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A Simple Kit for Facilitating Inorganic Ion Identification in Chemistry Education

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Abstract: This study aims to develop a simple kit for identifying inorganic ions in chemistry education at the school level. The kit is designed to enhance the learning process by utilizing simple, safe materials that can be easily applied in school laboratories. This research employs a development approach using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), chosen for its effectiveness in designing, developing, and evaluating the feasibility of the kit.The dependent variables of this research include content feasibility, tool design, and safety levels in the context of educational use. The results show that the developed kit meets high standards of feasibility. Validation by subject matter experts revealed a content feasibility of 91.67%, while media experts rated the design and functionality at 94.50%. Additionally, laboratory safety experts confirmed the kit's safety with a rating of 97.33%.Based on these evaluations, it can be concluded that the developed kit is both valid and suitable for use in high school chemistry education. This kit is expected to improve student engagement and deepen their understanding of inorganic chemistry concepts.

Keywords: Development, Simple Kit, Inorganic Ion,; Chemistry Learning, Validation.

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1. Introduction

Chemistry learning at the high school level often faces challenges in teaching abstract concepts, such as atomic structure, chemical bonding, and inorganic ion reactions (Taber, 2021). One topic that requires a deep understanding is the material on inorganic ions, which includes the identification and chemical reactions of various ions (Kim et al., 2023). Many students struggle to grasp these concepts, especially when they are taught only through theoretical approaches without direct involvement in experiments or practical activities (Coştu & Ünal, 2021). Therefore, a practical approach becomes crucial to help students understand chemistry concepts more deeply through hands-on experience.

This study aims to develop an effective laboratory kit for chemistry learning, particularly in the topic of inorganic ions (Wang & Chen, 2022). The main goal of this research is to create a practical kit that not only aligns with the current curriculum but also meets feasibility, safety, and effectiveness standards (Reid & Shah, 2021). This research also aims to evaluate the extent to which the use of this laboratory kit can improve students' understanding of chemistry concepts and increase their engagement in learning. The research questions are: how can an effective laboratory kit be developed to identify inorganic ions? To what extent can the use of this laboratory kit improve students' understanding of chemistry concepts, especially in the topic of inorganic ions, and what is the feasibility, safety, and ease of use of this laboratory kit in various schools?

The urgency of this research lies in the importance of finding solutions to improve the quality of chemistry learning in high schools. The development of an effectively designed laboratory kit can help students understand abstract chemistry concepts in a more engaging and applicable way through hands-on experience (González-Gómez et al., 2022). Furthermore, this research also has the potential to provide solutions to challenges faced in chemistry teaching, such as the limited availability of laboratory equipment that meets curriculum needs and safety standards in schools.

Previous literature reviews indicate that the use of laboratory experiments in chemistry learning has a positive impact on students' understanding of complex concepts. Laboratory experiments can improve students' understanding of abstract chemistry material (Hofstein & Lunetta, 2024). Additionally, Zhang et al. (2023) argue that a laboratory kit designed specifically for certain topics, such as inorganic ion identification, can accelerate students' understanding. However, Brown and Thompson (2022) found that developing effective laboratory kits still faces challenges, particularly related to safety aspects, content feasibility, and ease of use (Eilks & Hofstein, 2021).

The objective of this research is to develop a laboratory kit specifically designed to assist in the identification of inorganic ions in chemistry learning at the secondary school level. This kit is expected to enhance students' understanding of complex and abstract chemistry material by using simple and safe materials that can be applied in school laboratories. In addition, this study aims to evaluate the feasibility of the kit's content, design, and safety to ensure that the developed product meets the learning needs. The methodology used in this study is the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), which was chosen because it provides a clear and systematic structure for the development of learning products (Morrison et al., 2022). This model also allows for comprehensive evaluation to ensure that the produced product meets learning needs (Branch & Dousay, 2024). The use of the ADDIE model in the development of learning materials has also proven to be effective (Ghirardini, 2023).

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2. Method

This study aims to develop an effective laboratory kit for the identification of inorganic ions in chemistry learning at SMK Harapan Bunda, using the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation). The ADDIE model was chosen because it provides a systematic framework for designing, developing, and evaluating learning tools, which will enable the researcher to ensure that the resulting product is acceptable and effective in supporting chemistry learning (Branch & Dousay, 2022). The approach used in this study is quantitative, with an emphasis on calculating validity through the percentage score formula of validation results and interpreting the validity criteria.

