Advancing SDG 4: Enhancing Students' Science Numeracy in Fluid Concepts through the RODE Model

Arief Ertha Kusuma[1*], Suciati[2], Degi Alrinda Agustina[1], Nurul Mazidah[2], Pradini Agustina[2], Rusmansyah[3]

[1] Elementary School Teacher Education Department, Universitas Borneo Tarakan, Tarakan, Indonesia.
[2] Mathematics Education Department, Universitas Borneo Tarakan, Tarakan, Indonesia.
[3] Department of Chemistry Education, Lambung Mangkurat University, Banjarmasin, Indonesia.

Abstract: This study examines the application of the RODE (Read, Outline, Discussion, Evaluation) learning approach to improve pre-service teachers' science numeracy skills, aligned with the Sustainable Development Goal 4 (Quality Education). A quantitative study with a one-group pretest-posttest design was conducted with 37 PGSD FKIP UBT students. The assessment of scientific numeracy was conducted via a written examination featuring five distinct indicators related to fluid concepts. Given the non-normal distribution of the data ($p < 0.05$), the Wilcoxon signed-rank test was utilized. The results demonstrated a statistically significant improvement in skills post-intervention ($p < 0.001$), with the mean score increasing from 45.57 to 68.94. The computed N-gain score of 0.43 indicates a moderate enhancement in numeracy proficiency. The data indicate a positive trend across all measures; however, the one-group design suggests that these gains should be viewed as indicative improvements within the cohort rather than conclusive evidence of the RODE model's sole causality, as external factors were not controlled. In conclusion, the RODE model is an effective pedagogical framework for enhancing foundational numeracy skills in prospective educators, therefore supporting the formulation of sustainable teaching practices.

Keywords: Fluid materials; Pre-service teachers; RODE learning model; Science-numeracy skills; SDG 4

Introduction

Numeracy is a 21st-century skill that emphasises understanding and applying numbers, symbols, and arithmetic operations based on basic mathematical concepts, presented in tables, graphs, and diagrams (Gelbgiser et al., 2025; Kamila et al., 2023; Mesfin et al., 2024; Rakhmawati et al., 2022; Rosalina et al., 2025; Siswandari et al., 2025). Numeracy skills extend beyond mathematics to applications in science, known as scientific numeracy. Scientific numeracy is the ability to interpret, use, and communicate quantitative information in scientific contexts. It involves using mathematical concepts to analyse scientific data, evaluate evidence, make predictions, and support scientific reasoning. Scientific numeracy skills enable students to make informed and accountable decisions (Listianingrum et al., 2023; Nafaida et al., 2023; Putra et al., 2023; Viyanti et al., 2023).

The Programme for International Student Assessment (PISA), administered by the OECD, evaluates student performance in mathematics, reading, and science worldwide, including Indonesia. In 2022, only 34% of Indonesian students achieved Level 2 or higher in science, well below the OECD average of 76%. Since 2018, average science scores in Indonesia have declined, highlighting an urgent need to enhance science education. Science scores dropped from 426 in 2012 to 383 in 2022, with a brief increase to 403 in 2015 and a marginal change to 396 in 2018. The proportion of students attaining Level 2 or higher remained at 34% in 2022. In rural Indonesian classrooms, approximately 10

out of 30 students understand basic scientific concepts, whereas the majority lack foundational knowledge. This trend parallels declines in mathematics and reading scores: mathematics decreased from 383 in 2012 to 366 in 2022, and reading from 396 in 2012 to 359 in 2022. Although Indonesia's ranking improved to 67th out of 81 countries in 2022, an increase of 5-6 places since 2018, most students continue to perform at low levels. In mathematics, 82% of students scored below Level 2. The decline in scores, attributed to the COVID-19 pandemic and persistent systemic challenges, underscores the urgent need for improved science education in Indonesia to support student achievement and community development (Choirunnisa et al., 2023; Febrila et al., 2024; Hidayah et al., 2025; Mastuang et al., 2025; OECD, 2023).

Improving numeracy skills in science is crucial given the complexity of today's problems. The World Economic Forum report shows that science numeracy is one of six essential skills for the 21st century (Ferniawan et al., 2025; Sole, 2021). Science numeracy enables students to address social issues effectively. Students with strong skills can better understand and apply scientific concepts. These competencies enable students to analyse phenomena, solve problems, and make informed decisions that affect their quality of life (Choirunnisa et al., 2023; Hariyadi et al., 2023; Novaldy et al., 2024; Ruqoyyah et al., 2025). Therefore, developing science numeracy helps students adapt to situations and solve everyday problems.

