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TEACHING DESTRUCTIVE NATURAL EVENTS THROUGH EXPLICIT REFLECTIVE NATURE OF SCIENCE EDUCATION: EFFECTS ON ACADEMIC ACHIEVEMENT AND NATURE OF SCIENCE VIEWS

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Abstract. *Developing students' understanding of destructive natural events requires not only conceptual knowledge but also an understanding of how scientific knowledge is generated and applied. This study examined the effects of explicit-reflective Nature of Science (NOS) education integrated into destructive natural events on students' academic achievement and NOS views. A quasi-experimental pre-test–post-test control group design was employed with 111 fifth-grade students from a public lower-secondary school in Türkiye. Academic achievement was assessed using the Destructive Natural Events Achievement Test (DNEAT), and NOS views were examined using the Views of Nature of Science Questionnaire–Form E (VNOS-E). Quantitative data were analysed using analysis of covariance (ANCOVA), and students' NOS views were analysed through qualitative content analysis. After pre-test achievement was controlled, students in the experimental group achieved significantly higher post-test achievement scores than those in the control group. Furthermore, students receiving explicit-reflective education demonstrated more informed views across all five NOS aspects, with the most pronounced changes observed in their understanding of the tentativeness and subjectivity of scientific knowledge. These findings show that destructive natural events can be used as a context for explicit-reflective NOS education while addressing students' scientific content knowledge and NOS understandings within the same educational process.*

Keywords: *academic achievement, destructive natural events, explicit-reflective, fifth-grade students, nature of science*

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Introduction

Destructive natural events provide a meaningful context for science education because understanding them requires students to connect scientific knowledge with events that have direct consequences for human life, society, and the environment. The growing frequency and impacts of natural disasters further increase the importance of developing such understanding, as these events continue to cause substantial human, environmental, and economic losses worldwide (United Nations Office for Disaster Risk Reduction [UNDRR], 2022). Recent disasters, including earthquakes, floods, landslides, volcanic eruptions, hurricanes, and wildfires, have highlighted the importance of disaster education in preparing individuals to respond effectively to natural hazards (Becker et al., 2017; Izadkhah & Gibbs, 2015). Türkiye is among the countries most vulnerable to destructive natural events because of its geographical and geological characteristics (AFAD, 2023). The 2023 Kahramanmaraş earthquakes, which resulted in significant loss of life and substantial social and economic disruption (Maden, 2023), have underscored the need to enhance disaster education from the earliest stages of schooling. Students may hold scientifically inaccurate or incomplete understandings of destructive natural events, including earthquakes, erosion, and landslides (Kılıçoğlu & Akkaya Yılmaz, 2024). Therefore, fostering a comprehensive understanding of destructive natural events has become a central objective in science education.

Disaster education seeks not only to expand students' knowledge of natural hazards but also to equip them to make informed decisions before, during, and after disaster events (Yalçınkaya-Önder & Tatlı, 2026). Achieving this objective requires more than acquiring scientific facts. Students also need to understand how scientific knowledge is generated, evaluated, and

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applied when explaining natural phenomena and making evidence-based decisions. This perspective is consistent with the goals of scientific literacy, which emphasize understanding both scientific concepts and the processes through which scientific knowledge is developed (Lederman et al., 2002). Park (2020) similarly argues that stronger dialogue between science and disaster education requires curricula that enable teachers to establish and sustain cross-disciplinary connections. From this perspective, destructive natural events can serve as a relevant context for connecting science content with reflection on scientific knowledge and its development. Within this framework, disaster education provides a basis for integrating Nature of Science (NOS) education into science teaching (Canlas & Karpudewan, 2023; Cerulli & Holbrook, 2019). Because disaster-related topics combine well-established scientific evidence with issues of societal relevance, they may also help extend students' understanding of NOS beyond isolated and decontextualized science topics (Khishfe, 2025).

NOS refers to the values, assumptions, and characteristics underlying the development of scientific knowledge (Lederman, 2007). Previous research has shown that students often develop naive conceptions of NOS when these ideas are addressed only implicitly during science education, whereas explicit-reflective approaches are more effective in promoting informed views (Abd-El-Khalick & Lederman, 2023; Lederman et al., 2002). Beyond improving students' understanding of science as a way of knowing, explicit-reflective education may also promote conceptual learning by encouraging students to evaluate evidence, justify claims, and reflect on scientific explanations (Khishfe, 2022). Nyarko and Rudge (2022) reported that an explicit-reflective lesson based on the historical development of plate tectonics significantly improved undergraduate students' understanding of the tentative nature of scientific theories and the influence of society and culture on scientific knowledge. These findings provide a rationale for examining explicit-reflective NOS education within the context of destructive natural events.

Research Problem

Although disaster education has gained increasing attention in science education, existing studies have primarily focused on students' disaster awareness, preparedness, risk perception, and disaster literacy (Kuloğlu et al., 2024; Ventura & Madrigal, 2020). While these studies have contributed to understanding how students learn about natural hazards, they have paid limited attention to the epistemic dimensions of science, particularly students' understanding of how scientific knowledge is generated, evaluated, and revised in the context of destructive natural events (Khishfe, 2019).

NOS is widely accepted as an important component of scientific literacy because it helps learners understand how scientific knowledge is constructed and justified (Lederman, 2007). Informed NOS views include understanding the role of scientific evidence, distinguishing between observations and inferences, and recognizing the tentative and theory-laden nature of scientific knowledge (Abd-El-Khalick & Lederman, 2023; Lederman et al., 2002). These understandings are particularly relevant when students consider disaster-related information because scientific explanations may be revised as new evidence becomes available (Cerulli & Holbrook, 2019).

