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ARTICLE

The Language of Memory and Pedagogical Discourse: Representing Nuclear Testing in School Curricula of the USA and Kazakhstan

Maksat Zhanibek [1*] **, *Karlygash Aubakirova*** [2] **, *Gulmira Mussinova*** [3] **, *Kuralay Tulebayeva*** [3]

[1] *Department of History and Geography, Alikhan Bokeikhan University, Semey 071400, Kazakhstan*

[2] *Department of Kazakh Philology and Journalism, Shakarim University of Semey, Semey 071412, Kazakhstan*

[3] *Department of Philology, Alikhan Bokeikhan University, Semey 071400, Kazakhstan*

ABSTRACT

This article presents a discourse-oriented and pedagogical-linguistic analysis of how nuclear testing is represented in school textbooks, focusing on the comparative contexts of the United States and Kazakhstan. The study investigates how nuclear-related content is linguistically constructed and pedagogically communicated in secondary education, with particular attention to discourse structures, lexical choices, and task types. A content analysis of Kazakhstani history textbooks, especially those addressing the Semipalatinsk Test Site, revealed a predominance of descriptive and fact-based language that limited students' interpretive engagement. In contrast, an examination of U.S.-based resources, including materials from the National WWII Museum, the Bradbury Science Museum, and the Columbia AFE Project, demonstrated the use of multimodal representations, problem-oriented tasks, and inquiry-driven narratives that foster critical reflection. The methodological framework combined discourse analysis, genre-based pedagogy, and a comparative review of textbook language to highlight how narrative modes, rhetorical strategies, and evaluative lexis influence the construction of nuclear literacy. The findings indicate that U.S. educational discourse tends to integrate argumentative and reflective strategies, whereas Kazakhstani materials remain largely expository. The article argues that enriching Kazakhstan's history education with discourse-rich and genre-aware practices—emphasizing multimodal design, the pragmatic functions of historical narratives, and text-mediated learning—would enhance students' capacity for critical engagement with complex historical phenomena.

*CORRESPONDING AUTHOR:

Maksat Zhanibek, Department of History and Geography, Alikhan Bokeikhan University, Semey 071400, Kazakhstan;
Email: m.zhanibekov@gmail.com

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1. Introduction

The discourse surrounding nuclear test sites should not be confined solely to military or geopolitical narratives. Rather, it represents a multidimensional topic that invites interdisciplinary linguistic analysis across educational genres. In particular, it includes environmental discourse, health communication, and socio-historical narratives that require careful examination of how language constructs meaning and positions readers. Nuclear testing and its consequences are encoded through a variety of semiotic and discursive means in educational texts, including lexical choices, evaluative framing, and narrative structures. These linguistic constructions shape students' perceptions of historical relevance and influence how memory is institutionalized in the school context[1].

From a discourse-analytical perspective, the way nuclear themes are represented in school curricula plays a crucial role in forming students' interpretive stances and epistemological engagement with risk, science, and social responsibility. Textbooks that incorporate explicit argument structures, causal connectors, and value-laden lexis contribute to a deeper cognitive and pragmatic understanding of nuclear-related issues. Educational discourse thus becomes a site of both knowledge transmission and identity construction, particularly in contexts that have experienced nuclear events firsthand[2].

Historically, the first documented reference point in nuclear education is often the "Trinity" test of 1945. Subsequent global nuclear testing campaigns — carried out by various states — are represented in textbook discourse through chronological listing, statistical data, and schematic illustrations. However, such presentations frequently lack discursive diversity and overlook genre-specific strategies that encourage critical reflection, such as contrastive comparisons, narrative scenarios, or embedded voices. These representational choices affect how students linguistically engage with the material and interpret the scope and implications of nuclear history.

In Kazakhstan's educational context, the discursive treatment of nuclear topics remains limited in scope and depth. Current curricula often prioritize factual enumeration over interpretive or analytical engagement. Key concepts such as radiation, environmental contamination, and technological risk are typically presented in decontextualized formats. As a result, students are seldom exposed to the pragmatic functions of such discourse, including hypothesis formation, ethical reasoning, and intertextual connections. To address these issues, the integration of nuclear themes into school curricula should rely on genre-aware, linguistically enriched pedagogical models that support multimodal comprehension, narrative empathy, and scientific literacy.

2. Materials and Methods

This study applied a set of qualitative research methods rooted in discourse and genre analysis, including historical textual review, comparative discourse analysis, and content analysis of pedagogical materials. The historical dimension of nuclear education was approached not only through chronology but also through the discursive framing of cause–effect relationships and the rhetorical structuring of narrative sequences in educational texts from Kazakhstan and the United States. Special attention was paid to the linguistic realization of explanatory and argumentative structures related to the Semipalatinsk Test Site and other key nuclear events.

Content analysis was used to examine how the topic of nuclear testing is encoded in the lexical, syntactic, and semantic layers of ninth-grade history textbooks in Kazakhstan. This included an exploration of how nuclear discourse is framed in tasks and exercises, such as the degree of evaluative language, the presence of modality, and the use of interrogative and imperative constructions to engage students in analytical reasoning. Parallel analysis of U.S. educational materials (e.g., PBS, FPRI, and the National WWII Museum) allowed for comparison of genre conventions, multimodal integration, and pedagogical pragmatics in textbook design.

The comparative approach enabled the identification of similarities and differences in genre structuring, thematic pro-

gression, and discursive strategies across both education systems. For instance, U.S. materials tend to include problem-oriented tasks and perspective-taking prompts, whereas Kazakhstani materials often rely on fact-reproductive modes of instruction. Documentary discourse analysis extended to academic publications, curricular guidelines, and museum-based educational content, allowing for an in-depth study of linguistic representations of nuclear history across institutional genres.

The research also focused on how school texts facilitate critical discourse engagement. This was operationalized through the analysis of textbook questions, tasks, and expository paragraphs, assessing whether they promote reflective reading, inference, and discursive argumentation. Findings suggest that the development of students' discursive competence in this domain requires not only factual content but also linguistically rich formats that support cognitive activation and pragmatic inference.

The corpus of sources was divided into four functional categories:

1. Academic discourse. Peer-reviewed articles discussing the linguistic and discursive representation of nuclear testing, disarmament, and environmental narratives. Authors such as L. Kenausis and R. C. Ewing contributed to the conceptual framing of nuclear-related texts as complex sociolinguistic artifacts.
2. Educational platforms and scholarly blogs. Resources such as PBS LearningMedia and Columbia University's AFE Project were analyzed for their use of multimodal pedagogical discourse, including video narration, historical simulation scripts, and reflective writing prompts.
3. National curricular materials. ninth-grade textbooks (Kazakhstan History, Global Competencies, and World History) were studied for their semantic density, textbook genre conventions, and text-task alignment with regard to nuclear topics.
4. Museum-based educational discourse. Institutional exhibits and online materials (e.g., Bradbury Science Museum, Chernobyl Museum) were examined as examples of experiential and narrative discourse in informal education settings, integrating visual and verbal semiotic resources.

Altogether, the analyzed materials formed a coherent linguistic base for comparing nuclear education practices through the lens of textual structure, discourse typology, and pedagogical genre variation.

