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Evaluating student satisfaction of terminological apparatus with natural and mathematical textbooks in Kazakhstani schools

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ABSTRACT

This study evaluates student satisfaction with the terminological apparatus in natural and mathematical textbooks used in Kazakhstani schools. A quantitative cross-sectional design was employed, using a structured questionnaire administered to 678 students across various school types. Stratified random sampling ensured diversity in gender, residence, and study language. Key findings indicate that 84.7% of students found textbook terms clear, with males reporting significantly higher clarity than females ($p < 0.001$). Kazakh-speaking students reported slightly higher clarity than Russian-speaking counterparts, though this difference was not statistically significant. Most students relied on teachers to resolve unclear terms, making it the most effective strategy. Additional illustrations were useful for 81.1% of participants, especially in IT and natural sciences, though mathematics terminology remained challenging. These findings have educational policy implications, suggesting improvements in textbook terminology, teacher training, and curriculum design. Enhancing clarity through precise definitions, visual aids, and teacher support could improve student comprehension. Study limitations include reliance on self-reported data and the exclusion of qualitative insights from teachers and policymakers. Future research should integrate these perspectives for a more comprehensive understanding of textbook effectiveness.

IMPACT STATEMENT

This study explores how students in Kazakhstan understand the terms used in their math and science textbooks. Clear language in textbooks is important because it helps students learn more effectively. We surveyed 678 students from different types of schools to find out how well they understood the terms in their textbooks and what strategies they used to overcome confusion. The results showed that most students relied on their teachers for help, and that additional illustrations were very useful for understanding difficult concepts, especially in science and IT subjects. The study highlights the importance of teacher support and well-designed textbooks in helping students succeed, offering valuable insights for educators and policymakers aiming to improve learning materials.

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1. Introduction

The quality of the instructional materials has a significant impact on how students learn and perform. In Kazakhstan, the educational system has undergone significant reforms aimed at enhancing the effectiveness of teaching and learning processes, particularly in natural and mathematical sciences (Tursynkulova et al., 2023). However, despite these efforts, challenges persist in ensuring that textbooks meet the

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needs of students. A critical aspect that influences student engagement and comprehension is the terminological apparatus used in textbooks (Bond, 2020). The terminology must be clear and appropriate for students' cognitive levels to facilitate understanding of complex concepts (Akhmet et al., 2023).

In natural sciences (biology, chemistry, physics, and earth sciences), precise terminology is crucial. If terms are not adapted to students' cognitive levels, confusion and disengagement may result (Lodge et al., 2018). Similarly, in mathematical sciences, clear definitions of abstract terms and processes are essential for students to build a robust understanding of the subject (Ortiz-Laso et al., 2023).

This study examines how clear and appropriate terminology in natural and mathematical textbooks impacts students' learning in Kazakhstani schools (Balmagambetova & Karimbek, 2021). Although online resources are growing in use (Castro, 2019), textbooks remain essential, and their terminology must meet students' needs. In this study, satisfaction refers to the degree to which students perceive the terminology in their textbooks as clear, comprehensible, and appropriate for their age and cognitive level. It encompasses not only the ease of understanding the material but also how engaging and supportive the terminology is in facilitating their learning. By focusing on satisfaction, we assess how effectively the terminological apparatus enhances the overall learning experience, motivation, and academic performance.

The terminological apparatus refers to the set of terms and definitions used to convey subject content (Aspinall, 2020; Durán-Muñoz & Bautista-Zambrana, 2017). Effective terminology can bridge the gap between abstract concepts and student comprehension, while poor terminology can hinder learning and discourage student interest (Beeson et al., 2015).

The clarity of textbook terminology directly affects students' comprehension, motivation, and academic performance (Sangwan et al., 2024). Firstly, it directly impacts students' ability to grasp and retain subject matter knowledge. Secondly, understanding students and their clear evaluation of terminology can influence students' attitudes toward the subject, affecting their motivation and overall academic performance. Third, the insights from these evaluations can inform educators, textbook authors, and policymakers in making data-driven decisions to improve educational resources (Gardner, 2007; Grix, 2002).

Despite significant reforms in Kazakhstan's education system, textbooks still face challenges in supporting student learning, particularly in natural and mathematical sciences (Chulakova et al., 2024; Deardorff, 2006). One critical, yet often overlooked, component of this support is the terminological apparatus, the specific terms and definitions used within textbooks. One critical component of this support is the terminological apparatus—the specific terms and definitions used in textbooks. The clarity, accessibility, and appropriateness of these terms are crucial for fostering student comprehension and engagement.

Current research lacks sufficient empirical data on how well students understand and evaluate the terminological apparatus in their textbooks (Bergenholtz & Tarp, 2010). Without this understanding, efforts to improve educational resources may be misaligned with student needs, thereby limiting learning outcomes (Koehler, 2020).

The core problem this research addresses is the difficulty students face in understanding and evaluating the clarity of the terminology used in natural and mathematical textbooks in Kazakhstani schools. In particular, it examines whether the terminology used in these textbooks meets students' cognitive and educational needs, and how it impacts their learning experiences and outcomes.

In other words, the task of intensifying students' cognitive activity in Kazakh schools stems from the tension over whether the terminology in these textbooks meets students' cognitive and educational needs and how it impacts their learning experiences and outcomes. Consequently, a study is needed to evaluate the impact of the clarity and appropriateness of the terminological apparatus in natural and mathematical textbooks on students' comprehension and learning outcomes in Kazakhstani schools. In this study, 'comprehension' refers to students' ability to understand the terms used in their textbooks and apply this understanding to grasp subject matter content. 'Learning outcomes' refer to the broader impact that clear and appropriate terminology has on students' academic performance and engagement, as measured through their perceptions of how well the textbooks support their learning process.

At the same time, the question arises: How can terminological apparatus in natural and mathematical textbooks affect students' comprehension and learning outcomes in Kazakhstani schools? Unfortunately, our country's educational system is not based on new scientific knowledge about how terminological

apparatus in natural and mathematical textbooks affects students' comprehension and learning outcomes in Kazakhstani schools and does not fully utilize it as needed. There has not been extensive research on how terminological apparatus in natural and mathematical textbooks affects students' comprehension and learning outcomes in Kazakhstani schools, despite its increasingly recognized benefits. To assess the clarity and accessibility of the terminological apparatus in natural and mathematical textbooks used in Kazakhstani schools and to assess the overall satisfaction of schoolchildren with these textbooks can be extremely useful in resolving these issues.

