

## Development of Handouts on Redox Material to Improve the Students Cognitive Abilities Using the *Sorogan-Bandongan* Learning Model

Nur Ainun, Rinaningsih\*

Chemistry Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya,  
Surabaya, Indonesia

\*e-mail: [rinaningsih@unesa.ac.id](mailto:rinaningsih@unesa.ac.id)

Received: March 10, 2026. Accepted: May 1, 2026. Published: May 21, 2026

**Abstract:** The *Sorogan-Bandongan* learning model is a traditional approach to enhancing students' cognitive abilities through a structured series of activities, including diagnostic testing, independent practice, and self-reflection. This model effectively bridges student-centered individual learning (*Sorogan*) with collective discussion and evaluation (*Bandongan*), fostering both personal responsibility and collaborative engagement. This Research and Development (R&D) study, employing Thiagrajan's 4D model (Define, Design, Develop, Disseminate) through the development stage, aims to evaluate the feasibility of a chemistry handout on redox reactions based on this model. The feasibility was assessed through three main criteria: validity, practicality, and effectiveness. Analysis of the research instruments revealed that the handout is highly qualified across all parameters. In terms of validity, both content and construct aspects received a mode score of 4, placing them in the "highly valid" category. Regarding practicality, the handout earned a 94.11% student response rate, while direct observations of student activities across three sessions yielded consistently high scores between 96.67% and 97.78%, categorizing it as "very practical." Finally, the effectiveness of the handout was demonstrated by a significant improvement in student learning outcomes. The analysis of pretest and posttest results showed an average N-Gain Score of 0.77, which falls into the "high" category, with a class mastery rate of 100%. These results confirm that integrating the *Sorogan-Bandongan* learning model into chemistry handouts is a highly effective and feasible strategy for improving students' cognitive understanding of redox material.

**Keywords:** Handout; Redox; *Sorogan-Bandongan*.

### Introduction

Chemistry is a natural discipline that focuses on the characteristics, composition, structure, and energy of substances as they change. Chemistry is a much bigger discipline that includes grasping the idea of cognitive knowledge in addition to mathematics [1]. Chemistry requires a thorough grasp, as it involves abstract and difficult topics. Real chemistry may be understood by grasping the idea of abstract chemistry. Strong comprehension becomes crucial in this course this abstract idea necessitates that students be able to connect theory to actual facts [2]. Knowing or comprehending science and using science in technology are the three primary phases of learning chemistry as a component of science. A range of learning materials and new learning models are among the advances in education that make use of technology advancements [3]. A Handout is a summary of material that is organized systematically, concisely, and is easy to understand. This teaching material is designed to help students understand important concepts in a relatively short time, making it suitable for supporting complex chemistry learning [4]. For learning to be more effective, the use of handouts should be reinforced by the implementation of a learning model that encourages active student participation [5]. One model that is in line with the principles of the independent curriculum is the *Sorogan-Bandongan* learning model [6].

Through a variety of learning activities, such as reading and working on handouts, diagnostic tests, independent practice based on test results, teacher reinforcement of concepts, and self-reflection, the *Sorogan-Bandongan* learning model is a traditional approach that effectively trains learners' responsibility [7]. Individual (*Sorogan*) and group (*Bandongan*) techniques are given priority in this paradigm so that students are not only accountable for their own work but also participate in group discussions and evaluation [8]. According to recent studies, this methodology may greatly enhance students' learning outcomes. For example, in redox chemistry, posttest scores surpassed the minimum completion criteria, and the n-gain values reached the medium category (0,60) [9]. Unlike the study, which focused on the instructional effectiveness of the *Sorogan-Bandongan* model in acid-base topics, the uniqueness of this study lies in the formalization of that model into a learning medium in the form of a handout [10]. This integration aims to synchronize traditional individual tutoring patterns with the needs of redox material, which has high cognitive complexity, so that it is expected to produce an improvement in more structured and independent thinking skills for students.

Additionally, this strategy accounts for students' different learning styles to efficiently enhance understanding of the concept [11]. While the previous study focused on developing chemistry handouts based on Chemoentrepreneurship for topics such as buffer solutions,

### How to Cite:

N. Ainun and R. Rinaningsih, "Development of Handouts on Redox Material to Improve the Students Cognitive Abilities Using the *Sorogan-Bandongan* Learning Model", *J. Pijar.MIPA*, vol. 21, no. 3, pp. 446–456, May 2026. <https://doi.org/10.29303/jpm.v21i3.11769>

salt hydrolysis, and colloids, achieving 75% validity and 85% practicality, my study emphasizes redox reactions, integrating the *Sorogan-Bandongan* learning model. The fundamental difference lies in the orientation of their objectives; Deswita and Dona's study placed greater emphasis on the entrepreneurial aspects of chemistry, whereas this study specifically aims to enhance students' cognitive abilities through a traditional pesantren learning approach adapted to science content. Thus, this study is expected not only to produce valid and practical teaching tools but also to provide deeper cognitive stimulation through the intensive interaction patterns characteristic of the *Sorogan-Bandongan* model [12]. The uniqueness of this study lies in the integration of the traditional *Sorogan-Bandongan* learning model into structured handout teaching materials, specifically designed to address the cognitive complexity of redox concepts, thereby combining the effectiveness of personalized guidance in Islamic boarding schools with the practicality of modern learning media.

Teaching materials used in learning determine the quality of students' understanding. At MAN 2 Gresik, after preliminary research, students are no longer allowed to purchase workbooks. As an alternative, teachers provide teaching modules that include textbooks, e-books, modules and PowerPoint (PPT) presentations. However, based on questionnaire and interview results, most students stated that they rarely read these teaching materials because the language was difficult, there was too much material, and the presentation was unattractive. As a result, students' understanding of chemistry concepts was low, as evidenced by daily and formative assessments with scores below the Minimum Passing Criteria (MPC) and minimal active student participation in class discussions. As many as 85% of students never use handout-based teaching materials in chemistry learning, so the potential of this medium has not been fully realised.

By combining Handout learning media and the *Sorogan-Bandongan* learning model in redox material, which aims to produce teaching materials that are interesting, useful, and have the ability to optimize students' cognitive understanding, as well as having the ability to assist teachers in carrying out learning that is relevant, practical, and capable of improving students' cognitive understanding and assisting teachers in the learning process in the classroom [13].

The Handouts development format includes key components such as the cover, preface, table of contents, concept map, learning objectives, instructions for use, reading materials, and practice questions. The developed handout is accompanied by picture illustrations [14]. The presence of picture illustrations in the Handout greatly helps students understand the material visually and contextually, facilitating learning, especially for abstract concepts. Handouts are a tool for compiling printed teaching materials that are more structured, easier to understand, and more interesting. Students actively participate in classroom learning activities without having to take many notes [15]. Handouts can include explanations, questions, students' activities, and responses or follow-ups. Handouts can serve as teaching materials, with functions added to develop them, such as evaluation instruments. Based on this background, the author was interested in conducting a research project titled "Development of Handouts on Redox Material to

Improve the Cognitive Abilities of Students in Madrasah Aliyah Using the Sorogan-Bandongan Learning Model." The novelty of this research lies in the development of a handout on redox materials using the Sorogan-Bandongan learning model, which includes tasks designed to improve cognitive abilities. The purpose of this research is to develop and determine the feasibility of the Handouts on redox material based on validation, practicality, and effectiveness [16].