Previous research has consistently shown that explicit-reflective approaches are more effective than implicit approaches in developing informed NOS views (Abd-El-Khalick & Lederman, 2023; Khishfe, 2019; Lederman et al., 2002). Explicit-reflective approaches have been examined across a range of science contexts (Karaman, 2019; Khishfe & Abd-El-Khalick, 2002). However, few studies have examined explicit-reflective NOS education in the context of destructive natural events (Khishfe, 2019). Addressing this gap is important because destructive natural events provide a real-world context in which students can examine evidence, consider alternative explanations, and reflect on the tentative nature of scientific knowledge (Khishfe, 2017; Kolstø, 2001). Furthermore, studies show that when education is placed in familiar and meaningful contexts, students are more likely to transfer their NOS understandings (Khishfe, 2019, 2025). This suggests that destructive natural events may provide a relevant context for NOS education in Türkiye.

Previous studies suggest that explicit-reflective NOS education may contribute to conceptual learning as well as the development of more informed NOS views (Kaya & Çakmakçı, 2012; Köprübaşı, 2018). However, relatively few studies have examined academic achievement and NOS views together following explicit-reflective NOS education, particularly in the context of destructive natural events.

Research Aim and Research Questions

The aim of this study was to examine the effects of explicit-reflective NOS education integrated into the teaching of destructive natural events on fifth-grade students' academic achievement and NOS views.

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RQ1. What is the effect of explicit-reflective NOS education integrated into the teaching of destructive natural events on fifth-grade students' academic achievement compared with the current science curriculum?

RQ2. How does explicit-reflective NOS education integrated into the teaching of destructive natural events influence fifth-grade students' NOS views compared with the current science curriculum?

Research Methodology

General Background

A quasi-experimental approach was used to compare the experimental and control groups before and after the educational process. Because the participating classes had been established before the study, random assignment of individual students was not feasible (Creswell & Creswell, 2018). The study was conducted during the second semester of the 2021–2022 school year with fifth-grade students in a public lower-secondary school in Türkiye. It examined the effects of explicit-reflective NOS education integrated into the teaching of destructive natural events on students' academic achievement and NOS views. Academic achievement was examined quantitatively, while students' open-ended responses were analysed qualitatively to identify changes in their NOS views.

Participants

The study was conducted in a public lower-secondary school in Istanbul, Türkiye. The school was purposefully selected because the science teacher who implemented the educational process had received prior academic preparation related to NOS during undergraduate education. This background was considered relevant to the implementation of the explicit-reflective NOS approach. At the time of the study, the school had six fifth-grade classes. Four of these six intact classes were randomly selected for participation. Of the four selected classes, two were randomly assigned to the experimental group (EG) and two to the control group (CG). Intact classes were used as the unit of assignment because reorganizing existing classrooms was not feasible in the school setting (Fraenkel et al., 2012). The four classes included 111 fifth-grade students in total. The EG consisted of two classes with 27 and 25 students (n = 52), whereas the CG consisted of two classes with 29 and 30 students (n = 59). The sample included 48 girls (43.2%) and 63 boys (56.8%). In the EG, 23 students were girls and 29 were boys, while the CG included 25 girls and 34 boys.

The sample size was determined by the intact-class structure of the study rather than by individual participant recruitment. A sensitivity analysis indicated that, with 111 students and an alpha level of .05, the ANCOVA was able to detect an effect of approximately f = .27 with 80% statistical power. However, because the study included only four classroom clusters from a single school, the sample structure limits the extent to which classroom-level dependencies can be modeled and the findings generalized beyond the study context.

Instruments and Procedures

Two data collection instruments were used in this study. The first instrument was the Destructive Natural Events Achievement Test (DNEAT), which was developed by the authors to assess fifth-grade students' knowledge of destructive natural events (Bilgin & Çavuş Güngören, 2022, 2025). The DNEAT consists of 24 multiple-choice items. Exploratory factor analysis supported a six-factor structure representing six conceptual domains related to destructive natural events and disaster preparedness. The DNEAT demonstrated satisfactory psychometric properties, with a KR-20 reliability coefficient of .76, an average item difficulty index of .62, and an average item discrimination index of .46.

Students' views of the NOS were explored using the Views of Nature of Science Questionnaire–Form E (VNOS-E). Developed by Lederman and Ko (2004) for elementary school students and later adapted into Turkish by Doğan et al. (2010), the instrument includes seven open-ended questions. These questions examine students' understanding of five NOS aspects: tentativeness, empirical basis, subjectivity, the role of creativity and imagination in science, and the distinction between observation and inference.

Ethical approval was obtained from the Scientific Research Ethics Committee of Çanakkale Onsekiz Mart University (Approval Date: 06.01.2022; Decision No: 01/47). Approval to conduct the research was also provided

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by the Turkish Ministry of National Education. Participation was voluntary, with written parental consent obtained before data collection. All responses were treated confidentially and used exclusively for research purposes.

The intervention was conducted over four weeks (12 class hours) using eight lesson plans. Students completed the DNEAT and the VNOS-E as pre-tests prior to the intervention, and the same instruments were administered after the intervention. In accordance with the Turkish Science Curriculum, the topic of Destructive Natural Events and Protection Methods was covered in both the experimental and control groups (MoNE, 2018). The CG followed the current science curriculum, whereas the EG received explicit-reflective NOS education integrated into the teaching of destructive natural events.

In the experimental group, the explicit-reflective approach was implemented by making the targeted NOS aspects explicit topics of education rather than expecting students to develop these understandings implicitly through participation in science activities. The reflective component involved providing structured opportunities for students to discuss and reconsider how scientific knowledge is generated, interpreted, and revised in relation to the activities they completed. Accordingly, the teacher used guiding questions and classroom discussions to draw students' attention to the targeted NOS aspects and encouraged them to reflect on these aspects in the context of destructive natural events.

