Asian Journal of Education and Training
Vol. 11, No. 3, 104-115, 2025
ISSN(E) 2519-5387
DOI: 10.20448/edu.v11i3.7419
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A comparative study of Italian and Turkish teachers' perspectives and practices regarding the instruction of the properties of matter

Ayçin Ünal[1] ✉
Lorenzo Gianni Santi[2]
Marisa Michelini[3]
Mehmet Fatih Taşar[4]

(✉ *Corresponding Author*)

[1,2,3]*University of Udine, Udine, Italy.*
[1]*Email:* aycinunal@gmail.com
[2]*Email:* lorenzo.santi@uniud.it
[3]*Email:* marisa.michelini@uniud.it
[4]*Georgia State University, Atlanta, GA, USA.*
[4]*Email:* mftasar@gmail.com

Abstract

The study examines the perspectives and practices of primary and secondary school teachers in Italy and Turkey regarding teaching properties of matter, using qualitative and quantitative research methods. Firstly, a review of the literature was conducted on teaching and learning the properties of matter. It revealed the significance of teaching this subject, effective methods employed, and the gaps in the literature. In the second phase, we investigated the perspectives and practices of Italian and Turkish teachers, collecting data through a survey from teachers in Turkey and Italy. Both Italian and Turkish teachers prioritize topics such as phase change during temperature changes, density, and thermal conductivity in teaching the properties of matter. Although both Italian and Turkish teachers share some teaching methods such as observation and relating activities to daily experiences, there are differences: Italian teachers emphasize argumentation and reading textbooks, while Turkish teachers focus on examples and verbal explanations. Findings from the statistical analysis suggest that school level (elementary, middle, or high school) does not have a significant influence on teachers' perspectives or practices, but there exists a significant difference in perspectives by country (Italy vs Turkey).

Keywords: Cross-country comparison, Properties of matter, Teacher perspectives, Teacher practices, Physics teaching, Comparative education.

Citation | Ünal, A., Santi, L. G., Michelini, M., & Taşar, M. F. (2025). A comparative study of Italian and Turkish teachers' perspectives and practices regarding the instruction of the properties of matter. *Asian Journal of Education and Training, 11*(3), 104–115. 10.20448/edu.v11i3.7419
History:
Received: 16 April 2025
Revised: 28 July 2025
Accepted: 19 August 2025
Published: 15 September 2025
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Publisher: Asian Online Journal Publishing Group

Funding: This research received funding from the PLS project of the Physics Education Research Unit with-in the Department of Mathematical Sciences, Computer Science, and Physics at the University of Udine.
Institutional Review Board Statement: The study involved minimal risk and adhered to ethical guidelines for social science fieldwork. Formal approval from an Institutional Review Board was not required under the policies of University of Udine, Italy. Informed verbal consent was obtained from all participants, and all data were anonymized to ensure participant confidentiality.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

Contents

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Contribution of this paper to the literature
This study addresses a gap in the existing literature by identifying patterns in how teachers instruct properties of matter, utilizing a newly developed questionnaire. It reveals instructional tendencies and differences across various school levels in a previously understudied area by offering a cross-cultural comparison between Italy and Turkey.

1. Introduction

Matter refers to anything that possesses mass and takes up space, and it is composed of tiny units known as atoms and molecules (Averill & Eldredge, 2011; Brown, LeMay, & Bursten, 2002). Matter is the material substance that makes up the physical universe (Flowers, Theopold, Langley, Neth, & Robinson, 2019). Properties refer to the distinctive features or characteristics that allow us to differentiate samples of matter from each other. These properties can be broadly categorized into two groups: physical and chemical (Murphy & Killcoyne, 2015; Petrucci, Herring, Madura, & Bissonnette, 2017). The physical properties of matter are qualities that can be perceived or gauged without causing any changes to the chemical composition of the substance, and these properties refer to observable characteristics in a sample of matter that do not result in alterations to its composition (Brown et al., 2002; Petrucci et al., 2017). For example, physical properties include characteristics such as color, texture, density, melting point, boiling point, solubility, and conductivity (Chemistry LibreTexts, 2024). Upon analyzing the treatment of matter in Next Generation Standards, it becomes evident that the emphasis lies on its intensive and extensive properties for the purpose of defining matter (NGSS, 2013). Properties that vary directly with the amount of matter present, such as mass, volume, and heat capacity, are considered extensive properties (Yan, 2024). Properties that remain constant regardless of the amount of matter present, such as melting/boiling point, refractive index, and thermal conductivity, are considered intensive properties (Yan, 2024). (Adams & Feagin, 2017) they have listed the properties of matter, objects, and materials that NGSS focuses on. This list is provided in Table 1.

Table 1. Properties of objects, matter, and materials (Adams & Feagin, 2017).

Properties	Examples
Properties of objects	Weight
An extensive physical property depends on the sample's size. It is useful for describing an object but not helpful in identifying it because it can change size.	Mass
	Volume
	Length
	Size
Properties of matter	Melting point/Boiling point
An intensive physical property is independent of the sample's size. Generally, intensive properties reveal some essential quality of a substance that is true for any sample size. They are useful in identifying unknown substances.	Color
	Odor
	Hardness
	Density
	Elasticity
	Luster
	Malleability
	Conductivity
	States of matter
Properties of materials	Transparent
Materials include both intensive and extensive physical properties, but the focus is on how these physical attributes make the material useful. For example, plastic is a good insulator because it does not conduct electricity.	Waterproof
	Absorbent
	Strong/Weak
	Insulator/ Conductor
	Flexible/ Rigid