Several factors indicate that scientific numeracy among students in Indonesia continues to decline. One factor is teachers' use of unsuitable learning strategies. These strategies do not align with students' learning conditions and fail to adequately develop their numeracy skills. Purnadewi et al. (2023) stated that scientific numeracy skills can decline when classroom learning is teacher-centred. When this occurs, students lack the experience to explore and elaborate on their learning. Teacher-centred learning focuses only on delivering material, without encouraging students to think creatively, logically, or systematically. Such methods can lead to boredom and sleepiness, rendering lessons ineffective. Therefore, innovative learning strategies are crucial for capturing students' attention and directly engaging them. This enables the proper development and improvement of their numeracy skills in science (Fatih et al., 2024; Nuri et al., 2025; Qotrunnada et al., 2022; Wahyuni et al., 2024; Widiartini et al., 2025; Winarno et al., 2024).

The Read-Outline-Discussion-Evaluation (RODE) model guides students to read, outline, discuss with peers, and evaluate their understanding. This process makes learning more efficient and helps build practical communication skills (Kusuma et al., 2022; Rahayu et al.,

2024). In science, communication is closely linked to numeracy, enabling students to share ideas and solve problems effectively. Numeracy goes beyond calculations to include clear, logical explanations (Kusumawati, 2017; Supartin et al., 2024; Wahyuni et al., 2024; Yennita et al., 2024). Strong numeracy enables students to analyze, explain, argue, calculate, and draw evidence-based conclusions (Choirunnisa et al., 2023). Therefore, communication skills and scientific numeracy complement each other. RODE uniquely adds value by integrating scientific numeracy for quantitative analysis with advanced communication strategies, ensuring the study's results are both robust and clearly understood.

The application of the Read Outline Discussion Evaluation (RODE) learning model to elementary school teacher education students' fluid mechanics material is a critical follow-up study for developing science learning theory and practice, particularly in the context of numeracy skills. The RODE model is effective in developing students' communication and numeracy skills, but its application to more complex materials, such as fluids, has not been widely investigated. Therefore, this research is essential for testing the effectiveness of the RODE model in a more specific context, namely among elementary school teacher education students, who play a crucial role in elementary science education. As explained by Hartono et al. (2022) developing learning models that improve students' numeracy skills is essential in science education, particularly for topics that require a deeper understanding of mathematical concepts, such as fluids in physics.

The success of the RODE model in improving communication skills has been demonstrated in several previous studies (Kusuma et al., 2022, 2024; Rahayu et al., 2024), but the focus on improving numeracy skills in the context of fluid material in elementary school teacher education students remains limited. This study aims to assess the feasibility of the RODE model for improving students' numeracy skills in teaching fluid materials to elementary education students, thereby enhancing learning quality in the study program. The urgency of this research is even greater, given that elementary school teacher education students' numeracy skills remain low in science subjects, particularly when the material taught includes complex physics concepts, such as fluid mechanics.

The RODE (Read, Outline, Discussion, Evaluation) learning model serves as a systematic pedagogical framework intended to enhance prospective teachers' science numeracy skills through four integrative phases that align with Sustainable Development Goal (SDG) 4. The Read and Outline phases are essential for establishing data literacy and mathematical modelling foundations, as students learn to deconstruct complex

variables in fluid phenomena into organised structures. This approach directly advances SDG 4, Target 4.6, which prioritises functional numeracy skills, and Target 4.4, which addresses the development of technical and critical thinking skills necessary for educators' future professional competence. The Discussion and Evaluation phases of the RODE model transform numeracy from routine calculation into a tool for scientific communication and reflection. Collaborative practices and social validation in the discussion phase promote an inclusive learning environment consistent with SDG 4.a. The evaluation phase strengthens scientific accountability and teaching quality in line with SDG 4.c standards (Albareda-Tiana et al., 2018; Leal Filho et al., 2021; UNESCO, 2017). Integrating all four phases allows the RODE model to enhance science numeracy outcomes and provide sustainable, innovative strategies for teacher-training institutions to prepare globally competent graduates.

Previous research by Angganing et al. (2022) found that learning models focused on numeracy exercises, such as those implemented by the RODE model, can be an alternative for improving students' understanding of physics concepts. This aligns with the study's objective of developing a model to help elementary school teacher education students overcome difficulties in understanding fluid materials through a more communicative and numerical approach.