3. Results

The Global Practice of Nuclear Testing: A Historical Overview

Since the first nuclear test detonation on July 16, 1945, nuclear discourse has evolved into a complex semiotic field reflecting global concerns, scientific innovation, and ethical debates. Educational materials and historical texts often recount that more than 2,000 nuclear tests were conducted by at least eight countries across various geographic zones, including Lop Nur (China), the Pacific atolls, the Nevada Test Site (USA), Algeria, Western Australia, the South Atlantic, the Semipalatinsk Test Site (Kazakhstan), and several Russian territories [3]. From a discourse-linguistic perspective, such enumeration of test locations in educational texts serves multiple rhetorical and didactic functions: it contextualizes the global scope of nuclear experimentation, introduces spatial deixis and geopolitical toponyms, and invites learners to interpret spatial distribution through cognitive mapping strategies. This global scope is visually represented in **Figure 1**, which illustrates the distribution of nuclear tests conducted worldwide between 1945 and 2017.

In educational discourse, the presentation of historical data regarding test environments often adopts a neutral or technocratic tone, especially in the earlier stages of curricular development. However, recent textbook analyses show increasing attention to the human impact implicit in spatial descriptors. For instance, the reference to test sites being "remote" or "distant from capital cities" encodes both geographical and sociopolitical distancing, subtly foregrounding the center–periphery dynamic in nuclear decision-making. The phrase "regions inhabited by local populations" introduces ethical undertones through agent suppression and passive construction, which are common linguistic strategies in institutional narratives that aim to downplay responsibility or soften evaluative content. The historical fact that more than 528 atmospheric explosions occurred before test bans is usually presented in quantitative lexical bundles within textbooks, which contribute to the perception of magnitude but often omit qualitative or affective perspectives [3]. In this

regard, the linguistic encoding of nuclear history remains predominantly referential and enumerative, with limited inclusion of personal or narrative discourse that could highlight the lived experiences of affected populations. This tendency is further illustrated in **Table 1**, which presents global data on nuclear testing.

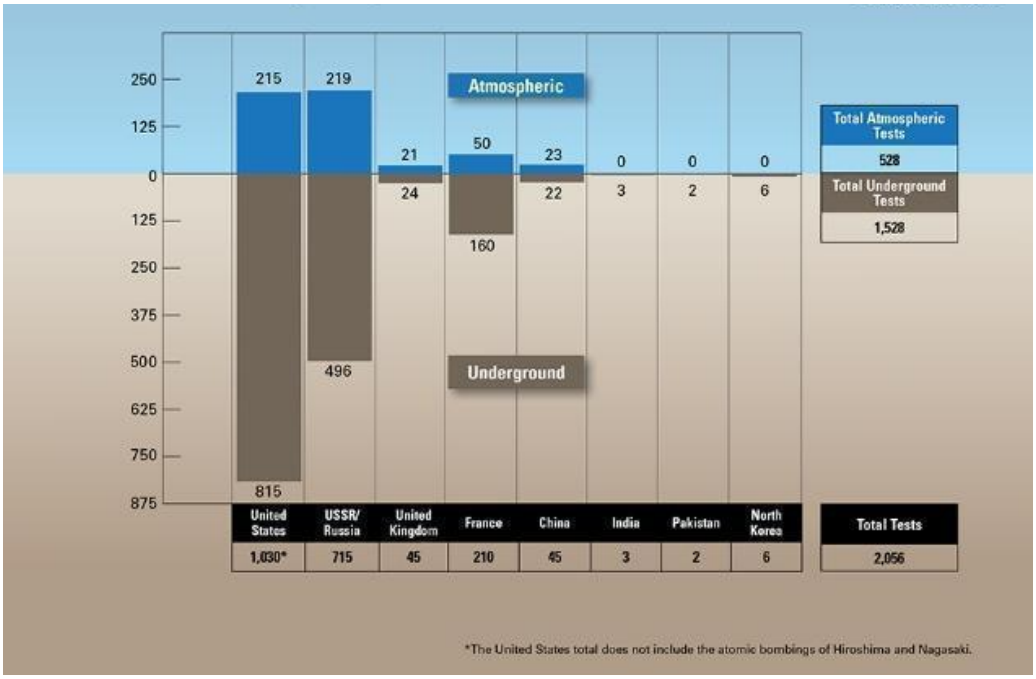

Figure 1. Global distribution of nuclear tests (1945–2017)[3].

Table 1. Global data on nuclear testing[3].

Test Type	United States	USSR/Russia	United Kingdom	France	China	India	Pakistan	North Korea	Total
Atmospheric	215	219	21	50	23	0	0	0	**528**
Underground	815	496	24	160	22	3	2	6	**1,528**
Total	**1,030** [1]	**715**	**45**	**210**	**45**	**3**	**2**	**6**	**2,056** [2]

Note: [1] Includes joint U.S.–U.K. nuclear tests conducted at the Nevada Test Site. [2] The total number may vary due to differences in classification and reporting practices among sources.

The representation of nuclear weapons in educational discourse often begins with the referential event of the 1945 atomic bombings of Hiroshima and Nagasaki. This event is widely presented in textbooks as a point of entry into the broader thematic field of nuclear history. From a linguistic perspective, such narrative framing often emphasizes causality, exemplification, and emotional intensification, establishing the genre convention of historical recounts blended with evaluative discourse.

Following World War II, textbooks frequently frame the geopolitical climate of the era through binary oppositions and ideologically marked terminology (”confrontation,” “rivalry,” “bipolar world order”). These lexical choices are embedded in the discourse of the Cold War and serve to position learners within a particular interpretive framework. As such, the educational presentation of nuclear history is not neutral: it is linguistically mediated and ideologically textured[4].

In tracing the development of nuclear technology, many pedagogical materials rely on quantitative formulations and factual enumerations (“528 atmospheric explosions,” “first test in 1949,” “Limited Test Ban Treaty, 1963”) that construct an impersonal and technical discourse[5]. However, occasional shifts toward affective language, such as references to “contamination” or “consequences,” introduce modality and stance, subtly influencing learner perceptions.

The Semipalatinsk Test Site, in particular, is presented in textbooks through a mix of factual exposition and eval-

uative modifiers, such as "significant" and "catastrophic." These lexical items function as discursive intensifiers, framing the event not only as historical data but also as a marker of collective memory within national educational narratives. The linguistic coding of nuclear testing thus plays a central role in shaping epistemological access to past events [3].

The article "Nuclear Disarmament Education Is Needed Now More Than Ever" [6] offers insight into how educational discourse constructs the theme of nuclear testing as a global and interdisciplinary issue. From a linguistic standpoint, this construction is often realized through the use of inclusive pronouns, affective lexis, and evaluative modality, which serve to position learners within a shared moral and epistemological community.

In such materials, nuclear discourse extends beyond specialist vocabulary and adopts features of publicly oriented pedagogical communication, with linguistic choices that foreground values such as cooperation, responsibility, and ethical reflection. These traits are linguistically marked by universalizing expressions ("for society at large," "younger generations"), which establish a collective subjectivity and appeal to shared norms.

Pedagogical materials on nuclear education often employ rhetorical strategies typically found in civic or global education discourse: for instance, positioning the student as a "global actor" or "future decision-maker" reflects the use of projective and agentive language, in which learners are constructed not just as recipients of knowledge but as participants in knowledge-based action. This rhetorical move is characteristic of a moralizing register, which draws on lexical and syntactic structures intended to elicit engagement and personal investment.

The discourse also features common genre-based tensions between informational density and motivational framing. While acknowledging curricular limitations and teaching workloads, such texts include motivational scaffolding to maintain the relevance of the topic. This is typically achieved through contrastive conjunctions ("nevertheless," "however") and prospective statements that embed values of foresight and critical awareness in future-oriented expressions ("tomorrow's decision-makers").