Prior research suggests that demographic factors such as gender, language of instruction, and residence (urban vs. rural) can influence students' perceptions of educational resources, including textbooks (Akhmet et al., 2023; Lamb & Fullarton, 2002; Myers et al., 2023; Opoku-Asare & Siaw, 2015). Additionally, students' learning strategies, such as relying on teachers for clarification or using online resources, have been shown to impact their satisfaction with educational materials (Wu et al., 2021). These factors are expected to play a role in shaping how students evaluate the clarity and appropriateness of terminology in natural and mathematical textbooks, influencing their overall satisfaction with the learning process.

Despite ongoing educational reforms in Kazakhstan, textbooks in natural and mathematical sciences still face challenges in effectively supporting student learning. One critical issue is the clarity and appropriateness of the terminological apparatus, which directly affects comprehension, engagement, and academic performance. While previous research has explored textbook quality, limited empirical data exist on students' perceptions of terminology clarity. Addressing this gap is essential for improving educational materials and ensuring they align with students' cognitive needs. This study evaluates student satisfaction with textbook terminology, identifies key factors influencing clarity, and provides recommendations to enhance textbook design and instructional strategies.

To the best of our knowledge, this study is the first in Kazakhstan to systematically assess student perceptions of textbook terminology clarity in natural and mathematical sciences. Its findings not only contribute to improving educational materials and policies within the country but may also be valuable for other developing nations facing similar challenges in textbook development. Moreover, this research demonstrates how national-level studies can inform global educational practices, emphasizing the importance of adapting instructional materials to align with students' cognitive needs and learning environments.

1.1. Research question

Q1. How do students perceive the clarity and appropriateness of the terminology used in natural and mathematical textbooks in Kazakhstani schools, and how do these perceptions relate to their overall satisfaction with the learning experience?

Q2. How are demographic variables (such as gender, residence, and language of study) and students' learning strategies associated with their satisfaction and evaluation of the clarity of terminology in natural and mathematical textbooks?

1.2. Objective

This study aims to assess the clarity and accessibility of the terminological apparatus in natural and mathematical textbooks used in Kazakhstani schools and evaluate students' overall satisfaction with these textbooks. Specifically, the study investigates how demographic factors (gender, residence, language of study, and school type) influence students' perceptions of terminology clarity and explores the effectiveness of different strategies used to resolve unclear terms.

1.3. Hypotheses

H1: Students' perceptions of textbook terminology clarity will vary based on demographic factors such as gender, residence (urban vs. rural), school type, and language of study

H2: Students from different school types (general schools, gymnasiums, and schools for gifted children) will show varying levels of satisfaction with textbook terminology, influenced by their academic environment and learning strategies.

H3: Students' strategies for resolving unclear terms will differ based on their perceived clarity of textbook terminology.

H4: The clarity of textbook terminology will differ across subject areas

H5: The most effective ways to improve terminology clarity will vary by subject.

1.4. Significance of the study

The importance of evaluating student satisfaction with the terminological apparatus of natural and mathematical textbooks in Kazakhstani schools is multifaceted and pivotal for several reasons:

1.4.1. Enhancing educational quality

The clarity and accessibility of terminology in textbooks directly impact students' comprehension and learning outcomes. If the terminology used in educational materials is confusing or overly complex, it can hinder students' understanding of fundamental concepts (Beauchamp & Thomas, 2009).

1.4.2. Supporting curriculum development

The findings of this study can provide valuable information for curriculum developers and educational policymakers. Understanding students' perspectives on the terminological clarity of their textbooks can inform the development of future educational materials. This ensures that the textbooks are not only aligned with educational standards but are also accessible and comprehensible for students at various levels of proficiency (Brumpton et al., 2013).

1.4.3. Promoting inclusive education

Kazakhstan's educational system serves a diverse student population with varying levels of language proficiency, especially considering the country's multilingual context. Evaluating the accessibility of textbook terminology ensures that all students, regardless of their linguistic background, can equally benefit from educational resources. This promotes inclusivity and equity in education, ensuring that no student is disadvantaged due to linguistic barriers (Shymansky et al., 1991).

1.4.4. Teacher orientation and training programs

Teachers play a crucial role in mediating the content of the textbook and facilitating student understanding. Insights from this study can be used to guide teacher training programs, equipping educators with the strategies and tools necessary to effectively explain complex terminology and concepts. This can improve classroom instruction and help students overcome difficulties with textbook terminology (Brickhouse, 1990).

1.4.5. Informing educational reforms

As Kazakhstan continues to reform its educational system to meet international standards, this study provides empirical evidence that can inform policy decisions. By identifying areas where students struggle with textbook terminology, educational authorities can prioritize reforms that address these challenges, ensuring that educational materials are conducive to effective learning (Rusilowati et al., 2016).

1.4.6. Fostering lifelong learning

A solid foundation in natural and mathematical sciences is essential for the future academic and career pursuits of students. By ensuring that textbooks are clear and accessible, this study contributes to fostering a positive learning experience that can inspire a lifelong interest in these topics. This is crucial for developing a knowledgeable and skilled workforce that can contribute to the country's socio-economic development (Yager, 1983).

This study is significant, as it addresses a fundamental aspect of educational quality: the clarity and accessibility of textbook terminology. The insights gained support long-term educational goals, promoting a more inclusive, equitable, and effective educational system in Kazakhstan.

2. Review of the literature

Textbooks serve as primary instructional tools, providing essential content and structure to the curriculum. In the context of natural and mathematical sciences, the effectiveness of textbooks is closely tied to the clarity and appropriateness of the terminological apparatus used (Carey et al., 2012; San Martín, 2022). Research has shown that the use of clear and accessible terminology is crucial for student comprehension and engagement (Dolba, 2022; Wachowiak et al., 2021).

Several studies have highlighted the challenges students face with complex and poorly defined terminology in textbooks. For example, Condamines (2017) and L'Homme (2020) found that students often struggle with scientific jargon, which can impede their understanding of key concepts. Similarly, Evans (1975) and van der Waal (2021) emphasized that technical terms must be carefully introduced and consistently used to facilitate learning. These findings suggest that an effective terminological apparatus is essential to help students grasp complex subject matter, particularly in disciplines such as the natural and mathematical sciences (Holtmeier, 2003; Ko et al., 2016).