## Research Methods

The type of research used in this study is research and development (R&D) [17]. In this study, Handout redox by adapting [18] The 4-D model research and development method by Thiagarajan consists of 4 stages: define, design, develop, and disseminate. However, this study is limited to the development stage. The research procedure is as follows. The define stage contains activities to analyse and determine the product, including learner analysis, which covers learner characteristics related to academic ability, cognitive development, motivation, and individual skills. Task analysis, which is related to the main tasks that students will do to be able to achieve the skills expected by researchers, analyzes the concepts to be taught and formulates learning objectives [19]. The design stage involves developing an initial research design, including selecting the media to be used to develop Handouts. The development stage is the stage in which a product is developed, including expert appraisal. At this stage, the learning media developed receive suggestions for improvement from the expert and are further revised accordingly. After being declared valid, developmental testing is carried out, which aims to get direct input from responses, reactions, and comments from students and observers on the learning tools that have been developed [17].

Data collection for this study was conducted with 30 students at MAN 2 Gresik through interviews with chemistry teachers and several students regarding the use of teaching materials at the school. Furthermore, a pre-research questionnaire, distributed online or in written form, was administered before the study began. This included a handout review questionnaire containing suggestions and critiques from the supervising lecturer regarding the developed handout. The handout validation form was completed by two chemistry education lecturers and one chemistry teacher using the provided validation sheet. The validation questionnaire was designed to ensure the handout was suitable for use in the study. The validation process included content validity and construct validity. Content validity covers the completeness and alignment of the handout material with the curriculum, learning objectives, the *Sorogan* learning method, and student learning outcomes. Construct validity covers whether the handout meets the requirements as teaching material, including presentation, language, and graphics. A student response questionnaire was completed by 30 students after using the developed handout. The distribution of the response questionnaire to students aimed to describe their reactions to the handout following the pilot test. The third method, the observation method, involves regular observation activities. In this study, student activity observation sheets were used to directly observe the trial of the handout on redox material

using the *Sorogan-Bandongan* learning model. Five observers each observed six students in this study. The final method was the test method, which consisted of multiple-choice questions administered to the students. There were two tests: the pre-study test, which aimed to assess students' knowledge of redox material and served as the basis for selecting the learning media, and the pretest-posttest, which aimed to identify differences in students' learning outcomes before and after the intervention, as well as to measure improvements in their understanding of the material.

The following is a description of the procedure for "Developing Handouts on Redox Materials to Improve Students' Cognitive Abilities in Senior High Schools Using the *Sorogan-Bandongan* Learning Model."

1. Definition (Define). The objective is to review the current curriculum, gather information about student characteristics, issues arising during the learning process, teaching strategies implemented by teachers, and other supporting materials.
2. Design. In this stage, the handout is designed to consist of five subtopics: redox concepts based on the release and combination of oxygen; redox concepts based on the release and acceptance of electrons; determining oxidation numbers; redox reaction concepts based on oxidation numbers; and determining IUPAC nomenclature of compounds based on oxidation numbers. There are two stages: format selection and initial design.
3. Development. The development phase aims to refine and validate the handout. The handout produced after the review was refined and became Draft II. Draft II was validated by chemistry education faculty members and chemistry teachers at MAN 2 Gresik. During this process, the validators utilized the media designed during the definition and design phases. Validators rate the developed handout based on the indicators on the evaluation sheet and provide comments or suggestions. Validation continues until the instructional material is proven valid for use in learning activities. The validation results are reviewed and followed up by revising the instructional material in accordance with the validators' comments or suggestions.
4. Limited pilot test. The revised and validated handouts can be used for teaching and learning activities. The objective of this stage is to collect research data, specifically on improvements in students' cognitive abilities related to redox materials. The results of this stage will be analyzed and form the conclusion of this study. The results of this limited pilot test will then be analyzed to determine the feasibility of the developed handout. This limited pilot test is conducted by administering a response questionnaire to students regarding the instructional materials used. Feedback on the instructional materials is considered valid if it meets the criteria. If not, the materials are revised and retested. [20].

The research sample amounted to 30 students of class XII MAN 2 Gresik [20]. The next step is to use data analysis techniques to assess the Handouts' applicability to redox content using a student's response questionnaire. The questionnaire consists of positive and negative statements, and then analyzed using quantitative descriptive methods.

The results are examined using the Guttman scale score as follows [21].

**Table 1.** Guttman Scale For Learner Response Questionnaire

Activity Implementation	Positive Statement Score	Negative Statement Score
Yes	1	0
No	0	1

From Table 1, it can be concluded that if a student answers "Yes" to a positive statement, they receive a score of "1"; if they answer "Yes" to a negative statement, they receive a score of "0." The following formula can be used to calculate the percentage of student responses. The data obtained was then analyzed using percentages.

$$\text{Percentage (\%)} = \frac{\text{number of scores on each aspect}}{\text{number of respondents}} \times 100\%$$

The percentages obtained are interpreted according to the criteria shown in Table 2. In this study, a student's response was considered to meet the criteria if it received a score of  $\geq 61\%$ , meaning the handout can be deemed good or very good for use.

**Table 2.** Criteria for Interpreting Student Response Scores

Percentage (%)	Criteria
0-20	Not Very Practical
21-40	Not Practical
41-60	Quite Practical
61-80	Practical
81-100	Very Practical

Furthermore, the response questionnaire was supplemented by student activity observation sheets. The students' observations revealed activities relevant to the observation indicators. The observational data were analyzed quantitatively. In evaluating the observational data, the students' activities were scored using the Guttman scale in Table 3.

**Table 3.** Guttman Scale For Observation of Student Activity.

Activity Implementation	Positive Statement Score
Yes	1
No	0

The data obtained was then analyzed using percentages.

$$\text{Percentage (\%)} = \frac{\text{number of scores on each aspect}}{\text{number of respondents}} \times 100\%$$

The results from the student response questionnaires and student activity observation sheets are interpreted as percentages of the practicality criteria as follows.

**Table 4.** Percentage of Practicality Criteria

Percentage (%)	Criteria
0-20	Not Very Practical
21-40	Not Practical
41-60	Quite Practical
61-80	Practical
81-100	Very Practical

Based on Table 4, Student activities in this study were deemed to meet the criteria if they achieved a percentage of  $\geq 61\%$ , meaning the handout can be considered good or very good for use [22]. Knowledge test data were collected through pretest and posttest questions. These test sheets were analyzed using quantitative descriptive methods to determine individual and class-level mastery of the material, as well as to assess improvements in student learning outcomes. Individual mastery is calculated using the following formula:

$$\text{Individual Mastery} = \frac{\text{Student's score}}{\text{Maximum score}} \times 100 \%$$

A student's knowledge assessment is considered passed on an individual basis if the student's score is  $\geq 75$  based on the minimum passing score. Meanwhile, the calculation of class-wide proficiency uses the following formula:

$$\text{Classical Mastery} = \frac{\text{Number of students who passed}}{\text{Total number of students}} \times 100 \%$$

The classical achievement scores obtained are interpreted according to the criteria shown in Table 5. A student's knowledge test is considered passed if the student scores  $\geq 75$  and achieves  $\geq 61\%$ . These scores indicate that the handout was used effectively or very effectively.