The overarching communicative goal of this discourse is to integrate nuclear education into broader civic and interdisciplinary frameworks. From a linguistic perspective, this is reflected in the blending of expository and hortatory styles, where factual content is interspersed with calls for reflection and moral positioning. Such hybrid discourse genres are increasingly prevalent in 21st-century educational texts that aim to align subject-matter content with competencies in critical thinking and ethical reasoning.

Sarah Z. Kutchesfahani, writing in the academic journal *Bulletin of the Atomic Scientists*, comments on the discursive invisibility of nuclear-related topics in contemporary U.S. school curricula. Her statement emphasizes the consequences of excluding such content, employing a rhetorical strategy based on conditional modality: "*If school administrators, curriculum developers, teachers, and professors ignore the topic of nuclear weapons and fail to incorporate it into classroom curricula, society will remain unaware of the existential threat posed by these devastating weapons and the professional field will suffer as a result*" [7]. Through this assertion, the nuclear policy researcher highlights the lack of attention paid to nuclear education in U.S. schools. She underscores the urgent need to incorporate nuclear history into educational programs and calls for systematic action at the state level to bring this issue to public attention.

This type of discourse — common in expert-driven educational advocacy — frequently relies on evaluative lexis ("existential threat," "devastating weapons," "fail to incorporate") and registers of urgency, which are used to mobilize educational stakeholders (such as administrators, curriculum developers, and instructors). The pragmatic function of such discourse is not only to inform but also to persuade, reflecting its hybrid nature at the intersection of academic commentary and policy-oriented recommendations.

Statements like these reflect a broader genre of educational reform discourse, in which language is used performatively to reframe curricular priorities. From a stylistic point of view, the emphasis on professional consequences ("the professional field will suffer") introduces institutional self-reference, reinforcing the speaker's authority and the legitimacy of the call to action.

In recent years, the discourse on nuclear education has expanded to include references to contemporary technological developments. However, educational materials typically recontextualize such developments within curricular boundaries through controlled vocabulary and genre-specific simplifications. Rather than detailing technical or geopolitical

specifics, materials often present nuclear themes in relation to energy discourse, environmental literacy, or scientific ethics in science education.

Within this context, initiatives such as the Nuclear Weapons Education Project at the Massachusetts Institute of Technology (MIT) exemplify the institutionalization of nuclear discourse within formal education. The project includes lectures and media-based pedagogical tools (such as film screenings), that represent a multimodal approach to disciplinary integration. Linguistically, such initiatives demonstrate a shift from monologic, textbook-based exposition toward interactive and affective communication, aimed at enhancing student engagement.

This evolution is marked by the adoption of participatory genres — including workshops, seminars, and audiovisual storytelling — that embed technical knowledge within narrative and dialogic formats. The goal is not only to convey content but also to foster a sense of interpretive agency among learners, aligning nuclear education with broader trends in competency-based and inquiry-driven learning.

The educational initiative described in the Nuclear Weapons Education Project has recently extended its scope to include secondary-level learners through the development of accessible, scientifically contextualized lecture formats. In linguistic terms, the project's communication strategy reflects a shift toward audience-sensitive register adaptation and interdisciplinary collaboration, with nuclear policy specialists such as Sara Kutchesfahani and Erin Connolly collaborating with educators in social studies and world history to co-develop educational content that conforms to school-level curricular frameworks and pedagogical conventions.

From a discourse perspective, this collaborative effort exemplifies genre hybridity, combining elements of expert discourse with instructional design. The lexical and structural choices made in educational materials – such as simplifying technical terminology, using examples, and contextual framing — are aimed at increasing comprehensibility and learner engagement. These features reflect broader principles of knowledge mediation in educational linguistics.

A dedicated website has also been developed to disseminate project materials and organize thematic content for various audiences. This move toward digital educational discourse signifies a growing reliance on web-based multimodal platforms for curriculum delivery. The platform serves not only as a repository of information but also as an interface for interactive knowledge exchange, illustrating the role of digital genres (educational blogs, video lectures, and infographics) in shaping student access to specialized knowledge domains.

The project positions itself within a public pedagogy framework, aiming to cultivate interest in nuclear topics among young learners. Its success is measured not only through quantitative indicators but also through qualitative markers of discourse impact, such as increased learner motivation and self-initiated exploration. Statements suggesting that the project is successful if "even a few students" pursue the topic further point to an affective dimension of educational discourse, in which emotional engagement and intrinsic curiosity are valued as pedagogical outcomes [1].

4. Discussion

4.1. Developing Nuclear Literacy: Content and Methodological Differences in Secondary Education Systems of the USA and Kazakhstan

The article *Teaching the Nuclear Age: A History Institute for Teachers* [8] presents a range of pedagogical strategies for introducing the topic of nuclear testing within school curricula. It adopts an interdisciplinary instructional model that integrates historical, environmental, and societal themes through multimodal educational resources, such as video materials, scripted lectures, and classroom-ready lesson plans. These materials are designed to mediate complex historical content via accessible genres and formats, allowing for narrative personalization (testimonies of individuals involved in nuclear programs), which in turn fosters affective engagement and enhances student identification with historical discourse.

From a discourse-analytical perspective, the article emphasizes the pragmatic role of experiential framing in educational communication. By embedding content within first-person narratives and visually supported genres, the material aims to reduce cognitive distance and increase students' empathy and comprehension. The discursive shift from impersonal historical narration to embodied experience represents a significant evolution in the genre conventions of teaching controversial or complex topics [8]. Jeffrey Lewis notes that effective nuclear education must combine factual

knowledge with analytical exercises that engage students in evaluating the risks and ethical implications of nuclear weapons, thereby fostering critical thinking and responsible citizenship[9].

Further insight is provided by Columbia University's Asia for Educators (AFE) website, which offers curated materials to promote critical-interpretive competencies in students. These resources include question sets and assignments that are structured to elicit reflexive reasoning, inviting students to articulate their own positions in relation to historical decisions. The language used in the assignments encourages dialogic learning through modality, open-ended questioning, and moral dimension framing, as seen in tasks such as, "What were the causes and consequences of using the atomic bomb?" and "What are the moral dimensions of political decisions?"[10].

In terms of methodology, AFE's framework supports collaborative meaning-making, recommending the use of group discussions, structured debates, and document-based analysis. These strategies align with constructivist educational discourse, wherein learners are positioned as active participants in the co-construction of historical knowledge. The instructional design thus reflects a shift from transmission-based models to student-centered discursive environments, where the interpretation of nuclear history is mediated by dialogical interaction, peer feedback, and inquiry-based learning[10].

On the U.S.-based educational platform *PBS LearningMedia*, the video segment titled *The Cold War and the Nuclear Weapons Threat: Retro Report* is presented as a concise multimodal teaching resource[11]. This six-minute video uses visual narration, archival footage, and commentary to represent the nuclear dynamics of the Cold War through culturally embedded discourses. The resource is linguistically structured to engage students in comparative historical reasoning, prompting reflection on questions such as "What decisions made during the Cold War were right or wrong?" and "How should nuclear security be ensured in today's world?" Such questions introduce modality and evaluative stance, key features in developing critical-discursive competence in learners.

From a discourse-analytical perspective, the video combines factual exposition with speculative inquiry, encouraging learners to navigate between historical narrative genres and hypothetical reasoning. This type of multimodal instruction supports interpretive flexibility, allowing students to actively construct meaning rather than passively absorb information.