In the context of Kazakhstan, educational reforms have placed a strong emphasis on the development of high-quality textbooks (Yelubayeva et al., 2023). However, research specific to the Kazakhstani educational system remains limited. Yakavets et al. (2023) conducted a study on the challenges students face in understanding mathematical terminology, highlighting a significant gap between textbook content and student comprehension. This gap underscores the need for a more detailed examination of the terminological apparatus in textbooks used in Kazakhstani schools.

In addition, international studies provide valuable insight into best practices for developing effective textbook terminology. For example, Yun and Park (2014) and Michalsky et al. (2009) argue that textbooks should be designed with the cognitive development of students in mind, ensuring that terms are introduced progressively and in a context that supports learning. Similarly, Bransford et al. (2000) suggested that textbook authors should collaborate with educators to create materials that are both pedagogically sound and linguistically accessible.

In addition to clarity and accessibility, student satisfaction with textbooks is influenced by the relevance and contextualization of terms. Research by Turner et al. (2021) indicates that when students find the terminology relatable and applicable to real-world contexts, their engagement and motivation to learn increase. This perspective is particularly relevant in the Kazakhstani context, where textbooks must cater to a diverse student population with varying levels of language proficiency and background knowledge.

3. Methods

This study employs a cross-sectional design to evaluate student satisfaction with the terminological apparatus in natural and mathematical textbooks used in Kazakhstani schools. The quantitative approach was used to assess student perceptions of the clarity of textbook terms in various subjects and identify the strategies they use to resolve unclear terms. Data were collected using a structured questionnaire that assessed students' perceptions of the clarity of textbook terminology.

3.1. Sample

A total of 678 students from various schools in Kazakhstan participated in this cross-sectional study. Stratified random sampling was used to ensure a representative distribution by gender, residence (urban vs. rural), and language of study (Kazakh vs. Russian). The sample included students from general schools, gymnasiums, and schools for gifted children.

The demographic breakdown of the participants is as follows: 297 (43.8%) were male and 381 (56.2%) were female. Regarding their residence, 157 (23.3%) were from rural areas and 521 (76.8%) from urban

areas. The language of study for the majority was Kazakh (537, 79.2%), while 141 (20.8%) studied in Russian. Participants were also categorized according to their type of school: 304 (44.8%) attended general schools, 324 (47.8%) were in gymnasiums, and 50 (7.4%) were in schools for gifted children (Table 1).

3.2. Measures

A structured questionnaire was administered to assess student's perceptions of the clarity of textbook terms in natural and mathematical subjects. To ensure content validity, experts in educational sciences reviewed the questionnaire, assessing its relevance, clarity, and appropriateness for the target population. The sample consisted of students from general schools, gymnasiums, and schools for gifted children. The questionnaire was divided into several sections. The first section gathered demographic information, including gender (male, female), residence (rural, urban), language of study (Kazakh, Russian), and type of school (general school, gymnasium, school for gifted children). The second section focused on the clarity of textbook terms, specifically in subjects such as math, IT, and natural sciences. The questionnaire was designed to gather data on a single instance of perception regarding the clarity of terms in textbooks. Students were asked to indicate the subject (natural sciences, math, or IT) where they found the terms most unclear. This was a one-time selection, not a subject-by-subject evaluation. Additionally, students were asked which strategy they typically use to resolve unclear terms. Students selected one of four strategies – 'looking for online resources', 'asking the teacher', 'searching for translations', or 'ignoring unclear terms' – to indicate how they typically resolve unclear textbook terms. This question was also posed as a single, overarching assessment of their usual behavior, rather than a separate evaluation for each subject. Moreover, the usefulness of additional illustrations in the textbooks was rated on a three-point scale (no, not sure, yes). Students were also asked to estimate the number of terms in their textbooks (low, middle, high). Additionally, students provided input on the best methods

Table 1. Study participants (N = 678).

Variables	n (%)
Gender	
Male	297 (43.8%)
Female	381 (56.2%)
Residence	
Rural	157 (23.3%)
Urban	521 (76.8%)
Language of study	
Kazakh	537 (79.2%)
Russian	141 (20.8%)
School	
General school	304 (44.8%)
Gymnasium	324 (47.8%)
For gifted children	50 (7.4%)
Subject with most unclear terms	
Math	231 (34.1%)
IT	197 (29.1%)
Natural sciences	
Strategies for unclear terms	250 (36.9%)
Looking for online resources	163 (24.0%)
Asking teacher	446 (65.8%)
Looking for translations	38 (5.6%)
Ignoring	31 (4.6%)
Usefulness of additional illustrations	
No	30 (4.4%)
No sure	98 (14.5%)
Yes	550 (81.1%)
Number of terms in the textbook	
Low	40 (5.9%)
Middle	477 (70.4%)
High	161 (23.7%)
Best way for terms clarity	
Additional illustrations (Yes – No)	208 (30.7%)
Practical examples (Yes – No)	257 (37.9%)
Short descriptions (Yes – No)	159 (23.5%)
Add. study materials (Yes – No)	192 (28.3%)

to improve term clarity, responding to whether they found additional illustrations, practical examples, short descriptions, or additional study materials helpful (yes/no responses).

Given that this study relies on self-reported perceptions, potential biases such as social desirability bias and recall bias may influence students' responses. To minimize these risks, several measures were implemented. First, the questionnaire was designed to capture a single instance of perception regarding the clarity of textbook terms, rather than requiring students to assess multiple subjects individually, reducing cognitive load and potential inconsistencies. Second, students were assured of anonymity and confidentiality, emphasizing that their responses would not affect their academic standing, which helped to encourage honest and unbiased reporting. Third, the use of neutral and structured response formats helped prevent leading responses and minimized the risk of exaggerated or extreme answers. Additionally, by limiting the evaluation to one primary strategy for resolving unclear terms, the questionnaire reduced ambiguity and the tendency for respondents to provide socially desirable or inconsistent answers.

3.3. Data analysis

Descriptive statistics were used to summarize the demographic characteristics and responses related to textbook term clarity. Chi-square tests were used to examine associations between demographic variables and textbook term clarity. Binomial logistic regression was used to analyze the relationship between the clarity of textbook terms (binary outcome: clear vs. unclear) and the predictor variables, including gender, residence, language of study, type of school, and subjects with unclear terms. This method allowed us to determine the likelihood of students finding textbook terms unclear based on these demographic and contextual factors. The strategies for resolving unclear terms were assessed by asking students to choose one strategy they used most frequently. These responses were analyzed to identify the predominant strategy used by students in relation to unclear textbook terms and its potential association with other variables. The 'Exploration', 'Frequencies', and 'Regression' modules in Jamovi (version 2.2.5) were employed for these analyses and a p value of <0.05 was considered statistically significant.