**Table 5.** Criteria for Interpreting Student Response Score

Percentage (%)	Criteria
0-20	Not Very Practical
21-40	Not Practical
41-60	Quite Practical
61-80	Practical
81-100	Very Practical

Improvements in learning outcomes can be observed from students' pretest and posttest scores. The magnitude of the improvement can be calculated using the N-Gain formula. The data analysis technique used to measure the effectiveness of the Handout on redox material is the learner's responsibility, using the n-gain analysis method.

$$\langle g \rangle = \frac{\text{posttest} - \text{pretest}}{S_{\text{max}} - \text{Pretest}}$$

The n-gain score obtained is interpreted based on the following table [10]. Based on the N-Gain score criteria, the developed handout can be considered suitable for use if the improvement in student learning outcomes meets  $\geq 0.7$  (high criterion) or  $\geq 0.3$  (moderate criterion).

**Table 6.** N-gain Scoring

N-gain score $\langle g \rangle$	Category
$g \geq 0.7$	High
$0.7 > g \geq 0.3$	Medium
$g < 0.3$	Low

## Results and Discussion

The results of the Handout development research on redox material, using the Sorogan-Bandongan learning model, aim to describe the feasibility of the Handout. There

are three aspects that qualify the feasibility of a media, namely validity, practicality, and effectiveness [23].

The four steps of Thiagarajan's 4D development design. Define, design, develop, and disseminate the wee applied in the creation of the Handout for this study. In order to ascertain the product's applicability, the study's development stage was restricted to the develop stage through a small number of trials [18].


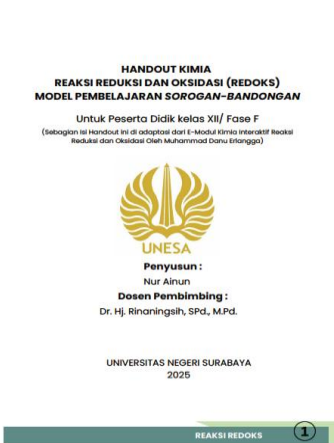
The first front-end analysis, second learner analysis, third task analysis, fourth concept analysis, and fifth formulation of learning objectives (specifying instructional objectives) are all completed within the define stage. The curriculum employed and the issues encountered by one of the Gresik schools are the outcomes of the front-end analysis. According to the interview's findings, the school is still implementing the autonomous curriculum, but because the learning materials are still in the adaptation stage, one of them has never used handouts, and they do not fully complement the applied curriculum [24]. Additionally, chemistry classes are considered rather challenging, particularly for students with middle- to lower-ability levels. This is especially true with redox materials. Therefore, there is a need for Handouts leaning resouces that can be accessed by students from anywhere and at any time [25].

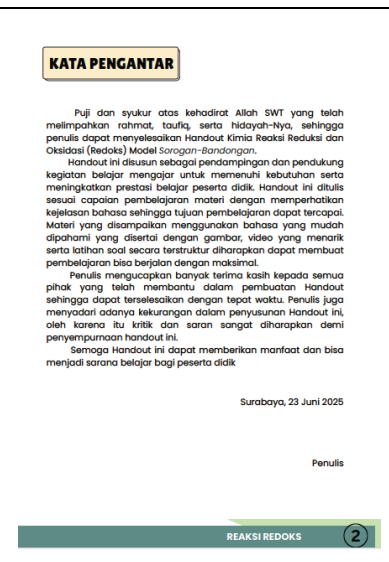
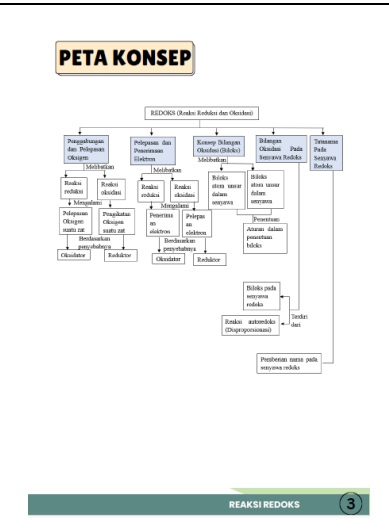
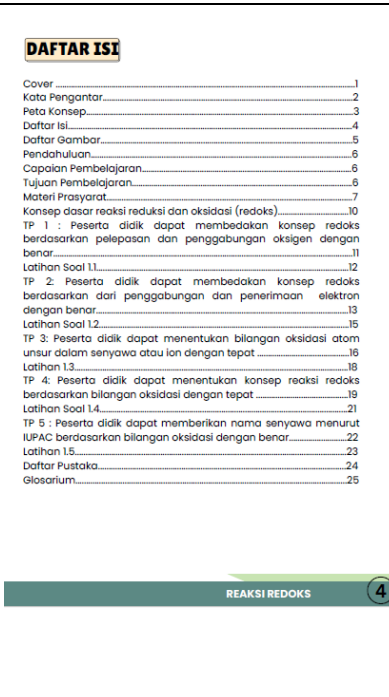
Based on these characteristics, it is necessary to develop learning media that focus on cognitive aspects. On relevant solutions in the development of Handouts as learning media, which have the advantage of encouraging students to learn independently and take responsibility for their learning process [26]. The use of this learning media significantly improves students' cognitive abilities. Therefore, the development and use of handouts as a learning media is not only an innovative alternative in overcoming the obstacles of abstract chemistry learning, but also a strategic means of fostering a sense of responsibility in students, which is essential for sustainable learning success [15]. Based on the analysis of the tasks created in the Handout on redox material, the main objective is to improve students' cognitive abilities, which are adjusted to the syntax of the *Sorogan-Bandongan* learning model [27]. Next is the formulation of the concept to be discussed in the Handout, and the determination of learning objectives based on the curriculum used and learning outcomes [28].

The next stage is design, which involves designing learning media developed in the form of a handout. The task in the design stage is to design learning media in the form of a handout. The process at this stage is described as follows: 1. Test Development. The test preparation stage is carried out after analyzing learning outcomes and setting learning objectives. Test preparation includes tasks to be included in the handout and related materials. Based on the formulated learning objectives, the handout is divided into five subchapters on redox material, with one prerequisite material that must be completed before studying redox material. The prerequisite material is Colligative Properties of Solutions. The 5 different redox material subchapters are the concept of redox reactions based on the combination and release of oxygen, the concept of redox reactions based on the release and acceptance of electrons, the concept of oxidation numbers (oxidation numbers), the concept of redox based on oxidation numbers and nomenclature in redox compounds [29]. The test can take the form of practice questions that help students understand the material on redox. These

questions are designed to help students better understand the ideas taught by using real phenomena as examples. Based on the questions presented, students can determine the oxidation number of an element or compound [30]. 2. Media Selection. In the research conducted to develop handouts suitable for students' needs, the platform selected was Canva, a web-based application for editing handouts. 3. Format Selection. The format selection stage is where the researcher determines the format for compiling the on redox material to improve students' cognitive abilities. The components in the independent curriculum handout are the title, subject, class, instructions for use, learning outcomes, learning objectives, and assignments. While preparing the handout, the feasibility of its presentation, language, and graphics must also be considered. This needs to be considered to develop an attractive, innovative handout that builds students' desire and interest. 4. Initial Design. The initial design outlines the main activities for developing a handout on redox materials using the *Sorogan-Bandongan* learning model. The designed handout is consulted with the relevant supervising lecturer to determine its suitability for use. The components of the handout on redox materials can improve students' cognitive abilities, as shown below [9].