Method

A one-group pretest–posttest design is used in this kind of pre-experiment. This study examines students' numeracy abilities in fluids using the RODE learning model. Sixth-semester primary school teacher education majors at the Faculty of Teacher Training and Education, the University of Borneo Tarakan, in North Kalimantan, Indonesia, constitute the study's population. A purposive sampling technique was used to select the research sample, comprising 37 students. This study used a five-question numeracy test to measure five different aspects of numeracy. The test was administered both before and after the implementation of the RODE learning model (pretest and posttest, respectively). An inferential test was used to analyze students' numeracy test results. If the data were normally distributed, a paired-samples t-test was used; otherwise, a Wilcoxon test was used. Hake's formula was used to assess the normality gain (N-Gain), which quantifies the difference between the mean pretest and posttest scores for students' numeracy skills.

$$N - Gain = \frac{Posttest\ Score - Pretest\ Score}{Ideal\ Score - Pretest\ Score} \qquad (1)$$

N-Gain Criterion

g > 0.7	: High
0.3 < g < 0.7	: Moderate
g < 0.3	: Low

Results and Discussion

Strong communication supports students' science numeracy, indicating that these skills are closely related (Choirunnisa et al., 2023; Kusumawati, 2017; Supartin et al., 2024; Wahyuni et al., 2024; Yennita et al., 2024). Based on this theoretical analysis, researchers tested the RODE learning model in fluid mechanics lectures and examined its effects on students' scientific numeracy skills. This finding presents a novel development in the RODE learning model. In this study, researchers measured scientific numeracy skills in five aspects: analysing data by identifying variables; understanding basic physics concepts (fluids); applying appropriate formulas to solve problems; solving problems related to fluid concepts; and interpreting information from graphs/tables. Table 1 presents the average pretest and posttest scores.

Table 1. Description of Average Science Numeracy Scores of Students

	N	Mean	Std. Deviation	Min	Max
Pretest	37	45.57	13.94	12.00	65.00
Posttest	37	68.94	4.53	50.00	74.00

Table 1 shows that the posttest average score exceeds the pretest average score. This means that using the RODE learning model has a positive effect on students' numeracy skills. The results of the normality test are also shown in Table 2.

Table 2. The Test of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.203	37	<.001	.894	37	.002
Posttest	.330	37	<.001	.586	37	<.001

a. Lilliefors Significance Correction

H_0: The data are normally distributed.
H_1: The data are not normally distributed.

The Shapiro-Wilk test results are used because there are only 37 data points (N<50). The p-value < 0.05 indicates that the pretest and posttest data are not normally distributed. The Wilcoxon signed-rank test, which is non-parametric, must be used because the data do not meet the normality assumptions. The results of the Wilcoxon Signed-Rank test are shown in Table 3.

Table 3. The Wilcoxon Signed-Rank Test

	Test Statistics[a]
	Posttest - Pretest
Z	-5.304[b]
Asymp. Sig. (2-tailed)	<.001

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

H_0: The scores on the pretest and the posttest do not differ significantly from each other.
H_1: The scores on the pretest and posttest differ significantly from each other.
H_0 is rejected since the p-value is less than 0.05. This demonstrates a statistically significant difference between the pretest and posttest results. According to these results, students' numeracy skills improved when the RODE learning model was used in lectures on fluid subjects.

Students' numeracy test scores improved after participating in the RODE model, suggesting that the model positively influenced their skills. The RODE model's social interaction system, drawing on social constructivism and information-processing theory, supports students' conceptual understanding and task completion by facilitating information exchange during group discussions. During the Read phase, students work in groups of four to five and are encouraged to read the LKM carefully, attend to the goals, and identify and read learning materials on fluids. During this phase, students develop their scientific numeracy by understanding variables and fluid concepts (Rakhmawati et al., 2022; Sesmiyanti et al., 2019).

This system resembles those in collaborative, active, and inquiry-based learning, all of which are claimed to impact science numeracy skills (Bøe et al., 2025; Rakhmawati et al., 2022). For instance, Alfazriani et al. (2024) and Ruqoyyah et al. (2025) proposed a cooperative learning model, which has been shown to enhance students' numeracy competencies. The process incorporates structured group learning that corresponds systematically to the outline and discussion phases of the RODE instructional model. Both models facilitate conceptual understanding through collaborative, interactive learning environments. Consequently, students not only grasp theoretical concepts but also demonstrate practical application through structured discussions and problem-solving activities. This pedagogical approach fosters active engagement and positive competition among students. Similarly, research by Pudjastuti et al. (2024) indicates that the Problem-Based Learning model positively affects numeracy skills, emphasizing students' abilities to comprehend and solve contextually relevant problems, collaborate effectively in the problem-solving process, and draw informed conclusions about their solutions.

These characteristics are congruent with the syntax and social system of the RODE instructional model (Asri et al., 2025; Ranak et al., 2023; Siska et al., 2023; Taufik et al., 2024; Wardani et al., 2024). Therefore, the RODE social learning system, by encouraging exploration of learning resources, development of critical thinking, participation in group discussions, and informed decision-making, contributes to the cultivation and enhancement of numeracy skills.

