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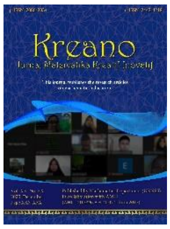

Group Investigation Model Through Concept Maps on Mathematical Problem Solving Ability and Self-Efficaciousness

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Abstract

Problem-solving abilities are often associated with student self-efficacy. This is important because it is one of the mathematics learning goals that students must achieve. Based on a preliminary study through observation, documentation, and interviews with basic mathematics education lecturers at one of the non-state universities in Yogyakarta shows that students' mathematical problem-solving abilities and self-efficacy still need to be improved. Development research was carried out with an investigative group through concept maps using the Dick and Carey model. The results of the effectiveness test on 33 primary education students at PGRI Yogyakarta University showed a significant increase in problem-solving abilities and self-efficacy, so it can be concluded that the development of an investigative group learning model is very valid and feasible to implement. Hopefully, this research can become a reference for lecturers applying cooperative learning at other universities.

Keywords: Investigation group; concept map

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Abstrak

Kemampuan pemecahan masalah sering dikaitkan dengan self-efficacy peserta didik. Hal tersebut penting karena merupakan salah satu tujuan pembelajaran matematika yang harus dicapai oleh peserta didik. Namun, berdasarkan studi pendahuluan melalui observasi, dokumentasi, dan wawancara dengan dosen mata kuliah Matematika 2 Program Studi Pendidikan Guru Sekolah Dasar salah satu perguruan tingi swasta di Yogyakarta menunjukkan belum optimalnya kemampuan pemecahan masalah matematis dan self-efficacy mahasiswa. Penelitian pengembangan dilakukan dengan grup investigasi melalui peta konsep menggunakan model Dick and Carey. Draf perangkat pembelajaran grup investigasi divalidasi oleh dua ahli dan satu user, menunjukkan kriteria valid dan layak digunakan. Hasil uji efektivitas terhadap 33 mahasiswa Program Studi Pendidikan Guru Sekolah Dasar Universitas PGRI Yogyakarta menunjukkan terdapat peningkatan signifikan pada kemampuan pemecahan masalah dan self-efficacy sehingga dapat disimpulkan pengembangan model pembelajaran grup investigasi sangat valid dan layak diterapkan. Penelitian ini diharapkan menjadi referensi penerapan pembelajaran kooperatif oleh dosen di perguruan tinggi lain.

INTRODUCTION

Humans generally encounter various problems in life, necessitating the development of a strategy to address them. We can make a variety of efforts to achieve better results. Similarly, in school learning, students require training to solve problems, be environmentally sensitive, and make decisions (Mitsea et al., 2021).

Implementation of learning to improve problem-solving skills in schools can be implemented in mathematics subjects (National Council of Teachers of Mathematics (NCTM), 2000). Problem-solving ability is one of the learning objectives of mathematics that students must achieve. Students must be skilled in solving everyday problems, especially in mathematics learning (Septhiani, 2022).

In the 21st century, problem-solving is a fundamental cognitive skill required in academic and professional life (Rahman, 2019). Learning through problem-solving in mathematics allows students to learn important mathematical concepts and procedures through problem-solving tasks and activities. It is declared to be able to instruct students to have a deeper understanding (Albay, 2019).

However, problem-solving skills are complex for most students, from elementary school to college (Wungo et al., 2021). Problem-solving ability is often associated with student confidence in solving problems. Confidence in students, better known as self-efficacy, is a belief that exists in students to be able to perform specific tasks.

Bandura initially presented the idea of self-efficacy. Self-efficacy results from a cognitive process in the form of beliefs about how individuals estimate their ability to deal with specific tasks or situations needed to determine an action for achieving the desired results (Santrock, 2008). Belief in one's ability can vary in each dimension, according to Bandura, who divides self-efficacy into three dimensions, namely the level dimension, the generality dimension, and the strength dimension.

An explanation of several aspects of self-efficacy is provided below. The first dimension, level, describes the task's degree of complexity that is believed to be able to be overcome. The higher the difficulty level of the task, the higher the demands on self-efficacy (Schunk & DiBenedetto, 2021).