Another example is the article *Beyond the Decision: Strategies to Teach the History of the Atomic Bombs and the End of World War II*[12], which provides methodological insights into delivering lessons on the atomic bombings and the conclusion of World War II. Developed by The National WWII Museum, the resource emphasizes multi-voiced narrative construction and the use of diverse textual genres – ranging from official documents and military archives to personal letters and testimonies. The discursive strategy centers on polyphonic framing: students are encouraged to engage with multiple perspectives (American, Japanese, and international) and to examine how narrative positioning and voice shape the representation of historical events.

Pedagogically, this approach fosters critical textual engagement by requiring learners to evaluate competing narratives and reflect on the ethical, cultural, and pragmatic dimensions of historical decisions. The emphasis lies not on content memorization, but on metalinguistic awareness, source triangulation, and dialogic reasoning.

The comparison of these materials with current practices in Kazakhstan reveals a significant difference in pedagogical discourse orientation. While U.S. resources adopt a constructivist, inquiry-based model grounded in argumentation and student agency, Kazakhstani materials largely rely on expository and monologic structures. The U.S. model promotes a transition from informational discourse to exploratory discourse, aiming to develop students' abilities to formulate arguments, evaluate source credibility, and articulate independent interpretations — key competencies in the contemporary global communicative environment.

An examination of history instruction methodology in the United States reveals a distinct emphasis on discourse practices that stimulate higher-order thinking. Rather than relying on fact-based, closed questions such as "What nuclear event occurred in the United States in 1945?", educational materials increasingly prioritize open-ended, evaluative prompts — for example, "What were the global moral and political implications of the atomic bombings of Hiroshima and Nagasaki?" Such question design reflects a pragmatic-linguistic shift toward epistemic engagement and argumentative discourse, inviting students to interpret historical events through

subjective positioning and intertemporal reflection.

These discursive features align with pedagogical models that support critical literacy — a competency that encompasses not only the decoding of content but also the capacity to interrogate narratives, question assumptions, and evaluate the consequences of past actions within contemporary contexts. Accordingly, U.S. curricula adopt inquiry-based frameworks that blend historical interpretation with communicative performance, encouraging learners to construct meaning through dialogic interaction with texts, peers, and instructional materials.

Although direct structural comparisons between the U.S. and Kazakhstani education systems must account for their respective socio-educational contexts, one observable contrast lies in the linguistic and cognitive orientation of curricular design. The U.S. approach tends to foreground evaluative and exploratory discourse genres, whereas Kazakhstani materials, particularly in the context of nuclear history, often rely on expository and descriptive genres that prioritize factual recall over interpretive depth.

For instance, while the history of the Semipalatinsk Test Site is included in Kazakhstan's school textbooks, the presentation is frequently limited to chronological listings and outcome summaries. This didactic register constrains students' opportunities to engage in reflective discourse, formulate value-based judgments, or explore the thematic complexity of nuclear history from ethical and intercultural perspectives.

To enhance nuclear history education in Kazakhstan, a shift toward genre diversification, task-based pragmatics, and critical discourse scaffolding is recommended. By integrating nuclear topics within a broader curricular discourse on peace culture and global awareness, educators can foster learners' abilities to critically navigate historical texts, develop informed stances, and articulate their interpretations within ethically grounded and socially relevant frameworks. This approach positions nuclear history not merely as a historical topic, but as a discursive field for civic identity formation and communicative competence in a globalized world.

4.2. The Semey Nuclear Test Site and Nuclear Education Issues in Kazakhstani School Textbooks: A Textbook Review

The history of the Semipalatinsk nuclear test site occupies a significant place within both national memory discourse and globally oriented educational narratives. Analyzing how this topic is linguistically constructed in the school history curriculum provides insight into the discursive framing, semantic density, and cognitive accessibility of textbook materials, as well as the extent to which these texts promote critical interpretive engagement among students.

Within this study, a qualitative content analysis was conducted on ninth-grade textbooks used in general secondary education institutions across Kazakhstan. The selected materials included *History of Kazakhstan* [13], *World History* [14], and *Global Competencies* [15]. The central research question addressed was: "What discourse strategies and representational choices are employed in Kazakhstani textbooks when presenting the history of nuclear testing?" The analytical focus on ninth-grade textbooks is pedagogically justified, as the curriculum at this level addresses mid- to late-20th-century events — most notably the period following 1949, when the Semipalatinsk test site became historically relevant.

Textbooks for this grade level typically cover the sociopolitical and scientific developments of the 20th century, including the emergence of nuclear technologies and their local implications. In contrast, tenth- and eleventh-grade textbooks emphasize post-independence national development, thus making the ninth-grade materials the most appropriate corpus for examining lexical choice, genre structure, and pedagogical modality in representations of nuclear history.

The objective of the study was to explore how the Semipalatinsk test site — and nuclear issues more broadly — are positioned within educational discourse, and how such positioning affects students' acquisition of conceptual knowledge related to nuclear safety, discourses of peace, and civic epistemology. The findings offer a linguistic and pragmatic lens through which to evaluate the textbooks' potential to support not only factual comprehension but also dialogic reflection, semantic evaluation, and multimodal meaning-making in the context of complex historical themes.

As part of an evaluative discourse-analytical study of how nuclear testing is presented in Kazakhstan's secondary school history curriculum, a content-based review was conducted on the 9th-grade textbook *History of Kazakhstan (from 1945 to the present)* [13]. This textbook, approved for use under the national education standard, is publicly accessible through Kazakhstan's official digital platform — okulyk.kz.

Within the chapters "Kazakhstan in the Postwar Years

(1946–1953)" and "The Establishment of the Military-Industrial Complex in Kazakhstan," the Semipalatinsk Nuclear Test Site is briefly introduced. The representation includes general information regarding the site's creation, early testing, and the resulting environmental and demographic impacts[13]. Linguistically, the material demonstrates a factual, denotative register with limited engagement in narrative framing or emotive language, favoring an encyclopedic style.

From a methodological perspective, the textbook includes a research-based learning task that encourages students to seek additional materials on the Semipalatinsk Test Site and to engage with audiovisual content (a documentary film)[13]. This suggests an intent to promote multimodal literacy and independent source evaluation, though the instructions remain open-ended and are not scaffolded with critical discourse prompts.

Subsequent chapters, such as "Demographic Processes in Kazakhstan during the Perestroika Years" and "Socio-Political Movements in Kazakhstan," include a brief reference to the Nevada–Semipalatinsk movement. However, the section occupies less than half a page, and the linguistic framing remains informational rather than analytical. The tasks following the section — which include *"What was the goal of the Nevada–Semipalatinsk movement?"* and *"What forms of struggle did this organization use to achieve the closure of nuclear test sites?"* — are formulated in a closed, fact-recall format[13], limiting opportunities for interpretative reasoning, perspective-taking, or semantic negotiation.

In sum, the textbook provides a basic referential framework for the topic but lacks the textual strategies and discursive scaffolding necessary to cultivate reflective engagement with nuclear history as a linguistically and ideologically charged narrative domain.

Although the textbook includes content related to the Semipalatinsk Nuclear Test Site and references the anti-nuclear movement, these topics are presented primarily through a brief, fact-oriented narrative. The dominant discursive mode remains informative-descriptive, with limited presence of interactive, reflective, or inquiry-based language structures. Consequently, tasks that could stimulate critical thinking, promote discourse-based reasoning, or foster student engagement with multimodal and source-critical materials are underdeveloped.

The representation of nuclear history in the analyzed textbooks tends to rely on chronological and statistical enumeration, focusing on key data points such as the initial test year (1949), the approximate number of detonations (around 450), and the closure year (1991). While these facts are linguistically structured in a declarative mode, they lack contextual elaboration, narrative framing, or dialogic questioning strategies that would enable deeper learner engagement.

