SPIN 7 (1) (2025) 97-103

SPIN
JURNAL KIMIA & PENDIDIKAN KIMIA
https://journal.uinmataram.ac.id/index.php/spin

DESIGN OF TEACHING MATERIALS FOR ELECTROLYTE AND NON-ELECTROLYTE SOLUTIONS TO SUPPORT THE IMPLEMENTATION OF NON-ROUTINE STRATEGY LEARNING FOR PRE-SERVICE CHEMISTRY TEACHER STUDENTS

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DOI: 10.20414/spin.v7i1.14031

History Article
Accepted:
Feb 27, 2025
Reviewed:
May 28, 2025
Published:
July 10, 2025

Keywords:
Electrolyte and non-electrolyte solutions, Non-routine learning strategies, Teaching materials

ABSTRACT

This study aims to design teaching materials that can optimize the implementation of non-routine learning strategies in the classroom. Non-routine learning focuses on the development of critical, creative, and adaptive thinking skills, so flexible, contextual devices are needed that can encourage active student participation. The research method used is Research and Development (R&D) with an iterative design approach. The teaching materials that were designed were then validated by three experts, revised based on their input, and subjected to limited trials in the classroom. The study's results showed that non-routine-based teaching materials, which support the implementation of non-routine learning strategies, were highly significant. The average difference in the increase in the abilities of UIN Sultan Syarif Kasim Riau students was 7.83, while that of UIN Ar-Raniry Banda Aceh was 7.9. Therefore, it is recommended that this non-routine learning strategy be continued and expanded for use in other universities to enhance the quality of education in learning chemistry.

How to Cite

Mujakir. (2025). Design of Teaching Materials for Electrolyte and Non-Electrolyte Solutions to Support The Implementation of Non-Routine Strategy Learning for Pre-Service Chemistry Teacher Students. *SPIN-Jurnal Kimia & Pendidikan Kimia*. 7(1). 97-103.

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p-ISSN: 2580-2623
e-ISSN: 2745-6854

INTRODUCTION

In the 21st-century education era, developing thinking skills for prospective chemistry teacher students is a primary requirement in the learning process. These thinking skills are trained continuously, from designing teaching materials to implementing them. This process is a serious concern for lecturers as academics who produce professional prospective teachers in the field of chemistry. Chemistry has unique and distinctive characteristics in its learning. These characteristics are marked by the material's properties, which reveal or study abstract and fundamental concepts. Based on these characteristics, prospective teacher students must be well-prepared so that in their delivery, they can reduce conceptual errors.

Understanding chemical concepts is similar to understanding concepts in other fields. However, when transferring knowledge, it is essential to focus on designing teaching materials that are prepared to serve as sources for students, who are the primary recipients of the knowledge or information being delivered. The impact is that students can easily acquire knowledge about the material they are studying. On the other hand, the design that is built must also be effective, efficient, and attractive. The right learning design can improve students' understanding and motivation to learn (Arsyad, 2017). Systematic planning and orientation to the needs of students are critical for achieving optimal learning goals (Kemp et al., 2010). Trianto (2011) stated that students will more easily absorb knowledge if the material is presented contextually and engagingly, which supports the process of active and creative thinking. This is also a task in constructing students' understanding in learning from fundamental concepts experienced every day about academic concepts in the learning process.

These efforts aim to improve the quality of education, particularly in chemistry subjects related to electrolyte and non-electrolyte solutions. To carry out learning activities with products that have been designed, the support of learning strategies is important to consider. The selection of learning strategies that are based on the characteristics of the material is the leading indicator in facilitating students' absorption of the material to be taught. Kemp, Morrison, and Ross (2010) emphasize the importance of the suitability between learning strategies and material characteristics so that the learning process runs effectively.

The design of the teaching materials designed is intended to support the implementation of the teaching and learning process using non-routine learning strategies that have been developed (Mujakir, 2024), proper strategy planning can help students build a more profound and contextual understanding of the learning material (Trianto, 2011) this strategy describes how teachers scaffold students from abstract concepts related to the behavior of ions in the solution that the five senses cannot prove into an explanation that can convince students that the events in electrolyte and non-electrolyte solutions, both the ions and the molecules contained therein, are real events.

