



## VALIDITY OF SUPPLEMENTARY TEACHING MATERIALS ON BUFFER SOLUTION TO TRAIN ARGUMENTATION SKILLS

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### ABSTRACT

Supplementary teaching materials are tools used as an addition to learning. Good teaching materials must pass through a feasibility assessment, such as validity. Validity is important to review the quality and content of teaching materials, by measuring the suitability between aspects of teaching materials. The research purpose is to determine the validity of supplementary teaching materials on buffer solutions that can train argumentation skills. This research is a type of development research that focuses on developing products for learning using the ADDIE model that is limited to the development stage. The instrument used in this research is a validation sheet consisting of content and construct validity. The target of the research is supplementary teaching materials in practicing argumentation skills on buffer solutions. The teaching materials were assessed by 3 validators, that is, experts in chemistry learning. The assessment results from the validation sheet are content validity has a mode of 4 and construct validity has a mode of 4 is declared valid. From this assessment can conclude that the supplementary teaching material on buffer solutions material is valid in supporting argumentation skills training. Based on the results, it is expected to contribute to producing additional teaching materials that are feasible to help train the argumentation skills of students. In addition, the results of this study are also expected to help readers, especially educators, to gain knowledge and references to teaching materials that can be used in training argumentation skills.

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## 1. INTRODUCTION

The curriculum is an important aspect of sustainability education in Indonesia. The curriculum in Indonesia has undergone several changes that are adjusted to the competencies needed by students. One of the competencies that can improve the ability of students in learning, namely 21<sup>st</sup> century skills. That is an era where reforms in various fields are developing rapidly (Mashudi, 2021). This is in line with the challenges that will be faced in the 21<sup>st</sup> century. Learning in the 21<sup>st</sup> century requires students to be able to play an active role, be independent in learning, communicate well, and be able to solve problems. According Trilling & Fadel in (Akili et al.,

2022), the skills that must be learned by students include critical thinking and problem-solving skills, effective communication skills, collaboration skills, and creativity & innovation skills.

One of the important skills possessed by students is argumentation skills. Argumentation skills are a skill in convincing or proving the truth of a statement, opinion, attitude, or belief, proven by facts. Argumentation skills include two skills that must be have in the 21<sup>st</sup> century, that is critical thinking skills and communication skills (Devi, Susanti, & Indriyanti, 2018). Argumentation skills are related to the components of critical thinking skill, namely the first component of critical thinking, using criteria and evidence to evaluate knowledge, this is the main competency in argumentation where showing evidence in supporting claims to strengthen their opinions (Roviati & Widodo, 2019). Argumentation skills can help students to express opinions rationally and accepted (Wulansari, Nurmilawati, Utami, & Christiono, 2020). In addition, Demircioglu, Karakus, & Ucar, (2023) also stated that argumentation skills are a form of communication skills in conveying scientific ideas or opinions. Several reasons why important to profile students' argumentation abilities, that it can play a role in making the right decisions in everyday life, argumentation can restore the goals of science education in a balanced manner, and underlie students to be able to think and communicate scientifically (Tanfiziyah & Rochintaniawati, 2021).

According to Budiyo, Wildani, & Mahardika, (2020), students' argumentation skills in learning activities are still very low, this is due to the lack of application and practice provided. The low level of argumentation is evidence by the result of previous research conducted on grade X high school students who indicated that they had low argumentation skills. The factors causing the low level of argumentation in students are that students are not used to working on questions related to argumentation skills, learning activities in class do not facilitate students in arguing that is still teacher-centered, and the lack of training and development of argumentation skills provided by teachers (Hardini & Alberida, 2022).

Teaching materials are defined as all forms of materials and references to assist teachers in carrying out learning activities in the class (Nuryasana & Desiningrum, 2020). Along with developments in the field of education, teaching materials have also begun to be developed in various forms. One of these teaching materials is supplementary teaching materials. Supplemental teaching materials can complement existing teaching materials in learning to deepen and enrich knowledge (Risianti et al., 2022). Supplement books are needed in learning activities to complement learning materials that are not detailed or less detailed and can add insight to students (Arif & Rukmi, 2020).

Validation is one of the important aspects in the development of teaching materials. Validation of this product through two components, namely content and construct. Validation of teaching materials needs to be conducted to obtain a product that is suitable for use by readers. The reason this validation is important is because it can identify the weaknesses of the teaching materials as evaluation material to improve and refine the product. According to Hera in (Nurofik et al., 2022), the validation results of this teaching material can be said to be feasible if it obtains assessment results in the valid category, which can indicate the teaching materials have been developed are good quality and can lead to improving a desired skill.

One of the topics in chemistry is acid-base material, namely buffer solutions. This buffer solution material is include in the material that has characteristics related to acid-base reactions contained in the buffer solution. The concept of a buffer solution that is difficult for students to

understand is the sub-matter of buffer solution in the body of living things and daily life (Marsita in Sariati et al., 2020). A buffer solution is a material that discusses the calculation of the pH of a solution by maintaining the pH in the addition of substances. A buffer solution is contained in basic competencies 3.12 class XI. Basic competencies 3.12 about buffer solution can be enriched with argumentation skills.

Teaching materials have been developed with various materials and skills, such as research (Prastiwi et al., 2020), developing supplementary teaching materials in the form of multimedia tutors on acid and base materials. Then, another research (Widiastiningsih et al., 2022) on argumentation skills, that is developing e-module teaching materials to improve students' argumentation skills on acid-base material. In previous research (Khoiroh & Azizah, 2021), there was also a discussion about the validation of supplementary teaching materials in cognitive skills on thermochemistry material. From previous research, there has been no development of supplementary teaching materials that can train argumentation skills on buffer solution material.

Based on the problems described above, it is necessary to develop supplementary teaching materials to overcome the lack of availability of teaching materials used to train argumentation skills. The supplementary teaching materials develop by the author use indicators of Toulmin's argumentation skills with buffer solution material. Supplementary teaching materials developed require feasibility testing, one of which is validity. This validity consists of content and construct validity. Content validity is the measurement of items selected to reflect the suitability of the construct variable measured (Sugiono et al., 2020). Construct validity is a measurement that shows the relationship between product indicators and existing theory (Sugiono et al., 2020). Validity can be measured through content and construct validation sheets assessed by validators to obtain valid categories. The purpose of this research was to determine the validity of supplementary teaching materials on buffer solution material to train argumentation skills, so it can produce supplementary teaching materials that are valid and feasible to use in the learning.