For example, in the *ninth-grade Global Competencies* textbook[15], the Semipalatinsk topic is briefly mentioned within the section on environmental sustainability. The text consists of four sentences, framed as a "Keep in Mind" box, and references the estimated number of affected individuals[15]. However, this formulation remains lexically minimalistic and lacks any pragmatic scaffolding that would guide students toward reflective interpretation or ethical evaluation.

Similarly, the *9th-grade World History* textbook[14] addresses the global discourse on nuclear weapons in the context of Cold War geopolitics but omits any direct reference to Semipalatinsk or other test sites. The dominant focus remains on the rivalry between the USSR and the U.S.[15], and the associated nuclear threat is presented in generic internationalized terms, without localization or connection to Kazakhstan's socio-historical experience[16].

The overall textual analysis of these materials reveals an underutilization of pedagogical linguistics tools, such as evaluative modality, epistemic stance-taking, and critical questioning formats. History education, in its current configuration, leans heavily on rote memorization and factual recall tasks, such as *"In what year was the first nuclear test conducted?", "Where did it occur?", "How many tests were carried out?"*[17]. These univocal question formats restrict opportunities for dialogic engagement or metadiscursive reflection.

To enhance students' analytical and argumentative competencies, a shift toward higher-order question prompts is recommended. For instance, *"What socio-geographic factors may have influenced the selection of the Semipalatinsk region?"; "How do you interpret the linguistic framing of nuclear testing in historical narratives?"; "How does language shape our perception of scientific achievement versus humanitarian impact?"; and "What kinds of lexical or rhetorical strategies would you expect in a textbook aiming to promote a peace-oriented worldview?"* Such prompts activate not only cognitive complexity but also metalinguis-

tic awareness and the capacity for discourse ethics. This linguistically informed approach situates the topic within a broader textual and semantic ecology, encouraging students to interrogate how nuclear history is represented, legitimized, and transmitted through educational discourse.

If the subject of history is taught through rote learning and fact-recitation, several linguistic-cognitive limitations may emerge that hinder students' development as critical language users and reflective learners [18]. Firstly, the conceptualization of historical discourse may be reduced to lexically dense lists of names and dates, preventing students from constructing coherent mental representations of causal relationships and temporal dynamics. Secondly, when history is framed as a discipline for memorization rather than interpretation, students may disengage from the subject and perceive it as semantically inert — a body of inert facts rather than a medium for discourse-based reasoning.

Most importantly, students may be deprived of opportunities to develop key textual and communicative competencies, such as historical argumentation, evaluative stance-taking, and the ability to justify perspectives through language. In this regard, historical literacy is not only about content retention but about learning to formulate, communicate, and negotiate meanings in socially significant contexts [19].

To revitalize the linguistic and cognitive value of history education, it is essential to restructure textbook materials and teaching approaches around dialogic, comparative, and problem-based methodologies. These approaches stimulate students to move beyond passive information reception toward discourse production, critical inquiry, and intertextual comparison. Below are several instructional strategies that reflect this paradigm:

Comparative Analysis Tasks: These tasks activate contrastive reasoning and encourage learners to analyze conceptual differences and discursive framings of historical phenomena. Example prompts: Compare the discursive representations of nuclear events at the Semipalatinsk site and in Hiroshima and Nagasaki. How do language and framing differ? How is the concept of environmental damage articulated in textbooks from Kazakhstan versus those from other countries?

Opinion-Based Questions: Prompts that require linguistic justification of individual views enhance students' argumentation skills. Example: If you were to construct a textbook section on the Semipalatinsk Test Site, which lexical and rhetorical strategies would you employ to promote ethical awareness?

Contextualization in Contemporary Discourse: By linking historical content to current events or global debates, students can practice discourse mapping and contextual reasoning. Prompts may include: How is the closure of the Semipalatinsk Test Site discussed in current international discourse? What metaphors or evaluative terms are used in media or textbooks to describe Kazakhstan's nuclear legacy?

In classroom practice, these prompts may serve as scaffolds for group discussions, written reflections, or oral presentations. The aim is not merely to learn historical facts, but to understand how such facts are constructed, represented, and communicated within academic and public discourses. This aligns with the broader shift in education from knowledge transmission to meaning-making and discourse-based engagement.

In this respect, pedagogical models from the U.S. — particularly those that emphasize source analysis, dialogic inquiry, and multimodal interpretation — may offer valuable insights for the linguistic enrichment of history instruction. Their emphasis on questioning strategies and language-centered pedagogy can inform textbook design and teacher training in other contexts as well.

4.3. Comparative Discursive Strategies in U.S. and Kazakhstani Curricula

The comparison of textbook structures in the United States and Kazakhstan provides essential contextual insights for understanding how historical and nuclear education topics, such as the Semey Nuclear Test Site, are presented to students. Differences in pedagogical goals, organizational formats, and engagement strategies shape the learning experience and influence students' comprehension and critical thinking skills [13–16]. U.S. textbooks generally prioritize critical thinking, interdisciplinary connections, and interactive learning, whereas Kazakhstani textbooks emphasize knowledge transmission and national history through a more linear, chapter-based structure.

Table 2 provides a comprehensive comparison of U.S. and Kazakhstani school textbooks, highlighting differences not only in genre focus, organization, visual support, interactivity, contextualization, and language style, but also in discursive and multimodal engagement. U.S. textbooks fos-

ter student-centered learning by integrating narrative forms, case studies, problem-solving tasks, visual aids, and interactive activities, which together promote critical reflection, argumentative competence, and real-world application [4,6,8–12]. Teachers and students actively engage with content through debates, role-playing, and multimedia resources, enabling learners to construct and evaluate historical knowledge in nuanced ways.

Table 2. Comparative Overview of Genre Structures and Organizational Features in U.S. and Kazakhstani School Textbooks.

Feature/Aspect	U.S. Textbooks	Kazakhstani Textbooks	Notes/Observations
Genre Focus	Narrative, case studies, problem-solving tasks	Expository, factual, historical narratives	U.S. textbooks emphasize critical thinking; Kazakhstani focus on content delivery
Text Organization	Modular chapters, headings, subheadings	Linear, thematic progression	U.S. texts allow flexible learning paths; Kazakhstani are more structured
Use of Visual Aids	Charts, diagrams, infographics, photos	Limited illustrations, mostly static images	Visual learning more integrated in U.S. textbooks
Interactivity/Activities	Exercises, discussions, debates, project-based tasks	End-of-chapter questions, summaries	U.S. approach encourages active engagement; Kazakhstani more passive
Contextualization/Real-world Application	Frequent references to contemporary cases, simulations	Mainly historical or theoretical context	U.S. texts link knowledge to everyday life; Kazakhstani less applied
Language Style/Readability	Accessible, student-friendly; includes argumentative and evaluative language	Formal, academic, sometimes dense	U.S. texts prioritize readability and stance-taking; Kazakhstani texts more descriptive
Discursive/Argumentative Dimension	Promotes stance-taking, claim–evidence reasoning, dialogic engagement	Limited discursive tasks; convergent questioning dominates	U.S. textbooks foster argumentative competence; Kazakhstani textbooks emphasize recall
Multimodal/Experiential Learning	Videos, simulations, case studies, interactive tasks	Mostly textual; minimal multimodal content	U.S. integrates multimodal scaffolding; Kazakhstan could expand museum and digital resources
Teacher & Student Engagement (from interviews)	Active discussion, role-play, debate	Students often passive; teachers constrained by textbook content	Highlights gap between pedagogical potential and classroom reality in Kazakhstan

Kazakhstani textbooks, in contrast, prioritize expository and historical narratives, linear text organization, limited visual materials, and formal academic language, with few opportunities for interactive or discursive tasks [13–16]. Interviews with teachers and students confirm that classroom engagement is largely shaped by textbook content, resulting in passive learning and the limited development of critical thinking, argumentation, and multimodal literacy.

