Chapter I

Introduction

1.1. Background of the Problem

The capacity to convey mathematical ideas through words, symbols, visual representations, and reasoning is a critical competency that shows mastery of higher-level mathematical concepts and thinking. Modern mathematics education requires more than just the ability to apply methods. In order to give a visible and measurable indicator of students' thought processes, mathematical communication includes the ability to explain solution stages, express problems using symbols or diagrams, and provide and evaluate mathematical reasoning. Since these communication skills are closely linked to problem-solving, teamwork, and critical thinking abilities, they are considered crucial by many educational criteria in the age of 21st-century skills. It is believed that active and cooperative learning strategies can promote symbolic and verbal exchanges that enhance these mathematical communication abilities.

The Two Stay Two Stray (TSTS) structure is one cooperative learning model that teachers commonly employ to promote interaction and knowledge sharing among students. It is intended to optimize idea sharing between groups and give each student the chance to act as a temporary "teacher." The TSTS mechanism promotes debate, conceptual clarification, and practice in reporting mathematical reasoning both orally and in writing. Two students who stay in the group explain their work, while two additional students (stray) share and compare their solutions. Theoretically, TSTS is appropriate for improving aspects of mathematical communication including representation, explanation, and informal proof since it places a strong emphasis on peer discussion, reflection, and accountability. Thus, a methodical empirical investigation should concentrate on the connection between the application of the TSTS model and the enhancement of students' mathematical communication abilities.

In this study, the independent variable is the Two Stay Two Stray (TSTS) cooperative learning model, and the dependent variable is students' mathematic communication skills, which can be broken down into sub-dimensions such as the ability to formulate problems, select and write mathematical representations, explain procedures, and present mathematical reasons/arguments. The TSTS model, as an intervention, places students in a reciprocal situation of explaining and receiving explanations, which theoretically improves mathematical language fluency, symbolic accuracy, and the ability to organize arguments—all components measured by the mathematical communication instrument. Practically, teacher actions in facilitating TSTS (e.g., assigning assignments that require reasoning, monitoring discussions, and providing feedback) also serve as mediating factors influencing the extent of improvement in mathematical communication skills.

This method is different from traditional direct learning, which limits possibilities for pupils to practice elucidating mathematical concepts by framing them as passive recipients of information. From a measuring standpoint, group interactions, essay tests, and communication assessment rubrics can all be used to examine mathematical communication; the selection of these instruments affects how sensitively the research captures change. According to pedagogical research, cooperative structures like TSTS help students develop their verbal and social reasoning skills, which include "teaching a peer," error clarification, and mathematical redaction construction. Therefore, a crucial first step in proving causation is to develop research that connects the features of TSTS techniques to operational indicators of mathematical communication.

Indonesia routinely does poorly on international tests of mathematics proficiency; its average PISA math score is significantly lower than the OECD average. Indonesia scored almost 379 on the math test in PISA 2018, while it dropped to about 366 in PISA 2022. This suggests that significant obstacles still exist in acquiring and using mathematical knowledge. PISA cycle comparisons show a pattern of stagnation or deterioration, which calls for policy attention because of the inadequacy of mathematical communication skills and the capacity to apply mathematics in real-world circumstances. The Ministry of Education, Culture, Research, and Technology is implementing the National Assessment/Minimum Competency Assessment (AKM) at the national level, emphasizing the need to strengthen reading and numeracy as core competencies.

Regional and national education report cards, as well as AKM data, show differences in performance between levels and areas, calling for more intensive learning interventions that enhance communication and numeracy abilities. Additionally, macro-education indicators, like the Central Statistics Agency's (BPS) Indonesian Education Statistics, show that although access to and duration of education have increased, the quality of learning outcomes (as determined by international indicators and the AKM) has not kept up with these numerical advancements. Research assessing tangible learning methods, like TSTS, that are believed to enhance students' mathematical communication abilities is urgently needed, as evidenced by national policies (AKM), international data (PISA), and national education statistics (BPS). Stated differently, there is a need to investigate empirically learning strategies that could help close the gap between more time spent learning and less-than-ideal achievement of mathematical competency. These facts offer the empirical foundation for methodically evaluating creative teaching methods that are successful, quantifiable, and pertinent to the national curriculum.

