Examining Non-Science Majors' Knowledge of Scientific Practices in Evaluating Scientific Media Claims*

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Abstract

This study examines the knowledge of scientific practices that non-science undergraduate students need to critically evaluate scientific claims in the media. Employing a cross-sectional quantitative research design, the study gathered data through a self-report instrument involving 266 undergraduate students from non-science disciplines. A twelve-item, two-tier multiple-choice assessment was utilized, featuring questions from two research articles adapted from popular media. Findings reveal that non-science majors often struggle to understand the scientific practices necessary to evaluate scientific reports in mainstream media. Results also indicate that many participants fail to recognize the importance of controlled, randomized experimental designs in establishing cause-and-effect relationships. Additionally, findings suggest that students do not fully grasp that hypotheses are supported by evidence rather than proven and that scientific claims must be based on substantial proof. The study further shows that many participants underestimate the importance of peer review in validating scientific claims. Finally, the analysis revealed no significant gender differences in students' competencies related to critiquing these reports.

Keywords: Evaluating scientific claims, non-science majors, popular media, gender.

*Portions of the data utilized in this study were previously presented as an oral presentation at the European Conference on Educational Research. The present study extends the analysis with a different focus.

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Introduction

Scientific literacy is essential in today's education, enabling individuals to critically assess scientific claims, make informed decisions, and actively engage in scientific discussions (National Research Council [NRC], 2012; Osborne, 2014). As science becomes increasingly intertwined with societal and technological developments, it is vital to understand how scientific knowledge is created, validated and communicated (Busch & Rajwade, 2024; Lederman, 1992; McComas, 1998; Rudolph, 2023; Sjöström, 2024). A fundamental framework for promoting scientific literacy is the Nature of Science (NOS), which sheds light on scientific knowledge's philosophical, methodological, and social aspects (Erduran & Dagher, 2014; Osborne et al., 2003). However, scientific literacy is not merely an abstract understanding of NOS but also requires active engagement with scientific practices that emphasize how knowledge is constructed and refined through inquiry, experimentation, and critical evaluation (Bybee, 2011; Duschl & Grandy, 2013). While NOS has mainly been viewed as a theoretical concept in the past, current conversations in science education emphasize the significance of scientific practices that focus on how knowledge is constructed and refined (Busch & Rajwade, 2024; Matthews, 2015; Osborne, 2014; Rudolph, 2023). Scientific practices encompass formulating hypotheses, designing controlled experiments, analyzing empirical data, and deriving conclusions based on evidence (Next Generation Science Standards [NGSS] Lead States, 2013; NRC, 2012).

Furthermore, scientific literacy goes beyond just grasping scientific concepts; it also encompasses the ability to critically engage with science-related information within public discussions. The growing influence of mass media and digital platforms in shaping how the public perceives science makes it crucial to distinguish credible scientific claims from misinformation (Norris & Phillips, 2003; Pellechia, 1997). In particular, scientific literacy in the media era necessitates a deep understanding of scientific practices to critically assess claims in journalistic reports. Individuals must discern between methodologically sound research and sensationalized interpretations of scientific findings (Rosenthal, 2020). Developing critical reasoning skills in science education is key to preparing students to navigate the complexities of media-reported scientific findings, ensuring that they can evaluate sources, assess evidence, and interact with scientific information knowledgeably (Cavagnetto & Hand, 2012). This ability requires familiarity with essential scientific practices such as differentiating correlation from causation, understanding the significance of peer review, and evaluating the validity of sample sizes in experimental research (Leung et al., 2017).

The capacity to critically evaluate scientific claims is influenced by various factors, including one's educational background, confidence in scientific reasoning, and broader societal contexts (Eccles, 1987; Wang & Degol, 2017). Notably, gender differences in scientific engagement have been widely recognized (Cheryan et al., 2017). These differences underscore the need to explore how students from diverse backgrounds and experiences develop the essential skills to engage critically with scientific information in a world where science and society are increasingly interconnected. By integrating scientific practices into educational settings, students can be better equipped to assess scientific claims in a world saturated with science-related media, enabling them to participate in informed discussions and make evidence-based decisions (Strimaitis et al., 2014).

Literature Review

The Role of NOS in Advancing Scientific Literacy

NOS underscores the ever-evolving character of science, highlighting its provisional nature as it adapts to new evidence and refined methodologies (Kuhn, 1996; Shearmur, 2006). At its core, it emphasizes that scientific conclusions are grounded in empirical evidence, relying on systematic observation and experimentation to establish their reliability (Chalmers, 1999; Hanson, 1958; Osborne et al., 2003). Furthermore, NOS draws attention to the creative and inferential aspects of scientific practice, showcasing how human ingenuity and interpretation play critical roles in formulating hypotheses and designing experiments (Driver et al., 1996; Lederman, 1992). It also acknowledges the socio-cultural context in which science operates, recognizing that scientific advancements are deeply intertwined with the societal and cultural conditions that shape them (Kuhn, 1996; Shapin, 1995). Recent discussions in science education emphasize the necessity of integrating scientific literacy with socio-political and ethical dimensions, ensuring that science is understood within its broader societal framework (Sjöström, 2024).

A fundamental aspect of NOS is its distinction between observations and inferences. Observations arise from direct sensory experiences, while inferences stem from interpreting these observations (Hanson, 1958). Additionally, NOS clarifies the roles of scientific laws and theories, explaining that scientific laws describe phenomena, whereas theories offer frameworks for understanding them (McComas, 1998). Grasping these distinctions is vital for science education, as it influences students' understanding of how scientific knowledge develops and operates within society.