Table 7. Development of Handout

Information	Design
<p>The front cover of the handout serves as a visual cue to increase motivation to learn and provides an initial overview of the learning material.</p>	
<p>The author's Identity on the handout serves as a form of accountability and a reference source that facilitates coordination and verification of the material's authenticity by teachers, students, and school officials.</p>	

<p><b>Foreword</b> A preface is an introductory section in a written work (paper, thesis, report, book) that helps readers understand the context, purpose, and general overview of the content.</p>	
<p><b>Main Map</b> The primary purpose of a redox concept map is to visualize, simplify, and connect complex chemical concepts related to reduction and oxidation reactions, making them easier to understand and remember.</p>	
<p><b>Table of Contents</b> Functions as a navigation aid, content roadmap, and structural overview for Handout</p>	



Oxidation number concept material. The objective is for students to be able to correctly determine the oxidation numbers of atoms of elements in compounds or ions.

### Konsep Bilangan Oksidasi (Biloks)

**Tujuan Pembelajaran (TP) 3:** Peserta didik dapat menentukan bilangan oksidasi atom unsur dalam senyawa atau ion.

**Bilangan Oksidasi Senyawa** adalah jumlah muatan listrik yang dimiliki atom-atom suatu senyawa, dimana elektron ikatan didistribusikan ke atom yang lebih elektronegatif.

**Bilangan Oksidasi atom** adalah muatan listrik yang dimiliki suatu atom dalam sebuah senyawa.  
Contoh: biloks HCl adalah 0, biloks Mg<sup>2+</sup> adalah +2, dan biloks F adalah -1

Aturan - aturan di bawah ini disusun berurutan menggunakan aturan bernomor lebih rendah terlebih dahulu, lalu gunakan aturan bernomor lebih tinggi.

**Urutan aturan dalam penentuan bilangan oksidasi suatu unsur dalam senyawa:**

- Jumlah biloks seluruh atom dalam senyawa netral = 0
- Jumlah biloks seluruh atom dalam ion = muatan ion tersebut
- Biloks atom-atom unsur bebas (yaitu dalam keadaan tidak bergabung dengan unsur lain) = 0, contohnya O<sub>2</sub>, Cl<sub>2</sub>, P<sub>4</sub>, S<sub>8</sub>

**REAKSI REDOKS 16**

Practice questions on oxidation number concepts. The goal is for students to practice problems to improve their cognitive understanding of oxidation numbers.

**Penyelesaian:**  
a) H<sub>2</sub>S

**Aturan 1:** H<sub>2</sub>S adalah senyawa netral (tidak bermuatan). Sehingga jumlah biloks seluruh atom dalam senyawa tersebut = 0

**Aturan 5:** unsur H dalam senyawa memiliki biloks = +1 sehingga biloks H<sub>2</sub>S dapat dihitung dengan cara:

$$\begin{matrix} 2(\text{biloks H}) + \text{biloks S} = 0 \\ 2(+1) + \text{S} = 0 \\ 2 + \text{S} = 0 \\ \text{S} = -2 \end{matrix}$$

Jadi, didapatkan biloks S sebesar -2

b) SCl<sub>2</sub>

**Aturan 1:** SCl<sub>2</sub> adalah senyawa netral (tidak bermuatan). Sehingga jumlah biloks seluruh atom dalam senyawa tersebut = 0

**Aturan 7:** unsur Cl termasuk dalam golongan VII A memiliki biloks = -1 sehingga biloks SCl<sub>2</sub> dapat dihitung dengan cara berikut ini:

$$\begin{matrix} 2(\text{biloks Cl}) + \text{biloks S} = 0 \\ 2(-1) + \text{S} = 0 \\ -2 + \text{S} = 0 \\ \text{S} = +2 \end{matrix}$$

Jadi, didapatkan biloks S sebesar +2

**LATIHAN SOAL 13**

Tentukan Bilangan Oksidasi unsur Kromium (K) dalam senyawa berikut:

a) KMnO<sub>4</sub>      b) KClO<sub>3</sub>      c) KCl

**REAKSI REDOKS 18**

Oxidation number of the material in redox compounds. The goal is for students to be able to correctly analyze the concept of redox reactions based on oxidation numbers.

### Bilangan Oksidasi Pada Senyawa Redoks

**Tujuan Pembelajaran (TP) 4:** Peserta didik dapat menentukan konsep reaksi redoks berdasarkan bilangan oksidasi.

**1. Bilangan Oksidasi pada Reaksi Redoks**

Bilangan oksidasi dapat digunakan untuk menentukan zat yang mengalami oksidasi dan reduksi pada suatu reaksi redoks.

**Oksidasi** melibatkan naiknya bilangan oksidasi suatu unsur.

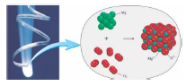
**Reduksi** melibatkan turunnya bilangan oksidasi suatu unsur.

Dalam reaksi redoks terdapat istilah oksidator dan reduktor. **Oksidator** adalah zat yang mengoksidasi zat lain dengan cara menerima elektron, (mengalami reduksi). **Reduktor** adalah zat yang mereduksi zat lain (mengalami oksidasi).

**Oksidator** mengalami reduksi.

**Reduktor** mengalami oksidasi.

Sebagai contoh, bagaimana definisi tersebut berlaku untuk reaksi antara logam magnesium (Mg) dengan gas oksigen (O<sub>2</sub>) membentuk magnesium oksida (MgO).



Gambar 4. Reaksi antara Logam Mg dengan gas O<sub>2</sub>  
(Sumber: Brown, 2018)

Pada gambar 4 memiliki persamaan reaksi yaitu:

$$2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$$

**REAKSI REDOKS 19**

Practice questions on oxidation numbers in redox compounds. The goal is for students to practice problems to improve their cognitive skills regarding redox concepts based on oxidation numbers

**Penyelesaian:**

1)  $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$

$\begin{matrix} 0 & + & -1 & \rightarrow & +2 & + & 0 \\ \text{Zn} & & \text{HCl} & & \text{ZnCl}_2 & & \text{H}_2 \\ \text{Oksidasi} & & & & \text{Reduksi} & & \end{matrix}$

Pada perubahan biloknya bahwa terjadi penurunan biloks pada unsur H dari +1 menjadi 0, menunjukkan bahwa unsur H tereduksi. Sedangkan terjadi penambahan biloks unsur Zn dari 0 menjadi +2 yang menunjukkan bahwa unsur Zn teroksidasi. Reaksi tersebut termasuk reaksi redoks.