## 2. METHOD

This research is a type of development research (Ula & Suyono, 2023). Development research focuses on developing and making products, to be followed up to determine the feasibility of these products (Setiawan & Sholiha, 2022).

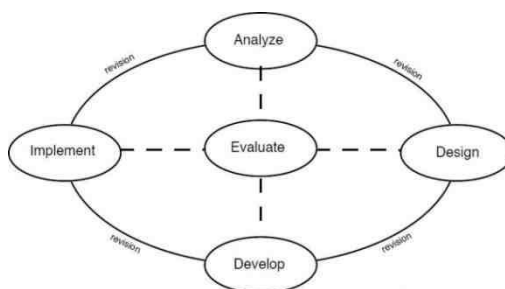


Figure 1. Concept Development of ADDIE Model

This research uses the ADDIE model with a process as shown in Figure 1. ADDIE is a method that can be used to develop teaching materials or learning products. ADDIE has five stages, namely Analysis, Design, Development, Implementation, and Evaluation (Rahmansyah, Muslim,

& Sinaga, 2022). Based on the picture in figure 1 of the ADDIE model research design concept, shows that each stage of ADDIE undergoes evaluation and revision so that the products produced through the development are good and can be implemented to reduce problems at schools (Branch, 2009). However, in this research, the procedures carried out were limited to the development stage with an evaluation at each stage.

### **2.1. Analysis Stage**

The first stage of this research was carried out through the analysis stage. This analysis stage includes analyzing the needs of students, this needs analysis can be done by interviewing students or teachers. Furthermore, the selection of material is by the results of the analysis of the needs of students. This research also connects with argumentation skills, so it is necessary to analyze the indicators of argumentation skills that will be included in the development of supplementary teaching materials. At the end of the analysis stage, evaluation and revision will be carried out to produce a good product.

### **2.2. Design Stage**

The results of the data from the analysis stage will be used to plan supplementary teaching materials. This design stage will assist in the development of supplementary teaching materials. The design stage provides an overview and flow of the supplementary teaching materials developed. This design stage includes several things that are done, such as determining topics/materials in teaching materials, collecting reference sources, and determining the design of teaching materials. The end of this stage will be evaluation and revision.

### **2.3. Development Stage**

The description and flow of the design will be used as an overview in developing supplementary teaching materials. At the development stage, teaching materials will begin to be developed into a product. The development stage consists of several steps, namely the development of teaching materials and validation. The validity test includes content validity and construct validity. This development stage will produce supplementary teaching material products that are valid from expert judgment. The end of this stage will evaluate by analyzing the validation results.

The operational steps taken in achieving the research objectives are as follows: (1) formulating indicators of argumentation skills, (2) designing draft supplementary teaching materials, (3) consulting supplementary teaching materials with supervisors, (4) developing supplementary teaching materials, (5) developing validation sheets along with guidelines, (6) validation process through expert judgment by three validators in the field of chemistry learning, (7) data analysis, and (8) collecting research results.

Validity data were obtained from content and construct validation sheets given to three validators. The validation sheet was analyzed descriptively using a Likert scale assessment with assessment categories as in Table 1.

Table 1. Likert scale

Assessment Scale	Assessment category
5	Very valid
4	Valid
3	Enough valid
2	Less valid
1	Not valid

This validity data was obtained through expert judgment consisting of three validators, then analyzed by descriptive method, that is using the mode or score that often appears. The supplementary teaching materials developed can be concluded as valid if they meet the requirements with a minimum mode of 4.

### 3. RESULTS AND DISCUSSION

#### 3.1. Results

The results of this study will discuss the development of supplementary teaching materials as a learning medium in training the argumentation skills of class XI high school students on buffer solution material. The results of the research stages carried out are described as follows.

##### 3.1.1. Results of the Analysis Stage

This analysis stage aims to obtain information related to problems and needs found in schools as a consideration in developing appropriate products. The description of the course of research should be supported by references, so the explanation can be accepted scientifically.

###### 3.1.1.1. Needs analysis

Needs analysis is used as the basis for determining the products needed by students tailored to the needs and conditions of learning activities at school. This needs analysis was conducted through observations and interviews with chemistry teachers at school. The results of the interview obtained that in learning chemistry class XI uses teaching materials, namely student books supported by other learning media, such as power points, but still has not used additional teaching materials as teaching materials to support the chemistry material contained in student books. In addition, the results of interviews related to the application of argumentation skills found that argumentation skills are still not applied in class XI in learning.

###### 3.1.1.2. Curriculum Analysis

Curriculum analysis is carried out as an effort to determine the appropriate material to be used in developing a product. This curriculum analysis was obtained through an interview with the vice principal for curriculum to find out the curriculum used. The results of the interview obtained that in class XI the curriculum used is the 2013 curriculum.

### 3.1.1.3. Analysis of argumentation skills indicators

Analysis of argumentation skills indicators is obtained through literature studies on several books or journals. This argumentation skill has indicators conveyed by several figures. Researchers used Toulmin's argumentation skills indicators which consisted of 5 indicators, namely claims, evidence, warrant, backing, and qualifier.

### 3.1.2. Evaluation and Revision of the Analysis Stage

Evaluation at the analysis stage was carried out regarding the use of argumentation skills indicators. As a result of the evaluation with the supervisor, there were changes in the use of argumentation skills indicators, which were originally only 5 indicators without rebuttal, but it would be better to use 6 indicators because rebuttal is also an indicator that can strengthen argumentation. The results of this evaluation will be used as a reference in making revisions.

### 3.1.3. Results of the Design Stage

The results of the analysis that have been obtained can be used as material in the design stage of teaching materials. This design stage is the first step in making a picture in developing a product.

#### 3.1.3.1. Determination of topics/materials

The material used in this study is a buffer solution on basic competencies 3.12. This buffer solution in class XI includes several subchapters. This study uses 4 subchapters consisting of the definition of buffer solutions, properties and working principles of buffer solutions, various kinds of buffer solutions, and the application of buffer solutions. Each of these subchapters will be adjusted to the phenomena that occur in everyday life.

#### 3.1.3.2. Collection of reference source

Chemical materials making products require references that can be used to develop products. The reference sources used come from high school chemistry books, journals, and news. This reference is used as support in developing research products.