Traditionally, NOS has focused on scientific knowledge's epistemological and philosophical foundations, but its role in science education has evolved over time (Rudolph, 2023). Traditionally, NOS has focused on the epistemological and philosophical foundations of scientific knowledge, but recent discussions increasingly spotlight the role of scientific practices in generating and validating this knowledge through established methodologies (Matthews, 2015; Osborne et al., 2003). While earlier frameworks primarily examined the philosophical dimensions of science, contemporary approaches have begun to advocate for a more integrated view that includes scientific practices as a crucial element of NOS. The Family Resemblance Approach (FRA) to NOS posits that these practices are integral and distinct within this framework (Irzik & Nola, 2011). FRA conceptualizes NOS as a multidimensional construct, weaving scientific methods, social dynamics, institutional norms, and historical context into a cohesive understanding (Erduran & Dagher, 2014). Recent studies further highlight the importance of understanding NOS as a community-driven construct, where scientific literacy is shaped by public engagement with scientific information and its social implications (Busch, 2024).

Incorporating this perspective into science education helps bridge the gap between understanding science theoretically and applying it in practice. This viewpoint highlights the dynamic nature of scientific inquiry and the myriad factors that influence scientific knowledge. When students engage in scientific practices, they develop a deeper appreciation for these processes and recognize the importance of evidence-based reasoning when evaluating scientific claims. Moreover, the evolving role of NOS in education underscores the necessity of equipping students with critical analytical skills to navigate misinformation and scientific discourse effectively (Donley, 2024). Ultimately, NOS serves as a foundational framework that enables students to grasp the complexities of scientific knowledge and its development, while fostering critical reasoning and informed engagement with scientific claims.

The Role of Scientific Practices in Advancing Scientific Literacy

Integrating scientific practices into educational frameworks effectively supports the primary objective of fostering scientific literacy (Duschl & Grandy, 2013; Osborne, 2014). Scientific literacy is cultivated through conceptual understanding and active engagement in scientific reasoning and evidence evaluation (NRC, 2007; 2012). In an era marked by rampant misinformation, equipping students with the skills for critical engagement with scientific discourse is essential (Cavagnetto & Hand, 2012). Science education, therefore, increasingly embeds scientific argumentation and critical evaluation within its curricula, enhancing students' competencies in analyzing and assessing scientific claims.

The adoption of scientific practices is reflected in various curricular standards, such as the Framework for K-12 Science Education (NRC, 2012). Through this framework, students engage in scientific and engineering practices such as inquiry, data analysis, and evidence-based argumentation. Crosscutting concepts like patterns, cause-effect relationships, and systems thinking further enhance their ability to connect insights across disciplines and foster holistic reasoning (Duschl & Bybee, 2014; NRC, 2012). Disciplinary core ideas anchor science in real-world contexts, addressing societal challenges like energy conservation and ecosystem dynamics while illustrating scientific knowledge's practical and ethical relevance (NGSS Lead States, 2013; McComas, 1998). By integrating these dimensions, students develop the ability to evaluate scientific claims critically, comprehend the evolving nature of inquiry, and recognize its broader societal impact, ultimately fostering scientific literacy and informed decision-making in an ever-advancing, technology-driven world (Krajcik et al., 2008; Kuhn, 1996). This integration ensures that students understand what science is and acquire the ability to think and act scientifically.

Proficiency in science necessitates a solid foundation in understanding, applying, and interpreting scientific explanations. This skill set is developed by constructing and evaluating scientific reasoning and evidence and understanding how scientific knowledge advances. Active participation in scientific discourse and practices is also crucial (NRC, 2007). Scientific literacy involves a mastery of scientific content and the capacity for critical engagement with scientific claims. This critical engagement requires understanding the processes by which scientific knowledge is produced, validated and communicated (Lederman et al., 2014; Strimaitis et al., 2014). Scientific practices can be categorized into two primary components (Matthews, 2015; Okasha, 2002). The initial discovery component involves observing, developing hypotheses, and systematically gathering, analyzing, interpreting, and showcasing data. This multifaceted process employs both inductive and deductive reasoning to ensure a thorough examination of scientific phenomena. The second component, justification, involves articulating how data are interconnected with various theories or hypotheses and advocating for prioritizing specific evidence over alternative information. Integrating these components into science education fosters analytical thinking, equipping students to navigate scientific claims in an increasingly media-driven world. Strimaitis et al. (2014) emphasize that proficiency in these "scientific practices" is essential for people to critically assess scientific assertions presented in mainstream media.

By embedding scientific practices into educational frameworks, students are better prepared to navigate the complexities of scientific information in a rapidly evolving media landscape. This approach enhances their analytical and reasoning skills and empowers them to make informed decisions and actively engage in societal and scientific discourse.

The Role of Media in Scientific Practices in Advancing Scientific Literacy

Scientific literacy is crucial in modern society, where media is a primary vehicle for disseminating scientific information. However, the increasing prevalence of scientific misinformation, particularly on digital platforms, has raised concerns about the public's ability to critically assess scientific claims (Cinelli et al., 2020; Gabarron et al., 2021; Norris & Phillips, 2003; Pellechia, 1997). Effective science communication requires cognitive engagement with empirical data and an understanding of the broader socio-political and economic influences on scientific discourse (Happer & Philo, 2013; Leung et al., 2017). Scientific literacy extends beyond basic comprehension of scientific concepts; it encompasses the ability to critically evaluate, interpret, and apply scientific knowledge in diverse contexts, including personal decision-making and public policy debates (Korpan et al., 1997). While media can enhance public understanding of scientific topics, it also plays a role in disseminating misinformation (Ahmed & Rasul, 2022; Rosenthal, 2020). Studies indicate that non-science majors often struggle to critically assess scientific claims presented in the media, emphasizing methodological rigor more while overlooking the broader social and institutional factors that shape scientific research (Leung et al., 2017).