3.4. Ethical considerations

This study was conducted in accordance with ethical research guidelines and principles for research involving human participants. Prior to data collection, ethical approval was obtained from the Ethical Committee of the Academic Council, Republican Scientific and Practical Center for Educational Content Expertise, Kazakhstan (24 September 2022, Ref. No. 3) ensuring compliance with all relevant regulations. Parental or guardian consent was obtained through the school administration. Anonymity and confidentiality were strictly maintained, and no personally identifiable information was collected. The study posed no risks to participants, and they had the right to withdraw at any time without consequences.

4. Results

The clarity of textbook terms was assessed across several variables (Table 2). Overall, 574 participants (84.7%) found the terms in their textbooks to be clear. A significantly higher proportion of males (89.9%) reported clear textbook terms compared to females (80.6%), $p < 0.001$ (Cramer's $V = 0.128$, Figure 1(A)). There was no significant difference in the clarity of textbook terms between participants from rural and urban areas. Participants studying in Kazakh reported slightly higher clarity (85.5%) compared to those studying in Russian (81.6%), though this difference was not statistically significant. The clarity of textbook terms did not differ significantly across different school types.

Participants identified unclear terms primarily in Natural Sciences (36.9%), followed by Math (34.1%) and IT (29.1%). Clarity was reported by 87.8% in Natural Sciences, 83.1% in Math, and 83.6% in IT ($p = 0.341$). Students from different school types showed different experiences with term clarity in subjects like Math, IT, and Natural Sciences. Thus, students from general secondary schools were more likely to have problems with terminology in mathematics (39.5%), whereas students from gymnasiums and lyceums and schools for gifted children were more likely to have problems with natural sciences (42.3%

Table 2. Predictors of textbook terms clarity (N = 574).

	Textbook terms clarity					
Variables	n (%)	χ^2, p	Beta (SE)	OR	OR 95%CI	p
Gender						
Male	267 (89.9%)	11.2,	0.707 (0.255)	2.028	1.23–3.34	0.006
Female	307 (80.6%)	$p < 0.001$	ref	ref	ref	
Residence						
Rural	136 (86.6%)	0.607,	ref	ref	ref	0.756
Urban	438 (84.1%)	$p = 0.436$	0.097 (0.313)	1.102	0.60–2.04	
Language of study						
Kazakh	459 (85.5%)	1.32,	0.663 (0.330)	1.942	1.02–3.71	0.044
Russian	115 (81.6%)	$p = 0.251$	Ref	ref	ref	
School						
General school	263 (86.5%)	2.64,	ref	ref	ref	0.466
Gymnasium	272 (84.0%)	$p = 0.268$	−0.205 (0.281)	0.815	0.47–1.41	0.119
For gifted children	39 (78.0%)		−0.708 (0.454)	0.493	0.20–1.20	
Subject with most unclear terms						
Math	192 (83.1%)	2.15,	ref	ref	ref	
Natural sciences	209 (83.6%)	$p = 0.341$	−0.224 (0.277)	0.800	0.46–1.38	0.419
IT	173 (87.8%)		0.062 (0.308)	1.064	0.58–1.95	0.841
Strategies for unclear terms						
Looking for online resources	132 (81.0%)	48.9,	1.536 (0.457)	4.646	1.90–11.39	<0.001
Asking teacher	399 (89.5%)	$p < 0.001$	2.080 (0.434)	8.002	3.42–18.73	<0.001
Looking for translations	29 (76.3%)		1.296 (0.571)	3.656	1.19–11.20	0.023
Ignoring	14 (45.2%)		ref	ref	ref	
Usefulness of additional illustrations						
No	23 (76.7%)	11.4,	ref	ref	ref	
No sure	73 (74.5%)	$p = 0.003$	0.071 (0.551)	1.074	0.36–3.16	0.897
Yes	478 (86.9%)		0.385 (0.502)	1.469	0.55–3.93	0.444
Number of terms in the textbook						
Low	31 (77.5%)	35.6,	ref	ref	ref	
Middle	429 (89.9%)	$p < 0.001$	0.809 (0.448)	2.24	0.93–5.40	0.071
High	114 (70.8%)		−0.336 (0.458)	60.715	0.29–1.75	0.462
Best way for terms clarity						
Additional illustrations (Yes – No)	179 (86.1%)	0.451, $p = 0.502$	0.218 (0.284)	1.243	0.71–2.17	0.443
Practical examples (Yes – No)	219 (85.2%)	0.098, $p = 0.755$	−0.047 (0.267)	0.954	0.57–1.61	0.861
Short descriptions (Yes – No)	131 (82.4%)	0.825, $p = 0.364$	−0.042 (0.280)	0.958	0.55–1.66	0.880
Add. study materials (Yes – No)	167 (87.0%)	1.11, $p = 0.292$	0.144 (0.303)	1.155	0.64–2.09	0.634
Total	574 (84.7%)			$R^2_{McF} = 0.137$, $p < 0.001$		

and 44.0%, respectively), $\chi^2 = 14.3$, $p = 0.005$ (Cramer's $V = 0.103$). The distribution of unclear terms rate in Natural Sciences, Math, and IT textbooks did not differ by gender and language of instruction.

Participants employed various strategies to understand unclear terms (Figure 1(B)): looking for online resources (24.0%), asking teachers (65.8%), looking for translations (5.6%), and ignoring them (4.6%). A significant difference was found among these strategies ($\chi^2 = 48.9$, $p < 0.001$, Cramer's $V = 0.269$), with asking teachers being the most effective (89.5%, Figure 1(C)). The gender, residence, and subject with the most unclear terms of the students did not influence the strategy of solving problems with unclear terms, while the language of instruction and school type had a significant effect (Table 3, Figure 1(D,E)).

Thus, a significant association was found between the language of instruction and the strategies employed to resolve unclear terms ($\chi^2 = 31.6$, $p < 0.001$). Among students studying in Kazakh, 69.5% preferred asking their teacher for clarification, compared to 51.8% of students studying in Russian. A higher proportion of Russian-speaking students (41.8%) relied on online resources, compared to 19.4% of Kazakh-speaking students. The use of translations was slightly more common among Kazakh-speaking students (6.3%) than Russian-speaking students (2.8%). Ignoring unclear terms was the least common strategy across both language groups, with 4.8% of Kazakh-speaking students and 3.5% of Russian-speaking students opting to ignore the unclear terms.