The explicit-reflective NOS education was integrated into the Human and Environment unit through activities focusing on earthquakes, volcanic eruptions, landslides, tornadoes, hurricanes, and floods. Students engaged in worksheets, scenarios, hands-on tasks, small-group discussions, and guided reflections designed to promote explicit consideration of the targeted NOS aspects. In contrast, the control classes did not receive explicit-reflective NOS education. They followed the instructional approaches suggested in the current science curriculum, including teacher explanations, textbook-based tasks, question-and-answer sessions, and classroom discussions.

Table 1
Overview of the Educational Procedures for the Experimental and Control Groups

Group	Pre-test	Educational Sequence (8 Lesson Plans)	Education	Post-test
EG	• DNEAT • VNOS-E	Lesson 1-2: Earthquakes Lesson 3-4: Volcanic Eruptions Lesson 5: Landslides Lesson 6: Tornadoes and Hurricanes Lesson 7-8: Floods	Science curriculum enriched with explicit-reflective NOS activities	• DNEAT • VNOS-E
CG	• DNEAT • VNOS-E	Lesson 1-2: Earthquakes Lesson 3-4: Volcanic Eruptions Lesson 5: Landslides Lesson 6: Tornadoes and Hurricanes Lesson 7-8: Floods	Regular science curriculum without explicit-reflective NOS activities	• DNEAT • VNOS-E

Note. EG = Experimental Group; CG = Control Group; DNEAT = Destructive Natural Events Achievement Test; VNOS-E = Views of Nature of Science Questionnaire–Form E.

To promote consistent implementation across classrooms, the same science teacher taught both the EG and CG. The teacher had previously completed undergraduate coursework related to the NOS. Before the intervention, the researchers met with the teacher to review the lesson plans and discuss the principles of explicit-reflective NOS education. The intervention was carried out using eight lesson plans developed based on the explicit-reflective approach. A representative lesson plan is provided as Supplementary Material 1 to illustrate the educational design. Throughout the intervention, regular communication was maintained between the researchers and the teacher to monitor the implementation process and ensure fidelity to the planned educational procedures. The lesson plans used in the experimental group were also reviewed by three science education experts and revised in line with their feedback to ensure alignment with the curriculum learning outcomes and the targeted NOS aspects.

Data Analysis

Quantitative and qualitative data were analysed independently using procedures appropriate to each type of data. Descriptive statistics (means and standard deviations) were calculated for the quantitative data, and the assumptions underlying the planned statistical analyses were evaluated before inferential analyses were conducted. Following the separate analyses, the quantitative achievement findings and qualitative NOS findings were inte-

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grated at the group level through a joint display to examine areas of convergence and complementarity between the two strands of evidence.

Because the intervention was implemented in two experimental and two control classes, pre-test equivalence was examined before combining the classes assigned to the same educational condition. The two experimental classes did not differ significantly from one another, nor did the two control classes, $t(50) = -1.04$, $p = .304$ and $t(57) = -1.45$, $p = .152$, respectively. In addition, a one-way analysis of variance (ANOVA) showed that the four classes did not differ significantly in pre-test achievement, $F(3, 107) = 1.53$, $p = .210$. For the main analyses, the two experimental classes were combined into a single EG ($n = 52$), and the two control classes were combined into a single CG ($n = 59$) for the main analyses.

Group differences in post-test achievement were examined using ANCOVA after adjusting for pre-test achievement. Educational group was specified as the fixed factor, and pre-test achievement was included as the covariate. Preliminary analyses were conducted to verify that the assumptions of the model were met.

Students' responses to the VNOS-E were coded as naive, transitional, or informed, following the evaluation framework adapted from Lederman and Ko (2004). Because some VNOS-E questions addressed more than one NOS aspect, students' responses were evaluated holistically rather than on an item-by-item basis. Frequencies and percentages were calculated for each NOS category before and after the intervention. To protect participants' identities, all student responses were anonymized using identification codes. To enhance the trustworthiness of the qualitative analysis, 20% of the responses were independently coded by one of the researchers and a science education expert. Intercoder agreement, calculated using the Miles and Huberman (1994) formula, was 95%. Disagreements were resolved through discussion before the remaining responses were coded using the agreed framework. Representative quotations were selected to illustrate changes in students' NOS views across the five aspects. No missing data were identified for the variables included in the analyses; therefore, all 111 participants were included in the final analyses.

Research Results

Academic Achievement

Table 2 presents the descriptive statistics for the pre-test and post-test achievement scores of the EG and CG together with the adjusted post-test means estimated from the ANCOVA. Preliminary analyses confirmed that the assumptions for ANCOVA were met. The interaction between educational group and pre-test achievement was not statistically significant, $F(1, 107) = 0.98$, $p = .325$, and Levene's test also indicated homogeneity of error variances, $F(1, 109) = 0.18$, $p = .673$.

Table 2
Descriptive Summary of Achievement Scores

Group	*n*	Pre-test *M* (*SD*)	Post-test *M* (*SD*)	Adjusted Post-test *M* (SE)
Experimental	52	11.94 (4.13)	16.25 (4.55)	15.91 (0.52)
Control	59	11.00 (4.34)	13.08 (4.86)	13.39 (0.49)

Note. Adjusted post-test means were estimated from the ANCOVA controlling for pre-test achievement scores.

As shown in Table 2, the EG obtained higher post-test and adjusted post-test achievement scores than the CG. ANCOVA was used to examine the group difference in post-test achievement levels, with the findings summarized in Table 3.

Table 3
ANCOVA Results for Students' Post-test Academic Achievement

Source	*df*	*F*	*p*	Partial η^2
Pre-test (Covariate)	1,108	66.18	< .001	.380
Group	1,108	12.47	.001	.104

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After controlling for pre-test achievement, the ANCOVA showed a significant group effect, $F(1, 108) = 12.47$, $p = .001$, partial $\eta^2 = .104$. The adjusted post-test mean was higher for the EG ($M = 15.91$, $SE = .52$, 95% CI [14.88, 16.94]) than for the CG ($M = 13.39$, $SE = .49$, 95% CI [12.42, 14.35]). The adjusted mean difference was 2.52 points (95% CI [1.11, 3.94]).