Understanding and characterizing the properties of matter are crucial in various scientific fields, including chemistry, physics, and materials science, as they form the basis for designing and developing new materials and understanding their behavior in different environments (Brown et al., 2002; Callister Jr & Rethwisch, 2010; Chemistry in Context, 2015). Among all scientific concepts, the concept of matter plays one of the most vital roles in fostering scientific literacy (Harrison & Treagust, 2002). This is the basis for the construction of scientific competence, leads to the foundation of the concept of physical quantities, and requires the distinction between system, state, and material properties. A clear understanding of the structure and properties of matter is also essential for making informed decisions in daily life (Hadenfeldt, Liu, & Neumann, 2014), and helping students to align their explanations of matter with scientific terminology enhances their comprehension of the surrounding universe (Adams & Feagin, 2017). Enhancing students' skills in explaining the nature and changes of matter has been a central focus of science education research (Piaget & Inhelder, 1974), and to help students connect the macroscopic and microscopic properties of matter, it is essential to shift the focus from extensive to intensive properties (Adams & Feagin, 2017). There is a substantial body of research in the literature addressing the properties of matter in the curriculum. However, the conceptual boundary between the properties of matter and those of materials remains ambiguous, often resulting in varied interpretations of what the properties of matter encompass (Averill & Eldredge, 2011; Callister Jr & Rethwisch, 2010; Der Podesta, 2002; Woolfson, 2010). A review of educational studies on the topic reveals that most of the research is situated within the realm of chemistry education, frequently concentrating on the structure of matter through the use of simplified models (Langbeheim, Ben-Eliyahu, Adadan, Akaygun, & Ramnarain, 2022; Şeşen, Kırbaşlar, & Avcı, 2019; Stamovlasis, Tsitsipis, & Papageorgiou, 2010; Talanquer, 2009, 2018; Vlassi & Karaliota, 2013).

As an example, Liu (2013) proposed a framework for high school chemistry instruction aimed at enhancing student comprehension of matter, energy, and scientific models. Similarly, Pimthong et al. (2012) examined the effectiveness of a conceptual change strategy in improving sixth-grade students' understanding of matter and its characteristics. The instructional design covered various topics, such as the properties of solids, liquids, and gases, phase transitions, solutions, mixtures, and chemical changes. Instructional methods like particle models, role-playing, experiments, and guiding questions were utilized to facilitate conceptual change. The findings indicated that this

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approach significantly enhanced students' conceptual understanding, improved teaching practices, and elevated the overall quality of science instruction.

In contrast, studies focusing on how students understand the properties of matter conceptually within the domain of physics education are relatively scarce. Some research has aimed to trace students' learning development concerning the concept of matter and has proposed conceptual frameworks for categorizing and describing materials (Krnel, Glažar, & Watson, 2003; Krnel, Watson, & Glažar, 1998; Krnel, Watson, & Glažar, 2005). Andersson (1990) introduced two primary categories to monitor students' learning progress in relation to matter:

i. Conceptions reflecting the particulate nature of matter, involving notions about atoms, molecules, and particle systems.
ii. Everyday conceptions that pertain to physical state changes, conservation of matter, and chemical reactions.

Building on Andersson (1990) framework, Hadenfeldt et al. (2014) and Liu and Lesniak (2005) extended the model into four conceptual dimensions necessary for under-standing matter:

a) Physical properties and transformations.
b) Chemical properties and changes.
c) The structure and composition of matter.
d) The conservation of matter.

Although the models developed by Andersson (1990) and Hadenfeldt et al. (2014) offer valuable frameworks for teaching the properties of matter, these studies are now over a decade old. The current research adopts a two-phase methodology to investigate how the properties of matter are addressed within physics education. The initial phase involves a comprehensive literature review to identify existing gaps, followed by the development and implementation of a survey designed to explore teaching practices and pedagogical approaches in this area.

2. Literature Review

In the initial phase of this research, a comprehensive literature review was undertaken to explore studies centered on the teaching and learning of the properties of matter within the context of physics education and to identify existing gaps in the field. The search process involved querying the Web of Science® and ERIC databases using the keyword "properties of matter" to locate pertinent academic publications. To ensure relevance and quality, the search was limited to peer-reviewed articles published in English over the past ten years.

From Web of Science®, 1133 results were obtained, and similarly, ERIC database search yielded 287 entries. A secondary search focusing specifically on physics education among the Web of Science® results by categories of "physics education," "education and educational research," or "distance education research" produced a refined list. This refinement reduced the pool to 20 articles. Similarly, from the ERIC database, 37 studies met the initial criteria based on the keyword and publication date. After applying predefined inclusion and exclusion criteria, a total of 15 articles were selected for in-depth review. The process of article selection based on these criteria is visually summarized in Figure 1.