2)  $2\text{H}_2\text{S} + \text{SO}_2 \rightarrow 3\text{S} + 2\text{H}_2\text{O}$

$\begin{matrix} -2 & + & +4 & \rightarrow & 0 & + & 0 \\ \text{H}_2\text{S} & & \text{SO}_2 & & \text{S} & & \text{H}_2\text{O} \\ \text{Oksidasi} & & & & \text{Reduksi} & & \end{matrix}$

Pada perubahan biloknya bahwa terjadi penurunan biloks pada unsur S dari +4 menjadi 0, menunjukkan bahwa unsur S tereduksi. Namun pada unsur S pula terjadi penambahan biloks dari -2 menjadi 0 yang menunjukkan bahwa unsur S teroksidasi. Reaksi ini merupakan reaksi autoredoks karena unsur yang sama mengalami oksidasi dan reduksi.

**LATIHAN SOAL 14**

Tentukan apakah reaksi berikut merupakan reaksi redoks atau bukan! Jelaskan dengan memeriksa perubahan bilangan oksidasi.

a)  $\text{Fe}_2\text{O}_3 + 6\text{HCl} \rightarrow 2\text{FeCl}_3 + 3\text{H}_2\text{O}$

b)  $2\text{Mg (s)} + \text{O}_2 (\text{g}) \rightarrow 2\text{MgO (s)}$

**REAKSI REDOKS 21**

Material on the nomenclature of redox compounds. The objective is for students to be able to correctly analyze compound names according to IUPAC based on oxidation numbers.

### Tatanama Pada Senyawa Redoks

**Tujuan Pembelajaran (TP) 5:** Peserta didik dapat memberikan nama senyawa menurut IUPAC berdasarkan bilangan oksidasi.

Pada tata nama senyawa biner khususnya yang terdiri dari logam dengan non-logam, di mana bilangan oksidasi memengaruhi nama senyawa tersebut. Jika suatu logam memiliki lebih dari satu macam bilangan oksidasi, bilangan oksidasinya ditunjukkan dengan angka romawi dalam tanda kurung setelah nama logamnya, yang kemudian diikuti nama unsur non-logam yang diberi akhiran -ida.

Logam + (Bilangan Oksidasi Logam) + Non-Logam + -ida

**Contoh Soal:**  
Lebih dari separuh logam vanadium yang diproduksi di Amerika Serikat dicampur dengan baja untuk meningkatkan kekuatan baja. adalah katalis penting dalam industri kimia dan digunakan dalam pembuatan nilon dan produksi asam sulfat, asetaldehid dan asam oksalat. V<sub>2</sub>O<sub>5</sub> juga menghasilkan pigmen hitam untuk industri pewarna. Tentukan nama senyawa V<sub>2</sub>O<sub>5</sub>.

**Penyelesaian:**

$$\begin{matrix} \text{V}_2\text{O}_5 \\ 2(\text{biloks V}) + 5(\text{biloks O}) = 0 \\ 2(\text{V}) + 5(-2) = 0 \\ 2\text{V} + (-10) = 0 \\ 2\text{V} = +10 \\ \text{V} = +5 \end{matrix}$$

Dalam senyawa ini unsur Vanadium (V) memiliki biloks +5. Sehingga nama senyawanya adalah **Vanadium (V) oksida**.

**REAKSI REDOKS 22**

Practice questions on redox compound nomenclature. The goal is for students to practice problems to improve their cognitive skills regarding the nomenclature of redox compounds

**LATIHAN SOAL 15**

Tentukan nama senyawa redoks berikut ini berdasarkan bilangan oksidasinya dan jelaskan!

a) N<sub>2</sub>O<sub>5</sub>      b) Fe(NO<sub>3</sub>)<sub>2</sub>      c) Na<sub>2</sub>SO<sub>3</sub>

**REAKSI REDOKS 23**

<p><b>Bibliography.</b> A bibliography serves to document sources used in research, establish credibility, and enable further exploration of a topic.</p>	<p style="text-align: center;"><b>DAFTAR PUSTAKA</b></p> <p>Azizah, U, dkk. (2017). <i>Kimia Dasar I</i>. Surabaya: Unesa University Press.</p> <p>Brown, T. L, LeMay, H.E, Bursten, B. E, Murphy, C. J, Woodward, P. M, &amp; Stoltzfus, M. W. (2018). <i>Chemistry : The Central Science (14<sup>th</sup> in SI Units ed.)</i>. Harlow: Pearson</p> <p>Chang, R. (2010). <i>Chemistry</i>. New York: McGraw Hill.</p> <p>Diangranda, L, Gregg, K.V, Hainen, N, &amp; Wistrom, C. (2014). <i>Glencoe Chemistry : Matter and Change</i>. New York: McGraw Hill.</p> <p>Jespersen, N.D, Brady, J. E., &amp; Hystop, A. (2012). <i>Chemistry: The Molecular Nature of Mater</i>. Hoboken: Wiley.</p> <p>Muchtaridi. (2017). <i>Kimia SMA Kelas XI</i>. Jakarta: Yudhistira.</p>
<p><b>Glossary.</b> A glossary functions as an alphabetical list of specialized, technical, or unfamiliar terms with definitions, usually located at the end of the handout.</p>	<p style="text-align: center;"><b>GLOSARIUM</b></p> <ol style="list-style-type: none"> <li>1. Atom : Atom adalah partikel terkecil dari suatu unsur yang masih memiliki sifat-sifat unsur tersebut.</li> <li>2. Bilangan Oksidasi : Muatan relatif suatu atom dibandingkan atom lain dalam molekul atau ion.</li> <li>3. Ion : Atom atau molekul bermuatan karena kehilangan atau menerima satu atau lebih elektron.</li> <li>4. Korosi : Perusakan logam karena adanya sebuah reaksi redoks antara logam dengan berbagai zat di lingkungannya.</li> <li>5. Logam transisi : Unsur-unsur logam yang menempati golongan transisi B dalam tabel periodik.</li> <li>6. Metaloid : Unsur yang sifat-sifatnya berada di antara logam dan nonlogam padat.</li> <li>7. Molekul : Gabungan dua atau lebih atom yang berikatan secara kimia.</li> <li>8. Non Logam : Unsur atau zat yang tidak memiliki semua sifat logam.</li> <li>9. Oksidasi : Hilangnya elektron dari atom suatu zat.</li> <li>10. Oksidator : Zat yang mengoksidasi zat lain.</li> <li>11. Produk : Zat yang ada pada akhir reaksi kimia.</li> <li>12. Reaksi Redoks : Suatu reaksi kimia di mana elektron berpindah dari satu zat ke zat yang lainnya.</li> <li>13. Reaktan : Zat yang ada pada awal reaksi kimia.</li> <li>14. Reduksi : Penerimaan elektron oleh atom suatu zat.</li> <li>15. Reduktor : Zat yang mereduksi zat lain.</li> <li>16. Senyawa : Gabungan dua atau lebih atom dari unsur yang berbeda jenis yang berikatan secara kimia.</li> <li>17. Spasi : Atom, molekul, dan ion yang mengalami reaksi kimia.</li> </ol>

The third stage develops an E-Worksheet through the steps of review, revision of review results, validation, and testing. The review was conducted to obtain expert suggestions/comments on the draft Handout, which had been prepared as a basis for improvement in the event of errors. The review was conducted by one lecturer from the Chemistry Education study program. The initial Handout (draft I) has been revised to draft II and then validated by the following validators: 1 chemistry teacher and 2 chemistry education lecturers.