#### 3.1.3.3. Determination of teaching material design

At this stage of determining the design, researchers began to compile the components used in the teaching materials developed. The components in the teaching materials are tailored to the needs of the learning activities carried out and argumentation skills. Determination of this design begins with determining the contents of the supplementary teaching materials, which consist of a cover, preface, introduction, concept map, argumentation skills indicator table, concepts, phenomena, evaluation, and bibliography. The design of this supplementary teaching material is made in the form of a product draft.

### 3.1.3.4. Determination of instruments and devices

Good teaching materials require feasibility testing. This feasibility test includes one aspect, namely validity. The supplementary teaching materials developed will be tested for feasibility using construct and content validation sheets given to validators.

### 3.1.4. Evaluation and Revision of the Design Stage

In this design stage, the product begins to be developed as a draft of teaching materials. The draft of this teaching material needs to be evaluated to obtain better results through a review of supplementary teaching materials by the thesis supervisor. The results of the review by the reviewer obtained that the claims contained in the supplementary teaching materials still tend to state theoretical claims, claims would be better if using claims formulated with contextual sentences so that students can more easily understand the phenomena presented. Revisions were made to the supplementary teaching material draft by improving the claims on each phenomenon that still did not refer to contextual claims.

### 3.1.5. Results of the Development Stage

This development stage is carried out by developing products and instruments/devices needed in research. The development stage is divided into 2, namely product development and product validation.

#### 3.1.5.1. Product development stage

The draft that has been reviewed at the design stage will be carried out during product development after going through the improvement or revision stage. The product developed in this study is supplementary teaching materials using argumentation skills indicators. Supplementary teaching materials at this stage were developed based on the results of suggestions from the supervisor as a reviewer. This supplementary teaching material contains several components, namely cover, preface, introduction, argumentation skills indicators, concept map, sections 1, 2, 3, and 4, evaluation, and bibliography. After revision and development, the teaching materials will be validated to determine the quality of the product developed.

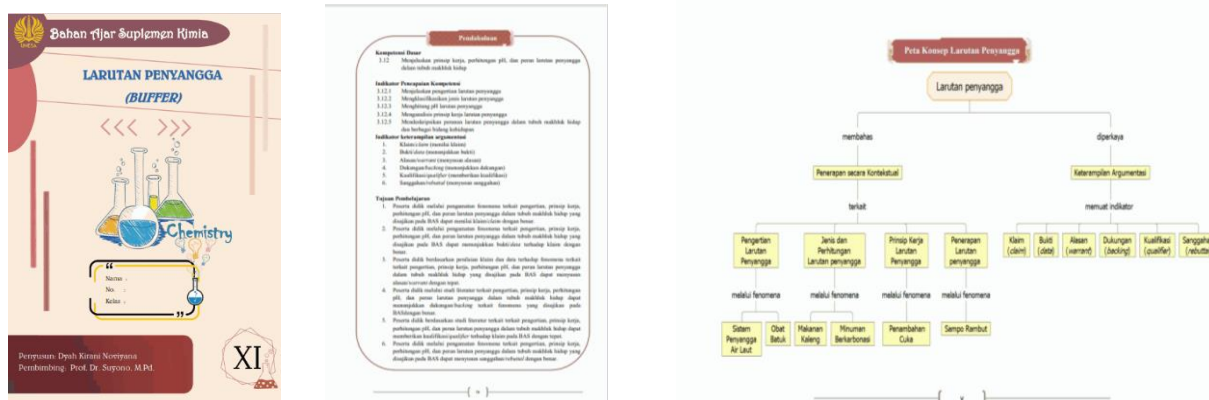


Figure 2. Cover, introduction, and concept map of supplementary teaching materials

Supplementary teaching materials at the beginning have a cover. After the cover, the supplementary teaching materials component continues with the preface, introduction, argumentation skills indicators, and concept maps. The introduction to the supplementary teaching material contains basic competencies, indicators of competency achievement, indicators of argumentation skills, and learning objectives. The basic competencies used are basic competencies 3.12 explaining the working principle of pH calculation, and the role of buffer solutions in the body of living things. The concept map used in this supplementary teaching material discusses buffer solutions enriched by argumentation skills.

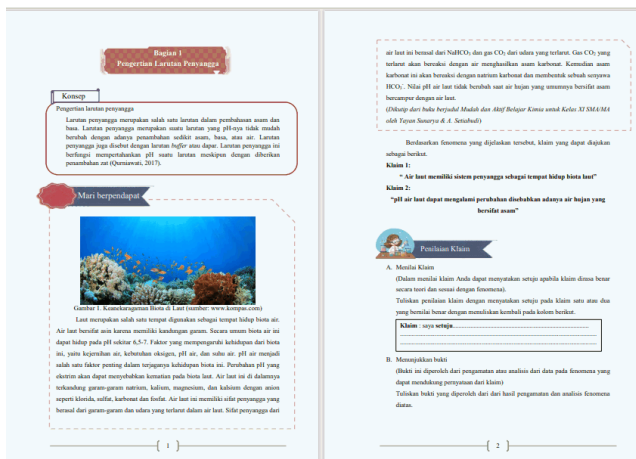


Figure 3. Part 1 of the supplementary teaching material

Supplementary teaching materials have a component of 4 parts which are divided based on the buffer solution subchapter. Each section consists of concepts, phenomena, and working columns for argumentation skills with 6 skill indicators.

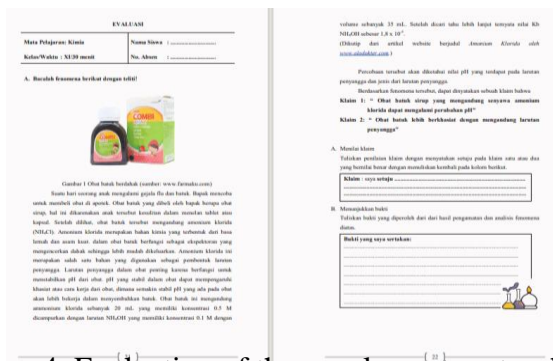


Figure 4. Evaluation of the supplementary teaching materials

This supplementary teaching material is also equipped with an evaluation, where this evaluation contains questions related to argumentation skills which are used as a medium for practicing students independently. This evaluation has 2 phenomena with 6 indicators of argumentation skills.

## 3.1.5.2. Product validation stage

Product validation is carried out using a validation sheet. This product validation was assessed through a validation sheet by 3 validators who are experts in chemistry learning. Validation consists of construct and content validity.

