The impact of implementing a scientific approach on the science learning achievements of 4th-grade students within the learning environment

Budi Tri Cahyono[1]*, Jovita Ridhani[1], Taufiq Subhanul Qodr[1], Nauroz Khan[2], Wazir Ali[1]

[1]Universitas Sebelas Maret, Ir. Sutami St. No. 36, Surakarta, Jawa Tengah, 57126, Indonesia
[2]University College of Dera Murad Jamali, Dera Murad Jamali, 80700, Pakistan
*Corresponding author, email: buditricahyono@staff.uns.ac.id

Article History
Received: 25 February 2025
Revised: 11 March 2025
Accepted: 28 March 2025
Published: 31 March 2025

Keywords
Formulating questions
Observational methods
Scientific approach

Abstract
This study investigates the influence of a scientific approach on the academic performance of 4th students in science. The scientific approach focuses on key processes such as observation, formulating questions, making connections, conducting experiments, analyzing data, drawing conclusions, and presenting findings, distinguishing it from traditional science education methods. Employing a quantitative research design with a quasi-experimental non-equivalent control group, the study targeted all Gugus I Gajah Mada Laweyan Surakarta 4th students. A sample of 120 students from eight elementary schools was selected, with participants divided into experimental and control groups, each comprising 60 students. Data collection involved both observational methods and essay assessments featuring 30 questions. The findings revealed a notable disparity in science learning outcomes between students instructed using the scientific approach and those who received conventional instruction. Specifically, students in the experimental group demonstrated significantly superior learning outcomes compared to their counterparts in the control group. The results of the study showed that the assessment of learning outcomes using observation sheets had a significant effect on teacher involvement during the learning process. The results of the Lillefors Statistical test show the difference between scientific and conventional classes, with the former showing a higher value of 0.95 compared to 0.87. This indicates that the use of digital learning media effectively attracts the interest of students and teachers.

How to cite: Cahyono, B. T., Ridhani, J., Qodr, T. S., Khan, N., & Ali, W. (2024). The impact of implementing a scientific approach on the science learning achievements of 4th-grade students within the learning environment. *Journal of Environment and Sustainability Education, 3*(1). 82–87. doi: 10.62672/joease.v3i1.61

1. Introduction

Education is fundamental in fostering both academic and non-academic knowledge and skills. The National Education System Law of the Republic of Indonesia No. 20 of 2003 highlights that education should be a deliberate and structured effort to create a conducive learning environment, enabling students to cultivate their potential actively. Adopting a practical approach to learning is vital to enhancing student learning outcomes (Adipat et al., 2021).

Recent observations in Gugus I of Gajah Mada Laweyan Surakarta indicate that science teaching primarily relies on traditional lecture methods, where instructors present information and pose questions without allowing sufficient opportunities for students to engage in problem-solving (Nugroho et al., 2022). Consequently, the science learning outcomes of students have not met the anticipated Minimum Completeness Criteria (KKM). Implementing an effective learning strategy can significantly aid students in grasping the material and achieving optimal educational results (Supena et al., 2021).

Learning outcomes serve as a crucial measure of the effectiveness of the educational process, reflecting positive transformations in students' cognitive, emotional, and physical dimensions (Svenningsson et al., 2022). In the realm of science education, it is essential that the selected teaching methods align with the unique characteristics of the subject matter and actively engage students in the exploration and comprehension of natural phenomena. Since science systematically investigates these phenomena, students must participate directly in their learning experiences (Dewanti, 2022).

doi: 10.62672/joease.v3i1.61

ISSN: 3025-0714

The scientific approach provides a robust framework for science education, focusing on key activities such as observation, formulating questions, making connections, conducting experiments, processing information, drawing conclusions, and presenting findings (Opdal, 2022). This methodology fosters the development of students' critical and analytical thinking skills as they tackle problems related to natural phenomena. Furthermore, international studies affirm the efficacy of scientific approaches in enhancing science learning outcomes (Harefa et al., 2023). For instance, research indicates that implementing a scientific approach significantly boosts elementary students' grasp of scientific concepts and procedural skills. Additional studies emphasize the role of this approach in cultivating critical thinking abilities within the context of science education. Comparative analyses reveal that students instructed through scientific methods generally achieve superior learning outcomes in science compared to those taught via traditional methods (Purnadewi et al., 2023). Consequently, this study seeks to investigate the impact of scientific approaches on the science learning outcomes of 4th-grade students, contrasting them with conventional teaching methods (Purnadewi et al., 2023).

