***Enhancing Science Teacher Students' Communication Skills: The Effect of Model-Based Learning***

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**Abstracts**
Effective scientific communication plays an important role in capturing public attention and promoting scientific knowledge. Preparing future science teachers with these qualities is critical for fostering scientific understanding in their students. The purpose of this study is to study the effects of using models as a basis for organizing learning on the science communication skills of science teacher students. In this study, student science teachers participate in Model-Based Learning exercises meant to improve their communication abilities in a range of circumstances, such as communicating science concepts to varied audiences. Students' communication skills during class are evaluated. The study's findings revealed that science teacher students who used Model-Based Learning as a basis performed well in science communication. According to the findings of the scientific communication behavior observation, science teacher students demonstrate a wide range of clear, accurate, and engaging scientific communication behaviors.

Keywords: Model-Based Learning, Communication Skills, Scientific Communication

## Introduction

### Scientific Communication

Effective science communication skills are essential for science teachers, as they play an important role in the teaching and inspiration of future generations. Science teachers are more than just information providers; they are interpreters and translators of difficult scientific concepts, making them accessible and exciting to pupils. The capacity to effectively communicate science improves student knowledge, encourages curiosity, and promotes scientific literacy, all of which are crucial in an increasingly technologically driven world. Strong science communication skills enable teachers to present information clearly, address misconceptions, and relate scientific concepts to everyday life, making learning more relevant and impactful. Moreover, these skills help in creating an interactive and dynamic classroom environment where students feel encouraged to ask questions, participate in discussions, and engage in critical thinking. Research underscores the importance of these skills in educational settings. According to a study by McDermott et al. (2018), teachers who employ effective science communication techniques can significantly improve students' comprehension and retention of scientific concepts. This study highlights that teachers who are adept at explaining concepts, utilizing analogies, and engaging students through interactive methods tend to achieve better educational outcomes. Additionally, these skills are crucial in fostering a positive attitude towards science, which can lead to increased interest and pursuit of science-related careers (McDermott et al., 2018). To summarize, scientific teachers' communication skills are critical not only for effective instruction, but also for inspiring the next generation of scientists, engineers, and educated citizens. By mastering science communication, teachers may bridge the gap between difficult scientific information and student comprehension, playing an important role in building a scientifically literate society.

### Model-Based Learning

Model-based learning has emerged as a powerful instructional strategy that enhances scientific communication skills among science teachers. This pedagogical approach involves the use of models to represent, explain, and predict scientific phenomena, thereby facilitating deeper understanding and more effective communication of complex concepts. Model-based learning encourages active engagement, critical thinking, and the ability to convey scientific ideas clearly and accurately, which are essential skills for science teachers. The effectiveness of model-based learning in enhancing scientific communication skills lies in its emphasis on constructing, using, and refining models. By engaging in these activities, teachers develop a more profound understanding of scientific concepts and improve their ability to articulate these ideas to students. The iterative process of model development and evaluation helps teachers identify and address misconceptions, communicate abstract concepts more concretely, and foster a more interactive and dynamic classroom environment. The effectiveness of model-based learning in enhancing scientific communication skills lies in its emphasis on constructing, using, and refining models. By engaging in these activities, teachers develop a more profound understanding of scientific concepts and improve their ability to articulate these ideas to students. The iterative process of model development and evaluation helps teachers identify and address misconceptions, communicate abstract concepts more concretely, and foster a more interactive and dynamic classroom environment. According to research, model-based learning considerably improves the communication skills of scientific teachers. Windschitl et al. (2008) discovered that teachers who incorporate model-based learning into their teaching techniques have better ability to explain complicated scientific facts, engage students in meaningful conversations, and use models for communication and education. According to this study, model-based learning not only helps with content delivery but also helps teachers develop abilities that help students learn and engage (Windschitl et al., 2008). Furthermore, model-based learning promotes a collaborative learning environment were teachers and students co-construct knowledge. This collaborative aspect is critical for developing communication skills, as it requires teachers to listen actively, ask probing questions, and provide clear explanations. Through these interactions, teachers refine their ability to communicate scientific ideas effectively, making them better equipped to inspire and educate their students. In summary, model-based learning is a valuable approach that enhances scientific communication skills in science teachers. By engaging in the creation and use of models, teachers develop a deeper understanding of scientific concepts and improve their ability to communicate these ideas effectively. This not only enhances the quality of science education but also fosters a more scientifically literate society.