Nature of Science Views

Students' views of the NOS were examined across five NOS aspects using the VNOS-E. Students' responses were categorized as naive, transitional, or informed, and changes in the distribution of these categories were compared before and after the teaching process (Table 4).

Table 4
Distribution of Students' Views of the NOS Before and After the Teaching Process

NOS Aspect	Group	Pre-test			Post-test		
		Naive *f* (%)	Transitional *f* (%)	Informed *f* (%)	Naive *f* (%)	Transitional *f* (%)	Informed *f* (%)
Tentativeness	EG	42 (80.8)	8 (15.4)	2 (3.8)	14 (26.9)	16 (30.8)	22 (42.3)
	CG	44 (74.6)	13 (22.0)	2 (3.4)	42 (71.2)	15 (25.4)	2 (3.4)
Empirical basis	EG	47 (90.4)	5 (9.6)	0 (0.0)	41 (78.8)	10 (19.2)	1 (1.9)
	CG	55 (93.2)	3 (5.1)	1 (1.7)	52 (88.1)	6 (10.2)	1 (1.7)
Subjectivity	EG	42 (80.8)	10 (19.2)	0 (0.0)	21 (40.4)	15 (28.8)	16 (30.8)
	CG	51 (86.4)	8 (13.6)	0 (0.0)	42 (71.2)	16 (27.1)	1 (1.7)
Creativity and imagination	EG	31 (59.6)	20 (38.5)	1 (1.9)	9 (17.3)	36 (69.2)	7 (13.5)
	CG	35 (59.3)	24 (40.7)	0 (0.0)	30 (50.8)	26 (44.1)	3 (5.1)
Observation and inference	EG	38 (73.1)	13 (25.0)	1 (1.9)	23 (44.2)	21 (40.4)	8 (15.4)
	CG	41(69.5)	18 (30.5)	0 (0.0)	40 (67.8)	18 (30.5)	1 (1.7)

Note. Values represent as frequencies (*f*) and percentages (%). EG = Experimental Group; CG = Control Group.

As shown in Table 4, changes were observed across all five NOS aspects in the EG following the educational process, whereas the CG showed little or no change in most aspects. The most pronounced changes in the EG were observed in the tentative and subjective aspects.

Tentativeness of Scientific Knowledge

The EG showed a clear shift in students' views of the tentativeness of scientific knowledge. Following the educational process, the proportion of informed views increased considerably, accompanied by a marked decrease in naive views, whereas the CG showed virtually no change in the distribution of students' views. Representative excerpts are presented below.

> *"I do not think scientists' knowledge can change because scientists are smarter than we are." (Pre-EG6-naive)*
>
> *"I think scientists' knowledge can change because scientific knowledge may change as scientists conduct more experiments and tests in the future." (Post-EG6-informed)*

Empirical Basis

Changes in students' views of the empirical basis of scientific knowledge were less pronounced than those observed for the tentative aspect. In the EG, the proportion of naive views declined in the EG, whereas transitional and informed views became more frequent. Only limited changes were observed in the CG. Illustrative responses are provided below.

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"Science is discovering new things." (Pre-EG2, naive)

"Scientists make predictions using meteorological instruments and explain their observations based on the data they collect." (Post-EG23-informed)

Subjectivity

A clear shift was observed in the EG students' views of the subjectivity of scientific knowledge. In particular, informed views became more common following the educational process, whereas the distribution of views in the CG remained largely unchanged. Examples of students' responses are presented below.

"Scientists know because they look at the bones left behind when dinosaurs died." (Pre-EG15-naive)

"Scientists may reach different conclusions because each person has different ideas and uses their own thinking and imagination when interpreting evidence." (Post-EG2-informed)

Creativity and Imagination

Although many students initially held transitional or naive views regarding the role of creativity and imagination in science, more informed responses were observed following the educational process. This shift was more evident in the EG, while comparatively little change was observed in the CG. Selected excerpts illustrating these changes are shown below.

"I do not know how scientists learn about dinosaurs." (Pre-EG7-naive)

"Scientists know that Tyrannosaurus rex was one of the largest dinosaurs, but they cannot know everything about what it looked like. They use their imagination and creativity to reconstruct dinosaurs based on the available evidence." (Post-EG25-informed)

Observation and Inference

The distinction between observation and inference remained challenging for many students. However, the distribution of responses in the EG shifted toward more informed views following the educational process, whereas little change was evident in the CG. Representative quotations are presented below.

"Scientists know these things because they memorize the information, and then they decide what something is like." (Pre-CG15-naive)

"Scientists cannot know for certain. They examine factors such as humidity and interpret their observations to make inferences." (Post-EG13-informed)

"Science involves examining questions, making observations and inferences, and generating knowledge through research and experimentation." (Post-EG25-informed)

Table 5 presents a joint display integrating the quantitative achievement findings with the qualitative patterns observed across the five NOS aspects. The findings are compared at the group level to identify areas of convergence and complementarity between the two strands of evidence.