Numerous empirical studies in the Indonesian context consistently demonstrate that the implementation of the TSTS model has a positive effect on mathematical communication skills. Une, Pomalato, and Machmud (2023) found that students taught with TSTS had higher mathematical communication skills than those taught with direct instruction, and they also found an interaction between the learning model and students' initial abilities. Research by Purba & Napitupulu (2023) on junior high school students demonstrated a statistically significant effect of TSTS on mathematical communication skills, with the experimental group's post-test mean score being higher than the control group's (experimental mean 74.34 vs. 68.75).

The TSTS intervention also increased mean mathematical communication scores, with a significant difference between the experimental and control classes, according to a high school study (Gulo & Mendrofa, 2024). In addition to the national context, studies conducted in elementary schools and other experimental research show that the TSTS framework consistently improves students' learning activities, engagement, and mathematics communication skills at all levels. The findings usually show that TSTS improves mathematical communication, despite the fact that each study is different in terms of design (often quasi-experimental), materials evaluated (e.g., SPLDV, coordinates, or basic algebra themes), and assessment tools. These results offer a solid empirical foundation for retesting and extrapolating these findings to perhaps various samples and circumstances. Replication and testing using more standardized tools and designs that take moderating factors into account are necessary, nonetheless, given the diversity in results pertaining to interactions with past ability and variations in assessment techniques. According to a summary of earlier findings, there seems to be preliminary agreement regarding the potential of TSTS; nevertheless, methodological variations must be resolved in future studies.

Although local literature suggests a positive effect of TSTS on mathematical communication, many previous studies have limitations that open up opportunities for further research. Among them, sample sizes were limited to one or two schools in a district, which makes the generalizability of the findings weak and does not reflect the broad range of school contexts. Most studies used non-randomized quasi-experimental designs with moderate sample sizes, so the threat of selection bias and generalizability still needs to be addressed through stronger designs or more heterogeneous samples.

Additionally, the methods used to measure mathematical communication vary; some studies employ different rubrics, while others use local essay tests that are not explicitly linked to AKM indicators or standard competency frameworks. This makes it challenging to compare implementations. Complex relationships between learning models and prior skill are also suggested by certain data.

1.2. Problem identification

The following is the problem identification in this study:

1. According to the findings of international tests like PISA, Indonesian mathematics instruction is still generally of poor quality. With a PISA 2022 math score of just 366, Indonesia fell well short of the OECD average (OECD, 2023). This suggests that there are still basic issues with pupils' comprehension of mathematical ideas and applications.
2. Mathematical communication abilities among Indonesian students are still lacking, as seen by their inability to build suitable representations, explain mathematical reasoning, and relate ideas to practical contexts. According to the findings of the Ministry of Education, Culture, Research, and Technology's Minimum Competency Assessment (AKM), a large number of students continue to have difficulty solving numeracy problems that call for justification and reasoning.
3. The teacher-centered learning paradigm is still the most common, and pupils often just listen, take notes, and copy what they see. Students' abilities to practice idea expression, idea discussion, and mathematics communication skills development—all crucial 21st-century competencies—are restricted by this circumstance.
4. Even while cooperative learning approaches are thought to enhance student participation, collaboration, and communication in grasping the topic, not all math teachers regularly use them. Two Stay Two Stray (TSTS) is one such approach; how ever. There is still little use of it in educational institutions.
5. Although prior studies have demonstrated that TSTS improves mathematical communication, there are still issues, including small sample numbers, a lack of school coverage, and uneven mathematical communication assessment tools. This calls into question the degree to which the efficacy of TSTS may be extended to larger groups and circumstances.

6. The impact of TSTS on pupils with varying starting capacities has been the subject of conflicting research findings. According to some research, students with higher starting abilities gain more from TSTS, whereas students with lower starting abilities do not get the same advantages. This points to a possible moderating element that needs more research.
7. Regarding the direct correlation between the TSTS model and advancements in standardized mathematical communication indicators, as those employed in the AKM or the PISA framework, there is still a study gap. This association cannot be tested with validated instruments due to a lack of empirical evidence.
8. The specific issue with this study is that, particularly when contrasted with traditional learning models, it is still unclear how the TSTS cooperative learning model implementation affects secondary school students' mathematics communication abilities. Furthermore, it is unknown how pupils' past skills contribute to this influence's strength or weakness.

1.3 Scope

The following issues can be recognized based on the problem's background:

1. Broad Scope

The goal of this project is to improve the quality of mathematics education in relation to the demands of 21st-century capabilities, specifically problem-solving, critical thinking, communication, and teamwork.

2. Competency Scope

This study focuses on students' mathematical communication abilities, which include factors like using mathematical representations (tables, graphs, and symbols), communicating mathematical reasoning and arguments both orally and in writing, and clearly expressing mathematical ideas.