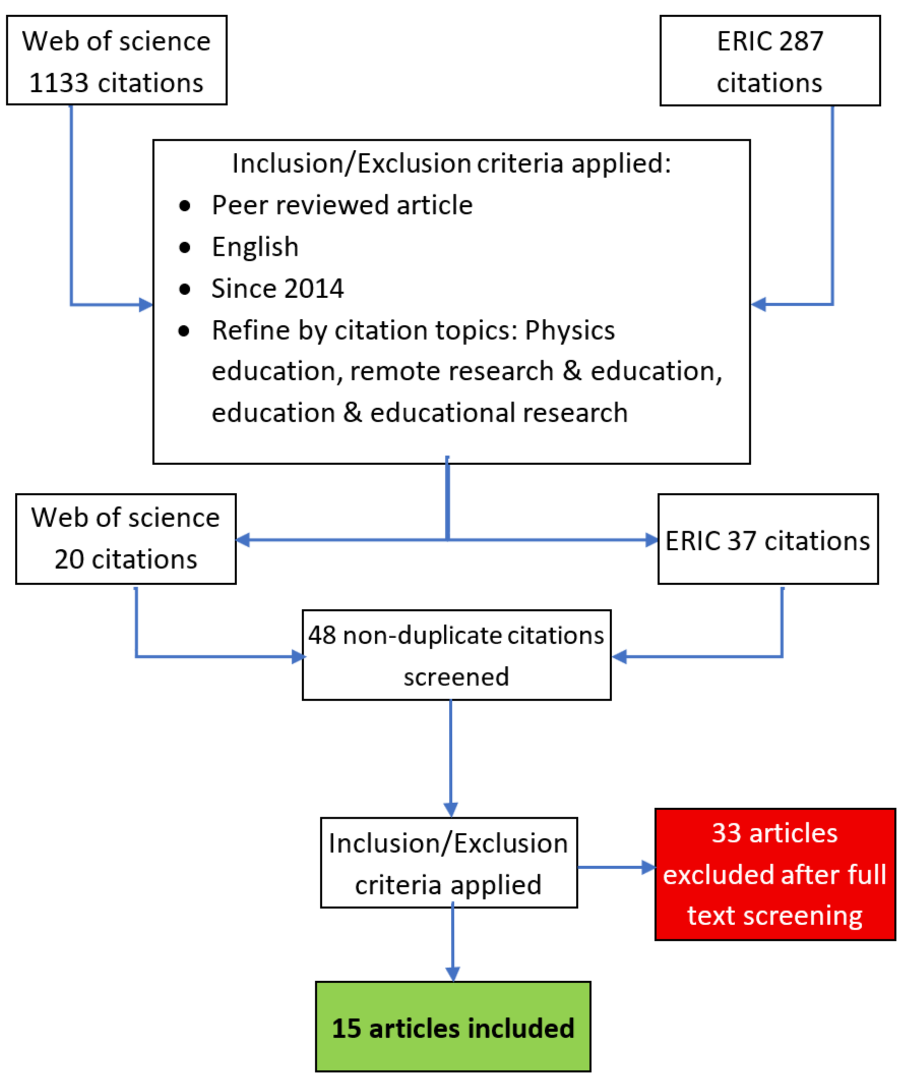

Figure 1. The process of selecting articles.

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The first stage of this study on teaching and learning the properties of matter within physics education includes a detailed analysis of 15 selected articles. These scholarly works were thoroughly examined to improve our understanding of this fundamental subject in physics education. First, we independently identified potential codes in the studies that were examined. Thereafter, we assessed the relevance of these codes, compared, and verified disparities in suggested codes during subsequent meetings, and then recognized common features among the codes to establish categories. By organizing the studies according to their focus/purpose and teaching or understanding related questions about the properties of matter, we clearly identified four distinct research themes. These research lines are detailed further below.

2.1. Student Ideas and Conceptual Changes

The research within this category primarily investigates students' ideas and their conceptual grasp of the properties of matter. One assertion is that a heuristic approach to model-based science writing is effective and that it enhances students' conceptual understanding of matter and strengthens their skills in developing model-based scientific arguments (Kara & Kingir, 2022). This method encourages students to participate in writing tasks that require model construction and articulation of scientific explanations, thereby supporting conceptual transformation.

Students often struggle with the concept of mass, frequently confusing it with density and weight (Stamenkovski & Zajkov, 2014). The findings emphasize the necessity for revising curricula and textbooks, as well as improving instructional strategies in physics, to effectively resolve these conceptual misunderstandings.

We also know through investigation that even short (3-day) instructional interventions on the properties of matter can provide significant gains (Wilcox, Reiter, Rose, Alberts, & Murano, 2022). They can underline how important it is to teach some crosscutting concepts together with the nature of science that involves inquiry-based practices. Moreover, participatory activities and inquiry learning can significantly facilitate conceptual change. By actively conducting experiments and evaluating their findings, students develop a greater comprehension of properties of matter and can adopt a better scientifically acceptable viewpoint. The study suggests that to create conceptual change, both teaching and assessment practices must be aligned accordingly.

With the aim of helping students discover the intensive and extensive properties of matter, an implementation of the 5E learning cycle model was investigated (Adams & Feagin, 2017). The study revealed challenges students face in understanding these properties. Both formal and informal assessment methods were utilized: informal assessments involved group discussions and collaborative tasks, while formal assessment was performed using the Pirate Adventure app. The results showed that students effectively improved their ability to understand and classify properties of matter.

These studies illuminate the difficulties learners encounter when grasping the properties of matter and suggest multiple instructional strategies to address these challenges. However, despite offering valuable perspectives on teaching approaches, there remains a need for further research to evaluate the efficacy of these methods in promoting conceptual change and to investigate more thoroughly the specific obstacles students face.

2.2. Methods/ Strategies in Educational Path

The study of teaching methods and strategies targeted at improving students' comprehension of the properties of matter is the main focus of the research grouped under this theme line. These studies investigated how different teaching methods, such as those that deal with density and states of matter, impact students' levels of engagement and conceptual understanding.

In an investigation (Allen & Rogers, 2015) the Claim, Evidence, and Reasoning (CER) framework was utilized as a writing instrument to help upper elementary students ex-press their conceptions on the interaction of "the properties of matter" and "light and sound". It was found that this methodical approach helped students better understand scientific concepts and enhanced their scientific literacy.

To promote long-term retention, a lesson plan was created and implemented that highlights the extensive and intensive properties of matter, gradually reinforcing these concepts (Adams & Feagin, 2017). More research is required to assess this strategy's effects on students' retention and comprehension, even though it seemed to be helpful for conceptual reinforcement.

It was found that practical and/or hands-on approaches can improved student engagement and interactivity (Kácovský, 2019). But more research is needed to determine how well these experiments support conceptual understanding and memory retention.

An investigation on how well modeling-based instructional strategies and cooperative learning worked together to teach subjects such as matter, particle structure, and thermal phenomena yielded gains in the dimensions of science process skills and academic performance (Zorlu & Sezek, 2020). However, more research is needed to determine whether these findings hold true for a variety of student demographics and learning settings.

An heuristic approach for model-based science writing was evaluated within the context of elementary science topics, such as matter and how it interacts with light and sound (Kara & Kingir, 2022). Students who were exposed to this approach performed noticeably better on concept tests compared to the control group students, which indicates enhanced conceptual clarity and model-based reasoning.

In a different study, an investigation was conducted on how well seventh-grade students learned the properties of matter with Reading-Writing-Presentation (RWP) and Subject Jigsaw (JG) approaches versus more conventional approaches (Akkus & Doymus, 2022). The post-test results showed that the RWP and JG groups outperformed the control group by a significant margin. Despite the encouraging nature of these results, it is critical to assess their consistency over long periods of time and in various educational contexts.

The question of how to incorporate educational games into the jigsaw method of teaching science to aspiring primary school teachers was also addressed very recently (Avcı, 2022) by exploring a wide range of matter-related subjects, including its measurable characteristics and heat transformation. Although participants expressed positive attitudes, it remains important to investigate whether these improved communication skills lead to better teaching methods and improved student outcomes.

Furthermore, model-based inquiry lessons were used with technological support to assist kindergarteners in creating their own models of matter (Samarapungavan et al., 2023). The study highlights the need for more research on the long-term retention and transferability of this knowledge, even though students in the intervention groups showed significant learning gains.