Non-routine strategies emphasize the presentation of unusual problems and challenge students to develop various innovative solutions. In the context of chemistry learning, especially in the material on electrolyte and non-electrolyte solutions, the non-routine approach is very relevant because it requires deep conceptual understanding and high application skills. Electrolyte and nonelectrolyte solution materials are often taught through solving routine problems, such as calculating ion concentrations, determining solution strength based on electrical conductivity, or classifying substances into strong electrolytes, weak electrolytes, and nonelectrolytes. These problems tend to be repetitive and have standard solution patterns. As a result, students tend to focus more on memorizing procedures than on critically understanding the concepts. In contrast, non-routine problems in this material require students to apply concepts in new situations (Trilling & Fadel, 2009), for example, analyzing electrical phenomena in various everyday solutions, designing simple experiments to prove the electrolyte properties of a substance, or predicting the behavior of solutions under unusual conditions. Presenting these non-routine problems can enrich the learning experience and develop high-level thinking skills (Jonassen, 2011).

The reality in the field shows that chemistry learning still tends to be dominated by learning strategies that focus on memorizing concepts and solving routine problems (Mujakir & Rusydi, 2019) without encouraging further exploration (Mujakir, 2018). So far, the concepts taught have been limited, primarily to the macroscopic phase. For example, the lights are bright, dim, and not on. This can prevent students from reaching the concept of substance.

Electrolyte and non-electrolyte solutions. The concept of substance refers to how particles, ions, and molecules interact in solution, resulting in lights being bright, dim, or off. In their work, these ions will transfer energy from positive ions and negative ions contained in the solution. When transferring energy, the ions in the solution will move according to their charge. Positive ions move towards the negative electrode, while negative ions move towards the positive electrode. The movement creates an attractive interaction between the ions and the electrodes, which produces energy. The energy formed from this interaction is then transmitted through an electrical circuit (Mujakir, 2019). Positively charged particles will transfer energy through the negative electrode, while negatively charged ions will channel their energy through the positive electrode. Thus, the process of ion transfer in solution plays an important role in the flow and transfer of energy in electrochemical systems.

At the State Islamic University of Ar-Raniry Banda Aceh and the State Islamic University of Sultan Syarif Kasim Riau, it was found that many students had difficulty in linking the concept of electrolyte and non-electrolyte solutions with everyday contextual phenomena. This suggests the need to develop teaching materials specifically designed to optimize non-routine learning strategies.

Innovative teaching material designs must be able to facilitate students in exploring concepts through open-ended problems, simple experiments, case studies, and collaborative discussions (Widodo & Jatmiko, 2016), as a result, these teaching materials not only function as information media, but also as tools to build independent thinking and problem-solving skills.

In practice, the presentation of routine problems in chemistry learning, especially in the material on electrolyte and non-electrolyte solutions, typically takes the form of standard questions, such as calculating ion concentration, determining electrical conductivity, or identifying types of solutions based on their electrolyte strength. These problems are important for building a foundation of knowledge (Cooper, 2015), but if used dominantly, they can limit students' critical thinking space. Repetitive question patterns cause students to rely on memorizing formulas or procedures without understanding the meaning of the concept as a whole.

Presentation of non-routine problems can invite students to think more deeply and apply concepts to complex and unstructured situations. For example, students are asked to analyze the difference in electrical conductivity of isotonic drink solutions and coconut water, design simple experiments to determine the type of solution based on empirical observations, or predict the effect of mixing two different solutions on their electrical properties. This type of problem encourages students to integrate various chemical concepts, reason, and develop creative solutions (Santrock, 2011) based on the data obtained.

Based on the description above, the design of teaching materials based on non-routine problems for electrolyte and non-electrolyte solution materials is fundamental in universities, including at UIN Ar-Raniry Banda Aceh and UIN Sultan Syarif Kasim Riau. In addition to improving conceptual understanding, this teaching material also aims to build students' learning independence and scientific skills, such as observing, interpreting data, drawing conclusions, and communicating results logically. With this active involvement, it is expected that students will be able to relate chemical concepts to real-life phenomena (Bybee, 2013), and be better prepared to face the challenges of competency-based learning in the future. Therefore, this study focuses on designing teaching materials that not only meet academic standards but also respond to the actual needs of students (Prince & Felder, 2006) at both institutions. The teaching materials developed will be in the form of activity-based modules, equipped with non-routine problems, simple experiments, conceptual reflection guides, and collaborative tasks. This strategy is expected to optimize the cognitive, affective, and psychomotor potential of students in a more balanced manner, while also serving as a model for developing innovative teaching materials in the field of chemistry education. Based on this background, this study aims to design teaching materials based on non-routine learning strategies for electrolyte and non-electrolyte solution materials, which will be implemented at UIN Ar-Raniry Banda Aceh and UIN Sultan Syarif Kasim Riau.