The next dimension is generality, which relates to an individual's mastery of a particular field or task. This relates to individual achievement areas such as material mastery, task mastery, and managing time to complete specific tasks thoroughly and well. People with high self-efficacy typically can master functions in various fields. Conversely, individuals who need more self-efficacy only succeed at specific activity areas because they only master a few areas needed to complete a task (Nasir & Iqbal, 2019).

The last dimension in self-efficacy is strength, which is closely related to the emphasis on the level of strength of one's beliefs. Self-efficacy indicates that the actions one takes will produce the expected results. A study explained that teachers and students significantly impact self-efficacy, which affects mathematical problem-solving ability (Zhou et al., 2019).

Children often feel unsure that they can solve the problem, even though they have not tried to do it. On the other hand, students with elevated self-efficacy endeavour to exert their utmost effort in solving mathematical issues (Ramlan et al., 2021; Santrock, 2018). For this reason, an educator needs to consider self-efficacy in students. It is intended that students can apply mathematics learning to everyday life so that the learning process can run optimally (Lusiana & Setyaningsih, 2020).

Based on initial observations, documentation studies, and interviews with lecturers of Mathematics 2 in the Elementary School Teacher Education Study Programme of one of the private universities in Yogyakarta, it shows that students' mathematical problem-solving skills are not yet optimal, as seen from the results of student assignments in the course. Students need help solving math problems correctly. While some students can identify the asked-for or known elements, others need help to determine the appropriate strategy for solving them. The causes of low problem-solving skills include the way students learn, where they pay less attention to lecturers' directions and the preference for memorisation of given problems. Students struggle to solve problems with modifications, as evidenced by their responses.

Ideally, prospective elementary school teachers should have good problem-solving skills because they will guide students in learning to solve problems later (Sumarni et al., 2019). Other research suggests that some skills, such as problem-solving, improve other skills in the thinking process (Fuad et al., 2019). For this reason, prospective elementary school teachers should get enough opportunities to develop their problem-solving skills.

Another problem lies in the low self-efficacy of students in Mathematics 2 courses. Students consider math a problematic subject requiring hard thinking and intelligent brains. This causes students to show low self-efficacy in math learning (Trisnawati, 2019).

The self-efficacy of prospective teachers in solving math problems should ideally be at a more than adequate level because it affects motivation in learning. (Ramadhini & Kowi-yah, 2022). Teacher self-efficacy shows psychological conditions that affect the condition of students (Gündüz, 2022). In addition to this, teacher self-efficacy also affects student self-efficacy and learning achievement (Kunhertanti & Santosa, 2018).

Efforts can be made to improve students' math problem-solving skills and self-efficacy by involving students actively in learning. To support the involvement of student roles in education, various learning models can be carried out, including experiential learning, cooperative learning, case study methods, simulations, role-playing, peer tutors, fieldwork, self-study, library assignments, and computer-aided instruction (Almulla, 2020).

Active learning in higher education is essential for three reasons: 1) it encourages independence and critical thinking; 2) it encourages collaboration; and 3) it increases student investment, motivation, and performance (Stanford University &

Marincovich, 2000).

Active learning can raise the level of learning from low-level thinking skills (observation, memorisation, and recall of information; knowledge of general ideas about what, where, and when) to higher-level thinking skills (problem-solving, analysis, synthesis, and evaluation of how and why). Active learning in higher education to develop higher-order thinking skills needs attention. Students can inquire about lecture material, assess their proficiency in applying acquired knowledge, and engage in collaborative activities with their peers (Onchwari & Keengwe, 2015).

Higher education uses cooperative learning as an alternative to active learning. (Loh & Ang, 2020). Collaborative learning is widely regarded as the most effective learning paradigm. To improve the achievement and activeness of students in achieving learning goals. (Slavin, 2013). It can improve social skills, cooperation, collaboration ability, and self-sufficiency in mathematical problem-solving (Tinungki et al., 2022).

Cooperative learning models encompass several approaches such as Student Team Achievement Division (STAD), Team of Experts (Jigsaw), Group Investigation, Think Pair Share (TPS), Numbered Head Together (NHT), and Team Games Tournament (Slavin, 2013). One of the cooperative learning models used in higher education is group investigation. Investigative group learning belongs to the realm of social interaction learning models that aim to develop skills in group work that emphasise interpersonal communication and scientific inquiry skills. (Joyce et al., 2009). In line with this, the efficacy of employing the group investigation approach in enhancing students' interpersonal skills, such as problem-solving ability, has been demonstrated. (Ainiyah et al., 2022).

