDL model guides the students to self-study [2]. Through the colloidal system module, students can build and practice their thinking skills. This is in line with that of Bruner, J.S, learning will be more meaningful to learners if they focus on understanding the structure of the material being studied. The learning process will occur if the teacher does not present the subject matter in its final form, but it is expected the students to organize themselves [34].

Chemical modules developed under the GDL model have been able to help teachers perform their roles as facilitators, motivators, mediators, reflectors, and mentors in chemistry learning. Students are encouraged to be responsible, independent and build their own understanding of every scientific concept. Therefore, the activities are student-centered, democratic and interactive. Availability of modules, facilitating and providing students with experience that enables them to use science process skills such as observing, measuring, classifying, communicating, summing up, using numbers, using space/time relationships, questioning, controlling and manipulating variables, formulating hypotheses, formulating models, designing experiments and interpreting data [2].

**Table 3** also shows the result of students' appraisal of the module, the average value of k values of the colloidal module system practicality obtained from the students ( $k = 0.71$ ) is lower than that given by the teacher ( $k = 0.89$ ). This data indicates that students in pilot schools are not yet accustomed to self-learning, the role of teachers is still dominant in learning, so the learning time with the module becomes longer according to the students. Whereas actually according to the teacher is faster than the allocation of learning time of colloidal system material written on the teacher Lesson Plan in the control class, is 3 weeks  $\times$  4 hours of learning.

The GDL model requires students to be able to write hypotheses of problems presented to modules, collect data through experiments, observe pictures, tables, work out exercises and summarize instructional materials as directed in the module. Classroom and laboratory activities conducted according to students in Senior High School Chemistry Padang require longer learning time than conventional learning. However, student who are learning using GDL-based module is fun in learning process, although it takes longer time, students still want to do every sheet of activity and worksheets that exist in the module properly and correctly. This makes students become active in learning, students' thinking skills become trained, and student learning achievement increases.

#### 4.3. Module Effectiveness

Based on **Table 3**, it appears that the GDL-PK colloidal system module is effective against improving student learning outcomes in school trials. The experiment class learning outcome was significantly higher than the control class learning outcome at Senior High School 10 Padang, Indonesia. That was increasing student learning outcomes in the experimental class that was studied with guided discovery learning colloidal system module. This module is based on the GDL-PK model syntax, which can guide students to learn, either independently or in groups. The use of colloidal system module in learning chemistry proved to improve student learning outcomes. Similar results were reported in several previous studies, such as electrochemical analysis materials [11], hydrocarbon compounds and their derivatives [12], chemical equilibrium [13], colloidal system [35], and buffer solutions [36]. The results also show that the use of modules can also stimulate students' intrinsic motivation to learn chemistry, intrinsic motivation of students who study chemistry using modules significantly higher than conventional learning (without modules) [15].

#### 5. Conclusions and Recommendations

Based on the results of research and data analysis, it is concluded that guided discovery learning based module has valid, practical, and effective to use in chemistry learning. The validity is in very high

category ( $\kappa = 0.89$ ), and so was the practicality test ( $\kappa = 0.87$ ) from teacher questionnaire, ( $\kappa = 0.71$ ) from students questionnaire. Field test results showed that guided discovery learning based module on colloidal system are effective in chemistry learning. So, this module valid, practical and effective to use in chemistry learning in senior high school.

### Acknowledgments

In the preparation of this module, the author has gained a lot of support, guidance and direction from various parties. Therefore, the authors express gratitude to Prof. Dr. Ellizar, M.Pd.; Prof. Dr. Agustina, M. Hum.; Hardeli, M.Si.; and Dr. Darmansyah, M.Pd., as a validator. Mr/Ms high school chemistry teacher who has assisted with research activities at school; Mr and Ms team observer, colleagues arms and all parties who have helped the author. Hopefully the support, guidance and direction given to be worship and receive a reward from Allah S.W.T.