## 3.1.6. Evaluation and Revision of the Development Stage

Evaluation of the development stage is carried out with product validation by validators. Validation of supplementary teaching materials was carried out by three validators who are experts in chemistry learning. This product validation is reviewed from content and construct validity. Supplementary teaching materials have 4 parts with evaluation. Validation of this supplementary teaching material is based on each section. Validation of this product is assessed using a Likert scale of 1-5 with a minimum mode of 4 to be considered valid. The results of the validator's assessment can be presented below.

## 3.1.6.1. Content validity

Table 2. Supplementary Teaching Material Content Validation Results

No	Component	The mode of validator's assessment of the part-				Mode	Category
		1	2	3	4		
1	The material presented in supplementary teaching material contains components in basic competencies and additional basic competencies.	4	4	4	4	4	Valid
2	The material presented describes the substance contained in the basic competencies.	4	4	4	4	4	Valid
3	Supplementary teaching material presents phenomena that are conceptually appropriate and based on appropriate facts to train argumentation skills.	4	4	4	4	4	Valid
4	The content/topic has relevance to the thinking skills set as learning targets.	5	4	4	4	4	Valid
5	The facts, concepts, and images presented are correct and appropriate	4	4	4	4	4	Valid
6	Correctness of facts, concepts, principles, laws, and theories	4	4	4	4	4	Valid

No	Component	The mode of validator's assessment of the part-				Mode	Category
		1	2	3	4		
	contained in supplementary teaching materials						

Content validity in supplementary teaching materials is a validation that discusses the suitability of the content of supplementary teaching materials with basic competencies and the material used. Content validity in the supplementary teaching material validation sheet contains 6 components related to the substance of the material used.

Based on Table 2, the results of content validation on supplementary teaching material obtained a mode from 3 validators out of 4 which can be categorized as valid. The assessment consists of 6 components, each of which obtained a mode with a value of 4 with a valid category.

### 3.1.6.2. Construct validity

In addition to content validity, the validation of supplementary teaching materials is also reviewed through construct validity. This construct validity discusses the consistency between the substance and the argumentation skills indicators contained in the supplementary teaching materials. This construct validity assessment is based on 3 validators who are assessed using a Likert scale of 1-5 with a minimum mode of 4 to be considered valid. The following are the results of the construct validity assessment on supplementary teaching materials.

Table 3. Results of Supplementary Teaching Material General Construct Validation

No	Component	The assessment of validator's			Mode	Category
		1	2	3		
1	Contains directions and explanations regarding indicators of argumentation skills used to equalize perceptions between researchers and students.	5	5	5	5	Very valid
2	Sufficiency of Supplementary Teaching Material components	5	4	5	5	Very valid

Based on Table 3, the general construct in supplementary teaching material obtained mode 5 with a very valid category in component 1 and component 2. Construct validity in this supplementary teaching material is also reviewed from the argumentation skills indicators in each section.

Based on Table 4, the results of construct validation on supplementary teaching material obtained a mode from 3 validators out of 4 which can be categorized as valid, indicating that the substance on supplementary teaching material contains indicators of argumentation skills to be trained. The assessment consists of 8 components, each of which obtained a mode with a value of 4 with a valid category.

Table 4. Results of Construct Validation of Supplementary Teaching Material Argumentation Skills

No	Component	The mode of validator's assessment of the part				Mode	Category
		1	2	3	4		
1	Making a claim	4	4	4	4	4	Valid
2	Showing data/evidence (data)	4	4	4	4	4	Valid
3	Develop a reason (warrant)	4	4	4	4	4	Valid
4	Showing backing	5	4	4	4	4	Valid
5	Showing qualifiers	4	4	4	4	4	Valid
6	Develop a rebuttal	4	4	4	4	4	Valid

The results of validation from the validator of the supplementary teaching materials still require some improvements to produce teaching materials that are of higher quality and feasible. These changes are made at the revision stage in ADDIE. The following revisions were carried out based on suggestions from validators.

Tabel 5. Before and After Improvements to Supplementary Teaching Materials

Before	After
The concept map does not yet contain the topics and phenomena in the supplementary teaching materials completely.	The concept map contains the application of the concept of buffer solution to each topic and argumentation skill indicator.

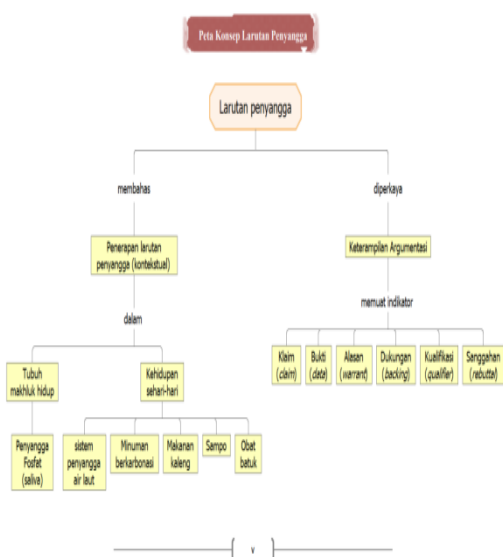


Figure 5. Concept map before revision

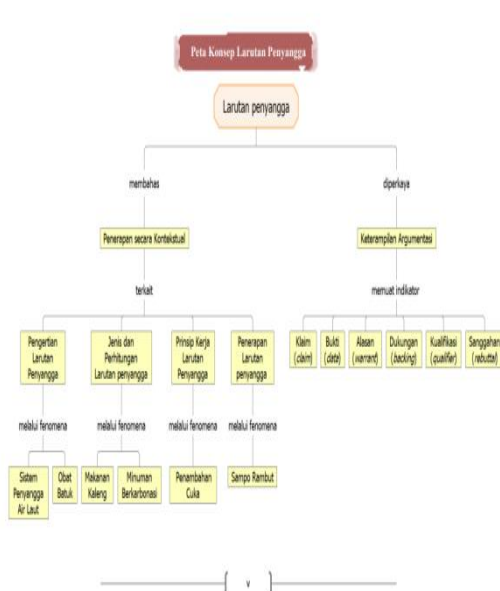


Figure 6. Concept map after revision

The arrangement of learning objectives in BAS does not fulfill the ABCD aspect and does not include indicators conceptually.

Learning objectives are arranged based on indicators of competency achievement and indicators of argumentation skills using the ABCD formula.