In the realm of Science education, educators need to modify their teaching approaches, as the core of learning science transcends mere knowledge transfer from instructors; it hinges on the active engagement of students (Tri Cahyono et al., 2023). Science systematically investigates natural phenomena and inspires individuals to innovate and create, emphasizing a learning experience that prioritizes hands-on involvement. According to Kite et al., 2021 the fundamental nature of science encompasses four key dimensions: first, science as a product, which refers to a compilation of discoveries organized into concepts; second, science as a process, which involves the stages of validating and uncovering facts within theories and ideas; third, science as an attitude, characterized by traits such as curiosity, critical thinking, objectivity, honesty, and attention to detail; and fourth, the practical application of knowledge in everyday life. Employing the scientific method can enhance students' comprehension of learning concepts, as it fosters their direct and active participation in the educational process (Pramana et al., 2021).

The scientific learning approach emphasizes scientists' systematic steps to enhance students' knowledge, skills, and attitudes throughout the educational experience. In this framework, students are regarded as the primary participants in the learning process, while teachers assume the role of facilitators, encouraging students to develop their critical thinking abilities (Teslo et al., 2023). The objective is to equip students to think critically and analytically when addressing issues related to natural phenomena. According to Eungoo & Hwang, 2021 the stages of the scientific method encompass: first, observation, which involves examining phenomena; second, question formulation, where students generate inquiries related to their observations; third, reasoning or association, which entails connecting the outcomes of their observations; fourth, experimentation, where students conduct tests based on data and hypotheses; fifth, data processing, which involves synthesizing knowledge; sixth, drawing conclusions, where students summarize their observational results; and seventh, presentation, which is the act of sharing findings based on the gathered evidence. Consequently, researchers are keen to explore the application of diverse learning methods, specifically scientific methods, to determine whether 4th-grade students utilizing these methods exhibit different levels of understanding and learning outcomes than their peers who engage in conventional methods (El-Sabagh, 2021).

According to Ahmadin 2022, the scientific method provides an extensive framework for learning in science, highlighting key components such as observation, formulating questions, making connections, conducting experiments, processing information, drawing inferences, and presenting findings. This method promotes the development of critical and analytical thinking abilities among students as they tackle issues associated with natural phenomena. Consequently, by comparing scientific and traditional teaching methods, this research aims to explore the impact of scientific approaches on the science learning outcomes of 4th-grade students (Fathurohman et al., 2022).

Scientific learning is believed to be one of the practical teaching models because it is able to accommodate and touch emotional, physical, and academic dimensions in an integrated manner that empirically succeeds in accelerating and increasing students' memory capacity. According to Inel-Ekici and Ekici (2022), the advantages of scientific learning are: (1) Improving thinking skills: Students can think critically, creatively, and systematically. (2) Increase learning motivation: Students and teachers can be motivated to improve their thinking skills. (3) Build conceptualization of knowledge: Students can understand scientific concepts and processes. (4) Getting used to analytical thinking: Students can make decisions appropriately, and (5) Develop character: Students can develop good and godly character. Based on the description of the research context mentioned above, the application of a scientific approach to science learning outcomes of 4th-grade students in the Learning Context by trying scientific learning methods as experiments and conventional learning as controls. Based on the description of the research context mentioned above, the objectives of this research are: 1) Encourage students to think critically analytically and solve problems, 2) Train students to solve problems systematically, and 3) Improve intellectual abilities, especially high-level thinking skills.

Based on the description of the research context mentioned above, about the impact of the application of scientific approaches on science learning outcomes of grade IV students in the Learning Context. Therefore,

research on "The Impact of Implementing a Scientific Approach on the Science Learning Achievements of 4th-grade Students within the Learning Environment" is essential to be carried out.

2. Method

This research employs a cross-sectional methodology, utilizing a non-probability sampling technique characterized by quota sampling. The stages starting from the beginning are focused on (Rahman, 2023) Formulating research questions and hypotheses, identifying research variables, determining the research subject, collecting data, and analyzing data. The study involves two sample groups, each comprising an equal number of participants from both an experiment class and a control class, with all subjects undergoing a pretest before the intervention. The scientific class engages in science education through a scientific approach, whereas the conventional class follows a traditional instructional method. The tools used in this study are in two ways, namely the distribution of questionnaires or questionnaires directly and through Google Forms.