3. The Learning Model's Scope

The Two Stay Two Stray (TSTS) cooperative learning model is the one under study. It is a method that stresses student engagement by using the "two students staying and two students visiting" mechanism to share information, compare outcomes, and practice communication.

4. The research subjects' scope

Only junior high school students at the particular school chosen as the research site are eligible to participate in the study. According to the research focus, the study only examined one degree of schooling rather than all of them.

5. The research design's scope

A control group was taught using traditional methods, and an experimental group was taught using the TSTS model. The design employed was quasi-experimental. Comparing the two groups' results in mathematical communication was the main goal of the study.

1.4 Problem Limitations

- Research Participants

Only junior high school pupils are included in this study. Only students from the particular schools where the study was conducted are included in the research sample; not all Indonesian students are included.

- Variables in the Research

The Two Stay Two Stray (TSTS) cooperative learning paradigm serves as the study's independent variable, and students' proficiency in mathematical communication serves as its dependent variable. Additionally, pupils' starting mathematical skills are taken into account as the moderator variable.

- Educational Resources

The mathematical resources utilized in this study are restricted to particular curriculum areas (e.g., Basic Algebra or Systems of Linear Equations in Two Variables, which were modified to fit the curriculum at the school where the research was conducted). The study's scope excludes materials that are not related to these subjects.

- Design of Research

There is an experimental group and a control group in this quasi-experimental investigation. Consequently, without additional research, the findings can only be applied to comparisons between the two groups and cannot be extrapolated to a larger population.

- Instruments of Assessment

A validated mathematical communication evaluation rubric and a descriptive test are used to gauge mathematical communication abilities. This tool concentrates on measures of mathematical communication, including the capacity to articulate mathematical reasoning, explain concepts, and show representations.

- Analysis's Scope

The impact of the TSTS implementation on students' mathematical communication abilities and how it interacted with their preexisting skills were the main topics of the research analysis. The family environment, learning motivation, and student learning styles, among other external elements, were not thoroughly investigated.

1.5 Problem Formulation

The problem formulation in this study is as follows:

- What is the overall state of the mathematical communication abilities of the students studying mathematics in secondary schools today?
- How well is the Two Stay Two Stray (TSTS) cooperative learning paradigm being applied in the teaching and learning of mathematics?
- Do students who are taught using the TSTS cooperative learning model and students who are taught using traditional learning models have different mathematical communication skills?
- What impact does the TSTS cooperative learning paradigm have on students' development of mathematical communication skills?
- Does the impact of the TSTS cooperative learning model on students' mathematical communication abilities depend on or be moderated by their past mathematical proficiency?

1.6 Research Objectives

In light of the problem formulation, the following are the study's goals:

- in order to characterize the overall state of secondary school pupils' mathematical communication abilities.
- to explain how the Two Stay Two Stray (TSTS) cooperative learning approach is being used in the teaching and learning of mathematics.
- to ascertain how students who were taught using the TSTS cooperative learning model differed from those who were taught using traditional learning models in terms of their mathematics communication abilities.
- to evaluate how using the TSTS cooperative learning approach affects students' ability to communicate mathematical ideas.

- to investigate how students' past capabilities can either enhance or diminish the impact of the TSTS cooperative learning paradigm on their ability to communicate mathematical ideas.

1.7 Research Benefits

The following are the advantages of this research:

1. Academic Advantages

- advancing the field of mathematics education, especially through research on cooperative learning approaches and how they relate to students' ability to communicate mathematical ideas.
- including more standardized evaluation tools in line with national (AKM) and international (PISA) indicators, as well as empirical data demonstrating the efficacy of the TSTS learning model in enhancing mathematical communication.
- establishing a reference base for future studies aiming to evaluate the efficacy of TSTS in a range of educational environments, using a variety of mathematical materials and at different educational levels.

2. Realistic Advantages

- For math teachers: acting as a guide for creating and putting into practice a successful TSTS cooperative learning model to enhance students' proficiency in mathematical communication.
- For students: offering a more dynamic, cooperative, and interactive educational experience that can improve their social, mathematical, and critical thinking abilities.
- To help schools meet the national literacy-numeracy standards and the Pancasila student profile, research findings can be utilized as assessment and creative resources for instructional practices.
- For legislators: offering factual data to back up policy suggestions aimed at raising the standard of mathematics instruction in curricula and teacher preparation programs.