Vol.11 (1), 2022, 53-63 DOI: 10.23960/jppk.v11.i1.2022.06
Jurnal Pendidikan dan Pembelajaran Kimia
e-ISSN: 2714-9595| p-ISSN 2302-1772
http://jurnal.fkip.unila.ac.id/index.php/JPK/index

Development of Chemical Representation-Based Modules on Materials Interaction Between Particles

[*]Ila Rosilawati [1] , Maya Margareta [2], Lisa Tania [3]

1,2,3 Chemical Education, Faculty of Teacher Training and Education, University of Lampung
Jl. Prof. Dr. Soemantri Brojonegoro No. 1 Bandar Lampung, Indonesia.
*Corresponding e-mail: ila.rosilawati@fkip.unila.ac.id

Received: April 4th, 2022 Accepted: April 9th, 2022 Online Published: April 14th, 2022

Abstract: Development of Chemical Representation-Based Modules on Materials Interaction Between Particles. This study aims to develop and determine the validity/feasibility of the module, as well as to describe the responses of teachers and students to the chemical representation-based module on the interaction material between particles that was developed. The research design used research and development according to Borg and Gall which only carried out the first five stages. The research data were analyzed using descriptive statistical analysis. The results of expert validation on aspects of content suitability, construction, readability and attractiveness were 78.65%, 77.79%, 71.44% and 77.14% with high criteria. The teacher's responses to aspects of appropriateness of content, construction, readability and attractiveness were 76.95%, 86.12%, 77.80% and 73.87% with high criteria. Students' responses to the attractiveness and readability aspects were 80.1% and 81.56%, respectively, with very high criteria. Based on this, the module based on chemical representation on the interaction material between particles developed is valid and suitable for use as teaching materials in schools.

Keywords: module, interaction between particles, chemical representation.

Abstrak: Pengembangan Modul Berbasis Representasi Kimia Pada Materi Interaksi Antar Partikel. Penelitian ini bertujuan untuk mengembangkan dan mengetahui kevalidan/kelayakan modul, serta mendeskripsikan tanggapan guru dan peserta didik terhadap modul berbasis representasi kimia pada materi interaksi antar partikel yang dikembangkan. Desain penelitian menggunakan penelitian dan pengembangan menurut Borg dan Gall yang hanya dilakukan lima tahap pertama.. Data penelitian dianalisis menggunakan analisis statistika deskriptif. Hasil validasi ahli terhadap aspek kesesuaian isi, konstruksi, keterbacaan dan kemenarikan berturut-turut adalah 78,65% , 77,79%, 71,44% dan 77,14% dengan kriteria tinggi. Tanggapan guru terhadap aspek kesesuaian isi, konstruksi, keterbacaan dan kemenarikan berturut-turut adalah 76,95%, 86,12%, 77,80% dan 73,87% dengan kriteria tinggi. Tanggapan siswa terhadap aspek kemenarikan dan keterbacaan berturut-turut adalah 80,1% dan 81,56% dengan kriteria sangat tinggi. Berdasarkan hal tersebut, maka modul berbasis representasi kimia pada materi interaksi antar partikel yang dikembangkan ini valid dan layak digunakan sebagai bahan ajar di sekolah.

Kata kunci: modul, interaksi antar partikel, representasi kimia.

- **INTRODUCTION**

Natural Sciences (IPA) is a science that deals with how to find out about natural phenomena systematically. Science is a very interesting science, in which there are lessons that allow us to understand various natural phenomena that exist in everyday life (Wahono, 2013). One part of science is chemistry. Chemistry is considered a difficult subject to learn because it consists of abstract concepts and topics. The complex and abstract nature of chemistry makes teaching and learning difficult for students and for teachers (Johnstone, 1991; 1993; Nakhleh, 1992; Gabel, 1998; Treagust & Chittleborough, 2001). Understanding most of the concepts in chemistry depends on understanding at the microscopic level of chemical phenomena, both of which are communicated by symbols. Thus, conceptual understanding in chemistry includes the ability to represent and translate chemical problems using the form of representation at the macroscopic (observable), microscopic (particulate) and symbolic levels (Gabel & Bunce, 1994).