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All these studies highlight a variety of innovative approaches to teaching the properties of matter. While these studies offer promising insights into teaching the subject, it is important to consider the broader applicability of these methods, potential differences in results among different student populations, and the long-term impact on students' scientific understanding and retention. Additionally, it is important to consider the adaptability of these approaches to different educational environments and how interdisciplinary connections can be established between the properties of matter.

2.3. Literature Review

An article was identified on teaching and learning properties of matter that provides an overview of the body of knowledge in the form of a literature review. As such, a systematic review of the literature was conducted on how students understand the subject, with a focus on identifying recurrent themes across various studies (Hadenfeldt et al., 2014). The results indicate that the focus has shifted from categorizing students' conceptions to examining how their knowledge of matter has evolved over time. The review identified common pathways through which students develop their understanding, based on previous frameworks related to atoms, molecules, conservation, physical states, and chemical reactions. By presenting a model that illustrates how students progress in their understanding of the subject matter, they contributed to the development of a K–12 learning progression. It is also important to note that this study was published in 2014. Since then, new research and developments in the constantly evolving field of education have emerged. Therefore, it is essential to investigate whether the model and results remain applicable today.

2.4. Teacher Education and Pedagogical Content Knowledge

We identified five articles focusing on pedagogical content knowledge (PCK). They suggest the following significant conclusions:

Even after training, misconceptions prevail among pre-service teachers about density (Harrell & Subramaniam, 2014), and elementary science teachers find it difficult to realize the importance of the small particle properties of matter (Hanuscin, Cisterna, & Lipsitz, 2018). The finding that pre-service teachers maintained their incorrect beliefs about intensity even after training (Harrell & Subramaniam, 2014). This raises concerns about how effectively these myths can be debunked by the pedagogical strategies currently in use. These studies' findings suggest that teachers need continual professional development and that their pre-employment training may be lacking. Both articles emphasize the significance of regularly evaluating teachers' subject-matter expertise and the need to consider the effectiveness of initial teacher education programs.

An instrument was developed for determining elementary science teachers' content knowledge (Mikeska, Phelps, & Croft, 2017). The properties of matter was one of the three topics of focus. The data indicates that the instrument can successfully detect variations in teachers' performance and expertise. However, it is important to consider how closely these assessment items match real-world teaching situations. Researchers explored the impact of educational games paired with the jigsaw technique on prospective elementary teachers' communication skills in the context of the properties of matter (Avcı, 2022). Findings indicated that this combination not only increased interest in science classes but also improved communication skills, suggesting that creative teaching strategies can support both content mastery and pedagogical development. Prospective elementary teachers' perceptions regarding assessment tasks related to teaching the properties of matter were examined (Cisterna, Bookbinder, Mikeska, & Lakhani, 2022). The results show that while the teachers recognized the importance of this subject for the elementary level, their knowledge of the topic was not sufficient. Examining how elementary prospective teachers view assessment tasks related to teaching properties of matter highlights the importance of bridging the gap between theory and practice in teacher education. The findings suggest that while these prospective educators recognize the importance of the subject, they struggle to connect it to their own pedagogical approaches. This emphasizes the need for more practical, hands-on experiences during teacher preparation programs as well as more mentoring support during early teaching experiences.

These articles highlight the challenges teachers and teacher candidates face in understanding and teaching the properties of matter. They also underline the potential benefits of innovative teaching methods and the importance of aligning assessment and teacher training with the realities of classroom teaching. We need to consider these findings more broadly in terms of improving science education regarding teaching the properties of matter and the success of teacher training programs.

In addition to previous studies, when we examined the curricula of various countries, we found that the properties of matter are often explained in a fragmented manner (MEB, 2018a, 2018b; Ministry of Education, 2018; NGSS, 2013). Based on this information, we realized the importance of investigating both the curriculum planned for regular use in schools and the curriculum perceived by teachers. The act of teaching is complex and individual, as it requires not only the application of professional expertise acquired from one's past experiences and perspectives but also the influence of personal attitudes, beliefs, and goals (Ho & Toh, 2000). Although existing teaching methods and their impact on student achievement are well-documented in the literature (Akkus & Doymus, 2022; Kácovský, 2019; Kara & Kingir, 2022; Zorlu & Sezek, 2020), this study contributes to this field by comparing the impact of teachers' cultural and educational contexts on their teaching practices. Therefore, this study aims to determine whether there are cross-country and school-level (primary, secondary) differences in teaching the properties of matter by examining the relationship between teachers' perceptions and perspectives on their practices according to the school level, type, and country in which they work. For this purpose, the following research questions regarding the properties of matter have been formulated for this study:

RQ1: Which subtopics and concepts do teachers cover?

RQ2: How do teachers instruct students on the properties of matter?

RQ3: When it comes to teaching, are there significant differences in

a) The viewpoints of teachers according to school level?

b) The practices used by teachers according to school level?

c) The viewpoints of teachers by country?

d) The practices of teachers by country?

e) The viewpoints and practices of teachers?

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3. Methods

In this research, we utilized a descriptive survey model, which seeks to describe facts and events by gathering the opinions and attitudes of a large group of individuals about a particular phenomenon or event. To comprehend the dynamics of events, communities, institutions, and objects, this research methodology is frequently employed (Cohen, Manion, & Morrison, 2007).

We created a questionnaire to find out more about the perspectives and practices of teachers toward the properties of matter. We employed various methods to ensure the internal validity of the developed survey. Firstly, we carefully designed the survey items to be directly related to the research questions. In this way, we aimed to increase the validity of the survey instrument. We received feedback from three academic experts regarding the appropriateness of the survey content and language. Based on the experts' suggestions, we made the necessary corrections to the survey items and ensured that the questions were more understandable and clearer. In particular, we paid attention to points such as the complexity, ambiguity, and avoidance of jargon in the questions. In addition to expert opinions, we re-evaluated the survey items in accordance with the criteria specified in Table 2. These criteria allowed us to check the compatibility of each question with the research content, its comprehensibility, and its linguistic appropriateness. During this evaluation process, we eliminated items that did not serve the research purpose or could be misleading, thus aiming to improve the overall quality of the survey. We divided the questionnaire into three parts: the first part collected demographic data, the second part concentrated on teaching the properties of matter, and the third part examined the viewpoints and methods of the teachers.

Table 2. Evaluation criteria of questionnaire items.