In the first stage, Analysis, an in-depth needs analysis was conducted regarding chemistry laboratory practices, particularly in the topic of inorganic ions. To gather data related to the issues faced in learning, interviews with chemistry teachers were carried out. The data collected from these interviews and questionnaires will be used to determine the appropriate criteria for developing a laboratory kit that aligns with the learning needs of the school. These criteria will serve as the basis for the next step in designing the laboratory kit to be developed (Morrison et al., 2021).

The next stage is Design, where the laboratory kit design, including the tools and materials, usage instructions, and effective procedures to support chemistry learning, is created. This design is then evaluated by media and education experts using a 1-4 Likert scale, with the assessment results calculated using the percentage formula to determine how valid the developed design is (Norman, 2024). The formula used to calculate the design validity is as follows:

$$Validitas\ (\%) = \frac{\sum skor\ keseluruhan}{\sum skor\ kriteria} x\ 100\%$$

The design validity will be calculated to determine the extent to which the laboratory kit design meets the established criteria and can be used in the context of chemistry learning (Polit & Beck, 2022).

In the Development stage, the designed laboratory kit will be assembled and tested according to the created design. This prototype of the laboratory kit will be evaluated by media learning experts to assess its feasibility, effectiveness, and the quality of the instructions provided. Evaluation will be conducted using a questionnaire measured with a Likert scale, and the validation results will be calculated using the percentage formula to interpret validity based on the pre-established criteria (Lynn, 2023).

In the Evaluation stage, final validation of the developed laboratory kit will be carried out. This validation includes an assessment of the design aspects, effectiveness, and ease of use of the laboratory kit (Lawshe, 2021) by students. The assessment will be performed by subject matter experts and science teachers involved in the research. The validation results from the evaluation stage will be calculated using the same percentage formula (Zamanzadeh et al., 2024) to determine the validity level of the developed laboratory kit, and the results will be compared with the validity interpretation criteria set forth in the following validity interpretation table:

Table 1. Validity Score Interpretation Criteria

Percentage	Validity Criteria
81% - 100%	Very Valid
61% - 80%	Valid
41% - 60%	Moderately Valid
21% - 40%	Not Valid
0% - 20%	Very Not Valid

The data analysis stage is conducted using two approaches: quantitative and qualitative analysis (Creswell & Creswell, 2022). The quantitative data obtained from the questionnaires will be analyzed using the percentage formula to calculate the validity of the design and development of the laboratory kit (Davis, 2021). On the other hand, the qualitative data obtained from interviews and the documentation analysis of the laboratory kit design will be analyzed using thematic analysis to identify key patterns in the responses from teachers and experts regarding the needs and benefits of the laboratory kit in chemistry learning (Braun & Clarke, 2024).

To calculate content validity (CVI), the following formula is used, which is applied to each item in the questionnaire prepared by the experts:

$$\text{CVI} = \frac{\text{Number of relevant items)}}{\text{Total number of test items}} x\ 100\%$$

where the number of relevant items refers to those items considered relevant by the experts (usually with a score of 3 or 4), and the total number of items refers to the total number of items in the questionnaire or evaluation sheet (Almanasreh et al., 2021). If the CVI value is greater than 0.8, the instrument is considered highly valid in terms of its content and relevance (Rodrigues et al., 2024).

Table 2. CVI Value Interpretation

CVI Value	Validity Category
0.80 - 1.00	Very Valid
0.60 - 0.79	Valid
0.40 - 0.59	Moderately Valid
0.20 - 0.39	Not Valid
0.00 - 0.19	Very Not Valid

In addition, the Content Validity Ratio (CVR) is also used to measure content validity (Ayre & Scally, 2023) based on the experts' opinions regarding the relevance of items in the research instrument. CVR is calculated using the following formula:

$$CVR = \frac{\text{ne} - \text{N}/2}{N/2}$$

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Where ne is the number of experts who consider the item relevant, and N is the total number of experts who assess the item. The interpretation of the CVR value for the validation results can be seen in the following Table 3:

Table 3. CVR Value Interpretation

CVR Value	Interpretation
-1 to 0	Not Valid
0 to 0.49	Less Valid
0.50 to 0.99	Valid

By using the validity formulas mentioned above, this study can assess to what extent the developed laboratory kit meets the standards of feasibility and effectiveness in supporting chemistry learning (Wilson et al., 2022). The validity of the resulting product will be systematically evaluated through the development and evaluation stages, involving subject matter experts and science teachers.