The digital age has amplified these challenges, reinforced cognitive biases and created information silos through algorithmically curated content (Farhoudinia et al., 2024; Happer & Philo, 2013; Rosenthal, 2020). The rapid spread of misinformation, particularly in health and environmental sciences, has eroded public trust in scientific institutions and contributed to the proliferation of conspiracy theories (Cinelli et al., 2020; Gisondi et al., 2022). The COVID-19 pandemic underscored the detrimental effects of misinformation, with social media platforms facilitating the circulation of false claims regarding vaccines, treatments, and the nature of the virus itself (Ahmed & Rasul, 2022; Gabarron et al., 2021). This phenomenon, often referred to as an "infodemic," highlights the necessity of fostering critical evaluation skills to navigate the overwhelming volume of both accurate and misleading scientific information (Cinelli et al., 2020; Gisondi et al., 2022; Martins et al., 2018). Misinformation thrives in environments where cognitive biases, such as confirmation bias, are reinforced through selective exposure to ideologically aligned content (Ahmed & Rasul, 2022). Additionally, research suggests that emotionally charged misinformation, particularly content designed to evoke fear or distrust, spreads more rapidly than factual scientific information, complicating public engagement with credible sources (Farhoudinia et al., 2024; Happer & Philo, 2013).

Individuals' ability to critically evaluate scientific claims is shaped by cognitive and contextual factors. Research shows that those without formal science training tend to rely on superficial indicators of credibility, such as methodological transparency and sample size, rather than examining epistemological concerns, such as funding sources, institutional affiliations, and peer-review processes (Korpan et al., 1997; Leung et al., 2017). Conversely, individuals with higher levels of scientific literacy demonstrate greater scrutiny of the credibility of sources and the mechanisms that regulate scientific knowledge production (Cinelli et al., 2020; Korpan et al., 1997). One of the major challenges in scientific communication is the oversimplification of complex scientific topics, often in an effort to make them more accessible to a general audience (Rosenthal, 2020). While simplification aids engagement, it can also foster misconceptions regarding the nature of scientific inquiry, particularly its tentative and evolving nature. Additionally, frequent exposure to misinformation in digital media has been linked to an increased likelihood of engagement with misleading content, particularly when it is framed in a way that aligns with pre-existing beliefs (Ahmed & Rasul, 2022; Happer & Philo, 2013).

Popular media consistently report on scientific research, and these reports serve as an essential foundation for public science education (Grandy, 1995; Wellington, 1991). The evaluation of scientific reports plays a significant role in shaping professional and personal decisions, influencing choices such as medical treatments and participation in socio-scientific debates, including those surrounding nuclear power and climate change policies (Cinelli et al., 2020; Norris et al., 2003; Pellechia, 1997; Zimmerman et al., 1998). A fundamental objective of compulsory education is to develop scientifically literate individuals capable of critically analyzing science-related media reports (Millar, 2006). If successfully implemented, such educational initiatives can enable all citizens, regardless of academic background, to engage with scientific information discerningly (Happer & Philo, 2013; Martins et al., 2018).

The interplay between media and scientific literacy is increasingly complex in a digital landscape where misinformation is prevalent. While media platforms serve as crucial spaces for public engagement with scientific concepts, they also present significant challenges in ensuring the accuracy and integrity of the information they distribute. In this context, the present study explores how non-science majors engage with scientific claims presented in media, identifying the key factors that shape their evaluation processes and the extent to which they consider methodological rigor and the broader societal context of scientific information. By doing so, this research seeks to contribute to developing more effective educational interventions that enhance students' ability to critically engage with science in media environments.

The Role of Gender in Scientific Practices in Advancing Scientific Literacy

Media portrayals of scientific research influence public understanding and perpetuate gender stereotypes in science engagement. Social perceptions of science, shaped in part by media representation, contribute to gender disparities in self-efficacy, interest in science, and reasoning skills (Eccles, 1987; Nisbett, 1993). Relevant research demonstrates that the gender gap in science is primarily due to environmental factors rather than genetics. Tindall and Hamill (2004) pointed out that girls and boys are raised under different ecological conditions starting from birth. Recent studies reinforce this notion, highlighting that societal norms and cultural expectations shape gendered play experiences, which, in turn, influence skill development and academic interests (Wang & Degol, 2017). Williams and George-Jackson (2014) further highlight that the underrepresentation of women in STEM is often linked to systemic cultural and institutional barriers rather than innate ability differences. For example, boys often engage in activities such as constructing models and solving puzzles, promoting their mathematics and science abilities, while girls participate in activities like drawing, sewing, playing house, and creating stories that enhance interpersonal, verbal, and fine motor skills (Aldridge & Goldman, 2002; Weisgram & Bigler, 2020). These early experiences establish foundational differences in competencies and interests that persist into adulthood.

Furthermore, girls are frequently expected to display passive behaviors and depend on others, while boys are encouraged to be proactive and self-reliant. This conditioning often results in male-dominated dynamics in science classrooms, where boys take the lead in discussions and laboratory activities, while girls may assume more passive roles focused on observation, note-taking, or data recording (Guzzetti & Williams, 1996; Woolfolk, 1998). Huang (2012) conducted a meta-analysis on gender differences in academic self-efficacy and found that males exhibited higher self-efficacy in mathematics, computer science, and social sciences, while females showed higher self-efficacy in language-related fields.These findings further reinforce the argument that gendered experiences in early education shape long-term self-beliefs and engagement in STEM fields. Studies indicate that these classroom dynamics are exacerbated by teacher biases, with teachers setting higher expectations for boys in science-related subjects and offering them more complex questions and corrective feedback, further reinforcing gender disparities in confidence and self-efficacy (Riegle-Crumb & Morton, 2017; Master et al., 2016). Additionally, Hacket and Betz (1981) argued that the differing socialization experiences of boys and girls significantly affect their confidence in science. Recent research supports this, showing that girls often internalize societal stereotypes about gender and STEM (science, technology, engineering, and mathematics), leading to lower self-efficacy even when they perform equally well or better than boys in science courses (Cheryan et al., 2017). These disparities highlight the need for targeted educational interventions to create equitable opportunities for all students to actively engage in science and overcome entrenched societal biases.

To address these gender disparities, it is essential to implement educational interventions that challenge societal stereotypes and promote equity in science education. Encouraging inclusive classroom dynamics, providing equal opportunities for active participation, and fostering confidence in scientific reasoning among all students can help mitigate the effects of early socialization and biases. Such efforts are critical for ensuring that both boys and girls are equally prepared to engage in scientific practices and contribute meaningfully to the advancement of scientific literacy.