The target population consists of 120 students from eight 4th-grade elementary schools within Gugus I Gajah Mada, located in the Laweyan District of Surakarta City. The sample for this study includes 60 students from four elementary schools designated as the experiment class and another 60 from four schools identified as the control class. Data collection methods encompass observation, testing, and documentation, with the research instrument comprising 30 essay questions that have undergone validity testing. Data analysis involves conducting normality tests using the chi-square formula. The essay tests utilized in this educational research evaluate students' knowledge and reasoning skills, particularly when the desired learning outcomes necessitate detailed explanations. These tests directly assess student learning, as they compel students to apply their acquired skills.

Furthermore, they can measure higher-order cognitive abilities, prompting students to organize, interpret, and synthesize information to address novel challenges. The design of the essay tests emphasizes validity and reliability; validation confirms that the tests accurately measure the intended constructs, while reliability ensures that the results are stable over time and consistent across different evaluators. The research design is visually represented in the accompanying Table 1.

Table 1. Research Design

Method Chi-Square	Pretest (x)	Treat (y)	Posttest (x-y)
Experiment	Ex	Ey	Ex-Ey
Control	Cx	Cy	Cx-Cy

The study took place in Gugus I of Gajah Mada Laweyan Surakarta, focusing on a population of 120 4th-grade students. The sampling techniques employed are categorized into two primary types: probability sampling, which is random, and non-probability sampling. Specifically, the methods utilized include cluster, purposive, and quota sampling. The research instrument comprises a set of 30 essay questions that underwent validity testing before their application to the research participants. For data analysis, the technique involves testing for normality using the Chi-Square formula, which calculates the sum of the deviations between the observed data for each class and the expected values (Chiu, 2021).

3. Results and Discussion

This study was conducted in Gugus I of Gajah Mada Laweyan Surakarta during the odd semester of the 2024/2025 academic year. The research took place from October 1 to October 20, 2025, involving a sample of 120 students. Data was collected through multiple methods, including observation, testing, and documentation. The purpose of the observation was to assess the students' behavior in the classroom throughout the teaching and learning process, with data reflecting both student and teacher activities as noted by the observers (Dignath & Veenman, 2021). Documentation was utilized to capture images of the learning activities, while the testing aimed to evaluate the effectiveness of the science learning method and the student's academic performance in Gugus I Gajah Mada Laweyan Surakarta, employing pretest and posttest assessments. Before data collection, the research instruments underwent validation and reliability testing (Açikgül, 2021).

The findings indicated notable differences in science learning outcomes between the scientific and conventional classes before and after the intervention. The results of the pretest and posttest interventions are summarized in Table 2, which presents the average scores of students from eight grade IV schools in Gugus I Gajah Mada Laweyan Surakarta, with a total of 120 students divided into two groups, namely the scientific class and the control class.

Table 2. Average Student Grades

Students	Experiment	Control
Number of students	60	60

By conducting the above research analysis using the SPSS data processing application with the number of respondents divided into two groups, namely the experimental class and the control class, the results were obtained as in Table 3.

Table 3. Frequency (Count)

Class	Succeed	Didn't work	Total
Experiment	45	15	60
Control	30	30	60

From the calculations in Table 3, the results are obtained assuming that each class conducts pretests and posttests with an assessment between "Successful" and "Unsuccessful" without any special treatment between the experimental class and the control class. The percentages obtained are in Table 4.

Table 4. Percentage in Row (%)

Class	% Successful	% Unsuccessful	Total
Experiment	75%	25%	100%
Control	50%	50%	100%

The percentage obtained can be assumed to be how many students are successful and unsuccessful. It is possible that each class, namely the experimental and control classes, has defined the value obtained. Then, from each class, a comparative or chi-square test (Table 5) was carried out on two classes with the data scale of the two variables as nominal.

Table 5. Chi-Square Test

Test	Value	Df	p-value
Pearson Chi-Square	6.67	1	0.010

Next, Lillefors Statistical was used to see the suitability of the distribution values of pretest and posttest by comparing the distribution of experimental classes to the control classes. The Lillefors Statistical test is a modification of the Kolmogorov-Smirnov test, but there are differences between the two, as seen in the table below in Table 6.

Table 6. Difference of Lilliefors vs. Kolmogorov-Smirnov (K-S) Test

Criterion	Lilliefors Test	Kolmogorov-Smirnov Test
Purpose	Especially for normality tests	Compare the sample distribution with the reference distribution (can be expected, uniform, etc.)
Parameter Estimation	Mean and variance are estimated from sample data.	The reference distribution is already known (e.g., standard with mean=0, std=1)
Sensitivity	More accurate for normality tests	Less accurate if the distribution parameters are unknown

From the explanation of the comparison above, the Lillefors Statistical test tests normality with a predetermined population number (Table 7).