One of the chemical materials studied by students is the interaction between particles which is a sub-material of chemical bonding material. Basic Competence for chemical bonding material is KD-3.7 which is to determine the interactions between particles (atoms, ions, molecules) and their relation to the physical properties of substances. KD-4.7 is to reason about the physical properties of the substances around us by using the principle of interaction between particles. The subject matter of chemical bonds is an abstract chemical substance..

Observations (field studies) were carried out in three high schools (SMA) in Lampung province, namely SMA N 1 Kebun Tebu, SMA Negeri 1 Banjar Agung, MA PSA Istiqomah Islamiyah Tulang Bawang Barat, observations were made by interviewing 1 teacher and 10 students in class X from every school. The results of observations show that in the learning process 66.7% of teachers have made teaching materials, but most of the teaching materials made are summaries of material quoted from several sources. As many as 33.3% of teachers have never made teaching materials, they use textbooks on the market and also from the Education Office given to schools. As many as 100% of teachers already know about submicroscopic phenomena in chemical representation, but only 33.3% of teachers apply chemical representation in making modules. Based on student respondents, 100% of students stated that they had obtained teaching materials from the teacher on the interaction between particles. The teaching materials used are in the form of textbooks and the rest states that the teaching materials used are in the form of material summaries and modules. As many as 50% of students stated that students had difficulties when using teaching materials because the language or sentences were less communicative so that they were difficult to understand, and as many as 16.7% of students had difficulties when using teaching materials because the language used was incomplete. As many as 33.3% of students stated that the teaching materials used were not interesting and the readability aspect was still lacking.

Based on the analysis of experimental-based chemistry books written by Raharjo (2008) on the interaction material between particles, many sub-microscopic pictures have been included but the material contained in the book is very few and concise so that students will have difficulty understanding the contents of the material, while in chemistry books for SMA/MA class X written by Sudarmo (2013) there are only a few sub-microscopic images used so that it is more difficult for students to understand the material. Then in the chemistry book written by Purba (2007), there are already quite a lot of sub-microscopic pictures listed, only the pictures listed are only in black and white so they don't attract the attention of students. Adisendjaja (2007) states that some teaching materials from various publishers still contain many errors and misconceptions and alternative concepts are needed.

Abstract chemistry material can be studied by using representations that can connect abstract things with concrete things, so that abstract material is easier for students to understand. For abstract materials that involve the interconnection of natural phenomena (macro, sub-micro, and symbolic) it is recommended to use chemical representation-based learning (Sunyono, 2015). The results of research by Ristiyani and Bahriah (2016) show that there is learning difficulty to understand concepts in chemistry due to the inability to connect macroscopic and sub-microscopic. According to Chittleborough and Treagust (2007), not applying the sub-microscopic level in learning is one of the reasons why students find it difficult to improve their representational abilities and understand chemical concepts

Johnstone in Chitleborough (2004) revealed, these chemical phenomena can be explained by three levels of chemical phenomena, namely macroscopic phenomena, submicroscopic phenomena, and symbolic phenomena. Macroscopic phenomena, which are real and can be seen, such as chemical phenomena that occur in everyday life and in the laboratory that can be observed directly. Submicroscopic phenomena, which are based on real observations but still require a theory to explain what is happening at the molecular level and use theoretical model representations, such as particles that cannot be seen directly. Symbolic phenomena, namely a reality, such as the representation of symbols of atoms, molecules, and compounds, both in the form of images, algebra, and forms resulting from computer processing

The availability of modules is expected to make it easier for students to understand chemical concepts. The module serves to clarify the presentation of messages, simplify the learning process, overcome the limitations of space, time and senses, eliminate passive attitudes in students and improve understanding of the material presented (Nuraini, Karyanto and Sudarisman, 2014).

A module can be said to be good and attractive if it has the characteristics of self-instructional, self-contained, stand-alone, adaptive, and user friendly. Self-instructional is a characteristic of the module being able to teach students independently without the need for other parties as a whole. Self-contained if all learning materials from one standard unit of competency and basic competencies studied are contained in one module as a whole, providing opportunities for students to learn learning materials because the material is packaged in a unified whole. Stand-alone characteristics are modules that are developed not depending on other media or do not have to be used together with other media. By using the module, students do not need to use other teaching materials when using the module. Modules should have a high adaptive capacity to the development of science and technology. By paying attention to the development of science and technology, module development should be kept up to date. User friendly characteristics if the module is friendly to the user. Every instruction and explanation given is to make it easier for students. The use of simple, easy-to-understand language and the use of common terms is a form of user-friendliness (Sukiman, 2012).