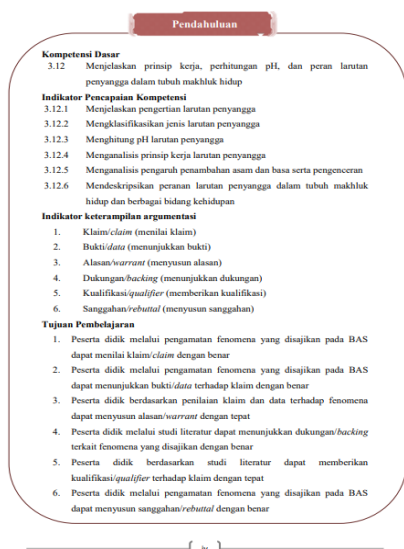


Figure 7. Learning objectives before revision

The source of literature on the concept of supplementary teaching materials has not been completed

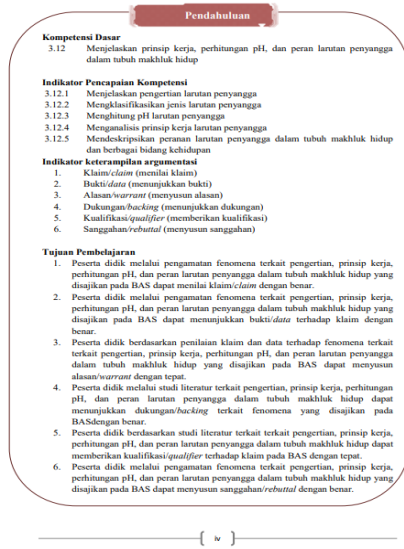


Figure 8. Learning objectives after revision

The concept or summary of material in the supplement teaching materials is equipped with literature sources used to strengthen the accuracy of the theory.

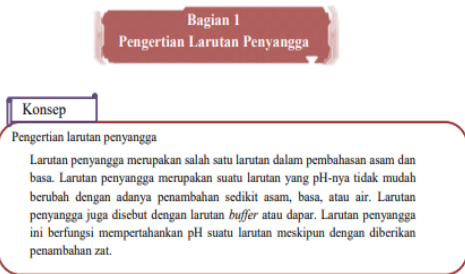


Figure 9. No source in concept before revision

The writing of the source in the image of the phenomenon in the supplementary teaching materials is still not appropriate

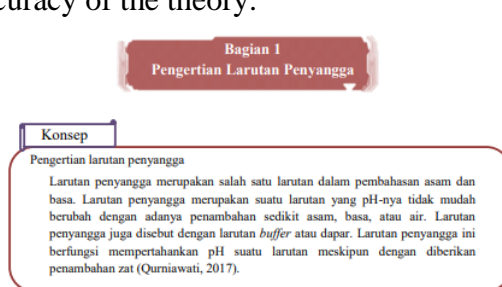


Figure 10. Source in concept after revision

The source in the picture is written by the writing rules in the picture



Figure 11. Source image before revision

There is no reaction to the concept of part 4



Figure 12. Source image after revision

Adding the reaction of  $H_2CO_3$  compound formation and phosphate buffer.

**Bab 4**  
Penerapan Larutan Penyangga

Konsep

A. Peran Larutan Penyangga dalam Makhluk Hidup

a) Penyangga Hemoglobin

Hemoglobin adalah zat warna darah atau pigmen darah yang dapat menjaga pH dalam darah agar dapat terkontrol dengan baik. Peristiwa ini dimulai ketika manusia bernapas menghirup oksigen. Oksigen yang dihirup masuk ke dalam tubuh pada kapiler darah yang menyelubungi alveolus. Oksigen akan diikat oleh hemoglobin dan diangkut ke sel jaringan tubuh. Peran oksigen dalam darah dapat menghasilkan darah berwarna merah terang akibat dari oksidasi. Darah yang belum teroksidasi akan menghasilkan warna merah gelap (Sunarya & Setiabudi, 2009).

Reaksi yang terjadi sebagai berikut.

$$\text{HHb}^+ + \text{O}_2 \rightleftharpoons \text{H}^+ + \text{HbO}_2$$

Asam hemoglobin (merah gelap)      oksidasi hemoglobin (merah terang)

Proses metabolisme tubuh menghasilkan karbondioksida ( $\text{CO}_2$ ), dimana  $\text{CO}_2$  ini akan bergabung dengan  $\text{H}_2\text{O}$  membentuk senyawa  $\text{H}_2\text{CO}_3$  dalam darah. Hal ini mengakibatkan pH berubah menjadi sekitar 4,5. Hemoglobin yang melepaskan oksigen menjadi basa. Peranan penyangga terjadi pada tahap ini,  $\text{H}_2\text{CO}_3$  yang kelebihan  $\text{H}^+$  mengalami perubahan pH dengan segera diikat oleh hemoglobin membentuk asam hemoglobin, sehingga pH darah dapat konstan (Sunarya & Setiabudi, 2009).

b) Penyangga Fosfat

Penyangga fosfat berkaitan dengan cairan intrasel dalam tubuh makhluk hidup. Penyangga fosfat memiliki  $\text{pK}_a = 7,2$  yang mendekati pH darah sehingga dominan mengontrol pH darah dalam sel. Apabila dalam proses metabolisme menghasilkan basa yang lebih banyak, maka basa akan bereaksi dengan ion  $\text{H}_2\text{PO}_4^-$ , sedangkan apabila proses metabolisme menghasilkan asam yang lebih banyak, maka asam akan bereaksi dengan ion  $\text{HPO}_4^{2-}$ .

Figure 13. Summary before revision

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$$\text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g}) \rightleftharpoons \text{H}_2\text{CO}_3(\text{aq})$$

Hal ini mengakibatkan pH berubah menjadi sekitar 4,5. Hemoglobin yang melepaskan oksigen menjadi basa. Peranan penyangga terjadi pada tahap ini,  $\text{H}_2\text{CO}_3$  yang kelebihan  $\text{H}^+$  mengalami perubahan pH dengan segera diikat oleh hemoglobin membentuk asam hemoglobin, sehingga pH darah dapat konstan (Sunarya & Setiabudi, 2009).

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$$\text{H}^+(\text{aq}) + \text{HPO}_4^{2-}(\text{aq}) \rightleftharpoons \text{H}_2\text{PO}_4^-(\text{aq})$$

Figure 14. Summary after revision

## 3.2. Discussion

This discussion will explain the results of validation by 3 validators on each component in each section. The validation results are in the form of content validity and construct validity.