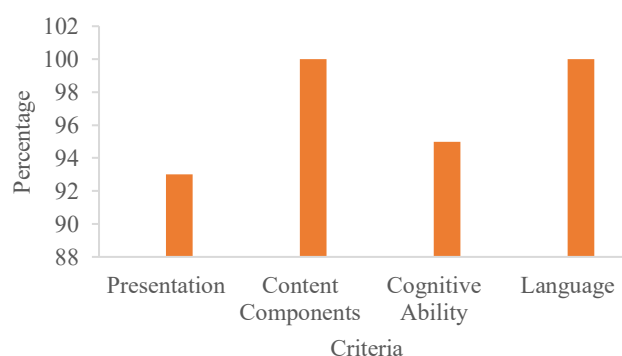
In content validation, the suitability of the Handout with respect to learning outcomes and learning objectives gets mode 4, the suitability with the Sorogan-Bandongan learning model gets mode 4, the suitability with cognitive ability indicators gets mode 4, and the suitability with language gets mode 3. In construct validation based on aspects of chemical characteristics gets mode 3, suitability with the characteristics of students gets mode 3, presentation criteria gets mode 4, and graphic criteria gets mode 4 [31].

Based on validation conducted by 3 validators of the Handout on redox material, the Handout is valid for use. The E-Worksheet has undergone comprehensive revisions based on input and suggestions from the three validators, and it is now declared valid and suitable for use as learning media and for testing. The validated handout is then called draft III.

After the validation stage, which yielded valid results, the Handout was then tested in a limited trial with 30 students in class XI at MAN 2 Gresik. The limited trial was conducted to determine the practicality and effectiveness of the developed Handout.

Practicality data are obtained through a learner response questionnaire and observation of learner activities during the use of the Handout, which directly reflect ease of use, media attractiveness, and learner involvement in the learning process. The Handout developed is declared practical if the percentage reaches  $\geq 61\%$  [16].

The presentation aspect of the Handout received an average classification of 93% as very practical, indicating that the material is easy to understand and interesting to students. In terms of content components, the Handout received an average score of 100% and was classified as very practical, indicating that the material presented is relevant, comprehensive, and appropriate for students' learning needs, making it an effective learning resource. In terms of linguistics, the Handout received an average score of 100% and was categorized as very practical, indicating that the language used in the Handout is communicative, easy to understand, and in accordance with Indonesian language rules.



**Figure 1.** Results of Student Response Questionnaire

Based on the students' response questionnaire to the Handout, the average positive response was 97%, and the average negative response was 3%, indicating that the Handout was in the very practical category and could be used for learning [32].

Relevant activities accounted for 96.67% in the first meeting, while irrelevant activities accounted for 3.33%. In the second meeting, relevant activities accounted for 97.22% and irrelevant activities for 2.78%. In the third meeting, relevant activities accounted for 97.78% and irrelevant activities for 2.22%.

In the first meeting, relevant activities included seven indicators, namely students paying attention to the teacher's explanation, students taking a pretest, students reviewing or reading handouts, students reading and understanding the information contained in the handouts and doing the exercises, students paying attention to the teacher explaining the redox material, students asking questions to the teacher, and students conducting learning evaluations. In activity 2, namely the pretest, students completed it for 15-20 minutes. The pretest consisted of 15 multiple-choice questions on redox material. The total relevant activity reached 96.67%, while irrelevant activity reached 3.33%. In the second meeting, relevant activities included seven indicators,

namely: students paying attention to the teacher; students reviewing or reading handouts; students continuing to work on exercises provided in the handouts; students performing well in sorogan (diagnostic tests); students making and presenting conclusions from learning activities; students asking questions or answering questions from the teacher; and students conducting learning evaluations. Based on observer data, all students performed these activities, with an average percentage of 16.67%. In activity 4, which involved taking a diagnostic test (Sorogan), the aim was to determine learning groups and group leaders to help their groupmates improve their understanding of redox material. Based on the observer's data, all students performed these activities, with an average percentage of 28.33%. The total relevant activities accounted for 97.22%, while irrelevant activities accounted for 2.78%. In the third meeting, relevant activities included seven indicators, namely: students paying attention to the teacher's explanations; students being able to complete the worksheets according to their assigned groups; students discussing with their groups; students making and presenting conclusions from the learning activities; students asking questions or answering questions from the teacher; students being conducive when completing the post-test; and students conducting learning evaluations. All of these activities reflect learner-centered learning, as students actively participate in every stage of the learning process. Based on observer data, all students performed these activities, with an average percentage of 16.67%. The total relevant activities accounted for 97.78%, while irrelevant activities accounted for 2.22%.

The overall results of student activities from meetings 1 to 3 showed an increase, with a percentage of  $\geq 61\%$ , indicating that the Handout on redox material is very practical. Furthermore, the effectiveness of the Handout on redox material is evaluated by the increase in students' observation scores for the learning outcomes at each meeting.

**Table 8.** Knowledge Test Results with Student N-Gain Scores

No	Name	Score Pretest	Score Posttest	N-Gain Score	Criteria
1	MNA	33	85	0.78	High
2	MSR	20	76	0.70	High
3	MHA G	67	89	0.67	Medium
4	MK	53	97	0.94	High
5	NAC	33	80	0.70	High
6	NAP	73	86	0.48	Medium
7	NNF	33	93	0.90	High
8	QA	40	83	0.72	High
9	RRPS	46	93	0.87	High
10	RAA	47	86	0.74	High
11	RS	53	86	0.70	High
12	SAM	40	77	0.62	Medium
13	SAMP	40	81	0.68	Medium
14	SNZP	67	84	0.52	Medium
15	SRD	67	93	0.79	High
16	ZQT	67	85	0.55	Medium
Average		47.16	88.59	0.77	High

Based on the N-Gain Score analysis, seven students scored in the moderate category: 0.65, 0.33, 0.67, 0.48, 0.62,

0.68, and 0.55. Meanwhile, one student obtained an N-Gain Score in the highest category, namely 1.00. In this study, the handout was considered effective if the criteria for learning outcome improvement yielded a moderate N-Gain Score ( $0.7 > [g] \geq 0.3$ ) or a high ( $[g] \geq 0.7$ ). Based on Table 6, 30 students who participated in the handout trial all obtained a posttest score of  $\geq 75$ , indicating complete mastery. This is in line with the minimum competency standard for chemistry applied at MAN 2 Gresik, which is 75. The 30 students who mastered the material achieved a classical mastery rate of 100% with a very effective criterion.

Based on the data described above, it was concluded that the redox handout using the *Sorogan-Bandongan* learning model, as evaluated against the three research objectives, namely validity, which achieved an average mode of 4 for content and construct validity, the second objective, namely the practicality of the response questionnaire, which was completed by 94.11% of the students, and the activity observation sheet, which showed an increase in each session, specifically from Session 1 to 3, respectively, at 96.67%, 97.22%, and 97.78%, meeting the criteria for "very practical." Furthermore, the third objective, effectiveness, was demonstrated through an increase in pre-test and post-test scores calculated using the N-Gain score, yielding a score of 0.77, categorised as "very good."