Moreover, school type also significantly influenced the strategies students used to understand unclear terms ($\chi^2 = 21.8$, $p < 0.001$). Students from general schools were more likely to ask teachers for help (66.4%), while 28.6% preferred to look for online resources. In comparison, gymnasium students were slightly more inclined to use translations (8.6%) and ignore unclear terms (6.2%). The highest proportion of students asking teachers for help came from schools for gifted children (64.0%), while only 24.0% of these students reported looking for online resources.

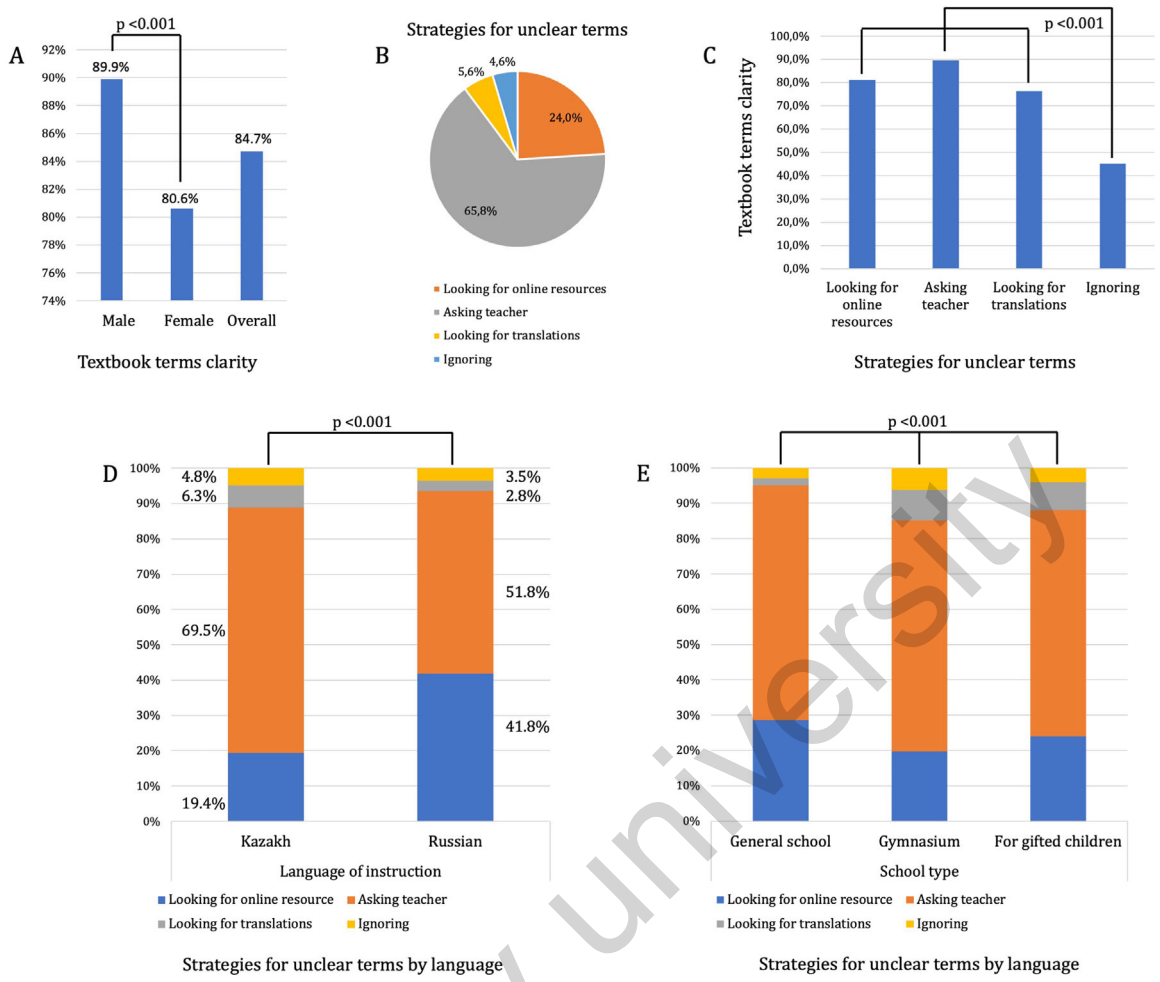

Figure 1. Gender differences in textbook term clarity and student strategies for resolving unclear terms, stratified by textbook clarity, language of instruction, and school type. (A) Gender differences in perceived textbook term clarity. (B) Distribution of student strategies for resolving unclear terms. (C) Association between strategy choice and textbook term clarity. (D) Influence of language of instruction on strategy selection. (E) Influence of school type on strategy selection.

Table 3. Influence of language of instruction and school type on students' strategies for understanding unclear terms.

Variable		Looking for online resource	Asking teacher	Looking for translations	Ignoring	χ^2, p	Cramer's V
Language of instruction	Kazakh	104 (19.4%)	373 (69.5%)	34 (6.3%)	26 (4.8%)	31.6, $p < 0.001$	0.216
	Russian	59 (41.8%)	73 (51.8%)	4 (2.8%)	5 (3.5%)		
School type	General school	87 (28.6%)	202 (66.4%)	6 (2.0%)	9 (3.0%)	21.8, $p < 0.001$	0.127
	Gymnasium	64 (19.8%)	212 (65.4%)	28 (8.6%)	20 (6.2%)		
	For gifted children	12 (24.0%)	32 (64.0%)	4 (8.0%)	2 (4.0%)		

The majority of participants (81.1%) found additional illustrations useful for understanding terms, with significant differences in clarity among those who found illustrations useful (86.9%) compared to those who did not (76.7%) or were unsure (74.5%), $p = 0.003$ (Cramer's $V = 0.130$).

The analysis revealed significant differences in how male and female students perceived the usefulness of additional illustrations ($\chi^2 = 13.2$, $p = 0.001$). Among male students, 84.5% found illustrations useful, 9.4% were unsure, and 6.1% did not find them helpful. In contrast, 78.5% of female students found illustrations useful, while 18.4% were unsure, and 3.1% did not find them helpful (Table 4). There were also significant differences in the perceived usefulness of illustrations based on the subject (Table 4).

Table 4. Perceived usefulness of additional illustrations based on gender and subject area.