The table demonstrates that differences in textbook design and pedagogical strategies significantly affect how students perceive, interpret, and engage with historical and nuclear education topics. Incorporating interactive elements, diverse media, experiential learning, and discursive scaffolding into Kazakhstani textbooks could enhance comprehension, promote critical engagement, and bridge the gap between factual knowledge and meaningful applied learning experiences.

4.4. Intersemiotic Dimensions of Educational Discourse

In addition to verbal texts, school curricula increasingly rely on multimodal materials such as maps, photographs, diagrams, and infographics. These visual elements serve not merely as illustrative add-ons, but as semiotic resources that shape meaning and frame students' understanding of complex

phenomena. From a discourse-analytic perspective, images and maps act as parallel narrative structures, complementing the verbal text through spatial, iconic, and affective modes of representation.

For instance, a map of the Semey region localizes the abstract notion of nuclear testing, transforming it into a spatially anchored discourse that connects history with geography in students' minds. Similarly, photographs of landscapes or archival images of test sites provide affective resonance — i.e., evoking emotional understanding of the topic, reinforcing its seriousness in ways that purely verbal descriptions cannot achieve. Such resources establish intersemiotic cohesion: a process by which visual and verbal signs are interlinked to construct a coherent educational message [4,6,11,12].

This highlights the multimodal nature of educational discourse: meaning is distributed across multiple channels, and students engage in interpretation not only of texts but of semiotic ensembles where words, images, and spatial arrangements operate together. As Topolovčan and Dubovicki note, the Cold War legacy in contemporary curricula is conveyed not only through verbal narratives but also through visual and symbolic resources, which together shape students' historical understanding [4]. Similarly, the Kazakhstani school textbooks analyzed in this study [13–19] integrate photographs, maps, and diagrams with written explanations, reinforcing the idea that multimodality fosters deeper cognitive and emotional engagement with curricular content. The following table systematizes these functions, illustrating how different visual resources contribute to meaning-making in school curricula.

The integration of multimodal resources demonstrates that educational discourse operates beyond the linearity of verbal narration. As shown in **Table 3** and **Figure 2**, maps, photographs, and diagrams not only illustrate textual content but also reshape its epistemic status by making abstract knowledge more tangible through spatial, affective, and logical forms of representation. This semiotic layering creates intersemiotic cohesion, where meaning emerges from the interplay of words, visuals, and student interpretation. Such cohesion operates discursively, guiding learners toward cognitive comprehension and emotional engagement, thereby reinforcing the pedagogical goals of history and civic education.

Table 3. Semiotic functions of multimodal resources in educational discourse.

Resource Type	Semiotic Function	Pedagogical Contribution
Map	Spatial anchoring of abstract concepts	Connects historical events with geography and locational context.
Photograph	Affective resonance and authenticity	Enhances empathy, emotional engagement, and credibility.
Diagram/Chart	Logical structuring of data	Supports analytical reasoning and systematic understanding.
Infographic	Condensed multimodal narrative	Facilitates retention, recall, and holistic comprehension.

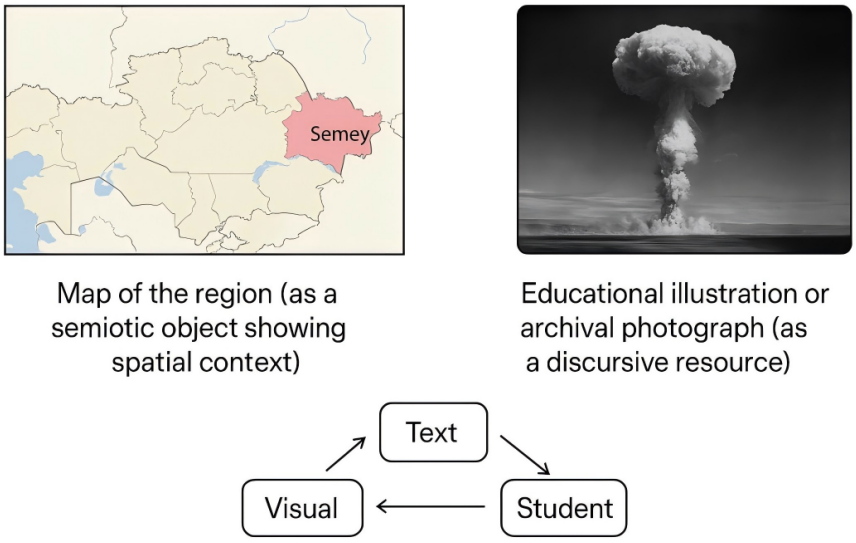

Figure 2. Model of Text–Visual–Learner Interaction.

The analysis suggests that multimodality is not a supplementary feature but a constitutive dimension of curricular discourse. By combining textual and visual modes, school materials construct a more nuanced narrative of complex phenomena such as nuclear testing. This interplay fosters critical literacy, enabling students to interpret not only what is written but also how meaning is visually and spatially framed. Ultimately, the multimodal design of curricula expands the horizon of student engagement, bridging abstract knowledge with lived experience and fostering deeper historical awareness.

4.5. Reader Positioning and Discursive Reception in the Classroom

To complement the textbook analysis, a qualitative study was conducted to explore how the topic of the Semey Nuclear Test Site is perceived and taught in real classroom settings. This study involved interviews and surveys with both teachers and students to gain insights into their understanding, teaching practices, and engagement with the subject. The objective was to examine the extent to which nuclear education in schools reflects the historical, social, and environmental dimensions of the Semey site, and to identify potential gaps between textbook content and actual classroom experience. By integrating the perspectives of educators and learners, this approach allows for a more comprehensive assessment of nuclear education in Kazakhstan and helps to contextualize the textbook review within real-world pedagogical practices [13–17,20–22].

Table 4 shows the responses of teachers and students regarding the representation of the Semey Nuclear Test Site in school education. The results indicate that teachers predominantly focus on the historical aspects of the site, while students' understanding varies, with some demonstrating detailed knowledge and others showing limited awareness. Teachers highlighted difficulties in fully engaging students, citing the abstract nature of the material and the scarcity of supplementary resources, such as visuals or interactive content [13–16]. Students similarly noted that textbooks provide insufficient information and do not adequately convey the environmental and social consequences of nuclear testing [14–16]. Importantly, both groups expressed interest in additional educational resources, including videos, case studies, and interviews, to make the topic more accessible and relevant [6,8–12]. These findings suggest that while current textbooks establish a foundational knowledge of the Semey site, they do not fully support a comprehensive understanding or foster critical engagement. Integrating diverse materials and pedagogical approaches could bridge this gap, enhancing both awareness and meaningful learning outcomes in nuclear education.

Table 4. Teacher and Student Perspectives on the Semey Nuclear Test Site in School Education.