Table 5
Integrated Summary of Academic Achievement and NOS Outcomes

Outcome	Experimental Group	Control Group	Main Finding
Academic achievement	Higher adjusted post-test achievement	Lower adjusted post-test achievement	Quantitative findings favoured the EG
Tentativeness	Large shift toward informed views	Minimal change	The pronounced qualitative shift in the EG accompanied its higher adjusted achievement

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Outcome	Experimental Group	Control Group	Main Finding
Subjectivity	Large shift toward informed views	Limited change	A similar group-level pattern was evident across achievement and subjectivity
Empirical basis	Increase in informed and transitional views	Very limited change	The qualitative shift favoured the EG but was less pronounced than for tentativeness and subjectivity
Creativity and imagination	Increase in informed views	Slight change	The qualitative pattern was consistent with the overall advantage observed for the EG
Observation and inference	Increase in informed views	Minimal change	The qualitative pattern again favoured the EG, although the shift was less pronounced

The joint consideration of the quantitative and qualitative findings revealed a broadly complementary pattern across the two forms of evidence. Quantitatively, the EG had higher adjusted post-test achievement than the CG after controlling for pre-test achievement. Qualitatively, the EG also showed clearer shifts toward informed NOS views across all five aspects, particularly tentativeness and subjectivity, whereas changes in the CG were generally limited. Thus, the two strands converged at the group level in showing more favourable outcomes for the EG, although the magnitude of the qualitative shifts varied across NOS aspects. This convergence should not be interpreted as evidence that changes in NOS views caused higher academic achievement, or vice versa, because the relationship between the two outcomes was not examined at the individual level. Rather, the findings provide complementary evidence that the explicit-reflective education created opportunities for both conceptual and epistemic learning within the same educational context.

Discussion

Academic Achievement

The findings showed that students who participated in explicit-reflective NOS education integrated into the teaching of destructive natural events had higher post-test achievement than those who followed the current science curriculum. This difference remained significant after controlling for pre-test achievement, $F(1, 108) = 12.47$, $p = .001$, partial $\eta^2 = .104$. Although mean achievement scores increased in both groups, the higher adjusted post-test achievement of the EG suggests an additional contribution of the explicit-reflective activities beyond the regular curriculum.

One possible explanation is that the explicit-reflective activities engaged students not only with scientific concepts but also with the evidence and reasoning underlying scientific explanations. Rather than treating NOS as a separate topic, the intervention embedded explicit reflection within activities related to destructive natural events. This integration may have provided opportunities for students to examine evidence, justify their interpretations, and reconsider their explanations while learning the relevant scientific content. Nyarko and Rudge (2022) reported a similar pattern in geoscience education, where explicit-reflective education situated within the history of plate tectonics supported students' engagement with scientific content and epistemic understanding.

Previous research also suggests that explicit-reflective NOS education can contribute to conceptual learning alongside the development of more informed NOS views (Eroğlu & Bektaş, 2022; Karaman, 2019). Contextualized approaches may be particularly useful because they allow students to consider how scientific knowledge is developed and interpreted while engaging with meaningful scientific problems (Khishfe, 2025; Nyarko & Rudge, 2022). The present findings add to this literature by showing that destructive natural events can serve as a context in which conceptual learning and reflection on scientific knowledge are addressed together. However, the achievement findings should be interpreted within the scope of the present study, particularly given the relatively short intervention and the use of intact classes from a single school.

Nature of Science Views

The findings of this study revealed shifts toward more informed views across all five NOS aspects among students who received explicit-reflective NOS education integrated with the teaching of destructive natural events. The most pronounced changes were observed in students' understanding of the tentative and subjective NOS aspects, whereas comparatively smaller changes were found for the empirical basis of scientific knowledge,

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creativity and imagination, and observation and inference. In contrast, the CG showed only limited change, with shifts occurring primarily within the transitional category and only minimal increases in informed views across the five NOS aspects. Because the transfer of acquired NOS understandings has been shown to depend on the similarity and familiarity of the educational context (Khishfe, 2019), the sustained use of destructive natural events as a meaningful context throughout the intervention may have contributed to the relatively consistent patterns of change observed across most NOS aspects in the EG.

The comparatively smaller changes observed in the CG may reflect the fact that NOS concepts were not explicitly addressed in this group. Previous studies have similarly reported that students receiving regular science education often retain naive or transitional views of NOS because these aspects are addressed only implicitly in science curricula and educational materials (Karaman, 2019; Lederman et al., 2002). In contrast, previous studies have shown that explicit-reflective education provides opportunities for students to discuss, question, and reflect on NOS concepts, which may contribute to the development of more informed views (Khishfe, 2025; Nyarko & Rudge, 2022). The present findings extend this evidence by illustrating how explicit-reflective NOS education may be integrated into the context of destructive natural events in elementary science education.

The most pronounced changes were observed in students' understanding of the tentative and subjective NOS aspects. Following the intervention, informed views increased markedly, whereas naive views decreased considerably in both aspects. Before the intervention, many students viewed scientific knowledge as certain and unchangeable, a view that has also been reported in previous research (Abd-El-Khalick & Lederman, 2023; Khishfe, 2019; Nyarko & Rudge, 2022). Following the intervention, many students no longer viewed scientific knowledge as fixed and unchangeable. Instead, they recognized that scientific explanations may be revised in light of new evidence and that different scientists can reach different interpretations of the same evidence. This pattern is consistent with earlier research reporting shifts toward more informed views of the tentative and subjective aspects of NOS following explicit-reflective education (Çil & Çepni, 2016). A similar pattern was reported by Nyarko and Rudge (2022), whose history-based geoscience intervention produced particularly marked changes in students' understanding of the tentativeness of scientific knowledge. The changes observed in the present study may reflect the opportunities students had to evaluate evidence, compare alternative explanations, and reflect explicitly on how scientific knowledge develops within the context of destructive natural events.

Less pronounced changes were observed in students' understanding of the empirical basis of scientific knowledge and the distinction between observation and inference. Although naive views decreased and informed views increased in the EG, these changes were less pronounced than those observed for the tentative and subjective aspects. In the CG, only minor shifts were evident. Before the intervention, many students associated scientific knowledge primarily with experiments or the memorization of facts and had difficulty distinguishing observations from inferences. Similar patterns have been reported in previous studies (Abd-El-Khalick & Lederman, 2023; Khishfe, 2019; Kaya & Çakmakçı, 2012). After explicit-reflective NOS education, students increasingly recognized that scientific knowledge is developed through the interpretation of evidence and that observations and inferences represent different aspects of scientific inquiry. Previous studies have likewise reported more informed understandings of evidence-based reasoning and the distinction between observation and inference following explicit-reflective education (Khishfe, 2019; Nyarko & Rudge, 2022). The comparatively limited changes observed in these aspects may indicate that they require repeated learning opportunities across different scientific contexts and potentially longer educational experiences (Khishfe, 2025).