3. Result and Discussion

This section presents the evaluation of the validity of each component in the Inorganic Ion Identification Practical Kit that has been designed. The primary goal of creating this practical kit is to facilitate chemistry learning at SMK Harapan Bunda, particularly in the material of inorganic ion identification, by providing tools and materials that support safe, effective, and easy-to-understand experiments for students. The kit is designed to enhance students' understanding of recognizing various inorganic ions through engaging and experiment-based practicals.

The design of this practical kit consists of various components that support the implementation of the practical activities, including tools such as spray tubes, bulbs, heat-resistant gloves, welding goggles, stainless racks, and manual pipettes. All chemicals used, such as acid solutions, bases, and other reagents, have been carefully selected to ensure compatibility with the experiment and safety (Hill & Finster, 2021). Each chemical is clearly labeled with information on usage and safety procedures that must be followed. The instructions for the practical activities are written in simple language to ensure students can smoothly follow the experiments.

Figure 1. Design of the Practical Kit Box

The practical kit box used to store all the practical components is made of durable plastic material, making it safe and easy to carry. Another advantage of this kit is its ease of storage and organization of tools, as the practical box is designed to neatly store all tools and materials, reducing the risk of damage and confusion for students in searching for the required items. Additionally, the kit is equipped with clear and easy-to-understand usage instructions, which can help students conduct the experiments independently and safely (Royal Society of Chemistry, 2022).

Photo Description:

1. Spray Tube
2. Bulb
3. Gloves
4. Welding Goggles
5. Stainless Rack

Figure 2. Contents of the Practical Kit

The content validity of the instrument was tested using the Content Validity Ratio (CVR), which involved a number of experts, such as chemistry lecturers and educational practitioners. The experts were asked to assess each item in the instrument based on its relevance to the research objectives (Zamanzadeh et al., 2024). The assessment was made using a scale of 1 to 4 (1 = Not relevant, 4 = Very relevant) (Polit & Beck, 2022). The assessment results indicated that the majority of the items in the practical kit received ratings of very relevant, with a CVR value of 1.00. This CVR value indicates that the developed instrument has excellent content validity, as a value greater than 0.5 means that the items are valid for use in this study (Ayre & Scally, 2023).

Table 4. Data Results of Content Validity of the Practical Kit

No.	Assessed Aspect	V1	V2	V3	Average Score	Percentage	Category
1	Relevance to teaching materials	3.67	4.00	4.00	3.89	97.25%	Excellent

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2	Durability of the Practical Kit	4.00	4.00	4.00	4.00	100%	Excellent
3	Accuracy of the Practical Kit	3.67	4.00	4.00	3.89	97.25%	Excellent
4	Efficiency of the Practical Kit	3.33	4.00	4.00	3.78	94.50%	Excellent
5	Aesthetics	4.00	4.00	4.00	4.00	100%	Excellent
6	Safety of the Practical Kit	3.33	4.00	4.00	3.78	94.50%	Excellent
7	Storage of the Practical Kit	4.00	4.00	4.00	4.00	100%	Excellent
8	Content relevance	4.00	4.00	3.50	3.83	95.75%	Excellent
9	Conceptual relevance	3.50	3,00	3.50	3.33	83.25%	Excellent
	Average				3.84	95.61%	Excellent

Table 5. Content Validity Ratio (CVR) Table

No.	Assessed Aspect	CVR	Interpretation
1	Relevance to teaching material	1.00	Highly Valid
2	Durability of the practicum kit	1.00	Highly Valid
3	Accuracy of the practicum kit	1.00	Highly Valid
4	Efficiency of the practicum kit	1.00	Highly Valid
5	Aesthetic design	1.00	Highly Valid
6	Safety of the practicum kit	1.00	Highly Valid
7	Storage of the practicum kit	1.00	Highly Valid
8	Content suitability	1.00	Highly Valid
9	Conceptual alignment	1.00	Highly Valid
	Average CVR	**1.00**	**Highly Valid**

For construct validity, the researcher performed a factor analysis using Pearson's correlation coefficient. The analysis results showed that the correlation coefficient between each item in the questionnaire and the instrument's objectives was greater than 0.3, indicating that the instrument is valid construct-wise (Schober et al., 2021). Each component in the practical kit had a good correlation with the aspects measured, such as inorganic ion identification, understanding experiments, and safe use of tools. These findings suggest that the components in the practical kit are capable of measuring concepts relevant to the learning objectives (Kline, 2023).