Participant Group	Question	Response Summary	Percentage/Frequency	Analysis
Teachers (n = 10)	How do you present the Semey nuclear site topic?	Mainly historical facts; some include health and environmental aspects	70% historical focus, 30% socio-environmental focus	Textbooks guide teachers to emphasize historical narrative; environmental consequences are less covered [13–16].
Teachers	Challenges in teaching this topic?	Students find topic abstract; textbooks lack visual aids; sensitive content	60% report student disengagement; 40% report insufficient materials	Confirms textbooks shape classroom discussion, limiting interactive engagement [13–16].
Students (n = 50)	What did you learn about the Semey site from textbooks?	Dates, locations, events; limited infomation on radiation or community impact	80% historical facts only; 20% recall some socio-environmental aspects	Highlights gaps between textbook discourse and critical understanding [14–16].
Students	Would additional materials help?	Videos, interviews, case studies, interactive tasks	90% yes; 10% no	Suggests integrating multiple resources can improve comprehension and engagement [6,8–12].
Teachers & Students	How relevant is the topic to everyday life?	Teachers: medium relevance; Students: low relevance	Teachers: 50% medium, 50% high; Students: 30% medium, 70% low	Reveals mismatch between textbook framing and students' perception of real-world relevance [4,7].

4.6. Peculiarities of Teaching Nuclear History in the USA

As noted in earlier sections, nuclear education initiatives in the United States frequently prioritize discursive engagement and critical thinking as central pedagogical outcomes. Educational platforms such as *PBS LearningMedia*, *Facing History*, and *Retro Report* provide multimodal materials – including video content, structured discussion guides, and essay prompts — that facilitate students' reflective engagement with nuclear history. These resources encourage learners to interpret events such as the atomic bombings of Hiroshima and Nagasaki through historical, ethical, and scientific lenses, fostering awareness of how such events are discursively constructed in different domains.

A key feature of these pedagogical models is their focus on argumentative structures and dialogic formats. For example, students are invited to participate in classroom debates structured around binary rhetorical stances ("agree" vs. "counterargument"), prompting them to articulate their position and engage with alternative viewpoints. An illustrative assignment might involve the question: "Does nuclear weaponry serve as a deterrent or as a global threat?" Such tasks promote students' development of stance-taking, evaluative language, and cohesive argumentative writing, all of which are critical components of academic discourse competence.

In contrast, current practices in nuclear history education in Kazakhstan, particularly in relation to the Semipalatinsk Test Site, tend to prioritize factual recall and chronological memorization over discursive inquiry [23]. A review of textbook content and classroom methodologies reveals limited integration of cognitive-linguistic structures such as cause–effect, claim–evidence, or synthesis–evaluation. Instructional discourse often centers on convergent questioning (questions with single correct answers), thereby narrowing the scope for students to develop their own discursive identities and engage in open-ended reflection.

Moreover, students may be insufficiently exposed to tasks that require the formulation of original viewpoints, critical interpretation of historical texts, or comparative source analysis. As a result, the linguistic scaffolding necessary for the articulation of informed historical positions remains underdeveloped. To enhance students' engagement with nuclear history and its sociolinguistic significance, it is essential to incorporate tasks that promote argument construction, dialogic reasoning, and cross-contextual discourse synthesis into the curriculum. This shift in pedagogical orientation and its possible adaptation to the Kazakhstani context is illustrated in **Figure 3**, which outlines potential ways to apply U.S. experience in Kazakhstan.

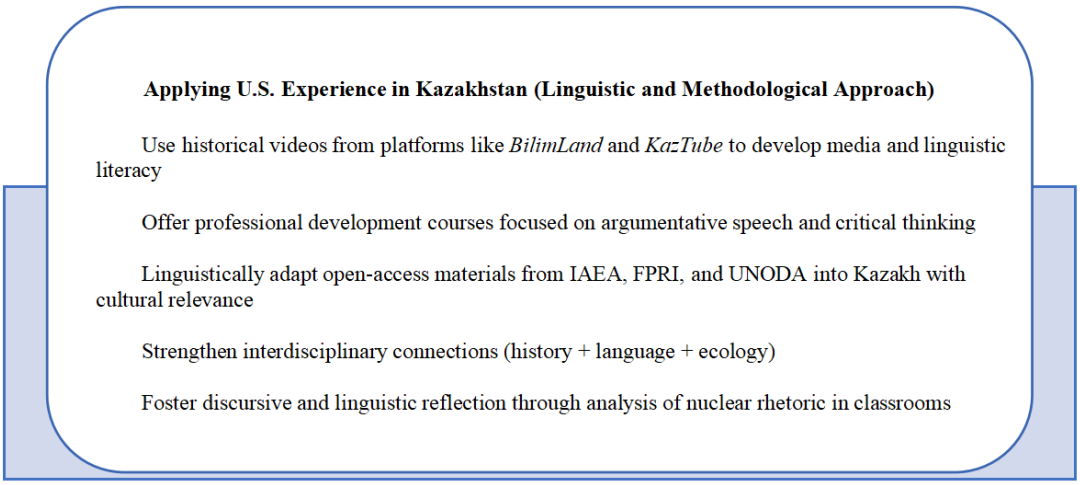

Figure 3. Ways to Apply U.S. Experience in Kazakhstan.

Adapting pedagogical practices from the U.S. context may assist Kazakhstan in forming a new paradigm for teaching history that centers on nuclear literacy, interdisciplinary awareness, and critical thinking. The linguistic representation of nuclear discourse in educational settings — particularly the ways in which historical narratives are constructed,

evaluated, and interpreted — plays a key role in shaping learners' interpretive frameworks and analytical capacities.

In the U.S. education system, the topic of nuclear weapons is integrated across multiple subject areas. In history classes, students examine discourse surrounding the Manhattan Project and Cold War policies. In physics, they learn technical vocabulary related to atomic structure and radiation. In literature, humanistic and ethical themes emerge through the study of nuclear narratives, including figures like Sadako Sasaki and references to cultural memory. These subject areas offer opportunities to develop students' genre awareness, argumentative writing, and pragmatic interpretation skills.

Students engage in classroom debates, structured academic writing, and simulations that promote evidence-based reasoning and dialogic interaction. This multimodal and metadiscursive approach helps learners to critically evaluate historical language, assess argumentative structures, and articulate nuanced positions on complex topics such as nuclear policy and global security.

In contrast, nuclear history in Kazakhstani textbooks is generally limited to concise factual summaries — often a brief narrative confined to a single page. There is minimal attention to linguistic framing, moral-ethical evaluation, or the ecological register of nuclear discourse. The absence of exploratory and inferential tasks results in limited opportunities for developing critical textual analysis or expressive writing skills.

National narratives in Kazakhstani textbooks frequently describe the country's disarmament decisions using emotionally charged or evaluative lexis that supports national identity formation. While these choices offer potential for discourse analysis in classroom settings, they are rarely problematized through tasks that invite interpretation or dialogic response. Reframing such texts as objects of linguistic inquiry could help students recognize rhetorical stance, modality, and voice — all essential for civic and communicative competence.

To enrich the linguistic dimension of nuclear education, Kazakhstan's school system would benefit from developing new teaching materials, integrating media texts (documentaries, oral histories), and offering professional development programs that train teachers to apply discourse-analytical and metacognitive strategies. This would enable a shift from content memorization toward interpretive engagement and discursive literacy in the study of historical topics.

4.7. Teaching the History of Nuclear Testing in Museum Spaces

Incorporating the historical experience of Kazakhstan's nuclear past into school education through museum-based and exhibition formats can enhance the pedagogical impact of history instruction. Moving beyond textbook-based learning, museum pedagogy offers opportunities to foster reflective thinking, multimodal literacy, and emotional engagement with historical events. Establishing a dedicated "*Nuclear Heritage*" museum on the territory of the former Semipalatinsk Test Site could function not only as a repository of national memory but also as an educational platform for cultivating civic awareness and environmental responsibility.