### 3.2.1. Content Validity

One aspect of feasibility is validity. Validity is divided into content and construct validity. Content validity is the measurement of items selected to reflect the suitability of the constructed variable measured (Sugiono et al., 2020). This content validity measures the suitability of the substance of the supplementary teaching materials with the material used, namely basic competencies 3.12 buffer solution. Content validity is assessed through a validation sheet consisting of 6 components that are assessed. This validity assessment uses a Likert scale with a range of 1-5. Supplementary teaching materials are declared valid if they get a minimum assessment mode of 4.

The first component discusses related material presented in supplementary teaching material containing components in basic competencies and additional basic competencies supporters. Based on Table 2, the first component in content validity from the assessment of 3 validators and all sections obtained a mode of 4 which was declared valid. The assessment shows that the material in the supplementary teaching materials developed by the basic competencies used, namely basic competencies 3.12 about buffer solution consisting of working principles, pH calculations, and the role of buffer solutions in the bodies of living things.

The second component discusses the substance of the basic competencies contained in the material in the supplementary teaching materials. The assessment of the second component in all sections obtained a mode of 4 which was declared valid. This supplementary teaching material presents buffer solution material in each section as a reference in showing backing. The validation assessment obtained in the valid category shows that the material content of the supplementary teaching materials contains the substance of the buffer solution in basic competencies 3.12.

The third component in the content validity assessment obtained a mode of 4 in the valid category. The phenomenon of each section in this supplementary teaching material is related to the concepts and facts in buffer solution and is presented before the column for argumentation indicators. The phenomena in these supplementary teaching materials serve as materials in supporting the fulfillment of argumentation skills indicators. Based on the assessment of this third component, shows the phenomena presented in each section by the concepts and facts in the buffer solution material.

Based on Table 2, the fourth component of content validity from the assessment of 3 validators in all sections obtained a mode of 5 which was declared very valid. The results of the validator's assessment show that the content in the supplementary teaching materials has a connection between thinking skills in basic competencies 3.12 with argumentation skills. The reason for using the material is because the indicators in argumentation skills are implicitly contained in the buffer solution which basic competencies 3.12 explain the working principle of pH calculation and the role of buffer solutions in the body of living things. The competencies in basic competencies 3.12 can be used and are relevant in supporting argumentation indicators. Basic competencies 3.12 contains an indicator of explaining which means explaining or describing clearly, where the indicator is also reflected in the Toulmin indicator in the warrant/reason section which explains the relationship between claims and data by forming a reason, to strengthen the argumentation of students to become more confident in their opinions.

The fifth component assessment on content validity obtained a mode of 4 which was declared valid. This fifth component discusses the correctness and suitability of the facts, concepts, and images presented in supplementary teaching materials. The phenomena presented in supplementary teaching material are equipped with images in each section. Based on this assessment, it shows that the images of the phenomena and concepts in the supplementary teaching materials are appropriate and correct so that they can have relevance between facts making it easier to train argumentation skills.

The sixth component discusses the correctness of the theory used in the supplementary teaching materials. The statements contained in this sixth component are the truth of the facts, concepts, principles, laws, and theories contained in supplementary teaching materials. The assessment of the sixth component on this obtained a mode of 4 which was declared valid, this shows that the theory contained in the supplementary teaching materials by existing laws and facts by reviewing using the correct literature. Teaching materials based on content validity are valid, indicating that the teaching materials are in accordance with the content of the curriculum and that the cognitive development of students makes the material easier to understand (Yati & Amini, 2020).

### **3.2.2. Construct Validity**

Construct validity is a measurement correlates substance with other indicators and is linked to the variables in the theory. Supplementary teaching materials are not only reviewed for content validity but also constructively. Construct validity is a measurement that shows the relationship between product indicators and existing theory (Sugiono et al., 2020). Construct validity of supplementary teaching materials obtained an overall component mode of 4 with valid criteria.

The construct validity assessment by 3 validators included 2 general construct components and 6 construct components of argumentation skills indicators.

Based on Table 3, the first component of construct validity from the assessment of 3 validators obtained a mode of 5 which was declared very valid. This first component discusses the direction and explanation of the argumentation skills indicators used to equalize perceptions between researchers and students. The assessment of this component shows that the supplementary teaching materials already have directions and instructions for conducting argumentation with 6 indicators and language features that can be used. The explanation of this argumentation skill indicator is contained in a table consisting of indicators, descriptions, and language features used.

The second component discusses the sufficiency of the components contained in the supplementary teaching materials. Components in this supplementary teaching material include title, preface, table of contents, basic competencies, indicators of competency achievement, learning objectives, concept map, overview of argumentation skills, argumentation skills indicators, sections 1, 2, 3, 4, evaluation, and bibliography. Based on Table 3, the assessment of the second component in this obtained a mode of 5 which was declared very valid, this shows the components in this supplementary teaching material can fulfill the sufficiency as teaching materials in use during learning.

Construct validity is also reviewed based on the sufficiency of the argumentation skills indicators. Toulmin's argumentation has 6 indicators, that is claim, data, warrant, qualifier, backing, and rebuttal (Tanfiziyah & Rochintaniawati, 2021). The components of argumentation skill indicators consist of 6 components.

Based on Table 4, the first component of construct validity from the assessment of 3 validators obtained a mode of 5 which was declared very valid. This first component discusses the direction and explanation of the argumentation skills indicators used to equalize perceptions between researchers and students. The assessment of this component shows that the supplementary teaching materials already have directions and instructions for conducting argumentation with 6 indicators and language features that can be used. The explanation of these argumentation skills indicators is contained in a table consisting of indicators, descriptions, and language features used as well as an overview of argumentation skills.

The second component discusses the sufficiency of the components contained in the supplementary teaching materials. Components in this supplementary teaching material include title, preface, table of contents, basic competencies, indicators of competency achievement, learning objectives, concept map, overview of argumentation skills, argumentation skills indicators, subchapter sections, evaluation, and bibliography. Based on Table 4, the assessment of the second component in this obtained a mode of 5 which was declared very valid, this shows that the components in this supplementary teaching material can fulfill the sufficiency as teaching materials in use during learning.

The first component discusses the first indicator of argumentation skills, namely constructing claims. Based on Table 4, the construct validity assessment in the first component obtained a mode of 4 in the valid category. Based on the assessment of this first component, it shows that the supplementary teaching materials developed are equipped with directions to make it easier for students to assess claims by writing an agreeing statement on a claim compiled from a phenomenon and data using existing language features. This supplementary teaching material has directions in assessing two claims that are considered correct so that in the answer column

learners can write a statement agreeing with one of the claims. The directions for assessing this claim are written in each section before the working column. In accordance with the claim statement, it contains a statement regarding a problem (Witri et al., 2020).