The effectiveness of *Sorogan-Bandongan* model-based handouts in improving cognitive abilities regarding redox material offers a new perspective compared to previous studies. Specifically, these findings confirm that individual interaction within the Sorogan model can reduce misconceptions; however, this study goes a step further by using handouts as a quality-control instrument to guide students. The increase in learning outcomes fell within the moderate criterion (N-gain 0,66) through the oral application of the model; the use of handouts in this study allows for a more concrete visualization of redox rules and reaction balancing, thereby enabling a better distribution of students' cognitive load. Furthermore, compared with the Chemoentrepreneurship-based handout, which achieved 85% practicality for the applied material, the handout in this study features a unique hierarchical presentation structure. This uniqueness lies in the "Sorogan" phase, which requires students to engage in self-guided learning based on the handout content, ensuring that the resulting cognitive development is not merely procedural memorization but a personally validated understanding of redox concepts through direct verification between teacher and student. This study achieved an N-Gain score of 0.77, classified as "very good," demonstrating improvement over the previous study, which achieved an N-Gain score of 0.66, classified as "medium." This study achieved an N-Gain score of 0.77, classified as "very good," demonstrating an improvement over the previous study, which achieved an N-Gain score of 0.66, classified as "moderate," and a response rate of 94.11%, compared to the previous study's response rate of 85%.

Theoretically, the effectiveness of this intervention is based on the synergy between reducing cognitive load through a systematic handout structure and optimization through dialogic interaction in the *Sorogan-Bandongan* model. Its pedagogical implications in chemistry education lie in a methodological transformation, where the values of traditional ethnopedagogy are revitalized to strengthen the humanization of science and conceptual accuracy in material with a high level of abstraction. Furthermore, this integration fosters self-directed

learning through mechanisms of personal accountability, thereby ensuring that students' cognitive mastery is authentically developed and verified.

## Conclusion

The Redox Reaction Chemistry handout, developed using the *Sorogan-Bandongan* learning model, has been deemed highly suitable for use as it meets the three primary criteria for development: validity, practicality, and effectiveness. In terms of quality, this handout has content and construct validity rated as excellent and has proven highly practical to apply, with the percentage of student activities and positive responses exceeding 94%. Furthermore, this instructional material has proven effective in significantly improving student learning outcomes, as evidenced by an N-Gain score of 0,77 and a cognitive mastery level reaching the high category. Suggestions for further development include adding learning objectives and practice questions to the prerequisite materials to assess students' readiness and identify initial misconceptions, and expanding the implementation of the *Sorogan-Bandongan* model to other chemistry topics to strengthen conceptual mastery in support of the Merdeka Curriculum initiative. Additionally, the author suggests transforming the media into an E-Handout format while maintaining student independence, requiring practice problems to be completed by rewriting or typing directly, without copying and pasting from the material.

## Author's Contribution

N. Ainun: contribution to research includes active involvement in the formulation of ideas and the design of the methodology, as well as in the analysis and the development of scientific arguments. Rinaningsih: originality and validity of the findings.

## Acknowledgements

Praise and gratitude to Allah SWT who has bestowed His grace, taufik, and guidance, so that the author can complete this thesis. Thank you to Dr.Hj. Rinaningsih, S.Pd., M.Pd., as the supervisor who has guided, given direction, and input, along with providing prayers, encouragement, and support both morally and materially, as well as love, continues to convince the author that she can complete this thesis. The author's best friend, who always provides prayer support, motivation, attention, and continues to remind the author to try to complete this thesis and not forget to be grateful for the achievements that have been obtained. To the principal, education staff, teachers, and students of MAN 2 Gresik, who have allowed and supported researchers during the research. As well as all parties that the author can't mention one by one, who have helped the author either directly or indirectly in completing this thesis.

## References

- [1] S. Wulandari, "Teori Belajar Konstruktivis Piaget Dan Vygotsky," *Indones. Digit. J. Math. Educ.*, vol. 2, no. November, pp. 191–198, 2015, [Online]. Available: <http://idealmathedu.p4tkmatematika.org/issn2407-7925>
- [2] M. Cholilah *et al.*, "Pengembangan Kurikulum Merdeka Dalam Satuan Pendidikan Serta Implementasi Kurikulum Merdeka Pada Pembelajaran Abad 21," vol. 01, no. 02, 2023, doi: 10.58812/spp.v1.i02.
- [3] N. Arwasih, Deri Hendriawan, Effy Mulyasari, Elmi Hanjar Bait, "Analisis Komparatif Capaian Pembelajaran, Tujuan Pembelajaran, dan Alur Tujuan Pembelajaran Kurikulum Merdeka dengan Kompetensi Inti, Kompetensi Dasar, Silabus dan Rencana Pelaksanaan Pembelajaran pada Kurikulum 2013," vol. 13, 2025.
- [4] A. Koswara and M. Mundilarto, "Pengembangan handout fluida dinamik terintegrasi metakognisi untuk meningkatkan kemampuan aplikasi siswa SMA dan MA," *J. Inov. Pendidik. IPA*, vol. 4, no. 1, pp. 11–25, 2018, doi: 10.21831/jipi.v4i1.6193.
- [5] N. Erlinda, "Penerapan Metode Pembelajaran Inkuiri Disertai Handout: Dampak Terhadap Hasil Belajar Fisika Siswa SMAN 1 Batang Anai Padang Pariaman," *J. Ilm. Pendidik. Fis. Al-Biruni*, vol. 5, no. 2, pp. 223–231, 2016, doi: 10.24042/jpifalbiruni.v5i2.122.
- [6] M. Elbanjari and F. N. Sahla, "meningkatkan pembelajaran formal berbasis metode pembelajaran pesantren (Sorogan dan Bandongan/Wetonan) (Analisis Deskriptif Terhadap Pembelajaran Mahaaratul Qiraah di MTsN 3 Tasikmalaya)," *EDUPESANTREN J. Pengabd. Masy. Berbas. Pesantren dan Madrasah*, vol. 2, no. 2, 2023.
- [7] Rinaningsih, "SOROGAN-BANDONGAN DALAM KIMIA ORGANIK DAN DAMPAKNYA pada Penguasaan Konsep, Tanggung Jawab, Kemandirian, dan Keterbukaan [Disertasi]. Universitas Pendidikan Indonesia.," 2019.
- [8] R. Rinaningsih, "Implementasi Model Perkuliahan Terpadu *Sorogan-Bandongan* Untuk Menentukan Pemahaman Mahasiswa Dalam Mempelajari Mekanisme Reaksi," *J. Pengajaran Mat. dan Ilmu Pengetah. Alam*, vol. 19, no. 2, p. 266, 2014, doi: 10.18269/jpmipa.v19i2.469.
- [9] E. Atminiati and A. Binadja, "Keefektifan pembelajaran guided note taking bervisi sets bermedia chemo edutainment dalam meningkatkan kompetensi siswa [the effectiveness of guided note taking learning with vision sets using chemo edutainment media in improving student competence.]," *J. Inov. Pendidik. Kim.*, vol. 11, no. 2, pp. 1988–1996, 2017.
- [10] F. Wulandari and R. Rinaningsih, "Implementasi Model *Sorogan-Bandongan* Untuk Meningkatkan Hasil Belajar Peserta Didik Pada Materi Asam Basa," *Chem. Educ. Pract.*, vol. 6, no. 1, pp. 1–7, 2023, doi: 10.29303/cep.v6i1.3583.
- [11] R. E. Slavin, *Psikologi Pendidikan Teori dan Praktik*. Jakarta: Jakarta: Indeks, 2009.
- [12] A. Deswita, "Pengembangan Handout Kimia Berbasis Chemoenterpreneurship pada Materi Larutan Penyangga, Hidrolisis Garam dan Koloid untuk SMA Kelas XI," *Konfigurasi J. Pendidik. Kim. dan Terap.*, vol. 6, no. 1, p. 44, 2022, doi: 10.24014/konfigurasi.v6i1.16256.
- [13] S. A. R. Wahdaniyah and R. Rinaningsih, "Profil Gaya Belajar Peserta Didik Pada Pembelajaran Model *Sorogan-Bandongan* Materi Kimia Asam Basa," *Chem. Educ. Pract.*, vol. 5, no. 2, pp. 142–150, 2022, doi: 10.29303/cep.v5i2.3561.
- [14] H. Cibro, "Pengembangan Handout Berbasis Literasi