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The skills to communicate scientific concepts effectively are a critical skill for science teacher students, as it directly impacts their future effectiveness as educators. However, traditional instructional methods often fall short in equipping these students with the necessary communication skills to translate complex scientific ideas into understandable and engaging lessons. This gap in pedagogical training can lead to challenges in student comprehension, engagement, and interest in science subjects. Research indicates that model-based learning offers a promising solution to this problem. By engaging students in the development and use of models to represent scientific phenomena, model-based learning can enhance their understanding and ability to communicate these concepts. Despite the potential benefits, there is a lack of comprehensive studies that specifically examine the impact of model-based learning on the communication skills of science teacher students. The problem, therefore, lies in the insufficient integration of model-based learning in science teacher education programs and the limited empirical evidence supporting its effectiveness in enhancing communication skills. Windschitl et al. (2008) emphasize the need for a shift towards model-based inquiry in science education to improve both content understanding and communication abilities. Addressing this problem is essential to ensure that future science teachers are well-prepared to engage and inspire their students through effective communication. This research aims to fill this gap by investigating the effect of model-based learning on the communication skills of science teacher students. By providing empirical evidence and practical insights, this study seeks to inform curriculum design and teaching practices in science teacher education programs, ultimately enhancing the quality of science education. From observing, the researcher noticed throughout the years of teaching experience in teacher students at Education Faculty UdonThani Rajabhat University, Thailand, that many student science teachers do not comprehend or recognize the value of science communication they believe scientific communication is not difficult. They think "only need to understand the issue and how the content should be communicated". But reality, when science student teachers presented in front of the classroom with the students, it might be difficult to remember to speak swiftly and engagingly. As a result, a question arises for science teacher students: what is science communication and how important is it? Why is it important to practice this skill? Therefore, an attempt has been being made through this study to find the "Enhancing Science Teacher Students' Communication Skills: The Effect of

Model-Based Learning." The participant of this study were science teacher students' that they are studying in Faculty of Education, Udon Thani Rajabhat University in Thailand. The current study's findings will assist science student teachers in understanding scientific communication abilities and becoming proficient at communicating strongly in front of a class or the general public, as well as developing our teaching abilities to teach well.

## Objectives of the Study

The purpose of this study is to study the effects of using models-based learning on the science communication skills of science teacher students. A research question was developed to guide the study "How did the process of models-based learning develop science student teachers understanding science communication skills and can communicate successfully?"

## Research Methodology

This research conducting was separated into 2 phases as follows:

### Phase 1: Developing and Identifying Educational Quality of Models-Based Learning

1.1 Developing models-based learning to development scientific communication skills by review literature about models-based learning, and scientific communication skills. The detail in 5 steps of model-based learning are as follows.

*Step 1: Introduction of Concepts*
The teacher teaches the key concepts and principles that will serve as the foundation for the topic being studied. This can be accomplished through lectures, multimedia resources, and demonstrations. It is critical to involve students in talks to examine their prior knowledge and identify any misconceptions they may have. This prepares the groundwork for the model construction phase by ensuring that all students have a solid understanding of the fundamental concepts. According to Windschitl et al. (2008), giving a coherent conceptual framework allows students to anchor their first models and improves subsequent learning.

*Step 2: Model Creation*
Students are tasked with developing models that reflect their current understanding of the ideas. These models may be visual (drawings or diagrams), physical (3D models), or mathematical (equations and simulations). The teacher's responsibility is to facilitate the creative process by providing direction and resources as needed. Encouraging numerous ways of representation accommodates varied learning styles and offers a thorough knowledge of the concepts. As Gobert and Buckley (2000) point out, model construction allows students to externalize their thoughts while also providing a solid foundation for additional exploration and refining.

*Step 3: Testing and Refinement*
Once the initial models are created, they need to be tested to see how well they predict or explain the phenomena. This can involve experiments, simulations, or comparisons with real-world data. Students analyze the results, identify any discrepancies, and refine their models accordingly. This iterative process is crucial for developing a deeper understanding and more accurate representations. Lehrer and Schauble (2006) emphasize that testing and refinement encourage critical thinking and help students develop a more nuanced understanding of scientific concepts.

*Step 4: Analysis and Interpretation*
After refining the models, students use them to make predictions and explain various phenomena. This phase involves interpreting the results of their tests and experiments within the context of their refined models. Discussions should focus on how well the models align with existing theories and what new insights they provide. This step is critical for helping students connect their models to broader scientific principles and understand the implications of their findings. As noted by Passmore and Svoboda (2012), analysis and interpretation deepen students' conceptual understanding and enhance their ability to communicate scientific ideas.