Criterion	Yes	No
Is this question regarding research content considered suitable?	X	
Is it comprehensible?	X	
Is it linguistically suitable?	X	

We met the criteria listed in Table 2 by using a total of 23 questions in the study. The first three questions collected demographic data. There were two multiple-choice questions in the second section. Ratings for the 18 Likert-type questions ranged from (1) strongly disagree to (5) strongly agree.

We tested construct validity during the development of the research questionnaire by conducting an exploratory factor analysis with the SPSS 24.0 package. Prior to conducting the exploratory factor analysis, the sample's suitability was assessed using Bartlett's test results and the Kaiser-Meyer-Olkin (KMO) value. Table 3 displays the results obtained.

Table 3. Results of the KMO and Bartlett's Test for the questionnaire.

KMO		**0.945**
Bartlett's Test	Chi Square	2723.408
	df	153
	P	0.000

As seen in Table 3, the KMO value calculated to determine sample adequacy is .945. Additionally, the Chi-Square value is 2723.408; df: 153, and p: .000, which is significant. These results indicate that the criteria for conducting factor analysis on the sample are sufficiently met.

The Maximum Likelihood method and Varimax orthogonal rotation technique were applied to determine the construct validity and the number of factors of the prepared scale. The factor structure of the scale resulting from this process is presented in Table 4.

Table 4. Factor structure of the questionnaire.

Item no.	Factor1	Factor 2
M8	0.738	
M9	0.744	
M10	0.653	
M11	0.635	
M12	0.596	
M13	0.713	
M14	0.594	
M15	0.737	
M16	0.727	
M17	0.658	
M18	0.683	
M19	0.614	
M20		0.773
M21		0.742
M22		0.781
M23		0.828
M24		0.835
M25		0.743
M11	0.635	
Variance ratio of factors	34.291	31.122
Total variance ratio	65.413	

Teachers' perceptions and practices regarding the teaching of the properties of matter were assessed through Likert-type questions in the third section of the survey. "Perceptions" refer to teachers' beliefs, thoughts, and attitudes towards the subject, while "practices" pertain to the behaviors they believe they demonstrate in the classroom and the teaching methods they employ. For example, the question "Teaching the properties of matter in

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elementary and middle school is necessary for a better understanding of physics" allowed teachers to express their viewpoints on the matter. Some items on the Likert scale were used to gather more detailed information about teachers' classroom practices. For instance, the question "While designing activities for learning the properties of matter, I create activities that facilitate students to work collaboratively" provided insights into teachers' practices. Analyzing the relationship between these two constructs helped examine the connection between teachers' beliefs and practices. Additionally, multiple-choice questions in the second section collected information on which properties of matter teachers teach, as well as the teaching methods and techniques they utilize. The full survey can be accessed at https://forms.office.com/e/qfFEU5FaEn.

We used the SPSS Statistics 24.0 program to encode and enter the collected data. With the score for negative items inverted, we analyzed the data using frequency, percentage, and arithmetic mean approaches. The Cronbach's Alpha coefficient was used to evaluate the questionnaire's reliability; results for Turkish and Italian participants were 0.958 and 0.954, respectively.

3.1. Participants

The participants in this study comprised 195 teachers from two distinct countries, Italy and Turkey. Among these participants, 85 teachers were from Italy, and 110 teachers were from Turkey, as illustrated in Figure 2.

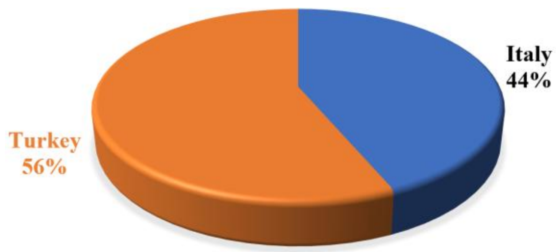

Figure 2. Distribution of participants by country.

The assumption that cultural backgrounds and educational systems of Italy and Turkey may offer significant differences in the ways they teach the properties of matter serves as the primary rationale for selecting these two countries as study participants. Despite being on the same continent and having similar cultures, the two countries' educational systems, curricula, and above all teacher preparation programs are very different. While Turkey's educational system is distinctive in that it blends aspects of Eastern and Western culture, Italy's standards are on par with those of Europe. When looking at the teacher training programs in these two countries, primary school teachers in Italy must complete a five-year program in elementary sciences (Decreto, 2010), while secondary school teachers must have a second-stage qualification in one of the teaching fields and acquire cultural, pedagogical, linguistic, and technological competencies through a 60 ECTS program (Legge, 2022). All teachers must complete an internship program organized by universities in addition to their second-stage qualifications (Decreto, 2011), and continuous professional development (CPD) is mandatory for all teachers in state schools (Teachers and Education Staff, 2024). In Turkey, on the other hand, there are education faculties, and within these faculties, there are departments that offer specific field and pedagogical knowledge for each area (physics, chemistry, science, classroom teaching, etc.) (Çetin, Ünsal, & Hekimoğlu, 2021; YÖK, 2018, 2020). It is thought that these differences may lead to the emergence of different approaches in teaching the properties of matter, and it is considered that these countries would form a suitable comparison ground for research. In this context, we aimed to obtain more widely generalizable conclusions by comparing the perspectives and practices of teachers in both countries regarding teaching the properties of matter. Participants were selected using the snowball sampling method. This method aimed to reach expert teachers in the field and facilitate the data collection process (Hossan, Dato'Mansor, & Jaharuddin, 2023). Initially, some key teachers identified by the researchers were reached and asked to participate in the study. Subsequently, the sample was expanded by contacting other teachers recommended by these teachers. The participants in the study consist of primary and secondary school teachers working in different school types in both countries. Participants were selected from both science and classroom teachers in both countries. This selection has allowed the findings to provide a more comprehensive overview of the teaching of the properties of matter. Additionally, considering the grade level and branch of the schools where the participants worked during the selection process, it was thought that these factors could potentially affect the methods and perspectives adopted by teachers when teaching the properties of matter, and this was taken into account in the analysis.

3.1.1. Demographics

The gender distribution of the participants revealed that the majority of the teachers were female, constituting 79% of the total sample, while male teachers accounted for 20%. Additionally, a small percentage (1%) of participants chose not to specify their gender. The distribution of the participants by gender is given in Figure 3.