More modest changes were observed in students' views regarding the role of creativity and imagination in scientific knowledge. Although informed views increased after the intervention, many students continued to hold transitional views. Similar findings have been reported in previous studies, suggesting that students often associate creativity and imagination with fiction rather than with scientific inquiry (Abd-El-Khalick & Lederman, 2023). Following the explicit-reflective NOS education, students increasingly recognized that scientists use creativity and imagination when interpreting evidence and developing scientific explanations. Previous studies have also reported more informed views of the role of creativity and imagination following explicit-reflective education (Dinç, 2022). The persistence of transitional views in the present study may indicate that developing informed views about the role of creativity and imagination in science requires longer and repeated educational experiences, as these ideas often conflict with students' pre-existing perceptions of science as an objective and purely factual enterprise.

When considered together, the quantitative and qualitative findings show a broadly convergent and complementary pattern. Quantitatively, the EG demonstrated higher adjusted post-test achievement than the CG, while the qualitative findings showed clearer shifts toward informed NOS views in the EG across all five aspects, particularly tentativeness and subjectivity. Thus, both strands favoured the EG at the group level, although the extent of

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change varied across the NOS aspects. This convergence suggests that the same educational context provided opportunities for both conceptual and epistemic learning. However, it should not be interpreted as evidence that changes in NOS views led to higher achievement, or vice versa, because the relationship between these outcomes was not examined at the individual level. Rather, the two strands provide complementary evidence for the potential value of integrating scientific content with explicit reflection on how scientific knowledge is generated, interpreted, and revised.

Conclusions and Implications

This study examined the effects of integrating explicit-reflective NOS education into the teaching of destructive natural events on fifth-grade students' academic achievement and NOS views. After controlling for pre-test achievement, students in the EG had significantly higher post-test achievement scores than those in the CG. In addition, shifts toward more informed views were observed across all five NOS aspects in the EG, with the most pronounced changes occurring in the tentative and subjective aspects.

The findings highlight the value of addressing NOS within meaningful scientific contexts rather than as a standalone topic. Integrating explicit reflection on NOS into the context of destructive natural events provided opportunities for students to engage with scientific content while considering how evidence is interpreted, how scientific explanations may change, and how scientific knowledge is developed. The concurrent patterns in academic achievement and NOS views further suggest that a common educational context can provide opportunities to address conceptual and epistemic learning as complementary goals. However, because the relationship between these outcomes was not examined at the individual level, no direct relationship between changes in NOS views and academic achievement can be inferred.

From a practical perspective, explicit-reflective NOS education can be incorporated into existing science units without introducing NOS as a separate component of the curriculum. Teachers can embed discussions of evidence, alternative explanations, observations and inferences, and the development of scientific knowledge into regular classroom activities. Such an approach may be particularly relevant to disaster-related topics, in which students need to understand scientific concepts while also interpreting scientific evidence and explanations.

This study has several limitations. The participants were drawn from four intact classes in a single public school, which introduces the possibility of selection bias and limits the generalizability of the findings. The use of intact classes also means that possible classroom-level clustering could not be fully accounted for. Because only four classes participated, the number of clusters was insufficient for reliable multilevel estimation. In addition, all four classes were taught by the same science teacher. Although this provided consistency in implementation across the experimental and control conditions, it may limit the extent to which the findings can be generalized to other teachers and classroom contexts. The DNEAT demonstrated acceptable but modest reliability (KR-20 = .76), which should also be considered when interpreting the achievement findings. Finally, the educational process lasted four weeks, and no delayed post-test was administered; therefore, the persistence of the observed achievement differences and changes in NOS views over time could not be examined.

Future studies should examine explicit-reflective NOS education with larger and more diverse samples involving multiple schools, teachers, and classrooms. Studies with a sufficient number of classroom-level clusters could also account explicitly for the nested structure of educational data. Longer interventions and delayed post-tests would help determine whether changes in NOS views and differences in academic achievement are maintained over time. Further studies could also examine whether NOS understandings developed in this disaster-related context are transferred to other scientific contexts.

Declaration of Interest

The authors declare no competing interest.

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References

Abd-El-Khalick, F., & Lederman, N. G. (2023). Research on teaching, learning, and assessment of nature of science. In N. G. Lederman, D. L. Zeidler, & J. S. Lederman (Eds.), *Handbook of research on science education: Volume III* (1st ed., pp. 850–898). Routledge. https://doi.org/10.4324/9780367855758-12

AFAD (2023). *Türkiye deprem tehlike haritası* [Turkey earthquake hazard map]. Afet ve Acil Durum Yönetimi Başkanlığı. https://www.afad.gov.tr

Becker, J. S., Paton, D., Johnston, D. M., Ronan, K. R., & McClure, J. (2017). The role of prior experience in informing and motivating earthquake preparedness. *International Journal of Disaster Risk Reduction, 22*, 179–193. https://doi.org/10.1016/j.ijdrr.2017.03.006

Bilgin, S., & Çavuş Güngören, S. (2022). *Achievement test development study on the subject of Destructive Natural Events*. Lisansüstü Öğretmen Çalışmaları Kongresi [Graduate Teacher Studies Congress] (LOCK).