*Step 5: Reflection and Discussion*
The final step is to reflect on the entire model-building process and discuss the outcomes. Students should discuss their experiences, obstacles, and insights discovered during the project. This reflection helps to solidify their learning and allows them to discuss the constraints of their models as well as potential areas for future research. Group conversations promote a collaborative learning atmosphere in which students can benefit from one another's perspectives. Schwarz et al. (2009) emphasize the value of reflection and conversation in establishing understanding and fostering ongoing investigation.

1.2 Three lessons plan by using the model-based learning that cover three science contents in body system, plant structure, and solar system, each lesson plan was for 8 hours that required 24 hours in total.

1.3 Finding educational quality of model-based learning by three experts in science education. The results of educational quality were at good level.

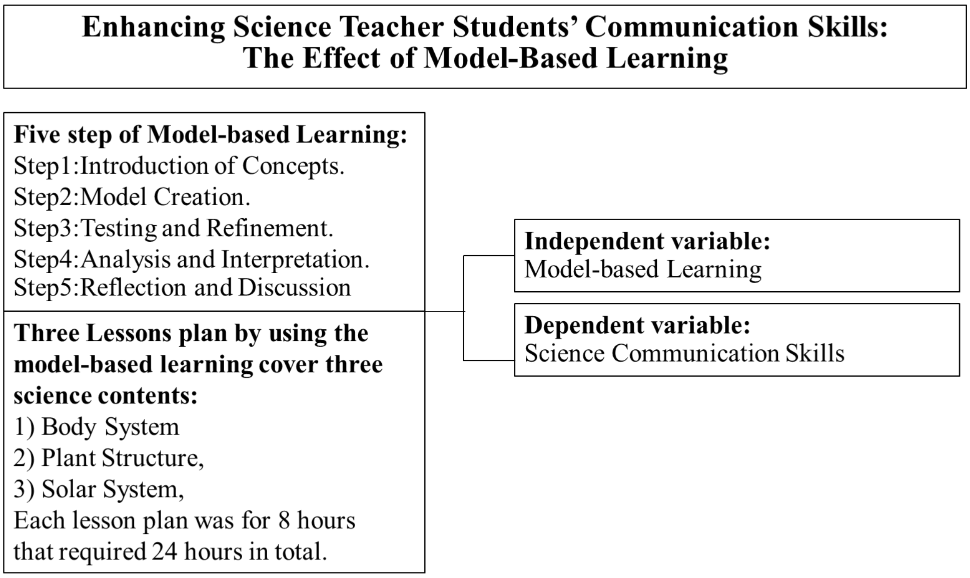

Fig.1 Model-based learning enhancing science communication skills

**Phase 2: Instructional Experimenting With Science Student Teachers**

2.1 The population for this study is 3$^{rd}$ years of science teacher students from the Faculty of Education at Udon Thani Rajabhat University, Thailand in Semester 2, academic year 2023, with 3 classroom and 75 students. The sample group used in this research, it is a population group of 21 students, obtained from cluster random sampling.

2.2 This study were two variables; the independent variable was instruction by using the model-based learning and the dependent variable were science communication skills.

2.3 Hypothesis of this study: After the experiment, the student who learned through the model-based learning had an average score in science communication skills higher than before.

2.4 The design of this study was a pre-experimental design. Research design used is one group pretest and posttest design (John & James, 2005).

2.5 The instruments evaluation of instructional experimenting was science communication skills assessment that related to rating scale according to the Likert method. The assessment related to 5 items 1) content clarity and accuracy, 2) organization and structure, 3) explanation and reasoning, 4) language and presentation, and 5) question handling and interaction.

2.6 The procedures in this study taught by using the model-based learning, before starting experimental the sample group have been applied a scale of pretest of science communication skills assessment. The teacher was informed about the purpose of the study and the model-based learning to develop science communication skills then using instruction, during the process teacher was observed, the interaction between teacher-students and students-students; participation and contribution of students into learning environment and teacher as well as the physical conditions and material availability of the classroom. Teacher only provided questions, suggested approaches, gave feedbacks, and assessed understanding. After finished using instruction the sample group have applied a scale posttest of science communication skills assessment that the test same pretest.

2.7 The pretest and posttest scores were used to analyze the statistical data to test the hypotheses further.

2.8 The data analysis using mean, percentage, and standard deviations of measured quantities were determine and t-test for one samples and t-test for dependent samples done for hypothesis testing

**Result of this Study**

**Science Communication Skills:** the result of science communication skills after applying model-based learning, the means of the pretest and posttest of science teacher students have compared by t-test for dependent samples. Generally, research data of this can be summarized in table 1 as below.