Significance of the Study

Scientific practices are a fundamental component of scientific literacy, particularly in an era where digital information is rapidly disseminated, requiring individuals to critically evaluate scientific claims (Busch & Rajwade, 2024; NRC, 2012; Rosenthal, 2020). The ability to engage with scientific reasoning is not only essential for those in scientific disciplines but is also crucial for non-science majors, who frequently encounter scientific information in everyday decision-making contexts. This study addresses a critical gap by investigating how non-science majors engage with scientific practices when assessing scientific claims presented in mainstream media.

The significance of this study lies in its focus on the role of scientific practices in enhancing media-based scientific literacy. While many studies have examined general scientific literacy, few have explored how non-science students develop the ability to critically evaluate scientific claims through engagement with scientific practices. Understanding these gaps is crucial for refining science education and ensuring that all students, regardless of their field of study, acquire essential reasoning skills necessary for informed decision-making (Osborne & Dillon, 2008; Tytler, 2007).

This study contributes to the broader discourse on science education by emphasizing the need for instructional strategies that integrate explicit engagement with scientific practices. Traditional curricula often emphasize factual knowledge at the expense of skills such as hypothesis testing, experimental design, and data interpretation (Duschl & Bybee, 2014; Lederman & Druger, 1985; Martin-Dunlop, 2013; Osborne, 2014). By investigating the challenges faced by non-science students in these areas, this research provides empirical support for curriculum reforms that promote inquiry-based learning and hands-on scientific engagement (Abd-El-Khalick et al., 2004; Martin-Dunlop, 2013).

Another key contribution of this study is its examination of potential demographic influences, such as gender, on students' engagement with scientific reasoning. Although prior research suggests that early socialization and educational experiences shape students' confidence in engaging with scientific discourse (Carli et al., 2016; Cheryan et al., 2017), findings from this study can help inform equitable science education practices that support diverse student populations (Williams & George-Jackson, 2014).

In summary, this study is significant for its focus on bridging the gap between theoretical scientific literacy frameworks and their practical applications in real-world decision-making. By identifying the challenges non-science majors face in engaging with scientific practices, this research informs future curriculum development and instructional strategies

Purpose of the Study

The primary objective of this study is to investigate the scientific practices that non-science major undergraduate students need to critically evaluate scientific claims in the media. This includes their understanding of hypothesis testing, experimental design, the role of peer review, and the ability to differentiate correlation from causation. Additionally, the study explores whether gender differences exist in students' ability to critically assess scientific claims.

Research Questions

The current research initiative is designed to address the following essential research questions.

1) What level of scientific practice knowledge is required for non-science major undergraduate students to effectively and critically assess scientific claims presented in the media?

2) Is there a gender distinction regarding the scientific practice knowledge required among non-science major undergraduate students to critically assess scientific claims presented in media?

Method

Participants

Participants were randomly selected from a public university in Turkey's Western Black Sea region, representing a spectrum of educational and socioeconomic backgrounds. The final sample comprised 266 undergraduate students enrolled in non-science major programs, categorized as follows: Turkish Language and Literature (28.2%), Philosophy (24.4%), Sociology (20.3%), Geography (19.2%), History (13.9%), and a small fraction from other disciplines (2.6%) (refer to Table 1). Among the participants, 186 were female and 79 were male, with ages spanning from 21 to 27 years (*M* = 23.20, *SD* = 1.12). The majority of students had completed their secondary education at General High Schools (45.9%) and were predominantly from Social Sciences and Humanities Tracks (50.9%). The average cumulative Grade Point Average (cGPA) of the cohort was 2.86 (*SD* = .39). Importantly, all participants reported no prior enrollment in science-related coursework or any studies related to the nature of science during their undergraduate tenure.

Table 1.
Demographic Information and Media Usage Preferences

Variables			Frequency (N)	Percentage (%)
Gender	Female		186	69.9
	Male		79	29.7
Department	Turkish Language and Literature		75	28.2
	Philosophy		65	24.4
	Sociology		54	20.3
	Geography		51	19.2
	History		37	13.9
	Other		7	2.6
High School Type	General High School		122	45.9
	Anatolian High School		70	26.3
	Vocational High School		45	16.9
	Religious Vocational High School		10	3.8
	Enhanced High School		2	.8
	Science High School		1	.4
	Other		15	5.6
High School Program Type	Social Sciences and Mathematics Track		124	46.6
	Social Sciences and Humanities Track		135	50.9
	Foreign Languages Track		1	.4
	Science and Mathematics Track		-	-
	Other		6	2.3
During Undergraduate Education, Courses Taken on	Science	No	266	100.0
		Yes	-	-
	Nature of Science	No	266	100.0
		Yes	-	-

Research Instrument

Evaluating Scientific Claims: A Two-Tiered Multiple Choice Assessment: This study utilized the *Evaluating Scientific Claims: A Two-Tiered Multiple Choice Assessment* to examine participants' ability to critically assess scientific claims presented in media, it was originally developed and validated by Strimaitis et al. (2014) within the framework of the NRC (2012) guidelines. Two real-world cases were incorporated into the assessment to assess students' ability to critically evaluate scientific claims in the media. The assessment instrument included two cases designed to evaluate students' ability to critically assess scientific claims presented in media reports. Each case was adapted from real-world research studies and focused on key aspects of scientific reasoning, empirical evidence evaluation, and methodological scrutiny.

The initial case investigated the biomechanical and musculoskeletal effects associated with prolonged use of high-heeled footwear. This examination was adapted from a study evaluating whether extended periods of wearing high heels adversely affect walking efficiency and musculoskeletal health. This case exemplifies how media framing can shape public interpretation of scientific findings, influencing the perceived credibility of health-related claims. Students were provided with a media report summarizing the findings of this research and were tasked with assessing the validity of its claims. In undertaking this evaluation, they were required to consider critical methodological aspects, including the existence of control and treatment groups, the adequacy of the sample size, and the differentiation between correlation and causation. This case encouraged students to critically assess whether the study sufficiently addressed potential confounding variables, such as pre-existing musculoskeletal conditions, variations in posture, or lifestyle factors that could influence the reported outcomes. Through this exercise, students engaged in a comprehensive analysis of experimental design and the evaluation of the strength of causal assertions within scientific media reports.