The investigation group learning model is an alternative solution to improve students' learning activities because it involves students from the planning to the evaluation stage. The investigation group is a cooperative model that Shlomo and Yael Sharan have developed with class planning, where students are in small groups with cooperative questions, team discussions, and cooperative project planning. (Development & Sharan, 2015). The researchers selected the investigative group learning model because the steps in this model focus more on discussion and investigation of predetermined topics to reduce the mobility of students who can interfere with the learning process. (Aulia et al., 2020).

Learners are involved in determining the subtopic to be studied and discussed to determine how to obtain information about the subtopic. The students strategise the tasks to be examined and execute the inquiry. Upon receiving the investigation results, each group compiles a final report for collective presentation and evaluation (Slavin, 2013).

Each learning model has several components or elements. These components include (1) syntax, (2) social system, (3) reaction principle, (4) support system, and (5) instructional and accompanying effects. (Joyce et al., 2009). The following is an explanation of the components of the investigative group learning model, from syntax to instructions and accompanying impacts.

The syntax of the group investigation learning model consists of six stages. (Fadilurrahman et al., 2019), Including: (1) The first stage presents a complex situation (planned or unplanned). (2) The second stage involves explaining and elaborating on reactions to the situation. (3) The third stage is formulating and organising tasks in learning. (4) The fourth stage is independent and group study. (5) The fifth stage is analysing the development and process. (6) Sixth stage: recycling activities. Some stages continue by presenting the same problem or developing a new problem that stimulates investigation.

The next component of the learning model is the social system. The social system in the investigative group learning model upholds democratic values. It is governed by an agreement developed, or at least validated, by the group's experience of the limits and relationships to complex phenomena, which an educator then explains as an object of learning. (Wardoyo & Sumilat, 2021). The social system in this model is based on democratic processes and group decisions with little external structure. The confusion created must be natural, not forced. Students and teachers have equal status but different roles. The atmosphere is one of reasoning and negotiation. (Joyce et al., 2009).

The investigation group's reaction principle is the third element in this learning model and the reaction principle of the investigation group. The role of the educator in this investigation group model is as a facilitator who is directly involved in the group process (helping learners formulate plans, act, and organise the group) as well as some of the needs in a study. (Keiler, 2018). In addition, the educator also functions as an academic counsellor.

The next element is support. The support system in this group investigation model should be extensive and responsive to all learners' needs. (Darling-Hammond et al., 2020). The environment must be able to respond to the varying demands of learners. Teachers and students should be able to gather what they need when needed.

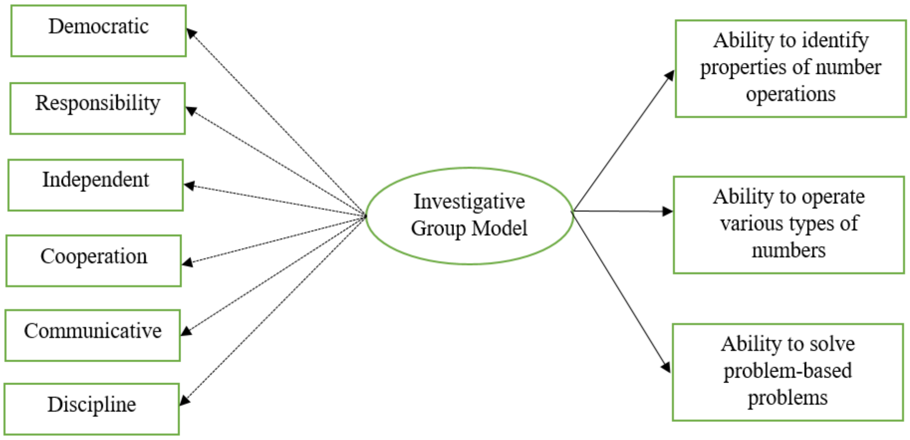
The final component of the learning model is instructional and accompanying effects. Instructional impact is the impact or learning outcomes directly from directing students toward the expected goals. The instructional impact of the investigative group model, in general, is (1) effective group process and management, (2) constructivist view of knowledge, and (3) discipline in collaborative research. (Suryani, 2023).