A good module is a module that contains at least learning instructions (student/teacher instructions), competencies to be achieved, content or material content, supporting information, exercises, work instructions (can be in the form of worksheets), evaluations, and feedback on evaluation results (Directorate of High School Development, 2008: 13).

The importance of using the three levels of representation in making modules is reinforced by the results of research conducted by Sunardi (2012) that the use of the three levels of representation in learning can improve students' understanding of concepts. Research conducted by Sari (2015) also proves that learning with the three levels of representation can increase the mastery of concepts and problem solving abilities of high school students.

To support the learning process that makes it easier for students to understand the content of the material, a module is needed that presents material based on chemical representations. Related to this, this article will describe the results of the development of a chemical representation-based module on the interaction material between particles.

- **METHODS**

Research Design

The research design used is Research and Development (R&D). There are ten steps in implementing the research and development strategy according to Borg and Gall (1989) but in this study only 5 steps were used in the implementation of the research and development strategy, namely: research & data collection, planning, product draft development, expert validation, and limited trial.

Research Subjects and Locations

The location of this research was conducted in 3 SMA in Lampung province. At the preliminary study stage, it was conducted at SMA N 1 Kebun Tebu, West Lampung, SMA Negeri 1 Banjar Agung Tulang Bawang, MA PSA Istiqomah Islamiyah Tulang Bawang Barat. At the initial field trial stage, it was carried out at SMA N 1 Kebun Sugarcane, West Lampung, SMA Negeri 1 Banjar Agung Tulang Bawang, MA PSA Istiqomah Islamiyah Tulang Bawang Barat. The subject of this research is a module based on chemical representation on the interaction material between particles.

Research Data Source

Sources of data in this study obtained from several stages. The field study stage, the development stage and the initial field trial stage. At this stage the field study was carried out in 3 high schools in the province of Lampung, namely SMA N 1 Kebun Tebu, SMA Negeri 1 Banjar Agung, MA PSA Istiqomah Islamiyah. Sources of data were obtained from 3 chemistry teachers and 30 students of class X science. In the development stage, the data sources were obtained from three lecturers of Chemistry Education FKIP University of Lampung. Furthermore, in the initial field trial stage, the data sources were obtained from three chemistry teachers from three public high schools in Lampung province and 30 students of class X science in Lampung province.

Research Instruments

The instruments used in this research are instruments for field studies, expert validation instruments, and limited trial instruments. The instrument for the preliminary study consisted of an interview guide sheet for teacher needs analysis and a student needs analysis questionnaire. The teacher needs analysis interview guide sheet was prepared to find out the types of teaching materials used by the teacher in the learning process, the expected interaction material between particles that could meet the needs of students, and the constraints in making modules. Student needs analysis questionnaire sheet is used to determine student responses to the use of modules in learning material interaction between particles. The instruments used in the expert validation include content, construct, readability and attractiveness validation instruments. The instrument used in the limited trial is that the teacher's response instruments include instruments on aspects of content suitability, construct, readability and attractiveness, while the student response instruments include instruments on aspects of readability and attractiveness.

Research Flow and Data Analysis Techniques

The first step in this research is a needs analysis consisting of field studies and literature studies. Data collection is done by filling out a needs questionnaire by teachers and students. The data obtained were analyzed using the following formula

$$\%J_{in} = \frac{\sum Ji}{N} \times 100\% \qquad \text{(Sudjana, 2005)}$$

Description: %Jin = Percentage of answer choices -i
∑Ji = Number of respondents who answered answer-i
N = Total number of respondents

The next stage is the planning stage and initial product development. The initial product development stage is divided into two stages, namely, the preparation of a rough draft of the module and the preparation of a validation instrument in the form of a validation questionnaire of conformity with KI-KD and content conformity with chemical representations, constructs, legibility and attractiveness. After the product has been developed, an expert validation stage is carried out by the validator to determine the validity of the chemical representation-based module on the interaction material between the particles developed. The module that has been validated and given suggestions for improvement by the validator, is then revised according to the suggestions for improvement. After the chemical representation-based module was revised according to the validator's suggestion, a limited trial was carried out to determine the teacher's and student's responses to the chemical representation-based module on the interaction between particles.