The second case study examined the potential health risks associated with energy drink consumption, requiring students to evaluate claims regarding the physiological effects of these drinks. This scenario was adapted from a published research article and presented a media report that summarized findings on both the short-term and long-term consequences of energy drink usage. Students were tasked with critically analyzing whether the claims made were substantiated by peer-reviewed scientific evidence, the rigor of the study's experimental design, and the validity of the conclusions drawn. This case encouraged students to consider whether the research accounted for variables such as pre-existing health conditions, individual differences in caffeine metabolism, and the possible influence of other lifestyle factors. Furthermore, students were required to assess the reliability of the reported claims by investigating the funding sources of the study, the peer-review status, and whether alternative explanations for the findings were adequately addressed. Both cases allowed students to apply critical scientific reasoning skills by evaluating the methodological soundness, reliability of evidence, and robustness of scientific conclusions derived from empirical data. Students were tasked with distinguishing between scientifically well-supported claims and potentially misleading representations of research findings in the media by actively engaging with these real-world examples.

Participants responded to a twelve-item, two-tiered multiple-choice assessment, in which each item consisted of two components. The first tier asked students to evaluate a specific scientific claim derived from the cases, while the second tier required them to justify their reasoning based on scientific principles. This structure provided insight into how non-science majors approach and justify their evaluations of scientific media claims. The first level assesses students' capacity to critically evaluate scientific claims, while the second level probes the reasoning behind their initial responses. This two-tier structure provides a deeper understanding of students' critical thinking and analytical skills. A single point is awarded only when both tiers of an item are answered correctly, ensuring that both the claim evaluation and the reasoning process are accurately assessed.

The scientific practices targeted by this assessment align closely with the core principles of scientific literacy, as summarized in Table 2. These include practices such as the importance of evidence-based claims, understanding the role of control groups in experimental design, and differentiating correlation from causation. For a detailed explanation of the original instrument and its development, refer to Strimaitis et al. (2014).

Table 2.
Scientific practices targeted by the instrument

Scientific practices	Items	Description
Scientific claims must be based on evidence	5B, 7A, 7B, 8A, 8B, 10B	Evaluate the sufficiency and relevance of evidence and reasoning provided to support scientific claims.
Scientific claims should be peer-reviewed	4A, 4B, 12A, 12B	Verify the credibility of scientific claims by confirming they have undergone expert peer review.
Manipulation experiments need control and treatment groups	3B, 6A, 6B, 9A, 9B	Assess the necessity of including control and treatment groups in experimental designs to ensure validity.
The sample size must support generalization of claim	1A, 1B, 2B, 10A	Determine whether the sample size is adequate for making reliable generalizations based on the study's findings.
Measurements have error associated	1B, 5B, 11A, 11B	Identify and account for potential errors in measurements when interpreting scientific results.
Hypothesis are supported, never proven	2A, 7A, 8A	Understand that scientific hypotheses are supported by evidence but cannot be definitively proven.
Correlation does not equal causation	3A, 3B	Distinguish between correlation and causation when analyzing relationships in data.
Axes on graphs can be manipulated to mislead	5A, 5B	Critically assess graphical representations to identify manipulations that could lead to misleading conclusions.

Validity and Reliability Analysis: The researcher of this article translated and adapted Evaluating Scientific Claims: A Two-Tiered Multiple Choice Assessment to Turkish (The Turkish version of the instrument can be obtained upon request from the corresponding author). In this process, forward and backward translations were conducted by two subject-matter experts and a language specialist, and the results were compared to correct any conceptual meaning deviations. Subsequently, a pre-test was conducted with six students to evaluate their comprehension of the items and the alignment of their responses with the expected distribution. The validity and reliability of the scale were examined using data collected from 266 nonscience majors and 177 science majors, totaling 443 participants. This approach was adopted to provide a more robust and comprehensive understanding of the scale's psychometric properties. The reliability analysis yielded a KR-20 value of .846, indicating a high level of internal consistency for the scale.

Item difficulty and discrimination indices were calculated for single-tiered (Tier 1) and two-tiered items. The Tier 1 difficulty values ranged from .33 to .75, while the two-tiered difficulty values ranged from .21 to .42. These values demonstrate that the items varied in their level of challenge, with an appropriate spread across different difficulty levels. Discrimination indices for Tier 1 ranged from .21 to .85, and for two-tiered items, they ranged from .47 to .69, suggesting that the items effectively distinguished between higher- and lower-performing participants (Table 3).

Table 3.
Item difficulty and discrimination indices

Item number	Tier 1 only difficulty	Two-tiered difficulty	Tier 1 only discrimination	Two-tiered discrimination
1	.75	.41	.26	.57
2	.69	.42	.26	.47
3	.33	.21	.69	.59
4	.48	.32	.55	.60
5	.41	.27	.60	.58
6	.53	.41	.58	.64
7	.37	.24	.85	.69
8	.39	.29	.59	.54
9	.60	.40	.50	.55
10	.66	.37	.21	.54
11	.68	.38	.38	.51
12	.49	.31	.60	.55

Exploratory Factor Analysis as Validity Evidence: The EFA was conducted to evaluate the construct validity of the Turkish version of the Evaluating Scientific Claims: A Two-Tiered Multiple Choice Assessment. The original scale comprises an 8-factor structure, and this analysis aimed to test whether the Turkish version aligns with the original factor structure. Accordingly, the number of factors was fixed at 8 during the analysis. Principal Component Analysis and Varimax rotation methods were utilized for the analysis.

The sample adequacy was evaluated using the KMO test, which yielded a value of .90, indicating excellent adequacy. Bartlett's Test of Sphericity demonstrated significant relationships among the variables ($\chi^2(276) = 1943.51$, $p < .001$), confirming the suitability of the data for factor analysis. The EFA results identified 8 factors, explaining 55.55% of the total variance (see Table 4). Factor loadings were generally consistent with the original factor structure. These findings provide strong evidence of the construct validity of the Turkish version of the scale. Importantly, no items were removed or added during the adaptation process.