Based on Table 4, the construct validity assessment in the second component obtained a mode of 4 in the valid category. This second component reviews the direction of the second indicator in arguing, namely showing evidence. The results of the assessment of this second component show that the developed supplementary teaching materials train students' argumentation in the indicator of showing evidence by providing directions to write down some evidence in the form of appropriate data to strengthen the claims that have been compiled. Claims can be strengthened by providing evidence in the form of data relevant to the claim (Witri et al., 2020). The assessment of the third component in all sections obtained a mode of 4 which was declared valid, this shows that the developed supplementary teaching materials provide directions for formulating statements explaining the suitability of the data submitted and strengthening the claims that have been compiled. Argumentation skills requires reasons or causes that can support claims to strengthen the claims given (Suartha et al., 2020).

The fourth component discusses directions for showing backing. The assessment of the fourth component obtained a mode of 4 which was declared valid, this shows that the supplementary teaching materials have directions for writing supporting statements in strengthening the reasons given in the form of theoretical and scientific explanations which are indicators of argumentation skills. Indicators of argumentation skills require backing to strengthen the reasons given (Witri et al., 2020). The fifth component obtained a mode of 4 in the valid category. Based on the assessment results Table 4, explains that the supplementary teaching materials developed are equipped with directions in providing qualifiers that can facilitate students in writing the level of certainty of the statements submitted. This direction is presented before the answer column for students. Qualification is an indicator of argumentation skills that give specific characteristics to claims (Witri et al., 2020).

The assessment results are based on Table 4, where this sixth component obtained mode 4 from 3 validators which are included in the valid category. Based on the assessment of this sixth component, it shows that the developed supplementary teaching materials provide directions for compiling rebuttals by writing a statement and including the proposed reasons related to statements that are considered inaccurate. Rebuttal is needed to lead to certain conditions of contra-claims (Witri et al., 2020). The overall assessment results can be declared valid, which means that there is consistency between the substance and the argumentation skills indicators contained in the supplementary teaching materials so that they can be used in learning in practicing argumentation skills. The results of construct validity provide an overview of the consistency of the results in accordance with the theory or indicators to be achieved (Hikmah et al., 2023).

Based on the results of content and construct validation, it shows that the supplementary teaching materials in practicing argumentation skills in buffer solutions are declared valid with an assessment mode of 4. Content validity obtained a value of 4 which was declared valid, which shows that the buffer solution theory contained in supplement teaching materials is by existing laws and facts by reviewing it using the correct literature. From construct validation, the supplement teaching materials were also declared valid by obtaining a score of 4, indicating consistency between the substance or content and the argumentation skill indicators in supporting students' argumentation skills. Based on these results, it can be concluded that the supplement

teaching materials are of good quality and suitable for application in learning. The results of this study are different in several aspects from other studies, that is research conducted by Khairul Anam, Siti Harnina Bintari, and Parmin (Anam et al., 2023) regarding "Development of Teaching Material Supplements Based on Socio Scientific Issues to Improve Student's Scientific Argumentation Ability." The results of this study state that the teaching material supplements developed are valid and can improve scientific argumentation skills (Anam et al., 2023). The research that has been conducted is this research, where supplementary teaching materials are suitable for use in practicing and improving argumentation skills.

#### **4. CONCLUSION**

Supplementary teaching materials in practicing argumentation skills developed are declared valid both in content (relevance) and construct (consistency). It was obtained from the results of assessing the validity of supplement teaching materials that is content validity with mode 4 which is declared valid and construct validity obtaining mode 4 which is declared valid. This supplementary teaching materials can be used to train the argumentation skills of students who study the chemistry of buffer solutions. Based on the results of this study, it is expected to contribute to producing additional teaching materials that are feasible to help train the argumentation skills of students, so that students have good argumentation skills. In addition, the results of this study are also expected to help readers, especially educators, to gain knowledge and references to teaching materials that can be used in training argumentation skills. Based on this conclusion, for further research, it is recommended to carry out further feasibility tests on additional teaching materials in terms of practicality and effectiveness.

#### **REFERENCES**

- Akili, A. W. R., Lukum, A., & Laliyo, L. A. R. (2022). Pengembangan Perangkat Pembelajaran Larutan Elektrolit Berbasis Model Argument-Driven Inquiry untuk Melatih Keterampilan Argumentasi Ilmiah Siswa SMA. *Jurnal Inovasi Pendidikan Kimia*, 16(1), 22–29. <https://doi.org/10.15294/jipk.v16i1.28996>
- Anam, K., Bintari, S. H., & Parmin, P. (2023). Development of Teaching Material Supplements Based on Socio Scientific Issues to Improve Students' Scientific Argumentation Ability. *Journal of Innovative Science Education*, 12(37), 32–39.
- Arif, M. H., & Rukmi, A. S. (2020). Pengembangan Buku Suplemen untuk Keterampilan Menulis Deskripsi Siswa Kelas IV Sekolah Dasar. *JPGSD*, 8(5), 1033–1043.
- Branch, R. M. (2009). *Instructional Design: The ADDIE Approach*. USA: University of Georgia.
- Budiyono, A., Wildani, A., & Mahardika, I. K. (2020). Analisis Korelasi Kemampuan Memahami dengan Kemampuan Berargumentasi Siswa melalui Model Pembelajaran Argument Based Science Inquiry. *Phenomenon: Jurnal Pendidikan MIPA*, 10(1), 36–50. <https://doi.org/10.21580/phen.2020.10.1.4539>
- Demircioglu, T., Karakus, M., & Ucar, S. (2023). Developing Students' Critical Thinking Skills and Argumentation Abilities Through Augmented Reality-Based Argumentation Activities in Science Classes. *Science and Education*, 32(4), 1165-1195. Springer Netherlands.