The accompanying impact is another learning outcome generated through acquiring knowledge because of establishing an educational environment that pupils immediately encounter without explicit guidance from the teacher. In terms of the accompanying impact through the group investigation model, it is hoped that the ability to be independent as a learner can be formed, such as having high curiosity so that they try to find out their knowledge, work scientifically, and take responsibility. (Darling-Hammond et al., 2020).

Research has demonstrated that group work in educational settings fosters an environment characterised by warmth, trust, positive reactions to established rules and policies, self-directed learning, and a heightened awareness of the rights of others. Furthermore, the investigative group model can enhance connection and communication among its members and foster the development of critical thinking and problem-solving abilities (Siddiqui, 2013).

The following chart illustrates the investigative group model's instructional and accompanying impact components (*see Picture 1*).

The component that can improve students' understanding of and ability to



Picture 1. The instructional impact and accompanying impact of the investigative group model

solve math problems as a learning implementation is the concept map. Using concept maps in learning creates new ideas, motivates students to find new concepts and linkages between concepts, helps students combine old concepts with new concepts, helps active students convey ideas more clearly, and expands students' knowledge. (Lin et al., 2022). Concept mapping with structured feedback can improve higher-order thinking skills such as analysing, evaluating, reflecting, and creative thinking. (Campbell et al., 2022).

The group investigation model motivates students to increase creativity in problem-solving. (Rahmawati et al., 2020). A study shows that concept maps can be successful as a tool for assessing, monitoring, and explaining conceptual understanding to students in college. (Hammad et al., 2021). Using cooperative learning with concept maps can strengthen the knowledge and expand the pedagogical awareness of prospective teachers for future teaching. (Chen, 2020).

In addition to problem-solving, applying the investigative group model can help students increase *self-efficacy*. (Tirta et al., 2019). Other studies have also shown that group investigations highly influence motivation, knowledge, and *self-efficacy*. (Martin et al., 2022). Investigative group learning affects communication skills in mathematics, thus increasing students' *self-efficacy*. (Kurniawan et al., 2021).

Based on the theoretical and practical analysis of the urgency of self-efficacy, self-efficacy has a vital role in supporting the success of mathematics learning. However, the facts in the field show that students' self-efficacy still needs attention. Learning based on activeness is one way to optimise this variable. The cooperative learning model of group investigation accompanied by concept maps is an active creative learning effort that improves cognitive abilities, especially mathematical problem solving, and the scientific attitudes of students, which affect *self-efficacy*.

Based on this explanation, it is necessary to research the "Investigation Group Model through Concept Maps on Problem Solving Ability and *Self-Efficacy.*" The following are the steps of the investigative group cooperative model with concept maps on problem-solving ability and *self-efficacy*.

Table 1. Steps of the Investigative Group Model

Steps	Original Models	Models Developed
Problem topic selection	Be free	In order of group division
Planning learning tools and groups	Group division students choose themselves	Random group division
Implementation Analysis	Investigation Analysis	Investigation Analysis
Presentation of student learning outcomes	Based on the guidebook	Using concept maps
Evaluation	Evaluation	Problem-Solving

Researchers have reviewed various literature on investigative group learning models, so this study aims to develop an investigative group model through concept maps and determine the effect of developing an *investigative group* learning model on students' mathematical problem-solving skills and self-efficacy.

METHOD

The learning device utilised in this study was developed based on the Dick and Carey model, which is a group investigation model. The rationale behind choosing this model during the development phase is to ensure that students possess the necessary knowledge and skills to effectively engage with the learning objectives at the outset of the learning process. Furthermore, it is worth noting that the interplay between various elements, particularly learning strategies and learning outcomes, can intersect (Aji, 2016).

This model, developed by Dick and Carey, comprises ten distinct stages. The learning process involves the following steps: (1) determining the overall learning goals of Mathematics 2, (2) conducting a thorough analysis of teaching methods, (3) identifying the learning behaviour and characteristics of the students, (4) formulating specific performance objectives, (5) creating benchmark reference test items, (6) devising effective teaching strategies, (7) selecting appropriate teaching materials, (8) designing and implementing formative evaluations, (9) revising learning materials, and (10) designing and implementing summative evaluations (Dick et al., 2015). This research aims to produce a *prototype of* learning tools that can improve problem-solving skills and *self-efficacy*. The components of the developed learning tools include the syllabus, semester learning plan, student worksheet, learning media, and assessment instruments.