METHODS

This study employs a Research and Development (R&D) approach with an iterative design model to develop teaching materials that incorporate non-routine learning strategies. This approach was chosen because it enables the production of products that meet user needs, while also allowing for continuous improvements through feedback received from each development phase (Borg & Gall, 2003). In the development of this teaching material, five stages were employed, namely needs analysis, design of the teaching material, validation and revision, product testing, and evaluation and finalization. Teaching Material Design: Based on the results of the needs analysis, teaching materials are designed with a focus on presenting non-routine problems that can stimulate students' critical and creative thinking skills. Teaching materials are designed to build a deeper conceptual understanding of electrolyte and non-electrolyte solutions (Taba, 1962). The final product in the form of improved teaching materials will be used for further reference in teaching at both universities (Sanjaya, 2013). The sample in the study consisted of students from Ar-Raniry State Islamic University and Sultan Syarif Kasim State Islamic University, Riau, who were enrolled in a solution chemistry course. The sample in this study was 200 students. The sample selection technique used was purposive sampling.

RESULT AND DISCUSSION

This section presents data on the results of validating the designed teaching materials, as well as data on student test results before and after using these materials to support the implementation of non-routine learning strategies. The data are presented in Tables 1 to 5.

Table 1. Validation of teaching materials

No	assessed aspects	Validator			Mean	Criteria	Coefficient.	Reliability
		V1	V2	V3		Validity	Reliability	
Content Suitability								
1	Memiliki daya Tarik	4	3	4	3.67	Sangat Valid	85.71%	Reliabel
2	Suitability of teaching materials with learning objectives	4	3	4	3.67	Very Valid	85.71%	Reliabel
3	The breadth of the material	3	4	3	3.33	Very Valid	85.71%	Reliabel
4	Into of the material	3	4	4	3.67	Very Valid	85.71%	Reliabel
5	Accuracy of facts	4	3	4	3.67	Very Valid	85.71%	Reliabel
6	Truth of concepts (content)	4	3	4	3.67	Very Valid	85.71%	Reliabel
7	The suitability of the phenomenon with the problem of the material to be taught through non-routine	4	3	4	3.67	Very Valid	85.71%	Reliabel
8	Cultivate curiosity	3	4	3	3.33	Very Valid	85.71%	Reliabel
9	Compliance with non-routine learning strategies	3	3	4	3.33	Very Valid	85.71%	Reliabel

No	assessed aspects	Validator			Mean	Criteria Validity	Coefficient. Reliability	Reliability
		V1	V2	V3				
10	Suitability with the latest scientific developments	4	3	4	3.67	Very Valid	85.71%	Reliabel
Language Components								
11	According to the level of development of students' thinking.	4	4	4	4.00	Very Valid	100.00%	Reliabel
12	According to the level of social-emotional development of students	4	4	4	4.00	Very Valid	100.00%	Reliabel
13	Accuracy of sentence structure and novelty of terms	4	3	4	3.67	Very Valid	85.71%	Reliabel
14	Creating communication	3	3	4	3.33	Very Valid	85.71%	Reliabel
15	Accuracy of grammar and spelling	4	3	4	3.67	Very Valid	85.71%	Reliabel
16	Does not cause double interpretation	4	3	4	3.67	Very Valid	85.71%	Reliabel
17	Easy to understand	4	3	4	3.67	Very Valid	85.71%	Reliabel
Presentation Components								
18	Logicality and balance of material substance	4	3	4	3.67	Very Valid	85.71%	Reliabel
19	Student-centered	4	4	4	4.00	Very Valid	100.00%	Reliabel
20	Presentation of text, tables, and images	4	4	4	4.00	Very Valid	100.00%	Reliabel
21	Updated bibliography	4	3	4	3.67	Very Valid	85.71%	Reliabel

Validator suggestions:
1. Illustrations need to be made more interesting
2. The breadth and depth of the material need to be added
3. Needs to be made more provocative
4. Creating interactive communication is less visible
5. Check the script

Table 2. Student ability tests before and after using non-routine

Results of student ability tests before		Results of student ability tests after	
High	20, 8%	High	72%
Medium	47,03%	Medium	22%
Low	32,13%	Low	6%

Table 3. Increase in value before and after using non-routine-based teaching materials.