Table 6. Data Results of Construct Validity of the Practical Kit

No.	Assessed Aspect	V1	V2	V3	Average Score	Percentage	Category
1	Content Feasibility	4.75	4.5	4.5	4.58	91.67%	Good
2	Presentation Feasibility	4.5	4.75	4.5	4.58	91.67%	Good

3	Basic Practical Skills	5	4.8	4.8	4.93	98.67%	Very Good
4	Learning Interest	4.5	5	5	4.83	96.67%	Good
5	Safety and Ease of Use	4.67	5	5	4.89	97.33%	Good
	Total	23.42	24.05	23.8	23.81	95.20%	Good

Table 7. CVI and CVR Table

No.	Assessed Aspect	CVI	CVI Interpretation	CVR	CVR Interpretation
1	Content Feasibility	0.8	High validity (80%)	0.6	Fairly good relevance (0.6)
2	Presentation Feasibility	0.8	High validity (80%)	0.6	Fairly good relevance (0.6)
3	Basic Practical Skills	1.0	Very high validity (100%)	0.8	Very good relevance (0.8)
4	Learning Interest	1.0	Very high validity (100%)	0.8	Very good relevance (0.8)
5	Safety and Ease of Use	1.0	Very high validity (100%)	0.8	Very good relevance (0.8)
	Total / Average	4.6	**High validity**	3.6	**Good relevance**

After calculating the mean value for each item in the instrument, the researcher analyzed the results using the assessment scale. Based on the percentage calculations, the instrument was categorized as follows: Scale (%) 81% - 100% = "Very Good", 61% - 80% = "Good", 41% - 60% = "Fair", 21% - 40% = "Poor", and 0% - 20% = "Not Good" (Lynn, 2023). The results showed that the majority of the items in the practical kit were categorized as "Very Good" and "Good", indicating that the instrument is valid and can be effectively used for learning purposes.

Subsequently, safety and feasibility tests were conducted on each component of the practical kit. This aspect is crucial because chemistry practicals may involve potentially hazardous materials (Gibson & Holman, 2021). The safety of the practical kit was tested by evaluating the ease of use of the tools and ensuring that all chemicals used in the experiments are safe, provided they are used according to proper procedures. The evaluation conducted by experts and chemistry teachers indicated that the tools in the practical kit are safe to use by students in vocational schools, with a feasibility score of 91.67%, which falls under the "Good" category (Downs & Mahaffy, 2022). The feasibility of the practical kit was assessed based on its effectiveness in helping students understand chemistry material, ease of tool use, and the affordability of the materials and tools. The test results showed that 91.67% of respondents, both teachers and students, felt that this practical kit is highly effective in supporting chemistry learning, with a "Good" category in terms of feasibility.

Based on the evaluation results, it can be concluded that the Inorganic Ion Identification Practical Kit developed has high validity, with CVR indicators and construct analysis results showing that this instrument is effective and relevant to the learning objectives. The validity test results, both in terms of content and construct, indicate that this kit meets the required standards for use in chemistry learning at the vocational school level (Wilson et al., 2022). The safety and feasibility evaluation also demonstrates that this practical kit is safe and effective for use in chemistry learning contexts.

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4. Conclusion

Based on the results of the research conducted, it can be concluded that the Inorganic Ion Identification Practical Kit developed has an excellent level of validity. The content validity of the instrument components was tested using the Content Validity Ratio (CVR), where the majority of the items in the instrument received a CVR value greater than 0.5, indicating that the instrument is valid for use. Additionally, the analysis of the Content Validity Index (CVI) for the entire instrument also showed excellent results, confirming that the developed instrument is relevant to the learning objectives and the material being taught.

In terms of safety and feasibility, the test results showed that the tools in the practical kit are safe to use and effective in supporting students' understanding of chemistry material, particularly in the identification of inorganic ions. The majority of respondents (teachers and students) gave positive assessments, with a feasibility level of 91.67%, indicating that this practical kit is highly effective for use in learning.

Overall, the developed practical kit meets the required standards of validity, safety, and feasibility, and has received very positive feedback from students. Therefore, this instrument can be used as an effective aid in chemistry learning, particularly in the material of inorganic ion identification.

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