Data from expert validation and limited trials were analyzed by: coding and classifying data, tabulating data based on the classification made, scoring respondents' answers based on the Likert scale in Table 1.

Table 1. Scoring on the questionnaire based on the Likert scale

No	Answer Choice	Score
1	Strongly Agree (SA)	3
2	Agree (A)	2
3	Disagree (DA)	1

After scoring the respondents' answers, processing the number of respondents' answer scores and calculating the percentage of questionnaire answers on each statement using the following formula:

$$\%\,X\,in = \frac{\sum S}{S\,maks} \times 100\% \qquad \text{(Sudjana, 2005)}$$

Description : $\%X\,in$ = Percentage of answers to the i-th statement questionnaire
$\sum S$ = Number of students total answer scores.
$S\,maks$ = Maximum score expected.

The next step is to calculate the average percentage of answers to each questionnaire to determine the level of conformity, construction, readability, and attractiveness of the chemical representation-based module with the following formula:

$$\%X_{in} = \frac{\sum \%Xin}{n} \qquad \text{(Sudjana, 2005)}$$

Description : % Xin = Average percentage of answer to question on the questionnaire
$\sum$ % Xin = Total percentage of answers to all statements in the questionnaire.
n = Number of statements in the questionnaire..

Then interpret the percentage of the questionnaire and interpret the validation criteria for the analysis of the percentage of expert validation products using the interpretation (Arikunto, 2008) in Table 2 and Table 3.

Table 2. Interpretation of the percentage of the questionnaire.

Percentage	Criteria
80,1%-100%	Very high
60,1%-80%	High
40,1%-60%	Moderate
20,1%-40%	Low
0,0%-20%	Very Low

Table 3. Interpretation of the validation criteria for the percentage of expert validation products.

Percentage	Validity Level	Description
76-100	Valid	Eligible / does not need to be
51-75	Quite Valid	Fair enough/partial revision
26-50	Less Valid	Inadequate/partial revision

<26	Invalid	Not worth it/total revision

- **RESULTS AND DISCUSSION**

Preliminary Research Results and Data Collection

The research from the development of this module was carried out with a needs analysis phase consisting of literature studies and field studies. The needs analysis in this study is an analysis of the class X chemistry books that are circulating and which are used for learning in schools, including 1) Experimental-based chemistry books written by Raharjo (2008). on the interaction material between particles, many sub-microscopic pictures have been included but the material contained in the book is very few and concise so students will have difficulty understanding the contents of the material, 2) chemistry book for SMA/MA class X written by Unggul (2013) there are only a few sub-microscopic images used so that it is more difficult for students to understand the material, 3) the chemistry book written by Purba (2007), there are already quite a number of sub-microscopic pictures listed, only the pictures listed are black and white. white so it does not attract the attention of students.

Literature study in the form of analysis of material interaction between particles which includes KI-KD, concept analysis, syllabus, and lesson plans, as well as reviewing theories regarding modules and similar research products in the form of research documents. The results of the study become a reference in the development of a chemical representation-based module on the interaction between particles. Literature studies were also carried out on relevant research.

The field study was conducted in 3 high schools in Lampung Province, namely SMA N 1 Kebun Sugarcane, SMA Negeri 1 Banjar Agung, MA PSA Istiqomah Islamiyah Tulang Bawang Barat by filling out online questionnaires using googleforms by 3 chemistry teachers (1 person in each school) and 30 students from three schools.

Based on filling out the questionnaire by the teacher, the data obtained: 1) there are teachers who have made teaching materials on interaction between particles in the form of a summary of material taken from several sources and learning modules; 2) teachers who have never made teaching materials, use books published by several publishers such as Erlangga and Bumi Aksara; 3) all teachers already know about chemical representations, especially submicroscopic phenomena, but they are not applied in making modules.

Based on filling out questionnaires by students, data obtained: 1) All students have received teaching materials from the teacher on the interaction material between particles in the form of textbooks and material summaries; 2) From the teaching materials obtained, students have difficulty understanding the teaching materials because the language or sentences are less communicative and the language used is incomplete; 3) Students stated that the teaching materials used were not interesting and their legibility was still lacking.