Table 4.
Total Variance Explained

Factor	Eigenvalue	% Variance Explained	Cumulative % Variance
1	5.557	23.16	23.16
2	1.360	5.67	28.82
3	1.209	5.04	33.86
4	1.119	4.66	38.52
5	1.090	4.54	43.07
6	1.057	4.40	47.47
7	.987	4.11	51.58
8	.952	3.97	55.55

Data Collection and Analysis

This study employs a quantitative, descriptive research design utilizing a cross-sectional survey methodology. Data collection was conducted over a four-week period during the spring semester. Participants were recruited from undergraduate programs at a state university. Ethical approval for this study was obtained from the Çankırı Karatekin University Ethics Committee. Before the data collection began, students were provided with a detailed explanation of the study's objectives and ethical guidelines, including distributing and signing informed consent forms. Students completed two distinct components: a demographic information questionnaire and Evaluating Scientific Claims: A Two-Tiered Multiple Choice Assessment. Both instruments were administered in a paper-and-pencil format under the supervision of the research team. Each session lasted approximately 30 minutes, with standardized instructions provided at the beginning to ensure consistent comprehension across all participants. Responses were securely stored and anonymized in compliance with ethical research standards for subsequent analysis.

Evaluating Scientific Claims: A Two-Tiered Multiple Choice Assessment's reliability was assessed using the Kuder-Richardson Formula 20 (KR-20), yielding high internal consistency. Construct validity was evaluated through exploratory factor analysis (EFA), utilizing the Kaiser-Meyer-Olkin (KMO) test and Bartlett’s Test of Sphericity. These analyses affirmed the data's adequacy and the items' alignment with intended latent constructs. Item difficulty and discrimination indices were also calculated to confirm the instrument's effectiveness in distinguishing between varying levels of participant performance.

Quantitative analysis was conducted to evaluate the collected data. Descriptive statistics summarized participant characteristics and performance. Descriptive statistics (mean scores and percentages) were used to summarize knowledge levels, providing a clear picture of overall performance and key areas of difficulty. Independent-sample t-tests were performed to investigate gender-based differences in critical evaluation skills.

Findings

Examination of Students' Knowledge of Scientific Practices

Findings revealed a significant gap in the participants' understanding of essential research methodologies. In particular, a striking 91% of participants were unaware of the essential importance of a controlled, randomized experimental study design for determining a cause-and-effect relationship, especially in the research focused on the risks linked to wearing high heels. This lack of awareness underscores a need for improved education on research principles among the participants (item 3B, see Table 5). The study involved nine women wearing high heels forty hours per week for at least two years and ten women wearing only flats. The walking efficiency of women was recorded. The women in the flat group walked barefoot, while women in the heels group walked both barefoot and in heels. The related item revealed that almost all participants (98.9%) failed to recognize a key limitation of the study. Based on the findings, it was impossible to claim that wearing high heels for forty hours per week over two years caused women to walk less efficiently than those wearing flats. This limitation arose because the study did not include a comparison group of women wearing flat shoes, randomly assigned at the beginning and end of the two-year period.

Table 5.
Participants' Responses to Individual Items

	Item Numbers	Incorrect (%)	Correct (%)	*M**	*SD**
Scientific claims must be based on evidence.	5B	54.1	45.9	.46	.50
	7A	90.6	9.4	.09	.29
	7B	73.7	26.3	.26	.44
	8A	79.3	20.7	.21	.41
	8B	66.2	33.8	.34	.47
	10B	70.3	29.7	.30	.46
Scientific claims should be peer-reviewed	4A	64.7	35.3	.35	.48
	4B	57.1	42.9	.43	.50
	12A	63.5	36.5	.36	.48
	12B	60.5	39.5	.39	.49
Manipulation experiments need control and treatment groups.	3B	91.0	9.0	.09	.29
	6A	58.3	41.7	.42	.49
	6B	46.2	53.8	.54	.50
	9A	48.5	51.5	.52	.50
	9B	54.9	45.1	.45	.50
Sample size must support generalization of claim	1A	29.3	70.7	.71	.46
	1B	67.7	32.3	.32	.47
	2B	45.9	54.1	.54	.50
	10A	33.1	66.9	.67	.47
Measurements have error associated.	1B	67.7	32.3	.32	.47
	5B	54.1	45.9	.46	.50
	11A	37.2	62.8	.63	.48
	11B	69.2	30.8	.31	.46
Hypotheses are supported, never proven.	2A	35.0	65.0	.65	.48
	7A	90.6	9.4	.09	.29
	8A	79.3	20.7	.21	.41
Correlation does not equal causation.	3A	89.8	10.2	.10	.30
	3B	91.0	9.0	.09	.29
Axes on graphs can be manipulated to mislead.	5A	75.6	24.4	.24	.43
	5B	54.1	45.9	.46	.50

*Statistics are obtained when correct answers are coded 1 and incorrect answers 0.

Many participants seemed to struggle with recognizing the essential role of peer review in validating scientific assertions. For example, only 36.5% correctly identified the Mayo Clinic Proceedings—a respected, peer-reviewed journal—as the most credible source for evaluating the concerns raised in an article about the dangers of energy drinks. In contrast, they mistakenly considered the New York Times and the University of Texas Health Center Bulletin equally qualified, revealing a notable gap in their understanding of reliable scientific assessment (item 12A, see Table 5). Only 19.5% of participants correctly answered both parts of the related question. They recognized the Mayo Clinic Proceedings as the most qualified peer-reviewed journal. They clarified their choice by noting that the journal evaluates claims through the expertise of multiple specialists in the field before publication (items 12A-12B, see Table 6). In the research about the risks associated with high heels, the feedback from students regarding the importance of peer review in assessing scientific assertions showed a steady pattern. Most participants (64.7%) believed that the most critical detail for assessing the claims was that the researchers belonged to the Musculoskeletal Research Program at Griffith University. Conversely, only 35.3% of participants correctly identified the importance of the research publication in the Journal of Applied Physiology from January 2012 as the key detail (item 4A, see Table 5). Furthermore, when analyzing responses across both levels, very few students (15.8%) were able to answer both questions correctly. This emphasizes the significance of publishing in a respected journal, suggesting that the research has undergone peer review by specialists in the field, which is essential for properly evaluating the claims (items 4A-4B, see Table 6).