### References

- [1] Brady J E 2003 *Chemistry Matter and Its Changes* (New York: Wiley)
- [2] Akinbobola A O and Afolabib F 2010 *Eurasian J. Phys. Chem. Educ.* **1** 16
- [3] Udo M E 2010 *Jurnal Multi-Disiplin Internasional, Ethiopi*, **17** 389
- [4] Akanbi A A and Kolawole C B 2014 *Journal of Education and Leadership Development* **6** 19
- [5] Lasisi N *et al* 2016 *American Journal of Innovative Research and Applied Sciences* **2** 98
- [6] Smitha V P 2012 *Inquiry Training Model and Guided Discovery Learning For Fostering Critical Thinking And Scientific Attitude* (Kozhikode: Vilavath Publications)
- [7] Sunismi and Nu'man M 2012 *Cakrawala Pendidikan*, **31** 200
- [8] Sunismi 2015 *Cakrawala Pendidikan* **34** 333
- [9] Yerimadesi *et al* 2017 *Jurnal Eksakta Pendidikan* **1** 17
- [10] Depdiknas 2008 *Pengembangan Bahan Ajar* (Jakarta: Departemen Pendidikan Nasional, Direktorat Jenderal Manajemen Pendidikan Dasar dan Menengah, Direktorat Pembinaan Sekolah Menengah Atas)
- [11] Novianty I, Sulistina O, Zakia N 2014 *Jurnal-online.um.ac.id*.
- [12] Febriana B W 2014 *Jurnal.fkip.uns.ac.id*.
- [13] Yerimadesi 2016 *Journal of Saintek* **8** 85
- [14] Yerimadesi *et al* 2018 *IOP Conf. Series: Materials Science and Engineering* **335** 012097
- [15] Vaino K *et al* 2012 *Chemistry Education Research and Practice*, Vol. 13, pp:410–419.
- [16] Thiagarajan S 1974 *Instructional Development for Training Teachers of Exceptional Children A sourcebook*. (Indiana: Indiana University Bloomington)
- [17] Yerimadesi *et al* 2018 *Model Guided Discovery Learning untuk Pembelajaran Kimia (GDL-PK)* (Padang)
- [18] Carin A A 1997 *Teaching Science Through Discovery* (Ohio: Pearson Prentice Hall, Inc)
- [19] Permendikbud Nomor 59 Tahun 2014 tentang Kurikulum 2013 Sekolah Menengah Atas/Madrasah Aliyah.
- [20] Depdiknas 2008 *Panduan Pengembangan Bahan Ajar*(Jakarta: Departemen Pendidikan Nasional)
- [21] Prastowo A 2011 *Panduan Kreatif Membuat Bahan Ajar Inovatif* (Yogyakarta: Diva Press)
- [22] Boslaugh S dan Paul A W 2008 *Statistics in a Nutshell, a desktop quick reference* (United Kingdom: Cambridge University Press)
- [23] Santrock J W 2008 *Educational Psychology* (Jakarta: Salemba Humanika).
- [24] Santrock J W 2007 *Psikologi Pendidikan* (Jakarta: Prenada Media Group).
- [25] Kemendikbud, 2016, *Silabus Mata Pelajaran Sekolah Menengah Atas/Madrasah Aliyah (SMA/MA) Mata Pelajaran Kimia*. (Jakarta: Kemendikbud).
- [26] Herron J D *et al* 1977 *Science Education* **16** 185
- [27] Plomp T 2007 *Educational Design Research: An Introduction* (Netherland: National Institute for Curriculum Development)

- [28] Daryanto 2014 *Pendekatan Pembelajaran saintifik Kurikulum 2013* (Yogyakarta: PT. Gavi Media)
- [29] Arikunto and Suharsimi 2005 *Dasar–dasar Evaluasi Pendidikan* (Jakarta: Bumi Aksara)
- [30] Rochmad 2012 *Jurnal Kreano*. **13** 69
- [31] Akbar S 2013 *Instrumen Perangkat Pembelajaran* (Bandung: PT. Remaja Rosda Karya)
- [32] BNSP 2010 *Paradigma Pendidikan Nasional Abad 21* (Jakarta: Badan Standar Nasional Pendidikan)
- [33] Plomp T and Nieveen N 2010 *An Introduction to Educational Design Research* (Netherland: National Institute for Curriculum Development)
- [34] Bruner J S 1961 *Harvard Educational Reviews* **31** 21
- [35] Yerimadesi, *et al* 2017 *Prosiding Semirata 2017 Bidang MIPA BKS-PTN Wilayah Barat*. pp: 1842-1852
- [36] Yerimadesi 2015 *The development of discovery learning-based module in buffer solution topic for senior high school instruction*  
<http://seminar.fmipa.unp.ac.id/icomset/files/Proseding%20ICOMSET%20FMIPA%202015%20rev.pdf>