Bilgin, S., & Çavuş Güngören, S. (2025). Development of an achievement test for the subject of Destructive Natural Events. *Cumhuriyet International Journal of Education, 14*(4), 755–772. https://doi.org/10.30703/cije.1446717

Canlas, I. P., & Karpudewan, M. (2023). Complementarity of scientific literacy and disaster risk reduction: A reflection from the science curriculum of the Philippine basic education program. *Curriculum Perspectives, 43*, 51–65. https://doi.org/10.1007/s41297-022-00178-4

Cerulli, D. A., & Holbrook, J. B. (2019). Exploring the effect of NOS/NOT learning and dispositions on undertaking behavioural actions in the case of natural hazards. *Journal of Baltic Science Education, 18*(4), 519–536. https://doi.org/10.33225/jbse/19.18.519

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage.

Çil, E., & Çepni, S. (2016). The effectiveness of conceptual change approach on the views of nature of science and academic achievement in light unit. *Hacettepe University Journal of Education, 31*(1), 82–96. https://doi.org/10.16986/HUJE.2015014184

Dinç, N. (2022). *The effect of explicit-reflective nature of science instruction based on context continuum on middle school students' science process skills and science misconceptions* [Unpublished master's thesis]. Adıyaman University.

Doğan, N., Çakıroğlu, J., Çavuş Güngören, S., Bilican, K., & Arslan, O. (2010). *The impact of classroom practices of teachers participating in the in-service training program on the nature of science on student opinions*. The 9th National Science and Mathematics Education Congress, İzmir.

Eroğlu, S., & Bektaş, O. (2022). The effect of 5E-based STEM education on academic achievement, scientific creativity, and views on the nature of science. *Learning and Individual Differences, 98*, 102181. https://doi.org/10.1016/j.lindif.2022.102181

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education*. McGraw-Hill Education.

Izadkhah, Y. O., & Gibbs, L. (2015). A study of preschoolers' perceptions of earthquakes through drawing. *International Journal of Disaster Risk Reduction, 14*, 132–139. https://doi.org/10.1016/j.ijdrr.2015.06.002

Karaman, E. (2019). *Teaching the elements of nature of science through context-based approach* [Unpublished master's thesis]. Balıkesir University.

Kaya, G., & Çakmakçı, G. (2012). *The influence of an explicit reflective approach on elementary students' views of nature of science and their academic achievements.* X. National Science and Mathematics Education Congress (UFBMEK).

Khishfe, R. (2017). Consistency of nature of science views across scientific and socioscientific contexts. *International Journal of Science Education, 39*(4), 403–432. https://doi.org/10.1080/09500693.2017.1287976

Khishfe, R. (2019). The transfer of nature of science understandings: A question of similarity and familiarity of contexts. *International Journal of Science Education, 41*(9), 1159–1180. https://doi.org/10.1080/09500693.2019.1596329

Khishfe, R. (2022). Nature of science and argumentation instruction in socioscientific and scientific contexts. *International Journal of Science Education, 44*(4), 647–673. https://doi.org/10.1080/09500693.2022.2050488

Khishfe, R. (2025). Nature of science conceptions and argumentation skills in different socioscientific contexts. *International Journal of Science Education, 47*(12), 1542–1567. https://doi.org/10.1080/09500693.2024.2368690

Khishfe, R., & Abd-El-Khalick, F. (2002). Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. *Journal of Research in Science Teaching*, *39*(7), 551–578. https://doi.org/10.1002/tea.10036

Kılıçoğlu, G., & Akkaya Yılmaz, M. (2024). An investigation of secondary school students' cognitive structures towards natural disasters. *Amasya Education Journal, 13*(1), 72–89. https://dergipark.org.tr/en/pub/amauefd

Kolstø, S. D. (2001). Science literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. *Science Education*, *85*(3), 291–310. https://doi.org/10.1002/sce.1011

Köprübaşı, M. (2018). *Examining the effect of explicit-reflective nature of science instruction on secondary school students' understandings and academic achievement* [Unpublished master's thesis]. Adıyaman University.

Kuloğlu, A., Tutuş, F., & Özer, M. (2024). Secondary school students' disaster preparedness perception: a mixed method approach. *Sakarya University Journal of Education, 14*(3), 563–580. https://doi.org/10.19126/suje.1382630

Lederman, J. S., & Ko, E. K. (2004). *Views of nature of science, Form E.* Unpublished paper. Illinois Institute of Technology, Chicago.

Lederman, N. G. (2007). Nature of science: Past, present, and future. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (1st ed., pp. 831–879). Lawrence Erlbaum Associates.

Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching, 39*(6), 497–521. https://doi.org/10.1002/tea.10034

Maden, S. (2023). 6 Şubat 2023'te Kahramanmaraş'ta yaşanan depremler ekseninde Türkiye'de deprem haberciliğine bakış: Prof. Dr. Süleyman İrvan ile söyleşi. *Etkileşim*, *11*, 406–420. https://doi.org/10.32739/etkilesim.2023.6.11.202

https://doi.org/10.33225/jbse/26.25.792

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Ministry of National Education [MoNE] (2018). *Fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı [Elementary (3, 4, 5, 6, 7, and 8th grades) science education curriculum].* Talim ve Terbiye Kurulu Başkanlığı.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Sage.

Nyarko, S. C., & Rudge, D. W. (2022). Using the history of plate tectonics to teach the nature of science. *International Journal of Science Education, 44*(12), 1958–1977. https://doi.org/10.1080/09500693.2022.2105977

Park, W. (2020). Beyond the 'two cultures' in the teaching of disaster: Or how disaster education and science education could benefit each other. *Educational Philosophy and Theory, 52*(13), 1434–1448. https://doi.org/10.1080/00131857.2020.1751126

United Nations Office for Disaster Risk Reduction [UNDRR] (2022). *Global assessment report on disaster risk reduction 2022: Our world at risk—Transforming governance for a resilient future*. https://www.undrr.org/gar2022-our-world-risk-gar

Ventura G. L., & Madrigal, D. V. (2020). Awareness and practices on disaster preparedness of students of a public high school in Antique. *Philippine Social Science Journal, 3*(2), 45–46. https://doi.org/10.52006/main.v3i2.210

Yalçınkaya-Önder, E., & Tatlı, S. (2026). Earthquake literacy and awareness among lower-secondary school students. *Problems of Education in the 21st Century, 84*(3), 417–444. https://doi.org/10.33225/pec/26.84.417

Supplementary Material-1

Sample Explicit-Reflective NOS Lesson Plan: Earthquakes

Topic: Destructive Natural Events and Protective Measures: Earthquakes
Grade Level: Grade 5
Duration: One class period (40 min)
Materials Required: Cardboard box, paper or plastic cup, string, scissors, ballpoint pen, pencil, paper, modeling clay, and small weights (e.g., coins, marbles, stones, or erasers).