The effectiveness test was carried out at PGRI Yogyakarta University using the study employed a quasi-experimental approach, specifically a one-group pre-test and post-test analysis. The sample in this study was students in class A7 of the Elementary School Teacher Education Study Program, totalling 33 people. We gave the class the investigative group learning model to test its effectiveness.

Data Analysis Technique Device Feasibility Criteria

Qualitative data collection involved specialists utilising a Likert scale to evaluate the device's viability. The categories in the assessment of the feasibility of the device include five categories, namely, 5 for the category very suitable or very feasible, 4 for the category suitable or feasible, 3 for the category quite suitable or quite feasible, 2 for the category less suitable or less feasible, and 1 for the category not suitable or not feasible (Sugiyono, 2018). The validator observed and assessed the following aspects of each learning device, using the validation sheet instrument that the researcher had created: (a) Syllabus, consisting of syllabus content, language, and time; (b) Semester Learning Plan (RPS), consisting of formulation of learning objectives, the content presented, language, and time; (c) Student Worksheet (LKM), consisting of the content presented and language; (d) learning media, consisting of presentation, language, and time; (e) assessment instruments, consisting of presentation, content, and language. Furthermore, we tabulate the feasibility assessment data of each learning device, calculate the average score, and then convert this value into a set of criteria. Table 2 below displays the criteria for your review.

Table 2. Criteria for the average total score of each component

Score	Score Interval	Category
A	80 %< Skor ≤ 100 %	Very valid
B	60 %< Skor ≤ 80 %	Valid
C	40 %< Skor ≤60 %	Not Valid
D	20 %< Skor ≤ 40 %	Very Invalid

Source: (Subali et al., 2012)

The value of product feasibility in this study is set at a minimum of "B" feasible criteria. Thus, if the results of the validator's assessment give the result "B" or feasible, then the development product is suitable for use in product trials. However, before being tested, each learning device was revised according to the comments and suggestions at the end of the device validation sheet.

The Data Analysis Technique Enhances Problem-Solving Abilities

The *pre-test* and *post-test* data on problem-solving skills obtained were tabulated, and then the average value was calculated. Researchers use the N-gain formula to determine whether there is an increase in students' problem-solving ability after applying the Group Investigation (GI) learning model.

$$N\ gain = \frac{posttest\ complete\ score\ -\ pretest\ complete\ score}{ideal\ score - pre\ test\ score}$$

(Hake, 2002)

This data aims to examine the hypothesis that students who learn with the investigative group learning model see an improvement in their problem-solving ability. In addition, the study hypothesis was examined through the utilisation of the t-test. A significant threshold of 5% was employed to assess the impact of the group investigation learning model on students' problem-solving abilities. The t-test formula was employed for this purpose.

$$t = \frac{Md}{\sqrt{\frac{\sum x^2 d}{N(N-1)}}}$$

The criteria for testing the hypothesis in this study are that Ho is rejected if t count> t table or can be seen from the p value> 0.05, then Ho is accepted; otherwise, if p <0.05, then Ho is rejected.

Self-Efficacy Data Analysis Technique

The question instrument used to measure this variable was developed from Gardner's research with a Likert scale score of 1–5. A Likert scale is a measurement tool utilised to assess individuals' or groups' attitudes, views, and perceptions about social issues.

Table 3. Descriptive Data Processing Criteria for Research Results

Score	Self-Efficacy Criteria	Test Result Criteria
≥Mean + 1,5 SD	Very High	Very High
≥Mean + 0,5 SD s/d <Mean + 1,5 SD	High	High
≥Mean - 0,5 SD s/d <Mean +0,5 SD	Medium	Medium
≥Mean - 0,5 SD s/d <Mean – 1,5 SD	Low	Low
<Mean – 1,5 SD	Very Low	Very Low

The self-efficacy data collected before and after the test were organised into tables, and the mean value was subsequently computed. This study aims to assess the potential impact of implementing the Group Investigation (GI) learning model development on student self-efficacy. Hypothesis testing is employed to determine whether there is a rise in pupils' self-assurance utilising the Group Investigation (GI) model as a learning technique. A t-test with a significance threshold of 5% was employed to test the study hypothesis. Criteria for hypothesis testing: The null hypothesis (Ho) is rejected when the t count exceeds the t table value or the p-value exceeds 0.05.