Based on the results of filling out preliminary questionnaires by teachers and students, all teachers and students gave their opinion that it is necessary to develop learning materials in the form of modules based on chemical representations on the interaction material between particles to help improve students' understanding of the interaction material between particles.

Chemical Representation-Based Module Development

The material for interactions between particles in this module consists of interactions between atoms, interactions between ions and interactions between molecules. The design of the module that is made contains the purpose of using the module to assist students in studying the interaction material between particles and to help teachers create student-centered learning activities. The users of this product are chemistry teachers and students of class XI science. The components of the module are: (1) The initial part consists of the outer cover, inner cover, preface, table of contents, KI, KD and indicators; (2) The content section consists of material titles, concept maps, material descriptions equipped with sub-microscopic images, sample questions, material summaries and evaluation questions along with their answers. (3) the closing part is the bibliography and the back cover

Figure 1. Title and subject matter of the developed module

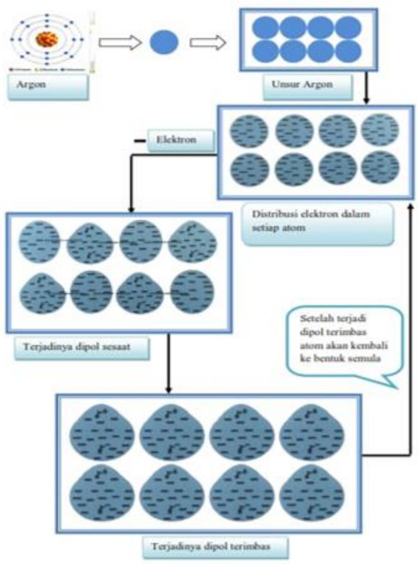

Figure 2. Example of a description of the material for the developed module

Expert Validation Results

Expert validation was carried out by 3 lecturers of chemistry education at the University of Lampung. This expert validation includes validation on aspects of content suitability, construct aspects, readability aspects, and attractiveness aspects. This validation is done by submitting the developed module to the validator and asking for an assessment of the statements contained in the questionnaire and writing suggestions for module improvement in the column provided. The average rating of the three validators can be seen in Table 4.

Table 4. Expert validation results on the developed module

No	Rated aspect	Percentage	Criteria
1	Content suitability	78,65%	High
2	Construct	77,79%	High
3	Legibility	71,44%	High
4	attractiveness	77,14%	High

The content suitability aspect consists of the suitability of the content of the material with KI-KD and the suitability of the content of the material with the chemical representation module. In the aspect of content suitability, the validator suggested that the core competencies and basic competencies be added to the learning curriculum. The construct aspect is to determine the suitability of the material construct in the chemical representation-based module on the interaction material between particles, the validator suggests that the image on the cover be changed according to the interaction material between particles and not just an image of a molecular model. The readability aspect is used to determine the readability of the module in terms of size and type of letters as well as the use of language. Several responses from validators on this readability aspect, namely, the font size on the cover title uses the largest size and the font size on the author's name uses the smallest size. The attractiveness aspect is used to determine the attractiveness of the module in terms of module size, module design, color combination, image layout, image quality, variations in font shape and size, and module print quality. As for suggestions on this aspect of attractiveness, namely the placement of pictures and picture descriptions must be appropriate so that students are not confused when observing pictures