Table 1: The comparison between pretest-posttest of science communication skills of science teacher students by using model-based learning.

| N | Score | Test | Mean | S.D. | % | t-test | |
|---|---|---|---|---|---|---|---|
| 21 | 25.00 | Pretest | 11.57 | 1.363 | 38.57 | 21.523** | p<.001 |
| | | Posttest | 22.48 | 1.778 | 74.92 | | |

Note. **p<.01

According to table 1, the mean science communication skills pretest score obtained by science teacher students was 11.57 (38.57%). After learning, their mean posttest score is

22.48 (74.92%). This is a comparison of science communication skills to determine how there is improvement from pretest to posttest; the results reveal that the posttest mean score was higher than the pretest.

## Finding and Discussion

According to research, model-based learning improves conceptual grasp of scientific principles among science teacher students. Windschitl et al. (2008) found that students who participated in model-based learning had a better knowledge of complicated scientific topics than those who used standard learning methods. This progress is ascribed to students' active participation in the iterative process of designing, testing, and improving models, which aids in their ability to comprehend and express scientific concepts. Model-based learning has been found to enhance science communication abilities among teacher students. Schwarz et al. (2009) found that students who participated in model-based learning activities were better able to explain scientific phenomena, both in writing and orally. This is because model-based learning forces students to communicate their models, justify their design decisions, and explain the underlying scientific principles, which improves their capacity to express difficult ideas simply and concisely. Research by Passmore and Svoboda (2012) found that model-based learning increases student engagement and motivation in learning science. The hands-on, interactive nature of model-based learning makes learning more engaging, as students are actively involved in constructing and revising models. This increased engagement translates to a higher level of interest and motivation, which is crucial for the effective learning and teaching of science. Model-based learning fosters the development of critical thinking and problem-solving skills. According to Lehrer and Schauble (2006), the iterative nature of model-based learning encourages students to critically analyze their models, identify shortcomings, and develop solutions. This process not only improves their scientific reasoning but also enhances their ability to tackle complex problems, an essential skill for future science teachers. While the benefits of model-based learning are evident, several challenges must be addressed to implement it effectively in science teacher education. One significant challenge is the need for adequate training and support for teacher educators to effectively facilitate model-based learning activities. Additionally, there may be resistance to change from traditional teaching methods to more interactive and student-centered approaches. Overcoming these challenges requires a concerted effort from educational institutions, policymakers, and educators to provide the necessary resources, training, and support.

## Students' Opinions on Learning Activities

> *"I really enjoyed it; I planned and thought about how to make the model as great as possible while allowing students to comprehend as quickly as possible."*

> *"I would like to study like this again, it let me explore and discover on my own."*

> *"I would like to employ this learning management technique with the students I'm going to train. It must be quite interesting."*

> *"According to the findings of the scientific communication behavior observation, science teacher students demonstrate a wide range of clear, accurate, and engaging scientific communication behaviors."*

## Conclusion

Model-based learning has demonstrated significant potential in enhancing the science communication skills of science teacher students. By fostering a deeper conceptual understanding, increasing engagement and motivation, and developing critical thinking and problem-solving abilities, model-based learning equips future science teachers with essential skills for effective science education. The iterative process of creating, testing, and refining models not only helps students internalize scientific principles but also improves their ability to communicate complex ideas clearly and accurately. However, the successful implementation of MBL requires addressing challenges such as providing adequate training and support for educators and overcoming resistance to change from traditional teaching methods. Overall, model-based learning offers a promising approach to preparing future science teachers to effectively teach and inspire the next generation of scientists, making it a valuable addition to science teacher education programs.

## Recommendation

1. Conduct long-term studies to evaluate the sustained impact of model-based learning on science teacher students. These studies should track the progress of students from their initial exposure to model-based learning through their early years of teaching to assess how model-based learning influences their teaching practices, science communication skills, and student outcomes over time.

2. Compare the effectiveness of model-based learning with other instructional strategies, such as inquiry-based learning and technology-enhanced learning environments. By examining different approaches, researchers can identify the unique contributions of model-based learning and determine how it can be most effectively integrated with other teaching methods to maximize its benefits.

3. Develop and validate assessment tools specifically designed to measure the science communication skills of students engaged in model-based learning. These tools should be capable of capturing both the content and clarity of students' explanations, as well as their ability to justify and defend their models. Reliable assessment methods will enable educators to more accurately gauge the impact of model-based learning on students' communication abilities.

4. Explore the role of technology in enhancing model-based learning experiences. Research should investigate how digital tools and platforms can support the creation, testing, and refinement of models, as well as how technology can facilitate collaboration and communication among students. Additionally, studies should examine the potential of virtual and augmented reality in providing immersive and interactive model-based learning experiences.

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