The data analysis technique in this study uses statistical methods. We use this statistical method to obtain quantitative data (Sugiyono, 2018). After collecting data on self-efficacy and student learning outcomes, the researchers proceeded to do a descriptive analysis. This involved the creation of a frequency distribution table, which served to depict the frequency of each variable. Subsequently, the variables were categorised into distinct groups: very high, high, low, and very low. The assessment criteria for each piece of data obtained refer to the limits put forward by (Usman, 2003).

RESULTS AND DISCUSSION

Results

Learning Tool Analysis

Learning tools, including the syllabus, semester learning plan, student worksheet, learning media, and assessment instrument used in research, have undergone validation by three experts before being used. The results of the validation of the learning tools developed are as follows.

Table 4. Recapitulation of Learning Tool Assessment Results.

Learning Tools	Average Presentation	Qualification
Syllabus	88 %	Very valid
The Semester Learning Plan	84 %	Very valid
Student Worksheet	80 %	Valid
Learning Media	82 %	Very valid
Assessment Instrument	83 %	Very valid
Average	83,4 %	Very valid

The results in Table 4 show that the average score of the learning tools developed is 83.4%; this score is in the very valid category, which means that all the learning tools developed are suitable for use in research. Table 4's results demonstrate the validity, practicality, and feasibility of implementing the investigation group learning model with concept maps in primary school teacher education at PGRI Yogyakarta University's Mathematics 2 course.

Analysis of Problem-Solving Ability

The data on the ability to solve mathematical problems described in this study is the average score obtained by the research subjects from the problem-solving ability test related to Mathematics 2 lecture material. The test, which measures problem-solving ability, takes the form of description questions. The student problem-solving ability test results will be presented in Table 5 below.

Table 5. The *pre-test* score of the problem-solving ability test.

Value Interval	Frequency	Completed	Not Completed
100 - 96	2	2	-
95 - 91	4	4	-
90 - 86	5	5	-
85 – 81	5	5	-
80 – 76	2	2	-
75 – 71	5	5	-
70 – 65	4	-	4
< 65	6	-	6
Total	33	16	17

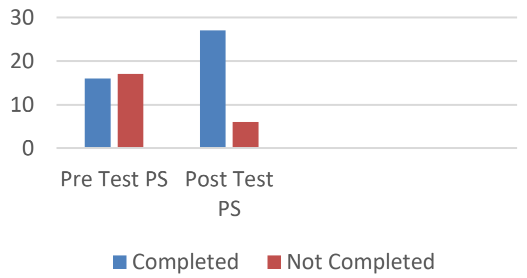
Value Interval	Frequency	Com-pleted	Not Com-pleted
Percentage		49 %	51 %

Table 5 shows that not all students scored above the minimum completion criteria (KKM). We applied a KKM value of 75 to the test. Table 5 shows that of the 33 people who took the problem-solving ability description test, 16 were complete and 17 were not.

Table 6. The value of the *post-test* results of the problem-solving ability test.

Value Interval	Frequency	Completed	Not Completed
100 - 96	4	4	-
95 - 91	7	7	-
90 - 86	4	4	-
85 – 81	5	5	-
80 – 76	2	2	-
75 – 71	5	5	-
70 – 65	4	-	4
< 65	2	-	2
Total	33	27	6
Percentage	100 %	82 %	18 %

Table 6 shows that not all students scored above the minimum completion criteria (KKM). We applied a KKM value of 75 to the test. Table 6 shows that of the 33 people who took the problem-solving ability description test, 27 were complete, and six were not complete. The pre-test and post-test results indicate a noticeable improvement in students' problem-solving abilities before and after implementing the GI paradigm. Figure 1 displays the overall outcomes of the pre-test and post-test worldwide.



Picture 1. Diagram of pre-test and post-test results of math problem-solving skills.

From the calculation results using the N gain formula, the N gain result is 0.75, which shows that the increase in students' critical thinking skills includes a high increase because the N gain is> 0.7.

The research hypothesis test using the t-test with a significance level of 5% obtained the following results.

Table 7. *Problem-Solving* Questionnaire *t-Test*

Variable	t	*Average Value*
Problem-Solving	48,557	0,000

From Table 7, the development of the *group investigation* learning model *through concept maps* influences improving students' problem-solving skills.