Average value before	78,23
Average value after	86,06
Increase	7, 83

Teaching materials are designed based on non-routine learning. The goal is to help students solve problems in more depth. In this process, three levels of macroscopic, microscopic, and symbolic representation are employed to solve problems and comprehensively re-explain concepts (Rusilowati et al., 2020; Nugraheni & Susilaningsih, 2022). This is particularly important because electrolyte and non-electrolyte solution materials exhibit distinct characteristics, especially in terms of how ions behave in solution (Pratiwi & Hidayah, 2021). Teaching materials are designed to train students' critical thinking skills through non-routine problems. Non-routine problems are those whose solutions differ from those encountered in everyday tasks (Nugroho & Sari, 2021). To solve non-routine problems, a special procedure is employed, which involves starting from problem analysis, finding a solution, and re-explaining the results obtained (Mujakir et al., 2024; Fitriyani et al., 2020; Zahroh & Yuliati, 2019). This strategy aims to develop critical thinking skills and conceptual understanding of students in more depth. The validation results obtained from three experts showed that all aspects of the validation score components ranged from 3.33 to 4.00, with a reliability percentage of 85.71% to 100%. This means that non-routine-based teaching materials are valid and reliable for use in supporting the implementation of non-routine learning strategies. The problems presented in training students to use teaching materials are non-routine, unstructured problems that still require the identification of main and supporting variables, and involve the concept of multiple representations to help students understand problems from various perspectives (Syahrul et al., 2021). The representation approach was initially developed and updated from the initial framework proposed by Johnstone, but is now increasingly developed in the context of modern chemistry learning (Putri & Fatmawati, 2022).

The purpose of presenting problems in the form explained above is to train students' ability to think analytically, carefully, precisely, and deeply when solving problems (Saputro & Wulandari, 2021). This goal is a basic indicator in training students to explain the phenomena that occur in chemical reactions. Chemical reactions are very abstract phenomena; for example, the interaction between negative partial charges and positive partial charges in a solution cannot be observed directly by the five senses. Therefore, students must be able to explain this abstract phenomenon in a macroscopic context. One way to prove it macroscopically is through observing the light, using a multitester, or a digital tool (Ramadhani & Prasetyo, 2020). This test allows students to understand that the energy transferred through the positive and negative electrodes is the result of interactions between ions, such as H^+ from water (H_2O) with Cl^-, as well as the interaction between OH^- from water with the positive partial charge of the Na^+ ion (Putri & Ningsih, 2019).

Training students' ability to explain phenomena that occur in electrolyte and non-electrolyte solutions should not be done separately between forms, phases, symbols, and abstract real-world events. This means that three levels of chemical representation — namely, macroscopic, submicroscopic, and symbolic —must be applied simultaneously in the learning process (Pratiwi & Kurniasih, 2021; Nurhayati et al., 2020). The goal is to encourage students to gain a better understanding of the concept as a whole in solving problems related to electrolyte and non-electrolyte solutions (Lestari & Hidayah, 2019). This integration of representations also helps overcome misconceptions and improve students' chemical thinking skills (Sari et al., 2022). Learning outcomes after applying teaching materials using non-routine learning strategies for electrolyte and non-electrolyte solution materials to students at UIN Sultan Syarif Kasim Riau, students who have abilities in three categories, namely high by 20.8% increased to 72%, medium ability 47.03% decreased to 22%, low ability 32.13% decreased to 6%. Overall, the average difference in improvement before and after learning activities using non-routine-based teaching materials was 7.83. While the learning outcomes after applying teaching materials using non-routine learning strategies for electrolyte and non-electrolyte solution materials to students at UIN Ar-raniry Banda Aceh, students who have abilities in three categories, namely high by 22.1% increased to 70%, medium ability 44.3% decreased to 23%, low ability 33.6% decreased to 7%. Overall, the average increase in learning outcomes of students at UIN Ar-Araniry Banda Aceh before and after using non-routine-based teaching materials was 7.9. This figure illustrates a difference in learning outcomes following the application of teaching materials in the implementation of non-routine strategies.

Based on the results of the implementation of non-routine-based learning activities, the findings in the study are as follows; (1) Students can explain concepts specifically by involving three levels of representation, (2) Students can solve problems presented in an unstructured form in a non-routine way, (3) Students understand the concept well and correctly as a result of non-routine exercises involving three levels of chemical representation.

CONCLUSION

This study successfully designed teaching materials based on non-routine learning strategies that can be applied to electrolyte and non-electrolyte solution materials at UIN Ar-Raniry Banda Aceh and UIN Sultan Syarif Kasim Riau. The application of these teaching materials yielded significant results, specifically an increase in students' understanding of the material being taught. The average difference in the increase in students' abilities at UIN Sultan Syarif Kasim Riau was 7.83, and at UIN Ar-Raniry Banda Aceh, it was 7.9. Therefore, it is recommended that this non-routine learning strategy be continued and expanded at other universities to enhance the quality of education in chemistry.

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