The results indicated that most participants were unaware that hypotheses are not proven but instead supported by evidence. For example, in a related study concerning the dangers of energy drinks, a claim was made that "energy drink consumption has harmful side effects." Participants were asked whether this claim was substantiated by the evidence presented in the article. Only 3% of participants correctly recognized that the assertion concerning the dangers of energy drinks required further validation, as the long-term side effects remain speculative (items 7A-7B, see Table 6). In one of the items, participants were informed that the FDA does not regulate many of the ingredients present in energy drinks, as noted in the article. They were then asked about their perceptions of safety regarding these beverages. Notably, 33.1% of the participants incorrectly believed that a study examining how the ingredients in energy drinks compare to those in other foods would increase their sense of safety. Conversely, 66.9% correctly identified that multiple studies evaluating the side effects of these drinks on human health could enhance their feelings of safety (see item 10A in Table 5). Only a quarter of the participants (25.2%) answered a related question correctly, suggesting that they would feel safer if multiple studies were conducted to investigate the side effects of energy drinks on human health. They needed replicable evidence to validate these claims (items 10A-10B, see Table 6). This finding indicates that most participants lacked a clear understanding of the significance of evidence in scientific claims and the role of sample size in supporting broader conclusions. In fact, 70.3% of participants chose incorrect explanations regarding their responses to the first-tier question, which compared the value of multiple studies to examining ingredients in other foods. Specifically, they believed that they required evidence from a single study showing the presence of the ingredients, insights into teenagers' exposure to caffeine, or proof that at least one individual had experienced adverse effects from energy drinks (item 10B, see Table 5). Regarding measurement errors, 26.3% of students correctly recognized that a 95% confidence interval is appropriate in a study because complete control of human error is unattainable (items 11A-11B, see Table 6).The overall mean score on the Evaluating Scientific Claims: A Two-Tiered Multiple Choice Assessment instrument was 2.08 (SD = 1.45) out of a maximum of 12, with individual scores ranging from 0 to 6.

Table 6.
Participants' Responses to Both Tiers

Assessment Item Numbers	Construct	Incorrect (%)	Correct (%)
-1- 1A-1B	Sample size must support generalization of claim (1A +1B) Measurements have error associated (1B)	71.1	28.9

Table 6 continuing

-2- 2A-2B	Hypotheses are supported, never proven (2A) Sample size must support generalization of claim (2B)	67.7	32.3
-3- 3A-3B	Correlation does not equal causation (3A + 3B) Manipulation experiments need control and treatment groups (3B)	98.9	1.1
-4- 4A-4B	Scientific claims should be peer reviewed (4A+4B)	84.2	15.8
-5- 5A-5B	Axes on graphs can be manipulated to mislead (5A + 5B) Scientific claims must be based on evidence (5B) Measurements have error associated (5B)	89.1	10.9
-6- 6A-6B	Manipulation experiments need control and treatment groups (6A +6B)	73.3	26.7
-7- 7A-7B	Hypotheses are supported, never proven (7A) Scientific claims must be based on evidence (7A+7B)	97.0	3.0
-8- 8A-8B	Hypotheses are supported, never proven (8A) Scientific claims must be based on evidence (8A+ 8B)	85.3	14.7
-9- 9A-9B	Manipulation experiments need control and treatment groups (9A + 9B)	70.7	29.3
-10- 10A-10B	Sample size must support generalization of claim (10A) Scientific claims must be based on evidence (10B)	74.8	25.2
-11- 11A-11B	Measurements have error associated (11A + 11B)	73.7	26.3
-12- 12A-12B	Scientific claims should be peer reviewed (12A + 12B)	80.5	19.5

Examination of Gender Difference

A t-test for independent samples was performed to examine the knowledgeof scientific practices needed for assessing scientific claims among male and female students. The findings revealed no significant difference, with male students achieving a mean score of 2.15 (SD = 1.50) and female students scoring a mean of 2.04 (SD = 1.43). The t-statistic was .56, and the p-value was .58.

Discussion, Conclusion, and Suggestions

The present research indicates that students not pursuing a science major frequently do not understand the scientific practices required to assess scientific reports in mainstream media with a critical approach. This finding aligns with prior studies suggesting that non-science students often struggle to apply scientific reasoning to real-world contexts, particularly when evaluating information presented in popular media (Leung et al., 2017; Strimaitis et al., 2014). This gap highlights a disconnect between the intended goals of science education and students’ ability to critically evaluate scientific information.

Scientific Literacy and Science Education Challenges

The participants, non-science majors, in this study all underwent the same elementary and middle school science curriculum implemented nationally in Turkey. The Turkish curriculum is designed to be student-centered, emphasizing the skills, knowledge, and attitudes required for scientific literacy. Therefore, it was anticipated that all students would become well-informed consumers of scientific information, irrespective of their chosen major. However, despite these curricular objectives, students' ability to apply scientific reasoning in media-related contexts remains limited. Research suggests that this issue extends beyond Turkey and is a global concern, as science curricula often fail to fully integrate scientific practices into instruction (Osborne & Dillon, 2008; Tytler, 2007). Prior studies also indicate that science curricula, even when well-designed, may not always be implemented effectively in classrooms, leading to gaps in students' ability to critically assess scientific information (Dindar & Yangın, 2007; Gökçe, 2006).