Self-Efficacy Analysis

The mathematical *self-efficacy* data described in this study is the average score obtained by the research subjects from the results of a self-confidence questionnaire related to Mathematics 2 lectures. Students receive a questionnaire to measure their confidence. The value of student *self-efficacy* pre-test results will be presented in Table 8 below.

Data analysis of the pre-*test self-efficacy of* class A7 students in the PGSD study programme is in Table 8.

Table 8. Self-efficacy test *pre-test* score

Highest Score	Lowest Score	*Average Value*	Standard Deviation
56	34	43,12	4,904

Table 9 presents the grouping of students' self-efficacy levels based on the average and standard deviation values above.

Table 9. Level and Percentage of *Self-Efficacy Pre-Test* Results

Self-Efficacy Levels	Interval	Fre-quency	Percentage (%)
Very High	≥50	3	9 %
High	≥46 s/d <50	6	18 %
Medium	≥41 s/d <46	14	43 %
Low	≥36 s/d <41	9	27 %
Very Low	<36	1	3 %
Total	33	100 %	

Data analysis of *post-test self-efficacy of* class A7 students in the PGSD study program is in Table 10.

Table 10. Self-efficacy *post-test* result value

Highest Score	Lowest Score	Average Value	Standard Deviasi
57	36	43,94	4,723

Table 11 presents the grouping of students' self-efficacy levels based on the average and standard deviation values above.

Table 11. Level and Percentage of *Self-Efficacy Pre-Test* Results

Self-Efficacy Level	Interval	Fre-quency	Percentage (%)
Very High	≥51	3	9 %
High	≥46 s/d <51	9	27 %
Medium	≥42 s/d <46	14	43 %
Low	≥39 s/d <42	6	18 %
Very Low	<39	1	3 %
	Total	33	100 %

Based on the results of the *pre-test* and *post-test of* students' *self-efficacy*, there is an increase in the average and frequency of the students at the level of *self-efficacy* from moderate to high to very high levels. The calculation using the N gain yielded a result of 0.54, indicating a moderate increase in student self-efficacy, as 0.3 is less than the N gain of 0.7. Research hypothesis testing using a t-test with a significance level of 5% obtained the following results.

Table 12. Questionnaire *t-Test* Results

Variable	t	Average
Self-Efficacy	12,441	0,000

From Table 12, developing an investigative group learning model through concept maps influences increasing student *self-efficacy*.

Discussion

The development of learning models is essential in education; this is based on adjustments to the needs of the fluctuating learning process (Asfar et al., 2023; Joyce & Weil, 2003). The objective of this study is to create an exploratory group learning framework using concept maps, which involves creating educational resources and evaluating the efficacy of the proposed model. Through the *Dick and Carey* development model, researchers developed the required learning tools. The **first finding of** this study relates to the results of the learning device validity test. The average validity score was 83.4%, with a very valid category. This means that the device developed meets the needs of the model implementation. The suitability of this device is essential to support the achievement of planned learning objectives and in the context of devices in the development of the group investigation model (Orlich et al., 2009).

The development of the investigative group model begins with identifying the learning outcomes (CP) and objectives contained in the syllabus. After identifying CP, formulate and develop a semester learning plan. Before formulating and developing the semester learning plan, researchers conducted a learning analysis, analysed student characteristics, formulated specific learning objectives, and developed reference test items for the strategy and development of the investigative group learning model. The determination of several specific aspects in the development of learning models at the school and the university level aims to provide an overview of the learning plan that will be carried out. Analysis of student characteristics, formulation of objectives, and evaluation plans are best planned in the learning tool (Farhang et al., 2023). Each learning session's planning is crucial in engaging students in learning. The statement supports this (Sehweil et al., 2022). Lesson plans are essential for helping teachers construct learning through relevant frameworks. So, the researcher's step in analyzing the lesson planning material is the right choice for making the appropriate learning tools. The researcher then selects and develops learning materials. One of the materials suitable for the investigative group model is the Real Number System. Researchers developed a group model with concept maps to modify the investigative group learning model so that students understand more easily. Through the development of investigation groups through concept maps, students are expected to understand the concept and be able to classify various real numbers.