Empirical evidence in this study shows that the RODE learning model effectively trains and improves students' science numeracy skills. This result highlights the RODE model's capacity to enhance numeracy among students with both low and high starting abilities, thereby supporting a more inclusive and adaptive learning environment. The model's success is closely linked to the alignment between the characteristics of the teaching materials and the science numeracy skill indicators assessed: analyzing variables, understanding fluid concepts, applying formulas, solving fluid-related problems, and interpreting information from graphs or tables. The RODE model's structure accommodates both conceptual knowledge and procedural skills required for mastering static and dynamic fluids, resulting in measurable gains across these indicators.

In this study, the five indicators are effectively trained using the RODE learning model in fluid teaching materials. This finding addresses prior research recommendations, such as those by Kusuma et al. (2022a, 2024), which urge testing the RODE learning model to develop soft skills relevant to 21st-century competencies. Additionally, this study draws on empirical evidence from Choirunnisa et al. (2023), Kusumawati (2017), Supartin et al. (2024), Wahyuni et al. (2024), and Yennita et al. (2024), all of which indicate a link between students' communication and numeracy skills. Evaluating the RODE learning model's effect on students' numeracy skills, therefore, marks a novel step in its application.

A Normalised Gain (N-Gain) calculation was conducted to assess whether the RODE learning model affects students' numeracy abilities. Table 4 summarizes the results of the N-Gain computation.

Table 4. The N-Gain Score Pretest-Posttest Numeracy Ability

Average Pretest score	Average Posttest score	Posttest-Pretest	Ideal Score-Pretest	N-Gain
45.54	69.00	23.46	54.46	0.43

Table 4 shows an average N-Gain of 0.43 for students' numeracy pretest and posttest scores, classified as moderate according to established benchmarks. The RODE learning model produced a significant, though not high, increase in students' numeracy proficiency. The moderate improvement in understanding abstract concepts such as static and dynamic fluids demonstrates that students engaged in substantial cognitive restructuring. Participants advanced from the "incompetent" category (average score 45.57) to the "competent" category (average score 68.94), marking clear progress for pre-service teachers and demonstrating alignment with SDG 4 quality standards. Although complete mastery of numeracy may require additional practice, the RODE framework provided essential numerical fluency for future educators.

The RODE model's effectiveness stems from its sequential scaffolding structure, which guides students through successive phases of learning. Scientific numeracy development starts with textual comprehension (Read), transitions to symbolic representation (Outline), and then moves to social validation (Discussion). Each phase builds on the previous one: first, students extract meaning from text; next, they convert this meaning into symbols; then, they discuss and validate their understanding with peers. Information-processing theory posits that students frequently encounter difficulties with numeracy due to excessive cognitive load when directly engaging with formulas. The RODE model addresses this challenge by segmenting cognitive load into four distinct stages, enabling incremental reductions in complexity at each transition. The achievement of a 0.43 gain by 37 students demonstrates that the model effectively mitigates cognitive barriers, allowing for the gradual and systematic development of mathematical reasoning.

Conclusion

The RODE learning model helped PGSD students improve their scientific numeracy skills, as shown by an increase in average scores from 45.57 to 68.94 (N-gain = 0.43). This progress supports SDG 4 by giving future teachers important scientific skills. However, since the study used only a one-group pretest-posttest design, it is difficult to say for sure that the RODE model caused these improvements. Future research should include a control group to better test the model's impact. While the results were statistically significant ($p < 0.001$) and showed a positive trend, the moderate gain of 0.43

should be seen as an early sign of success for this group, rather than definitive proof of causality. Other factors, like students' prior knowledge or natural development, may have played a role. Still, this study offers useful first evidence of the RODE model's potential. To address current limitations, future studies should use Randomized Controlled Trials (RCTs) to compare the RODE model with traditional teaching methods and clarify any causal effects. Further research could also examine how well the model performs across different physics topics and whether it helps students maintain their scientific numeracy skills over time. Including more students from different universities and increasing the sample size would make the findings more widely applicable and add to the discussion on SDG 4 and educational innovation.

Author Contributions
Conceptualization, A.E.K., R., and N.M.,; methodology, A.E.K., R., and S.; validation, A.E.K., R., and D.A.A,; formal analysis., A.E.K, N.M, and P.A.,; investigation, D.A.A., S., N.M., and P.A.,; resources, A.E.K., N.M., P.A., and R.; data curation, N.,M., P.A., and A.E.K.: writing-original draft preparation, A.E.K., N.M., P.A., and R; writing-review and editing, R., A.E.K., and.; visualization, A.E.K., R. and N.M. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest
The authors declare that they have no conflict of interest. The funders had no role in the design of the study, in the collection, analysis, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

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