Table 7. Lillefors Statistical Test

Class	Number of Students (n)	Lilliefors Statistics	p-value	Conclusion
Experiment	60	0,95	>0.05	Normally distributed data
Control	60	0,87	>0.05	Normally distributed data

From the results of several previous studies that were the same, according to Demir And Emre (2020), the implementation of learning formed by the experimental group had a higher score compared to the control group in terms of academic achievement, attitudes towards science, and misconceptions. According to Küçük & Yıldırım (2020), learning activities carried out within the scope of limited units increase knowledge of science and technology and the environment of the learning group, as well as their sustainability can be achieved over a long period. According to Muhsam et al., (2021) students who participated in CTL learning with conventional learning There was a difference in learning outcomes in students who participated in project assessments

between students who participated in CTL learning and students who participated in traditional learning. From the three previous research reviews, a similarity can be obtained with this study, namely that by making two groups, it will be seen that the results are done to describe the scientific class and the conventional class. Which scientific class results better because it is shaved by the method Scientific Approach

4. Conclusion

The findings from the research and learning outcome assessments indicate that the teacher activity observation sheet is utilized to gather data regarding teacher engagement during the learning process. The Lillefors Statistical Test revealed a value of 0.95 for the scientific class, accompanied by a p-value greater than 0.05, confirming that the data is usually distributed. In contrast, the conventional class yielded a value of 0.87, with a p-value exceeding 0.05, indicating normal distribution. The results of the Lillefors Statistical Test demonstrate a distinction between the scientific and conventional classes, with the former showing a higher value of 0.95 compared to 0.87. This suggests that the use of digital learning media effectively captures the interest of both students and teachers.

The results of this study are expected to add insight into knowledge for future research related to the application of scientific approaches to science learning outcomes of 4th-grade elementary school students in the context of learning and the factors that influence it. Especially with the development of media that is used to facilitate the explanation of the defense with a scientific approach, it is necessary to modify variables or add instruments and data so that the results obtained can complement previous research.

Author Contributions

All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

Funding

No funding support was received.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

Açikgül, K. (2021). Developing a two-tier proportional reasoning skill test: Validity and reliability studies. *International Journal of Assessment Tools in Education, 8*(2), 357–375. https://doi.org/10.21449/ijate.909316

Adipat, S., Laksana, K., Busayanon, K., Ausawasowan, A., & Adipat, B. (2021). Engaging students in the learning process with game-based learning: The fundamental concepts. *International Journal of Technology in Education, 4*(3), 542–552. https://doi.org/10.46328/ijte.169

Ahmadin. (2022). Social research methods: Qualitative and quantitative approaches. *Social Research Methods: Qualitative and Quantitative Approaches, 6*(1), 104–113.

Chiu, T. K. F. (2021). Digital support for student engagement in blended learning based on self-determination theory. *Computers in Human Behavior, 124*, 106909. https://doi.org/10.1016/j.chb.2021.106909

Depdiknas. (2003). *Undang-Undang RI No. 20 tahun 2003 tentang Sistem Pendidikan Nasional.* Retrieved from https://jdih.kemdikbud.go.id/sjdih/siperpu/dokumen/salinan/UU_tahun2003_nomor020.pdf

Demir, Y., & Emre, İ. (2020). The effect of learning activities based on 5E learning model on 4th grade science teaching. *Mersin Üniversitesi Eğitim Fakültesi Dergisi, 16*(3), 573–586. https://doi.org/10.17860/mersinefd.750957

Dewanti, B. A. (2022). Comparing student creativity skills in experiment-based and project-based science learning. *Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram, 10*(3), 786. https://doi.org/10.33394/j-ps.v10i3.5348

Dignath, C., & Veenman, M. V. J. (2021). The role of direct strategy instruction and indirect activation of self-regulated learning: Evidence from classroom observation studies. *Educational Psychology Review, 33*(2), 489–533. https://doi.org/10.1007/s10648-020-09534-0

El-Sabagh, H. A. (2021). Adaptive e-learning environment based on learning styles and its impact on the development of students' engagement. *International Journal of Educational Technology in Higher Education, 18*(1). https://doi.org/10.1186/s41239-021-00289-4

Eungoo, K., & Hwang, H.-J. (2021). Ethical conducts in qualitative research methodology: Participant observation and interview process. *Journal of Research and Publication Ethics, 2*(2), 5–10. http://dx.doi.org/10.15722/jrpe.2.2.202109.5