The **second finding of** this study relates to the results of developing the investigative group model, assisted by concept maps. Researchers chose to apply it to the real-number system learning material. Assuming that all materials are suitable to be the object of application of this model, it is hoped that students can explore, analyse, and construct their knowledge independently, as is characteristic of investigative group learning (Silva et al., 2023). Researchers developed a group model with a concept map to modify the investigation group learning model so that students understood it more easily. Through the development of investigation groups through concept maps, students are expected to understand the concept and be able to classify various real numbers independently. In addition, the researcher also designed and developed a formative evaluation to measure problem-solving skills and a questionnaire for student *self-efficacy* with valid results. Assessment is essential in learning at all levels because it is a continuous teaching evaluation (Tosuncuoglu, 2018). The researcher examined the relationship between the application of the concept map investigation group model and development to help foster students' problem-solving skills and *self-efficacy* in terms of the characteristics of each variable. The developed model directs students to solve challenges by exploring their creativity, which is closely related to their problem-solving ability. Meanwhile, self-efficacy increases student confidence to face challenges (Voica et al., 2020).

After the model's development process, along with the learning tools of the concept map investigation model, the researchers then implemented the development results to test its application's effectiveness. **The study's third finding demonstrates a notable enhancement in students' problem-solving abilities before and after implementing the investigative group model utilising concept maps. The significant gain in problem-solving skills is evident from the pre-test and post-test data in Tables 5 and 6, respectively. The results of the N gain test indicate a value greater than 0.7 (0.75) and a significantly different t-test with a significance level below 0.05.** This shows that applying the group investigation model through concept maps successfully influences students' problem-solving skills. The successful application of the results of the development of this model is associated with learning theory, according to Polya. Research results (Fitriya & Kurniawan, 2022), which also examine the application of the Polya model in the development of student worksheets, are considered adequate for improving the ability to explore ideas as part of problem-solving. In addition, some research (Daulay & Ruhaimah, 2019; Leong et al., 2012) also proved that applying Polya's theory in learning effectively improves problem-solving ability. As the results of this study show, Polya's theory has similar characteristics to the syntax of the investigation group model, which consists of several steps such as understanding, planning, implementing the plan, and evaluating the plan. This is by the syntax of the investigation group, which includes presenting the problem situation, outlining reactions, or planning solutions in groups, analysing the process of implementing solutions, and recycling activities to make improvements if there are process discrepancies. These indications support the third finding of this study that the group investigation model through concept maps significantly affects students' problem-solving skills.

Furthermore, the **fourth finding of** this study demonstrates that utilising the group inquiry model through concept maps not only enhances students' problem-solving abilities but also positively impacts their self-efficacy in mathematics education. The N-gain test yielded a result of more than 0.5 (0.54), whereas the t-test yielded a result greater than 0.05. Statistically, the utilisation of concept maps in the group investigation approach has the potential to enhance and influence student self-efficacy. The specific outcomes of this diagnostic examination are presented in Tables 9, 11, and 12 under the results subsection. The investigative group learning paradigm is characterised by its application through group-based learning. Several prior research, such as (Khong et al., 2017), have proven that group assignment can affect learners' self-efficacy, as it is directly related to group performance. Similarly, it was also found to support the results of this study that self-efficacy in group investigation-based learning can be achieved well. The research was conducted by (Indrawati et al., 2021) which examines group investigations for mathematical literacy regarding self-efficacy. So, it is appropriate that the group investigation learning model through concept maps affects students' self-efficacy.

Based on the statistical analysis results and a review of relevant theories to support some of the findings in this study, some new findings can be underlined. The findings include the validity of the learning tools of the investigation model through concept maps, the validity of the development of the investigation model through concept maps, and the implementation of the model to prove its effectiveness in improving problem-solving skills and self-efficacy, which is proven to have a significant effect. Research studies on model development like this are essential to do, with the hope of supporting learning that suits the needs of learners.

Implication of Research

This study will help researchers develop further research by developing group investigation models through other means. In addition, it can be used by lecturers or teachers as a basis for learning in universities or other institutions.

Limitation

This study has limitations, including the small number of respondents in one of the teacher training colleges in Yogyakarta. This study has not been conducted longitudinally to see whether students' problem-solving skills will change or persist over time. Nevertheless, the respondents involved came from various educational *backgrounds*.

CONCLUSION

Based on the research findings, it can be inferred that using concept maps in developing the group investigation model holds significant validity and feasibility for enhancing problem-solving abilities and self-efficacy among students pursuing elementary school teacher education at PGRI Yogyakarta University.

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