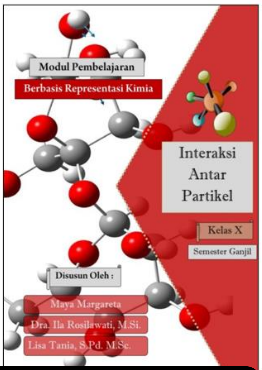

Figure 3. Outer cover before revision

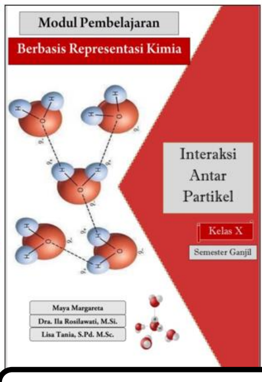

Figure 4. Outer cover after revision

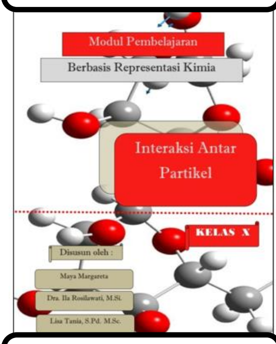

Figure 5. Inside cover before revision

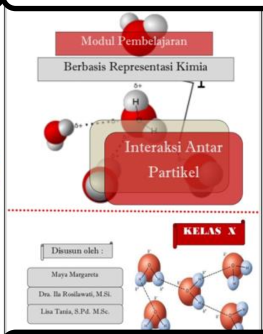

Figure 6. Inside cover after revision

The results obtained from expert validation are that the module has high criteria, so it is feasible to be used in the learning process. The module developed has been valid. This is in accordance with the opinion of Prasetyo (2012) that the results of the development are said to be valid if the results of expert validation have at least high criteria. Modules that have been declared valid or feasible by experts are expected to make it easier for students to understand the interaction material between particles.

Limited Trial Results on Teachers and Students

The limited trial was carried out at SMA N 1 Kebun Tebu, SMA Negeri 1 Banjar Agung, MA PSA Istiomah Islamiyah Tulang Bawang Barat, by submitting a chemical representation-based module on the interaction material between particles to teachers and students via online, to provide responses by filling out a questionnaire. available and write down suggestions for improvement. The teacher who was asked to respond to this module is a teacher in the field of chemistry studies who has graduated from chemistry education who has experience in teaching chemistry. The students who were asked to respond to the module development results were 30 students of class X in each school. The results obtained based on the responses of teachers and students are presented in Tables 5 & 6.

Table 5. Results of teacher responses to the module development results

No	Rated aspect	Percentage	Criteria
1	Content suitability	76,95%	High
2	Construct	86,12%	Very high
3	Legibility	77,80%	High
4	Attractiveness	73,87%	High

Table 6. The results of student responses to the module development results

No	Rated aspect	Percentage	Criteria
1	Legibility	80,1%	Very high
2	Attractiveness	81,56%	Very high

The teacher's response to the suitability of the content, construct and readability did not provide suggestions for improvement. While on the readability aspect, the teacher gave a response that the chemical representation image on the outer cover of the module was slightly broken, the teacher suggested improving the image quality so that it could be seen clearly. The teacher's response to the four aspects that are considered high and very high criteria, so that the interaction module between particles based on chemical representation is suitable for use in the learning process

The students' responses to the readability and attractiveness of the criteria module were very high, and students did not provide suggestions for improvement. Prasetyo (2012) revealed that the student's response was said to be positive if 50% of all questions received positive answers in high and very high criteria. So that the interaction module between particles based on chemical representation is suitable for use in the learning process. This is in accordance with the results of Julia's research (2017) which reveals that this positive response means that students are happy to use the developed module and the developed module can facilitate students' understanding of concepts.

- **CONCLUSION**

Based on the results of research and discussion, it can be concluded that (1). The chemical representation-based module on the interaction between particles developed is valid and suitable for use in learning at school. This can be seen from the percentage of validation results from the content validity, construction, readability, and attractiveness aspects of the three validators with high criteria; (2). The teacher's response to the chemical representation-based module that was developed included aspects of content suitability, construct, readability and attractiveness with high and very high criteria; (3). Student responses to the chemical representation-based module that was developed included aspects of readability and attractiveness which had very high criteria

- **REFERENCE**

Adisendjaja, Y. H. 2007. Analisis Buku Ajar Sains Berdasarkan Literasi Ilmiah Sebagai Dasar Untuk Memilih Buku Ajar Sains (Biologi). Seminar Nasional Pendidikan Biologi dan Biologi Jurusan Pendidikan Biologi FPMIPA UPI : Tidak Diterbitkan.

Borg,W.R.&Gall,M.D.1989. Educational Research: An Introduction, Fifth Edition. New York: Longman.

Cheng, M. dan Jhon, G. 2009. Towards a Better Utilization of Diagrams in Research Into the Use of Representative Levels in Chemical Education. In Multiple Representations in Chemical Education.p . 55-73.