Curriculum Learning Outcomes

- Explain destructive natural events caused by natural processes (earthquakes, volcanic eruptions, floods, landslides, tornadoes, and hurricanes).
- Describe ways to reduce the risks associated with destructive natural events.

Targeted Nature of Science (NOS) Aspects

- Observations and inferences
- The same evidence may lead to different interpretations.
- Creativity and imagination contribute to the development of scientific knowledge.
- Subjectivity

Lesson Sequence

1. Activating Prior Knowledge

(Targeted NOS aspect: Eliciting existing ideas about science and natural events)

Students completed a Know–Want to Know–Learned (KWL) chart after discussing the following questions:

- What comes to mind when you hear the term *destructive natural event*?
- Which destructive natural events do you know?
- Have you ever experienced a destructive natural event?

2. Earthquake-Resistant House Design

(Targeted NOS aspects: Observation and inference; Multiple interpretations; Creativity and imagination)

Working in small groups, students assumed the role of scientists and designed an earthquake-resistant house using identical materials. Before testing their models under simulated earthquake conditions, each group predicted how its structure would respond to weak and strong shaking. After the simulation, students recorded their observations, compared them with their predictions, and discussed the conclusions they had drawn.

Reflective questions

- How do you think your model house will respond to weak and strong earthquakes?
- What did you observe during the simulation?
- Which of your conclusions were based on observations, and which were inferences?
- How are predictions, observations, and inferences different?
- Why did different groups design different houses although they used the same materials?

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- Can scientists reach different conclusions when examining the same evidence? Why?
- Do scientists' experiences or backgrounds influence the explanations they develop?

The discussion explicitly emphasized that observations differ from inferences, that the same evidence may support different interpretations, and that creativity contributes to scientific explanations.

3. Seismograph Activity

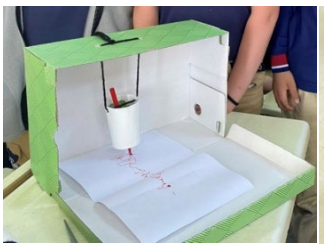
(Targeted NOS aspect: Empirical basis of scientific knowledge)

Students constructed a simple seismograph model and observed how ground movements could be recorded. The activity was followed by a discussion of how scientists collect evidence and use observational data to explain earthquake-related phenomena.

Reflective questions

- What information does the seismograph provide?
- What can be directly observed, and what must be inferred from the recorded data?
- Why is evidence essential when explaining earthquake events?





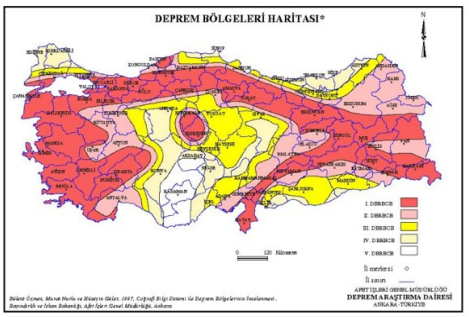

4. Comparing Earthquake Hazard Maps

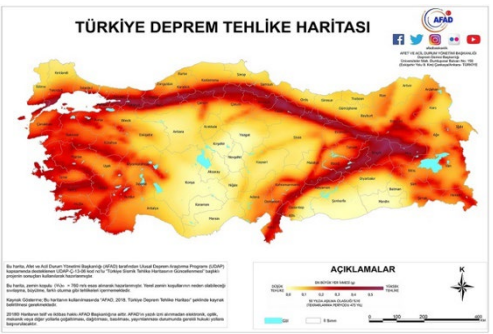
(Targeted NOS aspects: Subjectivity; Creativity and imagination)

Students examined three earthquake hazard maps produced using different approaches and compared similarities and differences among them.



Şekil 2. 1945 tarihli Türkiye'nin ilk resmi deprem bölgeleri haritası.
Figure 2. *First official seismic zoning map of Turkey.*





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Reflective questions

- Why might scientists produce different earthquake maps?
- Can different interpretations be supported by the same evidence?
- Why do scientists work collaboratively when developing scientific explanations?

The discussion emphasized that scientists may interpret the same evidence differently because scientific explanations are influenced by prior knowledge, experiences, and perspectives (subjectivity). Students also reflected on how creativity and imagination contribute to the development of scientific explanations and how collaboration strengthens scientific knowledge.

5. Developing an Earthquake Preparedness Plan

(Targeted NOS aspects: Creativity and imagination; Subjectivity; Collaboration)

Students worked in groups to prepare an earthquake preparedness plan for their local community. Plans included possible earthquake impacts, characteristics of earthquake-resistant buildings, community awareness, and household preparedness measures.

Reflective questions

- How does your preparedness plan differ from those developed by other groups?
- Why did different groups propose different solutions?
- If scientists prepared the same plan, what additional evidence or explanations might they include?
- Which NOS ideas did today's activities help you understand?

The lesson concluded with an explicit reflection on how scientific knowledge is generated, interpreted, and communicated, emphasizing the role of evidence, interpretation, subjectivity, creativity, and collaboration in scientific practice. Students completed the "Learned" section of the KWL chart to reflect on both the earthquake concepts and the targeted NOS aspects addressed during the lesson.

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