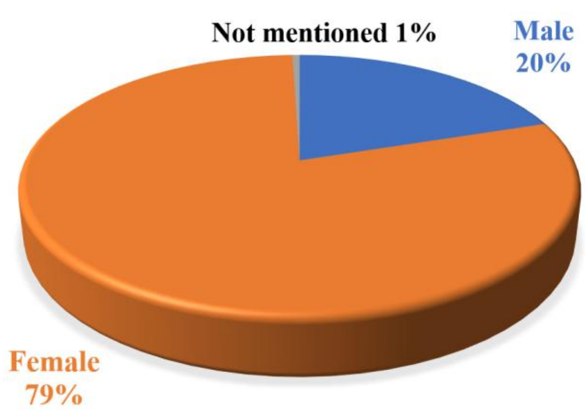

Figure 3. Distribution of participants by gender.

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3.1.2. School Level

In terms of educational levels, the participants work in elementary and middle schools. Specifically, 37% of the teachers are employed in elementary schools, while the remaining 63% are affiliated with middle schools. The distribution of the participants according to the schools they work in is given in Figure 4.

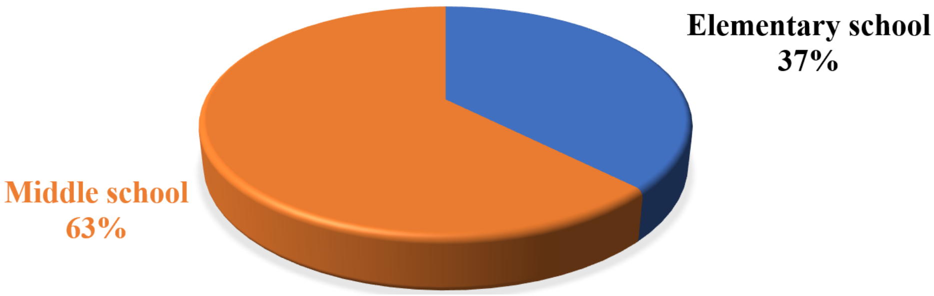

Figure 4. Distribution of Participants by School Level

3.1.3. Educational Background

The educational backgrounds of the participating teachers were diverse and reflected variations between the two countries. Among Italian teachers, 42.3% held a high school degree, 4.7% possessed a bachelor's degree, 51.8% had completed a master's degree, and 1.2% had attained a PhD degree. In contrast, Turkish teachers demonstrated a different distribution, with 71.8% having earned a university degree, 25.5% having completed a master's program, and 2.7% holding a doctorate degree. A visual representation of the distribution of participants based on their highest degree is given in Figure 5.

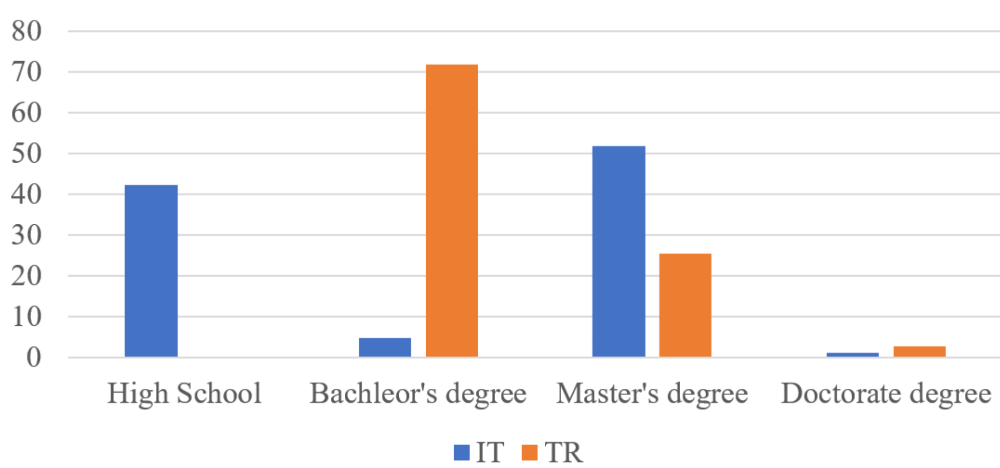

Figure 5. Distribution of participants according to their final degrees.

4. Findings

RQ1. Which subtopics and concepts do teachers cover regarding the properties of matter?

In response to Research Question 1 (RQ1), which sought to identify the subtopics and concepts that teachers teach concerning the properties of matter, the data collected from educators in Italy and Turkey unveiled a spectrum of themes commonly addressed in educational settings. The findings illuminate the prevalent subtopics while also revealing areas of divergence between the two countries. The answers given by the teachers participating in this study to the RQ1 are given in Figure 6.

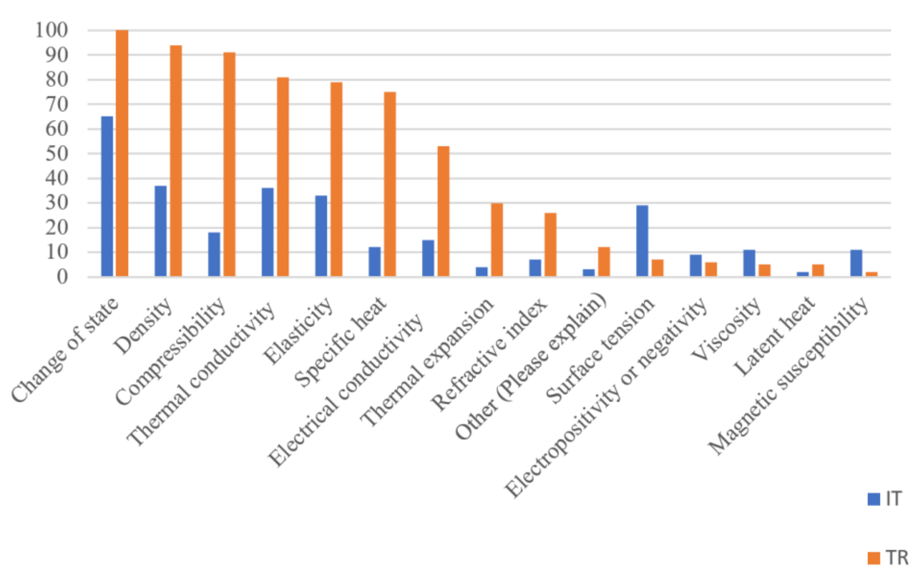

Figure 6. Subtopics/Concepts taught about the properties of matter in Italy and Turkey.