Variable		Usefulness of additional illustrations				
		No	No sure	Yes	χ^2, p	Cramer's V
Gender	Male	18 (6.1%)	28 (9.4%)	251 (84.5%)	13.2, p = 0.001	0.139
	Female	12 (3.1%)	70 (18.4%)	299 (78.5%)		
Subject	Math	10 (4.3%)	49 (21.2%)	172 (74.5%)	13.2, p = 0.010	0.097
	Natural sciences	11 (4.4%)	29 (11.6%)	210 (84.0%)		
	IT	9 (4.6%)	20 (10.2%)	168 (85.3%)		

The highest percentage of students who found illustrations useful was in IT (85.3%), followed by Natural Sciences (84.0%), and Math (74.5%).

Participants reported varying numbers of terms in their textbooks: low (5.9%), middle (70.4%), and high (23.7%). Those with a middle number of terms reported the highest clarity (89.9%) compared to low (77.5%) and high (70.8%) numbers of terms, showing a significant difference ($p < 0.001$, Cramer's $V = 0.229$).

Participants suggested several methods for improving term clarity: additional illustrations (30.7%), practical examples (37.9%), short descriptions (23.5%), and additional study materials (28.3%). However, there was no significant difference in terms clarity among these methods (χ^2 values ranging from 0.451 to 1.11, $p > 0.292$). There were no gender differences in how participants resolved unclear textbook terms ($\chi^2 = 3.32$, $p = 0.345$).

The logistic regression analysis (Table 2: $R^2_{McF} = 0.137$, $p < 0.001$) showed that gender was a significant predictor, with male students being more likely to find textbook terms clear compared to female students (OR = 2.028, $p = 0.006$). Language of study was also a significant predictor, as students studying in Kazakh were more likely to perceive textbook terminology as clear compared to those studying in Russian (OR = 1.942, $p = 0.044$). Furthermore, students who relied on online resources (OR = 4.646, $p < 0.001$) or asked teachers for help (OR = 8.002, $p < 0.001$) were significantly more likely to find the terms clear, compared to those who ignored unclear terms. However, the usefulness of additional illustrations and the number of terms in the textbook were not significant predictors of term clarity.

The binomial regression analysis revealed several predictors influencing the preference for additional materials that students found most suitable for understanding textbook terms. Table 5 summarizes the significant predictors for each type of additional material, including additional illustrations, practical examples, short descriptions, and additional study materials.

The analysis indicated that students from urban areas were significantly more likely to prefer additional illustrations compared to those from rural areas. Language of instruction also played a role, with students studying in Russian more likely to prefer illustrations and practical examples than those studying in Kazakh. At the same time, Kazakhs were significantly more likely to prefer additional study materials than those studying in Russian. Students attending general schools showed a significantly higher preference for additional illustrations compared to those studying in gymnasiums or schools for gifted children. However, students from schools for gifted children and gymnasiums showed a higher preference for short descriptions.

The analysis revealed that the preference for practical examples as a helpful method for understanding unclear textbook terms was significantly influenced by the language of instruction. Students studying in Russian were significantly more likely to prefer practical examples compared to those studying in Kazakh (OR = 1.771, $p = 0.009$). This indicates that Russian-speaking students may find practical examples more useful in clarifying textbook terms, potentially due to differences in how content is presented or interpreted between the two languages. Additionally, this could suggest that practical examples provide a more concrete method of learning that helps bridge linguistic or cognitive gaps in understanding. In addition to language of instruction, the preference for practical examples was significantly influenced by the subject with the most unclear terms. Students who found terms most unclear in Natural Sciences were significantly more likely to prefer practical examples compared to those who struggled with terms in Mathematics (OR = 1.765, $p = 0.004$). This suggests that students dealing with terminology in Natural Sciences may benefit more from concrete, real-world applications of the concepts, as practical examples can help clarify complex scientific processes.

Table 5. Predictors influencing the preference for additional materials that students found most suitable for understanding textbook terms.

	Additional illustrations $R^2_{McF} = 0.045$ $p < 0.001$				Practical examples $R^2_{McF} = 0.026$ $p = 0.002$				Short descriptions $R^2_{McF} = 0.022$ $p = 0.025$				Additional study materials $R^2_{McF} = 0.032$ $p < 0.001$			
Predictors	Beta	OR	OR 95%CI	p	Beta	OR	OR 95%CI	p	Beta	OR	OR 95%CI	p	Beta	OR	OR 95%CI	p
Gender																
Female-Male	−0.002	0.998	0.71–1.40	0.989	−0.245	0.783	0.57–1.08	0.131	0.365	1.441	0.99–2.08	0.053	0.058	1.060	0.75–1.50	0.742
Residence																
Urban-Rural	0.931	2.536	1.56–4.13	<0.001	0.068	1.070	0.71–1.61	0.746	−0.037	0.964	0.60–1.55	0.879	−0.611	0.543	0.36–0.82	0.004
Language of instruction																
Russian-Kazakh	0.444	1.559	1.01–2.41	0.045	0.572	1.771	1.15–2.71	0.009	0.326	1.385	0.84–2.29	0.204	−0.708	0.492	0.29–0.84	0.009
School type																
Gymnasium-GSch	−0.366	0.694	0.47–1.01	0.058	−0.191	0.826	0.58–1.18	0.295	0.436	1.547	1.02–2.35	0.042	−0.042	0.959	0.65–1.41	0.828
GCSch-GSch	−0.993	0.371	0.17–0.82	0.014	−0.173	0.841	0.43–1.64	0.613	0.982	2.530	1.26–5.07	0.009	−0.262	0.769	0.37–1.60	0.484
Subject with most unclear terms																
NS-Math	0.045	1.046	0.70–1.57	0.826	0.568	1.765	1.20–2.59	0.004	0.218	1.244	0.81–1.90	0.316	−0.206	0.814	0.54–1.23	0.325
IT-Math	−0.046	0.955	0.62–1.46	0.832	0.341	1.406	0.94–2.11	0.099	−0.161	0.851	0.53–1.37	0.505	−0.145	0.865	0.56–1.33	0.509

Note: GSch – General school, GCSch – School for gifted children, NS – Natural Sciences.

The preference for short descriptions was significantly predicted by school type. Students attending schools for gifted children or gymnasiums showed a higher preference for short descriptions compared to those from general schools. This might suggest that students in more academically rigorous environments prefer concise, straightforward explanations, as they may be more adept at handling complex terminology but still require some form of clarification for challenging terms. These students could benefit from more succinct descriptions that align with their advanced learning pace.