<https://doi.org/10.1007/s11191-022-00369-5>

- Devi, N. D. C., Susanti V.H. E., & Indriyanti, N. Y. (2018). Analysis of High School Students' Argumentation Ability in The Topic of Buffer Solution. *JKPK (Jurnal Kimia dan Pendidikan Kimia)*, 3(3), 141. <https://doi.org/10.20961/jkpk.v3i3.23308>
- Hardini, S. D., & Alberida, H. (2022). Analisis Kemampuan Argumentasi Peserta Didik. *Biodidaktika: Jurnal Biologi Dan Pembelajarannya*, 17(1), 93–99.
- Hikmah, S. I., Tukiran, T., & Nasrudin, H. (2023). Validity of Student Worksheets Based on Model Argument Driven Inquiry Integrated by STEM to Train Students' Argumentation Ability and Self-Efficacy in Chemical Equilibrium Material. *IJORER : International Journal of Recent Educational Research*, 4(4), 416–433. <https://doi.org/10.46245/ijorer.v4i4.300>
- Khoiroh, N. S., & Azizah, U. (2021). Validation of Thermochemistry Supplement Book Based Problem Solving to Train Students Metacognitive Skills. *JCER (Journal of Chemistry Education Research)*, 5(2), 41–50. <https://doi.org/10.26740/jcer.v5n2.p41-51>
- Mashudi. (2021). Pembelajaran Modern: Membekali Peserta Didik Keterampilan Abad Ke-21. *Al-Mudarris : Jurnal Ilmiah Pendidikan Islam*, 4(1), 93–114.
- Nurofik, A., Yuliana, Yanuardi, S., & Adabiah, A. (2022). Validitas Buku Pengantar Teknologi Informasi di Area SMK PPN Padang. *Jurnal Ilmiah Hospitality*, 11(2), 835–842.
- Nuryasana, E., & Desiningrum, N. (2020). Pengembangan Bahan Ajar Strategi Belajar Mengajar untuk Meningkatkan Motivasi Belajar Mahasiswa. *Jurnal Inovasi Penelitian*, 1(5), 967–974. <https://doi.org/10.47492/jip.v1i5.177>
- Prastiwi, D., Setyosari, P., & Husna, A. (2020). Pengembangan Multimedia Tutorial sebagai Suplemen pada Mata Pelajaran Kimia Materi Asam dan Basa Kelas XI. *JINOTEP (Jurnal Inovasi dan Teknologi Pembelajaran): Kajian dan Riset dalam Teknologi Pembelajaran*, 6(2), 69–80. <https://doi.org/10.17977/um031v6i22020p069>
- Rahmansyah, M. A., Muslim, & Sinaga, P. (2022). Studi Kelayakan Bahan Ajar Interaktif Multipresentasi Berbantuan Articulate Storyline 3. *Spektra: Jurnal Kajian Pendidikan Sains*, 8(2), 219–235. <https://doi.org/10.32699/spektra.v8i2.241>
- Risyanti, E., Lisdiana, L., & Isnaeni, W. (2022). Implementation of Supplement Teaching Materials Based on Problem Based Learning to Improve Concept Mastery and Health Care Attitudes. *Journal of Primary Education*, 11(2), 218–230.
- Roviati, E., & Widodo, A. (2019). Kontribusi Argumentasi Ilmiah dalam Pengembangan Keterampilan Berpikir Kritis. *Titian Ilmu: Jurnal Ilmiah Multi Sciences*, 11(2), 56–66. <https://doi.org/10.30599/jti.v11i2.454>
- Sariati, Kadek, N., Suardana, Nyoman, I., Wiratini, & Made, N. (2020). Analisis Kesulitan Belajar Kimia Siswa Kelas XI pada Materi Larutan Penyangga. *Jurnal Imiah Pendidikan dan Pembelajaran P-ISSN: 1858-4543 e-ISSN: 2615-6091*, 4(1), 86–97. <https://doi.org/10.23887/jipp.v4i1.15469>.
- Setiawan, A. M., & Sholiha, F. Y. (2022). Pengembangan Lembar Kerja Siswa Interaktif Berbantuan Aplikasi Liveworksheet pada Materi Pesawat Sederhana untuk Meningkatkan Motivasi Belajar Siswa SMPN 23 Malang. *Spektra: Jurnal Kajian Pendidikan Sains*, 8(2), 159–174. <https://doi.org/10.32699/spektra.v8vi2.266>
- Suartha, I., Setiawan, I., & Sudiatmika, A. (2020). Pola Argumen Toulmin pada Proses Pembelajaran IPA SMP. *Jurnal Imiah Pendidikan dan Pembelajaran*, 4(1), 1–11.
- Sugiono, Noerdjanah, & Wahyu, A. (2020). Uji Validitas dan Reliabilitas Alat Ukur SG Posture

- Evaluation. *Jurnal Keterampilan Fisik*, 5(1), 55–61. <https://doi.org/10.37341/jkf.v5i1.167>
- Tanfiziyah, R., & Rochintaniawati, D. (2021). Profil Kemampuan Argumentasi Siswa mengenai Isu Sosiosaintifik dalam Pembelajaran Online. *BIOSFER : Jurnal Biologi dan Pendidikan Biologi*, 6(1). <https://doi.org/10.23969/biosfer.v6i1.4081>
- Ula, F. R., & Suyono. (2023). Development of Argumentation Skills Assessment Instruments on Buffer Solution Material. *Jurnal Penelitian Pendidikan IPA*, 9(12), 10792–10799. <https://doi.org/10.29303/jppipa.v9i12.4760>
- Widiastiningsih, R., Asrial, A., & Effendi-Hasibuan, M. H. (2022). Pengembangan E-Modul berbasis Pola Argumentasi Toulmin untuk Meningkatkan Argumentasi Siswa pada Materi Asam Basa. *PENDIPA Journal of Science Education*, 6(2), 410–414. <https://doi.org/10.33369/pendipa.6.2.410-414>
- Witri, E., Ngatijo, N., & Haris Effendi-Hasibuan, M. (2020). Development of Electronic Student Worksheets Based on Toulmin Argumentation Patterns to Improve Argumentation Skills in Basic Acid Materials. *Jurnal Pendidikan Kimia*, 12(3), 116–123. <https://doi.org/10.24114/jpkim.v12i3.21160>
- Wulansari, W., Nurmilawati, M., Utami, B., & Christiono, E. B. (2020). Analisis Validasi Keterampilan Komunikasi dan Argumentasi Siswa Biologi SMA Kelas XI MIPA. *Efektor*, 7(1), 42–48. <https://doi.org/10.29407/e.v7i1.14340>
- Yati, W., & Amini, R. (2020). Pengembangan Bahan Ajar dengan Pendekatan Cooperative Learning Tipe Turnamen di Sekolah Dasar. *Jurnal Basicedu*, 4(1), 158–167. <https://doi.org/10.31004/basicedu.v4i1.335>