According to Italian and Turkish teachers' responses, the most frequently taught subjects are density, thermal conductivity, and change of state of matter. It seems that Italian educators are less concerned with the ideas of latent

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heat, thermal expansion, and the refractive index of light. However, the topics of viscosity, latent heat, and magnetic susceptibility seem to receive less attention from Turkish educators.

RQ2. How do teachers instruct students on the properties of matter?

In addressing RQ2, which sought to uncover the methods and techniques employed by teachers while teaching the properties of matter, the analysis of responses from Italian and Turkish teachers offers insights into the instructional approaches used within these two distinct educational contexts. The answers given by the teachers participating in this study to the RQ2 are given in Table 5.

The findings reveal that both Italian and Turkish teachers employ several common teaching strategies when teaching the properties of matter. A prominent shared strategy is the reliance on observing and describing the phenomena by the teacher. This approach enables students to engage directly with tangible instances of material properties, fostering a first-hand understanding of the subject matter. Moreover, both groups of teachers employ activities closely aligned with everyday experiences, thereby grounding theoretical concepts in relatable contexts, enhancing comprehension and relevance.

In the case of Italian teachers, the findings underscore a distinctive emphasis on the use of argumentation as a core teaching strategy. By encouraging students to critically analyze and construct coherent explanations for observed phenomena, Italian teachers foster an environment of active learning and intellectual exploration. Moreover, Italian teachers reported that reading the textbook and explaining content played pivotal roles in their instructional approach. This emphasis on textbook engagement and explanatory dialogue contributes to a comprehensive and structured transmission of subject matter knowledge.

Table 5. Italian and Turkish teachers' teaching methods and techniques for the properties of matter.

Answers	IT	TR
Teacher's illustrations of interpretations of the phenomena, for example, the melting of ice: explain what causes it to melt or what occurs inside the ice.	27	86
Teacher's observation and description of the phenomena, for example, the melting of ice: observe and describe.	52	79
Oral explanation of concepts and laws	38	72
Activities closely related to daily experiences.	47	72
Experiments with the POE method (Predict, Observe, Explain)	38	64
Read the textbook and explain	41	62
Analogies (Use of analogies to draw parallels between new ideas and specific/similar situations)	22	60
Model Comparison: Illustration and discussion of models and demonstrations	10	59
Translation activities. For example, role-play, modeling, drawing.	27	56
Requires students to think, describe, and represent models that explain (that is, interpret) the phenomena under study.	27	55
Learning based on laboratory and inquiry-based learning	31	41
Argumentation	56	21
Creative writing: Having students compare and share their written work with their classmates, illustrate and explain their ideas to the group.	10	18
Interdisciplinary activities of different kinds in STEM	18	18
Flipped classroom	11	8
Other (Please explain)	2	3

In contrast, it appears that Turkish teachers emphasize providing explanations, particularly through the use of illustrative examples. It can be said that Turkish teachers try to make the topics more understandable and relatable for students by embedding abstract concepts in concrete scenarios, filling the gap between theoretical constructs and real-life examples. Furthermore, Turkish teachers prioritize oral communication in their pedagogical repertoire, utilizing verbal explanations as a means of facilitating conceptual understanding and encouraging active participation.

The common reliance on observation, real-life examples, and verbal explanations highlights the universal significance of these approaches in promoting effective learning outcomes. The divergent emphasis on argumentation and explanation, as observed in Italian and Turkish teachers' instructional practices, respectively, underscores the role of cultural and contextual factors in shaping pedagogical preferences.

RQ3.

We used a combination of statistical tests, including the paired sample t-test for RQ3e and the independent t-test for RQ3a, RQ3b, RQ3c, and RQ3d, to answer the research questions raised in this study. Our research questions are listed below, along with an overview of the results that address each one.

RQ3a. Is there a significant difference in the viewpoints of teachers according to school level when it comes to teaching the properties of matter?

The t-test for independent samples was used to analyze the responses in order to determine whether teachers' opinions on teaching properties of matter differed based on the level of school they work in. Table 6 presents the results.

Table 6. T-test results for teachers' opinions on teaching properties of matter by school level.

Variable	N	$\bar{x}$	Std. deviation	t	p
Elementary school	72	4.0463	0.56379	0.209	0.835
Middle school	123	4.0257	0.71433		

Table 6 shows that there is no significant difference in teachers' opinions about teaching the properties of matter subject depending on the school they work at ($t(195) = 0.209$, $p = 0.835 > 0.05$).

RQ3b. Is there a significant difference in the practices used by teachers according to school level?

The t-test for independent samples was used to analyze the responses in order to determine whether the methods used by teachers to teach properties of matter differed based on the level of school at which they were employed. Table 7 presents the results.

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Table 7. Teachers' preferred methods for teaching properties of matter by level of schools (T- Test results).

Variable	N	$\bar{x}$	Std. deviation	t	p
Elementary School	72	4.0856	0.67017	1.088	0.278
Middle School	123	3.9729	0.71396		

It is clear from looking at Table 7 that there is no statistically significant difference in the ways that teachers teach properties of matter depending on the school level they work in ($t(195) = 1.088$, $p = 0.278 > 0.05$).

RQ3c. Are there significant differences in the viewpoints of teachers by nation regarding the teaching of the properties of matter:

The t-test for independent samples was used to analyze the responses in order to determine whether teachers' opinions on teaching properties of matter differed based on the nations in which they operate. Table 8 presents the results.

Table 8. T-Test results for teachers' perceptions of teaching properties of matter by nation.

Variable	N	$\bar{x}$	Std. Deviation	t	p
Turkey	110	4.1235	0.71568	2.252	0.025
Italy	85	3.9167	0.56651		

Table 8 reveals a statistically significant difference in teachers' practices regarding the teaching of properties of matter across different countries ($t(195) = 2.252$, $p = 0.025 < .05$). To comprehend the magnitude of the differences in teachers' perspectives on teaching the properties of substances across various countries, both statistical significance and effect size were calculated. Cohen's d statistic indicates a significance level of $d = 0.32$, suggesting a moderate significant difference.