The preference for additional study materials was significantly influenced by both the language of instruction and residence. Students studying in Kazakh were significantly more likely to prefer additional study materials compared to those studying in Russian (OR = 0.492, p = 0.009). Similarly, students from urban areas were less likely to prefer additional study materials compared to their rural counterparts (OR =0.543, p = 0.004). This could reflect a greater need for supplementary resources among Kazakh-speaking students or those from rural areas, who may face challenges in accessing or fully comprehending textbook content and thus require additional materials to support their learning.

5. Discussion

This study aimed to evaluate the clarity of textbook terms among secondary school students in Kazakhstan and identify factors influencing this clarity. The findings revealed that a significant majority of students (84.7%) perceived their textbook terms as clear, with notable variations across different demographic groups and educational contexts. However, gender, the language of instruction, and strategies for resolving unclear terms were significant predictors of clarity, while other factors, such as school type and subject, played a more limited role.

5.1. Gender differences in term clarity

One of the most notable findings is the significant difference between male and female students in their perceptions of textbook clarity. Male students were significantly more likely to report that the terms were clear (89.9%) compared to female students (80.6%). This aligns with previous research suggesting that gender disparities in educational outcomes can be attributed to differences in cognitive processing and educational experiences (Lindberg et al., 2010). However, the reasons for these disparities in textbook term clarity specifically warrant further investigation, considering potential cultural and pedagogical factors unique to Kazakhstan.

Similar to the findings of previous studies (Logan & Johnston, 2009; Nootens et al., 2018), the results indicate that male students are more likely to find additional illustrations useful compared to female students, with 84.5% of males reporting that illustrations help them understand textbook content compared to 78.5% of females. This significant difference (p = 0.001) suggests that male students may benefit more from visual aids or are more inclined to rely on them for comprehension.

However, the finding that more females were unsure about the usefulness of illustrations (18.4%) compared to males (9.4%) suggests that females may have different preferences when it comes to learning aids or might require additional contextual information alongside illustrations (Halpern et al., 2007). This implies that simply adding visual aids may not be equally effective for all students and that textbooks should consider offering complementary resources to support different learning styles (Carney & Levin, 2002; Pashler et al., 2008).

These gender disparities highlight the need for gender-responsive textbook design and instructional approaches. Educational policymakers should consider incorporating inclusive terminology explanations and supplementary visual aids tailored to diverse learning preferences. Teacher training programs should also focus on strategies to bridge these gender-based differences in comprehension.

5.2. Influence of language of instruction

While Kazakh-speaking students reported slightly higher clarity (85.5%) than Russian-speaking students (81.6%), the difference was not statistically significant. This suggests that language of instruction does not play a critical role in students' overall understanding of textbook terms, contrary to some studies

(Dockrell et al., 2022; Paudel, 2020; Wang, 2019; Yanaprasart & Lüdi, 2018), that have highlighted language barriers as a significant challenge in multilingual educational contexts. However, the significant finding from the regression analysis (OR =1.942, p = 0.044) indicates that language of instruction may still influence clarity in specific cases, warranting further investigation into how language impacts specific subjects or concepts. Thus, language of instruction has been shown to impact comprehension and academic performance (Cummins, 2000), and our findings underscore the importance of language support services to enhance understanding.

The results suggest that students studying in Kazakh are more likely to rely on their teachers for help, while Russian-speaking students are more independent in seeking solutions, often turning to online resources. This could be attributed to cultural or instructional differences in how language is used in the classroom. These findings are supported by research from other countries, such as Canada and the USA (Lee, 2015; Schulz, 2001). In Kazakh-language schools, there may be a stronger tradition of teacher-centered instruction, where students are encouraged to ask for clarification directly from the teacher. In contrast, Russian-speaking students may be more accustomed to autonomous learning practices, possibly due to the greater availability of online resources in Russian. The fact that Kazakh-speaking students are more likely to ask teachers for help suggests that teacher support is critical in these classrooms, which may reflect the need for more accessible resources in the Kazakh language. It may also indicate that students are more comfortable seeking help in a culturally familiar context, where teacher-student interactions are highly valued (Abildina et al., 2024; Nurgaliyeva et al., 2023).

5.3. Subject-specific challenges

The results show that the clarity of terms varies by subject, with the most unclear terms identified in Natural Sciences, followed by Math and IT. This finding aligns with prior research that suggests subjects with more abstract or technical terminology, like natural sciences, pose greater challenges for students (Sadler et al., 2004; Sengupta et al., 2013; Sinatra et al., 2014). Interestingly, students in general secondary schools reported more problems with math terminology, while those in gymnasiums and schools for gifted children identified more issues in natural sciences. This variation may reflect differences in curricular focus or teaching methods across different school types, highlighting the need for tailored instructional strategies to address subject-specific terminology challenges.

The subject-specific analysis shows that illustrations were considered most useful in IT textbooks (85.3%), followed by Natural Sciences (84.0%), and least useful in Math (74.5%). This significant difference (p = 0.010) likely reflects the nature of each subject. In subjects like IT and Natural Sciences, which often involve complex processes and abstract concepts, visual aids like diagrams, charts, and illustrations play a crucial role in helping students understand difficult material (Abdulrahaman et al., 2020; Bobek & Tversky, 2016; Dunlosky et al., 2013; Evagorou et al., 2015).

On the other hand, the relatively lower perceived usefulness of illustrations in Math could indicate that students find textual explanations or problem-solving exercises more beneficial for understanding mathematical concepts. This finding aligns with previous studies suggesting that mathematical reasoning is more reliant on abstract thinking and symbolic representations than visual aids (Richland et al., 2012; Van Garderen & Montague, 2003).

The higher percentage of students who were unsure about the usefulness of illustrations in Math (21.2%) further supports the notion that visual aids in mathematics might require careful integration to be effective.

Given these subject-specific challenges, policymakers should emphasize subject-adapted improvements in textbook design. For mathematics, including more step-by-step examples may be more beneficial than illustrations, whereas in IT and Natural Sciences, expanding the use of diagrams, visual aids, and real-world analogies can enhance understanding. Future textbook revisions should integrate these differentiated approaches to optimize student learning outcomes.

5.4. Strategies for resolving unclear terms

The study found that the majority of students (65.8%) rely on teachers to resolve unclear terms, and this strategy was significantly more effective than others (89.5% clarity). In contrast, strategies such as

looking for online resources or searching for translations were less effective, and ignoring unclear terms led to the lowest clarity (45.2%). These findings underscore the pivotal role that teachers play in helping students navigate complex academic language and suggest that students may lack the skills or resources to independently resolve terminology issues. This finding echoes previous research on the importance of teacher support in facilitating academic language acquisition (Lucero, 2014; Zhang & Zou, 2024).