Science education in various contexts tends to rely heavily on didactic instruction rather than fostering inquiry-based, student-centered learning environments, which are essential for developing scientific literacy (Duschl & Bybee, 2014). For instance, Leung et al. (2017) found that students in traditional lecture-based science courses often struggle to differentiate between correlation and causation, an issue also observed in our study. Teachers often rely on lectures rather than fostering learning environments that promote active student participation. Consequently, students not majoring in science might not possess the understanding required to assess scientific assertions, which could stem from insufficiently executing the science curriculum at earlier educational levels. Science teachers need comprehensive training to effectively implement the curriculum, equipping students with the necessary skills and knowledge for informed personal, public, and professional decisions.

Scientific Practices and Their Role in Scientific Literacy

Comparing science majors to non-science students, it appears that the limited engagement of non-science students with scientific practices could result from differences in how science is taught and contextualized. Scientific practices, which include hypothesis generation, experimental design, and data interpretation, form the foundation of scientific reasoning (NRC, 2012). Research suggests that students develop these competencies through active engagement with scientific inquiry rather than passively absorbing factual knowledge (Osborne, 2014). However, non-science majors often receive limited exposure to these practices, primarily due to traditional instructional approaches prioritizing rote learning over inquiry-based exploration (Duschl & Bybee, 2014). Without direct involvement in the scientific process, students may struggle to evaluate the reliability of claims presented in mainstream media or scientific reports (Busch & Rajwade, 2024).

Research by McNeill and Krajcik (2008) emphasizes the importance of teaching scientific practices, such as constructing explanations and engaging in argumentation from evidence, to improve students' ability to critically evaluate scientific claims. Their study showed that students who received explicit instruction in scientific practices were better equipped to assess the credibility of scientific information, particularly in media contexts. Similarly, Osborne (2014) highlighted that structured opportunities to practice these skills through inquiry-based learning significantly enhance students' analytical abilities and confidence when engaging with scientific claims. These findings underscore the need for curricula integrating scientific practices into learning experiences, ensuring students develop the critical thinking skills necessary to navigate scientific information in everyday life.

Prior studies indicate that students grasp scientific reasoning more effectively when actively engaged in inquiry-driven learning and hands-on experimentation (Lederman & Druger, 1985; Martin-Dunlop, 2013). Inquiry-based learning approaches, which encourage students to ask questions, test hypotheses, and analyze data, have enhanced scientific literacy and improved students’ ability to critically evaluate evidence (Abd-El-Khalick et al., 2004). However, traditional science curricula often fall short in incorporating these methods, particularly for non-science students, rarely providing structured opportunities to develop these skills. Project-based and hands-on science classes can potentially improve students’ scientific reasoning, but their effectiveness largely depends on explicitly integrating key scientific concepts and practices. Simply implementing practical activities without addressing the foundational aspects of scientific reasoning may not significantly enhance students' understanding (Moss, 2001). This issue becomes particularly important when designing introductory science courses for non-science students. Studies suggest that integrating the history of science into instruction provides a meaningful context for scientific concepts, enabling students to critically assess the evolution and validation of knowledge within the scientific community (Matthews, 2015; McComas, 1998; Millar, 2006). Engaging in historical experiment replications and analyzing their outcomes fosters a deeper understanding of scientific inquiry, emphasizing its methodological rigor and broader social and epistemological implications. Integrating scientific concepts into educational materials across different subjects has the potential to contribute positively to students' scientific literacy. For example, incorporating scientific themes into English coursebooks has been shown to support scientific literacy through interdisciplinary approaches, suggesting that similar strategies might be adapted for other subjects as well (Sağdıç & Yiğit, 2025).

Gender as a Demographic Factor and Scientific Practices

Gender is also analyzed as a demographic factor influencing the students' scientific practices. The lack of notable gender differences observed in this study aligns with previous research that highlights the importance of environmental factors such as early socialization, classroom experiences, parental expectations, and societal portrayals of science (Carli et al., 2016). For instance, Cheryan et al. (2017) emphasized that societal expectations significantly impact gender disparities in science participation, reinforcing self-perception differences rather than inherent cognitive ability gaps. Male students are often encouraged to take proactive roles in scientific discourse and laboratory activities, reinforcing their self-efficacy in conducting scientific inquiries (Schneider et al., 2015). Conversely, female students frequently face subtle biases that limit their participation, potentially shaping their long-term aspirations in STEM disciplines (Blickenstaff, 2005). Thus, while our study did not find gender disparities in scientific practices, educational interventions promoting gender-inclusive pedagogy remain necessary to ensure equitable access to scientific literacy skills (Williams & George-Jackson, 2014).

Contributions and Future Research Directions

The strength of this study is its focus on a relatively under-researched group. The study aims to contribute to the literature by identifying critical gaps in the scientific literacy of non-science majors, particularly concerning their ability to evaluate media-reported scientific claims. The findings obtained in this study align with recent work by Busch and Rajwade (2024), who emphasize the importance of bridging theoretical scientific knowledge with practical applications in media literacy education.

Future research should investigate how specific instructional strategies, such as integrating historical case studies of scientific discovery and utilizing interdisciplinary approaches, might enhance the ability of non-science students to evaluate scientific claims (Matthews, 2015). Additionally, longitudinal studies tracking students' development of scientific literacy over time could provide valuable insights into the long-term effectiveness of inquiry-based science instruction. Comparative research across different educational systems may further identify best practices for fostering scientific practices among non-science majors globally (Cinelli et al., 2020).

The reliance on a single institution limits the generalizability of reached findings. Expanding the sample to include participants from multiple universities across diverse geographic and academic contexts would provide a more robust understanding of the factors influencing non-science majors' scientific literacy. Additionally, qualitative research methods such as focus groups or interviews may yield deeper insights into students' reasoning processes and the challenges they face in evaluating scientific claims. By further refining science education to emphasize scientific practices, students can develop stronger critical thinking skills necessary for evaluating the increasing volume of scientific information disseminated through media platforms.

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Ethics statement: In this study, we declare that the rules stated in the "Higher Education Institutions Scientific Research and Publication Ethics Directive" are complied with and that we do not take any of the actions based on "Actions Against Scientific Research and Publication Ethics". At the same time, we declare that there is no conflict of interest between the authors, which all authors contribute to the study, and that all the responsibility belongs to the article authors in case of all ethical violations.

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