Chittleborough, G., (2004). The Role Of Teaching Models And Chemical Representation In Developing Mental Models Of Chemical Phenomena.Thesis. Science and mathematics education centre.

Chittleborough, G., dan Treagust, D. F. 2007. “The Modelling Ability of Non Major Chemistry Student and Understanding of The Sub-Microscopic Level. Chemistry Education Research and Practice”. 8(3). 274-712.

Direktorat Pembinaan SMA. 2008. Panduan Pengembangan Bahan Ajar. Jakarta: Dirjen Manajemen Pendidikan Dasar dan Menengah Depdiknas.

Gabel, D.L., & Bunce, D. M. 1994. Research on Problem Solving: Chemistry. In D.L. Gabel (Ed). Handbook of research on science teaching and learning, (pp. 301-325). New York: Macmillan.

Gabel, D. 1998. The Complexity of Chemistry and Implications for Teaching. In B.J. Fraser and K.G. Tobin (Eds). International handbook of science education (Vol. 1, 233– 248). London: Kluwer Academic Publishers.

Johnstone, A. H. 1991. Why is Science Difficult to Learn? Things are Seldom What They Seem. Journal of Computer Assisted Learning, 7(2): 75-83.

Johnstone, A. H. 1993. The Development of Chemistry Teaching: A Changing Response to a Changing Demand. Journal of Chemical Education, 70(9): 701-705.

Nakhleh, M. B. 1992. Why Some Students Don’t Learn Chemistry: Chemical Misconceptions. Journal of Chemical Education, 69(3): 191-196.

Nuraini, N., Karyanto, P ., Sudarisman, S. (2014). Pengembangan Modul Berbasis POE (Predict, Observe, and Explain) Disertai Roundhouse Diagram untuk Memberdayakan Keterampilan Proses Sains dan Kemampuan Menjelaskan Siswa Kelas X SMA Negeri 5 Surakarta (Penelitian dan Pengembangan Materi Pencemaran Lingkungan Tahun Pelajaran 2013/2014). Jurnal Bioedukasi , 7 (1), 37-43.

Prasetyo, W. 2012. Pengembangan LKS dengan Pendekatan PMR pada Materi Lingkaran di kelas VII SMPN 2 Kepohbaru Bojonegoro. Mathedunesa Journal Vol. 1 No. 1 Tahun 2012. Surabaya: Unesa.

Purba, M. 2006. Kimia SMA/MA , kelas X. Penerbit Erlangga, Jakarta.

Rahardjo, S. B. 2008. Kimia Berbasis Eksperimen 2 , Kelas XI SMA dan MA. Solo: PT. Tiga Serangkai Pustaka Mandiri.

Ristiyani, E., dan Bahriah, E. F., (2016), Analisis Kesulitan Belajar Kimia Siswa Di SMAN X Kota Tangerang Selatan, JPPI, Vol. 2, No. 1, e-ISSN 2477-2038, Pendidikan Kimia, Universitas Islam Negeri Syarif Hidayatullah Jakarta: Jakarta.

Sari, A. 2015. Pembelajaran dengan Multi Representasi untuk Meningkatkan Penguasaan Konsepdan Kemampuan Pemecahan Masalah Siswa SMA pada Materi Hukum II Newton. Tesis. Malang: Universitas Muhamadiyah Malang.

Sudjana, N. 2005. Metode Statistika. Edisi keenam. PT Tarsito. Bandung.

Sudarmo, U. 2013. Kimia Untuk SMA/MA, Kelas X. Jakarta: Penerbit Erlangga.

Sukiman. 2012. Pengembangan Media Pembelajaran. Yogyakarta: PT. Pustaka Insan Madani.
Sukmadinata, N. S. 2015. Metode Penelitian Pendidikan. Bandung: PT. Remaja Rosdakarya.
Sunardi, G. 2012. Penggunaan Representasi Diagram untuk Meningkatkan Pemahaman Konsep Siswa SMK Tentang Materi Momentum Impuls. Disertasi. Bandung: UPI.
Sunyono. 2015. Model Pembelajaran Multipel Representasi. Media Akademi.Yogyakarta.
Supriadi, D. 2000. Anatomi Buku Sekolah di Indonesia. Adi Cipta: Yogyakarta.