RQ3d. Is there a significant difference in teachers' practices by country while teaching the properties of matter?

The study aimed to determine whether teachers' practices regarding the teaching of properties of matter differ based on their country of employment. The responses were analyzed using the t-test for independent samples. The results are shown in Table 9.

Table 9. Results of T-Test for teachers' methodologies regarding the instruction of properties of matter, categorized by country.

Variable	N	$\bar{x}$	Std. Deviation	t	p
Turkey	110	4.0576	0.69929	0.979	0.329
Italy	85	3.9588	0.69765		

Analysis of Table 9 reveals that there is no statistically significant difference in teachers' practices in teaching properties of matter based on their country ($t(195) = 0.979$, $p = 0.329 > 0.05$).

RQ3e. When it comes to teaching, are there significant differences in teachers' view-points and practices?

Table 10 presents the outcomes of the paired samples t-test, undertaken to assess the disparity between the average scores of the teachers involved in the study concerning their views on the qualities of matter and their instructional practices.

Table 10. A comparison of teachers' viewpoints and methodologies on the instruction of the properties of matter.

	N	$\bar{x}$	Std. deviation	t	p
Perspectives	195	4.0333	0.66130	0.578	0.564
Practices	195	4.0145	0.69850		

The t-test revealed no significant difference between teachers' perspectives and practices regarding the teaching of properties of matter ($t(195) = 0.578$, $p = 0.564 > .05$).

5. Conclusion and Discussion

In this study, our aim was to investigate teachers' perspectives and practices for teaching the properties of matter. Based on their observations, the subtopics and ideas that Italian and Turkish teachers prioritize vary when teaching the characteristics of matter. In both countries, the most frequently included concepts are temperature variation during phase change, density, and thermal conductivity. These concepts complement the objectives of the curricula (MEB, 2018a; Ministry of Education, 2018). While some Italian teachers cover topics including thermal expansion, latent heat, and the refractive index of light, some Turkish teachers have asserted that they cover magnetic susceptibility and latent heat in their courses. When we examined the respective countries' primary and lower secondary school curricula (MEB, 2018a, 2018b; Ministry of Education, 2018) it was determined that these subjects were not included in the curricula. Perhaps, in a different future study, the question of when and how teachers incorporate these programs into their teaching can be investigated.

There are certain parallels between Italian and Turkish teachers' approaches to instruction. Teachers in both countries utilized activities that were appropriate to students' daily experiences and depended on observation and describing phenomena. Teachers in Italy also stressed the importance of reading textbooks, arguing, and providing explanations. However, Turkish teachers heavily emphasized orally explaining the concepts and laws as well as examples to explicate the events. Overall, these findings demonstrate that while the subtopics and instructional approaches varied in Italy and Turkey, some strategies were employed in both countries to help students grasp the concepts related to the properties of matter. Conversely, comparative research, particularly examinations like TIMSS video studies, have demonstrated that conventional activities are the predominant approach in mathematics and science classrooms across the majority of nations (Hiebert, 2003; Klieme & Vieluf, 2009) the finding that aligns with the outcomes of this study. In addition to all of these factors, when examining the studies on teaching the subject within the literature, it becomes evident that various methods are available for instructing students on the properties of matter, and these methods have been shown to have a significantly positive impact on learning outcomes (Adams & Feagin, 2017; Akkus & Doymus, 2022; Avcı, 2022; Kácovský, 2019; Kara & Kingir, 2022; Samarapungavan et al., 2023; Wilcox et al., 2022). However, the results obtained from this research reveal that teachers predominantly rely on the argumentation method in the literature when teaching the subject of the properties of matter

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(Samarapungavan et al., 2023; Wilcox et al., 2022) and are hesitant to utilize other proven methods, which have demonstrated their effectiveness in enhancing student success according to existing literature. This situation can be interpreted as teachers potentially being limited by their current knowledge and skills and feeling the need to learn more effective teaching methods. Effective teacher training is a critical tool for enhancing teachers' knowledge and skills (Asfahani, El-Farra, & Iqbal, 2023). In future studies, it may be beneficial to organize training programs for teachers aimed at raising awareness about the teaching methods and techniques outlined in the literature, whose efficacy has been demonstrated.

In this study, Likert-type questions were analyzed using independent t-tests and paired sample t-tests. The analysis addressed several research questions aimed at investigating potential differences in teachers' perspectives and practices based on the types of schools and countries in which they work. The results indicate that school level does not significantly influence teachers' perspectives or practices, while the country of employment does impact perspectives but not practices. Teacher training programs, as well as factors such as the country's education policies, curriculum, and the type of school they work at, also shape teachers' decisions and practices (Dieudé & Prøitz, 2024; Wermke, Olason Rick, & Salokangas, 2019). These results emphasize the need for more study and analysis of the elements influencing teachers' viewpoints and approaches to teaching the properties of matter. Klieme and Vieluf (2009) suggests that countries sharing similar cultural backgrounds and teaching methods are likely to exhibit similar characteristics or patterns in a given context. In the context of education, it implies that these countries may have similar approaches to teaching and learning, resulting in comparable educational outcomes or practices. This aligns with the findings derived from this study. It is crucial to take into account educators' understanding and convictions concerning science and the teaching of science (Eberle, 2008). This is because teachers actively adapt the planned curriculum to align it better with their unique teaching approaches and belief systems (Cronin-Jones, 1991; Schmidt et al., 1996). Furthermore, discrepancies have been documented in academic literature when it comes to teachers' convictions, their perspectives on teaching, and their actual teaching methods (Lim & Chai, 2008; Mellado, 1998). Alongside all of these, many factors can influence teachers' instructional approaches. These factors may include the socioeconomic status of the school, class size, and the diversity of students, among others. As a result, further research is necessary to explore the connection between teachers' perspectives and practices in teaching the properties of matter.

This study is limited to a particular setting and cannot be extended to other areas or educational systems beyond Italy and Turkey; therefore, it is not applicable elsewhere. Future studies should investigate other elements or characteristics that might affect teachers' opinions and approaches to teaching the properties of matter in different countries. These results shed light on the viewpoints and methods of elementary and secondary school teachers regarding the instruction of the properties of matter. Future studies might reveal the viewpoints and strategies teachers at the high school level use.

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