While Kazakhstan's disarmament decision is internationally recognized, the use of museum resources in formal education remains underdeveloped. In particular, the potential for museum-based learning to support curricular goals related to nuclear history is not yet fully realized. International practices demonstrate the pedagogical value of such approaches. For instance, *the National Chernobyl Museum in Ukraine*[24] presents the history of nuclear energy and its consequences through a combination of visual narratives, documentary exhibits, and personal testimonies. These materials create affective and ethical engagement, encouraging visitors to reflect on technological risks, human agency, and ecological impact.

By adapting similar models, Kazakhstan can strengthen interdisciplinary links between history, ethics, ecology, and media studies. Museum-based resources provide a platform for experiential learning and discourse development, enabling students to analyze historical evidence, engage in critical reflection, and relate past events to contemporary global challenges.

In the United States, institutions such as the Trinity Site in New Mexico and the museum affiliated with the Los Alamos National Laboratory[25] provide a comprehensive presentation of the history of nuclear weapons, encompassing scientific, historical, and ethical perspectives. These museums offer educational programs designed specifically for student audiences, including guided tours, interactive exhibits, laboratory workshops, and simulation-based learning formats. Such experiential pedagogies contribute to the de-

velopment of historical literacy and foster interdisciplinary competencies in science and ethics.

In Kazakhstan, the 1991 closure of the Semipalatinsk Nuclear Test Site represented a significant moment in international disarmament history. However, over three decades later, access to the research facilities in Kurchatov – the former administrative center of the test site – remains limited and requires special permits. These restrictions pose challenges to incorporating experiential learning formats into school education, thereby limiting opportunities for students to engage directly with the material and symbolic legacy of nuclear testing.

Integrating museum-based education into the curriculum should be viewed not solely as the transmission of historical facts, but as a multimodal teaching strategy aimed at developing students' affective and ethical awareness. A dedicated museum or exhibition space focusing on Kazakhstan's nuclear history, made accessible to school groups, could support a more holistic educational approach. Such a site would enable interdisciplinary teaching across history, ecology, medicine, and physics; promote critical analysis of primary materials such as documents, photographs, and oral histories; and support the formation of ethical and humanistic thinking by engaging students with testimonies of those affected by radiation exposure.

5. Conclusions

In Kazakhstan's general secondary education system, the topic of the Semipalatinsk nuclear test site represents a linguistically and cognitively complex area within the school curriculum. A review of current textbooks reveals that the textual and methodological treatment of this topic is primarily descriptive and fact-based, providing limited opportunities for language-based reflection or analytical engagement. While historical facts are presented, the semantic, discursive, and pragmatic dimensions of how this history is communicated remain largely unexplored. In particular, the educational materials lack guiding questions and tasks that would promote critical reading, discourse interpretation, and awareness of how language shapes understanding.

Moreover, the scarcity of multimodal and digital resources limits opportunities for learners to interact with this topic through varied linguistic registers and genres. As a result, the representation of historically significant events such as the Semipalatinsk test site reflects one of the key content- and discourse-level gaps in current pedagogical practice. Addressing this issue requires an interdisciplinary approach, integrating insights from linguistics, semiotics, and education. Discourse-based perspectives underscore the importance of rethinking how nuclear history is narrated and framed in educational texts.

Fairclough emphasizes that language is a form of social practice that not only conveys content but also structures relations of power and knowledge; thus, the linguistic framing of nuclear topics in textbooks shapes students' perceptions of responsibility, justice, and authority [20]. Van Dijk notes that ideologies are reproduced through discourse, particularly in school environments where curricular language may reinforce dominant worldviews while silencing others [21]. Gee argues that applying critical discourse analysis in education allows students to uncover implicit meanings, intertextual references, and cultural assumptions embedded in historical narratives, fostering deeper levels of critical literacy [22].

The analysis shows that, although the topic of nuclear history is thematically present in Kazakhstani school textbooks, it is not sufficiently developed in terms of interdisciplinary and discourse-based integration. In particular, the linguistic, pragmatic, and semiotic aspects of how nuclear history is framed for students remain underexplored. This indicates the need to systematically enhance the linguistic and communicative modeling of nuclear topics in secondary education.

The limited representation of nuclear history in textbooks leads to several pedagogical challenges. First, the lack of discourse diversity and multimodal resources constrains students' ability to interpret historical narratives critically. Without exposure to varied textual genres — such as eyewitness accounts, media discourse, or documentary narratives — learners may struggle to recognize how meaning is constructed through language. This limitation affects their ability to evaluate the communicative framing of Kazakhstan's nuclear past and to develop discourse competence in interpreting complex historical events.

To address these limitations and foster students' critical reading and nuclear literacy, the following linguistic and pedagogical measures are recommended:

1. **Revising and Expanding Textbook Content.** The sec-

tion on the Semipalatinsk Test Site should be presented as an independent thematic unit, supported by materials that illustrate the discursive and visual representation of nuclear testing (photographs, maps, archival excerpts, and oral narratives). Integrating such multimodal texts encourages students to interpret meaning beyond literal content.

2. **Introducing Interactive and Textually Diverse Lessons.** Inquiry-based learning formats – such as student-led projects, debates, and role-based simulations – can help learners analyze nuclear history through different narrative positions. For example, assuming the discourse roles of a Soviet-era scientist, a medical expert, or a local villager allows students to examine how language reflects social identity and epistemological stance.
3. **Professional Development for Teachers.** Specialized seminars should focus on how to use discourse analysis and critical reading strategies when teaching complex historical material. Adapting international open-access courses (from FPRI, IAEA, and UNODA) into the Kazakh language would enable educators to introduce global perspectives in ways that are linguistically and culturally accessible.
4. **Developing Interactive Video Content on Local Platforms.** Educational platforms like KAZtube and BilimLand can host linguistically scaffolded video content — accompanied by guiding questions and reflection tasks — to help students engage with the semiotics of nuclear history. Multilingual subtitles, commentary, and teacher's guides should be included to foster comprehension and interpretation.
5. **Expanding Interdisciplinary Integration.** Nuclear history can be incorporated across subjects through the lens of textual analysis. In biology, students can interpret medical reports and health narratives; in geography, they can analyze spatial discourse and map-based texts; in literature, they can explore narrative and metaphor in texts related to nuclear memory and trauma.

Rather than presenting the Semipalatinsk test site solely as a chronological fact, education should focus on how language, narrative, and representation shape student understanding. Linguistic approaches — particularly those informed by critical discourse analysis and text linguistics — can support the development of reflective, literate individuals capable of analyzing how meaning is constructed in public, scientific, and historical discourse. These methodological shifts would allow students not only to comprehend but also to evaluate how knowledge about nuclear history is framed, communicated, and internalized.

Author Contributions

Conceptualization, Z.M. and K.A.; methodology, Z.M.; validation, Z.M. and K.A.; formal analysis, K.T.; investigation, Z.M.; resources, K.T.; data curation, G.M.; writing—original draft preparation, Z.M.; writing—review and editing, K.A. and G.M.; visualization, K.T.; supervision, K.A.; project administration, K.T. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

No new data were created or generated during this study. The datasets analyzed in this research were derived from publicly available sources, including Okulyk, Foreign Policy Research Institute (https://www.fpri.org/), IAEA eLearning Platform, Disarmament Education Consortium, and the United Nations Office for Disarmament Affairs. Further details on accessing specific materials and educational resources used in this analysis can be provided by the authors upon reasonable request.

Conflicts of Interest

The authors declare no conflict of interest.

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