Fathurohman, M., Iqbal Al Ghozali, M., Purwati, R., & Permatasari, F. (2022). The effectiveness of experimental methods on student learning outcomes in science subject in elementary school. *Scentia: Social Science & Humanities, 1*(2), 388–390. https://doi.org/110.51773/icobba.v1i2.107

Harefa, D., Sarumaha, M., Telaumbanua, K., Telaumbanua, T., Laia, B., & Hulu, F. (2023). Relationship student learning interest to the learning outcomes of natural sciences. *International Journal of Educational Research & Social Sciences, 4*(2), 240–246. https://doi.org/10.51601/ijersc.v4i2.614

Inel-Ekici, D., & Ekici, M. (2022). Mobile inquiry and inquiry-based science learning in higher education: Advantages, challenges, and attitudes. *Asia Pacific Education Review, 23*(3), 427–444. https://doi.org/10.1007/s12564-021-09729-2

Kite, V., Park, S., McCance, K., & Seung, E. (2021). Secondary science teachers' understandings of the epistemic nature of science practices. *Journal of Science Teacher Education, 32*(3), 243–264. https://doi.org/10.1080/1046560X.2020.1808757

Küçük, A., & Yıldırım, N. (2020). The effect of out-of-school learning activities on 5th-grade students' science, technology, society, and environment views. *Turkish Journal of Teacher Education, 9*(1). http://www.tujted.com/files/15/manuscript/manuscript_1471/tujted-1471-manuscript-112650.pdf

Muhsam, J., Hasyida, S., Uslan, & Aiman, U. (2021). Implementation of contextual teaching and learning and authentic assessments to the science (IPA) learning outcomes of 4th grade students of primary schools (SD) in Kota Kupang. *Journal of Education Research and Evaluation, 5*(3), 380–390. https://ejournal.undiksha.ac.id/index.php/JERE/article/view/32338

Nugroho, A. S., Nursalim, M., & Sujarwanto. (2022). Spiritual intelligence is directly proportional to the improvement of social attitudes of elementary school students. *Jurnal Pendidikan Dasar Nusantara, 8*(1), 15–27. https://doi.org/10.29407/jpdn.v8i1.17990

Opdal, P. A. (2022). To do or to listen? Student active learning vs. the lecture. *Studies in Philosophy and Education, 41*(1), 71–89. https://doi.org/10.1007/s11217-021-09796-3

Pramana, C., Chamidah, D., Suyatno, S., Renadi, F., & Syaharuddin, S. (2021). Strategies to improve education quality in Indonesia: A review. *Turkish Online Journal of Qualitative Inquiry, 12*(3), 1977–1994. https://www.researchgate.net/publication/353299393

Purnadewi, G. A. A., Arnawa, N., & Tatminingsih, S. (2023). The influence of school culture, learning interest, and learning motivation on science learning outcomes. *Indonesian Journal of Educational Development, 4*(2), 126–138. https://doi.org/10.59672/ijed.v4i2.3040

Rahman, M. M. (2023). Sample size determination for survey research and non-probability sampling techniques: A review and set of recommendations. *Journal of Entrepreneurship, Business and Economics, 11*(1), 42–62. www.scientificia.com

Supena, I., Darmuki, A., & Hariyadi, A. (2021). The influence of the 4C (constructive, critical, creativity, collaborative) learning model on students' learning outcomes. *International Journal of Instruction, 14*(3), 873–892. https://doi.org/10.29333/iji.2021.14351a

Svenningsson, J., Höst, G., Hultén, M., & Hallström, J. (2022). Students' attitudes toward technology: Exploring the relationship among affective, cognitive and behavioral components of the attitude construct. *International Journal of Technology and Design Education, 32*(3), 1531–1551. https://doi.org/10.1007/s10798-021-09657-7

Teslo, S., Thurston, M., Lerum, Ø., Brekke Mandelid, M., Sørnes Jenssen, E., Resaland, G. K., & Eikeland Tjomsland, H. (2023). Teachers' sensemaking of physically active learning: A qualitative study of primary and secondary school teachers participating in a continuing professional development program in Norway. *Teaching and Teacher Education, 127*, 104113. https://doi.org/10.1016/j.tate.2023.104113

Cahyono, B. T., Prihatin, R., Suparmi, S., Sukmawati, F., & Santosa, E. B. (2023). Development of authentic assessment with project based learning approach in primary school students. *Qalamuna, 15*(1), 539–548. https://doi.org/10.37680/qalamuna.v15i1.3987