5.5. Impact of school type

The results also show clear differences in the strategies used by students from different school types. Students from general schools tend to rely more heavily on teachers, while gymnasium students are more likely to use translations and ignore unclear terms. This could be due to differences in instructional approaches across school types. General schools may focus more on direct instruction, where teachers play a central role in explaining terminology. In contrast, gymnasiums and schools for gifted children may encourage more independent learning, where students are expected to seek out translations or other resources on their own.

This finding suggests that instructional strategies should be adapted to the specific needs of different student groups. In general, schools, where students are more reliant on teachers, providing additional teacher training on how to effectively explain complex terms could improve student comprehension. In contrast, students in gymnasiums and schools for gifted children may benefit from more structured guidance on how to use online resources and translations effectively, as these are the strategies they are more likely to employ (Dickhäuser et al., 2017; Scheider et al., 2023).

5.6. Role of illustrations and number of terms

The study also highlighted the importance of additional illustrations in helping students understand textbook terms, with 81.1% of participants finding illustrations useful. This is consistent with research that suggests visual aids can enhance comprehension, particularly for abstract or technical concepts (Carney & Levin, 2002; Slough et al., 2010).

The significant influence of urban residence and language of instruction on the preference for additional illustrations suggests that students from urban areas and those studying in Russian may have greater exposure to or familiarity with visual learning aids. Urban students likely have better access to educational technology and resources that emphasize visual learning, making them more accustomed to relying on illustrations to aid comprehension. Meanwhile, the preference for illustrations among Russian-speaking students may reflect differences in the availability of resources, as Russian-language textbooks and supplementary materials often include more illustrations compared to Kazakh-language materials (Bekzhanova, 2024; Kucherbayeva & Smagulova, 2023).

However, the number of terms in the textbook had a significant impact on clarity: students who reported a 'middle' number of terms experienced the highest clarity (89.9%), while those with a 'high' number of terms reported the lowest clarity (70.8%). This suggests that textbooks with an overload of terminology may overwhelm students, while a balanced approach facilitates better understanding (Fischer et al., 2015).

5.7. Recommendations for improving term clarity

The results highlight the importance of teacher support in helping students understand unclear terms, particularly in Kazakh-speaking schools and general schools. This finding underscores the need for professional development programs that equip teachers with effective strategies for explaining terminology, especially in subjects like natural sciences, math, and IT, where students reported the most difficulty.

Additionally, the reliance on online resources among Russian-speaking students and students from gymnasiums suggests that schools should provide access to reliable and high-quality digital resources. Encouraging students to critically evaluate these resources could further enhance their independent learning skills.

Participants suggested several methods for improving the clarity of textbook terms, including additional illustrations, practical examples, short descriptions, and additional study materials. However, no significant differences were found in the effectiveness of these methods in improving clarity, suggesting that a combination of strategies may be needed to address the diverse needs of students. Future research could explore the specific conditions under which each strategy is most effective and how they can be integrated into textbook design and classroom instruction.

Nevertheless, these findings underscore the importance of considering both gender differences and subject-specific needs when designing textbooks and instructional materials. While additional illustrations are broadly effective across subjects, particularly in IT and Natural Sciences, their impact in Math may be limited. Therefore, educational content developers should take into account the varying effectiveness of visual aids and ensure that illustrations are tailored to the specific learning requirements of each subject. Moreover, our findings emphasize the importance of tailoring additional materials to meet the specific needs of students based on their demographic and educational contexts. Thus, teacher training should incorporate best practices for explaining terminology, particularly in subjects like Natural Sciences and Mathematics, where students face greater challenges. The integration of digital resources, such as interactive glossaries and multimedia explanations, could also be explored as part of future educational reforms.

5.8. Limitations and future directions

While this study provides important insights, it is not without limitations. First, the study relied on self-reported data, which may be subject to bias, particularly in terms of students' perceptions of term clarity. Additionally, while the study included a diverse sample of students from various school types, it did not capture the full range of potential factors, such as socio-economic background, that may influence term clarity. Future research should consider these factors and explore how different teaching strategies and resources can be optimized to improve terminology understanding across various contexts.

The study evaluates the terminological apparatus in natural and mathematical textbooks but does not extensively analyze other subjects or aspects of the textbooks, such as instructional design or visual aids. A more comprehensive analysis could provide deeper insight into the overall quality of educational materials.

Perform comparative studies between different regions, schools, and educational systems to identify best practices and successful strategies for terminology instruction. Comparing Kazakhstani textbooks with those of other countries could also provide valuable insight.

Investigate the effectiveness of integrating digital resources and interactive tools in improving understanding of terminology. Research could assess how these tools impact student engagement, satisfaction, and learning outcomes.

Expand the scope of research to include the evaluation of the terminological apparatus in other subjects, such as social sciences, languages, and technical subjects. Understanding terminological challenges in different disciplines can inform more holistic improvements in educational materials.

Design and implement intervention studies to test specific strategies to improve terminological clarity and accessibility in textbooks. Examples include the use of glossaries, visual aids, real-life examples, and teacher training programs. Measuring the effectiveness of these interventions can provide evidence-based recommendations for policymakers and educators.

6. Conclusions

In conclusion, this study highlights the significant role that gender, language, and teacher support play in determining students' understanding of textbook terms in Kazakhstani schools. Addressing these factors through targeted interventions and improvements in textbook design, such as balancing the number of terms and incorporating effective visual aids, could help enhance term clarity and improve overall educational outcomes. By recognizing the diverse needs of students and providing adequate support, educators and policymakers can ensure that all students have access to clear and comprehensible educational materials.

While this study provides key insights, its reliance on self-reported data may introduce bias, and it does not account for broader contextual factors such as socio-economic background or teacher perspectives. Future research should explore these influences and examine how different instructional strategies impact terminology clarity. Expanding the study to other subjects and conducting comparative research across educational systems could further enhance our understanding. Additionally, testing interventions such as structured glossaries, digital resources, and teacher training programs could provide actionable solutions for improving textbook terminology clarity.

Authors' contributions

Conceptualization, SN and SA; methodology, AZh, TK, BK, and AU; software, AZh, TK, BK, and AU; formal analysis, AB; resources, SN and SA; data curation, AZh, TK, BK, and AU; writing—original draft preparation, SN and AB; writing—review and editing, SA; supervision, BK and SA. All authors have read and agreed to the published version of the manuscript.

Institutional review board statement

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Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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