- Sains pada Materi Asam Basa di MAS Darul Ihsan,” Universitas Islam Negeri Ar-raniry Banda Aceh., 2021.
- [15] N. Salina, E. Daningsih, and R. Marlina, “Kelayakan Handout Struktur Dan Fungsi Jaringan Tumbuhan Dengan Tambahan Distribusi Stomata Dan Laju Transpirasi,” *EduNaturalia J. Biol. dan Kependidikan Biol.*, vol. 2, no. 1, p. 20, 2022, doi: 10.26418/edunaturalia.v2i1.45987.
- [16] F. Najah and A. M. Bashri, “Efektivitas Metode Pembelajaran Sorogan Pada Pembelajaran Hidayatun Shibyan Santri Madrasah Diniyah Kelas 1 Nurul Jadid Blumbang Pragaan Daya Sumenep,” *J. Jendela Pendidik.*, vol. 3, no. 01, pp. 66–73, 2023, doi: 10.57008/jjp.v3i01.408.
- [17] S. W. Putri and R. Rinaningsih, “Development of handouts on acid-base material with the sorogan learning method,” *J. Pijar Mipa*, vol. 18, no. 4, pp. 525–531, 2023, doi: 10.29303/jpm.v18i4.5151.
- [18] S. Thiagarajan, *nstructional Development for Training Teachers of Exceptional Children: A Sourcebook*. Bloomington: Indiana University., 1974.
- [19] S. A. Sari and S. N. Putri, “Pengembangan Handout Materi Sistem Koloid Berbasis Guided Note Taking untuk Meningkatkan Hasil Belajar dan Respon Siswa Kelas XI SMA,” *J. IPA Pembelajaran IPA*, vol. 4, no. 1, pp. 41–59, 2020, doi: 10.24815/jipi.v4i1.16226.
- [20] U. Lutvaidah, “Pengaruh Metode dan Pendekatan Pembelajaran terhadap Penguasaan Konsep Matematika,” *Form. J. Ilm. Pendidik. MIPA*, vol. 5, no. 3, pp. 279–285, 2016, doi: 10.30998/formatif.v5i3.653.
- [21] Riduwan, *Skala Pengukuran Variabel-variabel Penelitian*. 2016.
- [22] Riduwan, *Dasar-Dasar Statistika*. Bandung: Bandung: Alfabeta, 2015.
- [23] A. Rahman, S. A. Munandar, A. Fitriani, Y. Karlina, and Yumriani, “Pengertian Pendidikan, Ilmu Pendidikan dan Unsur-Unsur Pendidikan,” *Al Urwatul Wutsqa Kaji. Pendidik. Islam*, vol. 2, no. 1, pp. 1–8, 2022.
- [24] K. A. Nadiyya, E. S. VH, and B. Mulyani, “Analisis Miskonsepsi Siswa pada Materi Reaksi Redoks dengan Menggunakan Three-Tier Test Kelas X MIPA di SMAN 2 Karanganyar,” *J. Pendidik. Kim.*, vol. 9, no. 2, pp. 193–199, 2020, [Online]. Available: <https://jurnal.uns.ac.id/JPKim/article/view/35326>
- [25] R. Laela and Risnaningsih, “Review : Peran Handout Dalam Meningkatkan Hasil Belajar Pada Pembelajaran Kimia a Review : the Role of Handouts in Improving Learning Outcomes in Chemistry Learning,” *UNESA J. Chem. Educ.*, vol. 10, no. 2, pp. 122–130, 2021.
- [26] K. Nababan and R. S. Zega, “Pengembangan E-Modul Laju Reaksi Discovery Learning Berbasis Blog Untuk Meningkatkan Motivasi Belajar dan Komunikasi Siswa : Analisis Kebutuhan,” vol. 6, pp. 14–22, 2024, doi: 10.37033/ojce.v6i1.638.
- [27] F. Kamal, “Model Pembelajaran Sorogan Dan Bandongan,” *Paramurobi J. Pendidik. Agama Islam*, vol. 3, no. 2, pp. 15–26, 2020, doi: 10.32699/paramurobi.v3i2.1572.
- [28] I. Kurnia, R. Saputri, P. Studi, and P. Kimia, “pengaruh penerapan model discovery learning berbantuan handout terhadap kemampuan berpikir kreatif dan hasil The Effect of Application The Discovery Learning Model Assisted by Handouts For Creative Thinking Ability and Chemical Learning Outcomes,” 2024, doi: 10.29303/cep.v7i2.6069.
- [29] C. Dingrando, L., Gregg, K. v., Hainen, N., & Wistrom, *Glencoe Chemistry: Matter and Change (Second ed.)*. McGraw Hill., 2014.
- [30] R. Resa Amanda, B. Suharto, M. Jl Darmawan Pulau Sugara, and B. Kuala, “meningkatkan aktivitas dan hasil belajar siswa dengan model pembelajaran inkuiri terbimbing pada materi redoks Improving Students Activity and Learning Outcomes with Guided Inquiry Learning on Redox Material,” *J. Inov. Pendidik. Sains*, vol. 8, no. 1, pp. 2550–0716, 2017.
- [31] T. N. N. Plomp, *Educational Design Research*. Netherlands Institute for Curriculum Development, 2013.
- [32] D. B. R. A. Putera, W. P. Hadi, and Z. Abidin, “Implementasi Peningkatan Psikologis Literasi Dan Kreativitas Siswa Tunanetra Berbantuan Kartu Uno Kimia Unsur Berbasis Braille,” *JMM (Jurnal Masy. Mandiri)*, vol. 8, no. 6, p. 6354, 2024, doi: 10.31764/jmm.v8i6.27524.