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Conceptual Framework for Scientific Visual Literacy in Science Education: Insights from Armenian Graphic Narratives

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ABSTRACT

Scientific visual literacy is essential in science education because students must interpret diagrams, models, symbols, images, and other visual representations used to communicate scientific knowledge. This conceptual study develops a framework for scientific visual literacy using Armenian graphic narratives as illustrative visual cases. Two historical examples, *Abdag* and *Khatabala*, are examined through visual-narrative and semiotic analysis. The analysis focuses on five processes relevant to science learning: observation, representation, relational reasoning, evidence interpretation, and explanation. The study proposes a conceptual pathway linking these processes to the interpretation of scientific visual representations. Rather than measuring learning outcomes, the study provides a theoretical basis for future classroom research on visual reasoning, scientific representation, and evidence-based interpretation in science education.

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1. INTRODUCTION

Visual representations are fundamental to science education. Scientific ideas are frequently communicated through diagrams, models, graphs, photographs, and symbolic representations. These representations help learners understand phenomena that may be complex or not directly observable [1]. However, seeing a representation does not automatically produce understanding. Students must identify relevant information, interpret symbols, connect visual elements, and construct meaning from evidence [2, 3]. These abilities can be described as scientific visual literacy. Students need to understand both what a scientific representation shows and how its visual components communicate meaning. Studies have reported difficulties in students' interpretation of scientific diagrams, including misunderstanding visual conventions and relationships among represented elements [2]. Explicit instruction in diagrammatic reasoning can improve students' ability to learn science from visual representations [4]. Scientific modeling similarly requires learners to generate, explain, use, and critique representations rather than treat them as illustrations [5]. Developing these abilities does not necessarily require beginning with complex scientific diagrams. Interdisciplinary visual materials may provide simpler contexts for making the processes of observation, representation, relational reasoning, and interpretation explicit. Graphic narratives are particularly interesting because readers construct meaning by integrating images, symbols, text, spatial organization, and narrative relationships [6]. Visual-literacy instruction can improve readers' comprehension and inferential interpretation of educational comics [7].

Armenian graphic narratives provide distinctive cases for examining these visual processes. The historical publications *Abdag* and *Khatabala* use symbolism, caricature, image-text relationships, spatial organization, and implied narratives to communicate political and social meanings. Their original purpose was not science education. Nevertheless, interpreting these materials requires readers to observe visual information, distinguish representation from meaning, identify relationships, use contextual evidence, and justify interpretations. These processes parallel important practices involved in interpreting scientific representations.

A gap therefore exists between research on scientific visual representations and research on visual reasoning across other representational forms. Science-education research has extensively examined diagrams, models, and other disciplinary representations [1, 3-5], but interdisciplinary visual narratives have received less attention as conceptual resources for understanding the basic reasoning processes underlying scientific visual literacy.

This study addresses this gap by developing a conceptual framework for scientific visual literacy in science education, using *Abdag* and *Khatabala* as illustrative visual cases. The framework focuses on five processes: observation, representation, relational reasoning, evidence interpretation, and explanation. The novelty is not the use of Armenian graphic narratives as science content, but their use for identifying transferable visual-reasoning processes relevant to science learning. Accordingly, this study asks: How can visual-reasoning processes identified in Armenian graphic narratives inform a conceptual framework for scientific visual literacy in science education?

2. METHOD

This study employed a conceptual qualitative design to develop a framework for scientific visual literacy in science education. Armenian graphic narratives were used as illustrative visual cases rather than as scientific learning materials. Two historical publications, *Abdag* and

Khatabala, were selected from the original archival corpus because they contain clear visual relationships among symbols, text, characters, objects, and spatial organization. The original visual-analysis procedure was retained. It combined historical-context analysis, visual-narrative analysis, and semiotic analysis. The analysis examined composition, symbols, image-text relationships, spatial relationships, implied narratives, and contextual meaning. These dimensions are supported directly by the analytical procedure in the original study. For the science-education interpretation, the identified visual processes were mapped onto five dimensions of scientific visual literacy: observation, representation, relational reasoning, evidence interpretation, and explanation. These dimensions were derived from research on visual representations, diagrams, and modeling in science education [1-5]. **Table 1** presents the analytical framework. The analysis followed three stages. First, the visual characteristics of each case were identified without changing their original historical meaning. Second, the corresponding visual-reasoning processes were classified using **Table 1**. Third, their conceptual relevance to scientific visual literacy was interpreted using the science-education literature. The study did not involve students, teachers, classroom interventions, or assessments of science achievement. Therefore, it does not claim that Armenian graphic narratives improve science learning. Instead, it develops a conceptual framework that can be tested empirically in future science-education research.

Table 1. Conceptual framework for analyzing scientific visual literacy.

DIMENSION	ANALYSIS OF GRAPHIC NARRATIVES	SCIENCE-EDUCATION INTERPRETATION
Observation	Identification of figures, objects, text, and visual details	Identifying relevant information in scientific visuals
Representation	Interpretation of symbols and visual metaphors	Understanding diagrams, models, and scientific symbols
Relational reasoning	Relationships among images, characters, objects, and space	Connecting components, structures, or variables
Evidence interpretation	Use of visual and contextual clues	Interpreting visual evidence
Explanation	Justification of visual meaning	Constructing evidence-based scientific explanations

3. RESULTS AND DISCUSSION

The conceptual analysis identified five interconnected dimensions of scientific visual literacy: observation, representation, relational reasoning, evidence interpretation, and explanation. *Abdag* and *Khatabala* illustrate these processes differently. Their contribution to this study lies not in scientific content but in the visual-reasoning processes required to construct and justify meaning. This distinction is important because scientific representations also require learners to move from seeing visual elements toward interpreting and explaining their relationships [1-5].

3.1. Observation and Representation in Science Education

Scientific observation involves more than noticing visible objects. Students must determine which information is relevant and distinguish a representation from the phenomenon or concept represented [1, 3]. This distinction is particularly important when interpreting diagrams, models, symbols, and other scientific visuals. **Figure 1** presents *Abdag*, where typography, text, visual organization, and symbolic meaning operate together. In its original historical context, the “slap” functions as a metaphor for confrontation, criticism, and resistance. The reader therefore needs to distinguish the visible form from its intended meaning. The original manuscript similarly identifies the interaction of title, typography, symbolic imagery, and satirical text as central to interpretation. This process provides a conceptual parallel with scientific representation. A model, diagram, or scientific symbol is not the phenomenon itself; it selectively represents particular characteristics [1]. Students therefore need to ask not only “What do I see?” but also “What does this represent?”

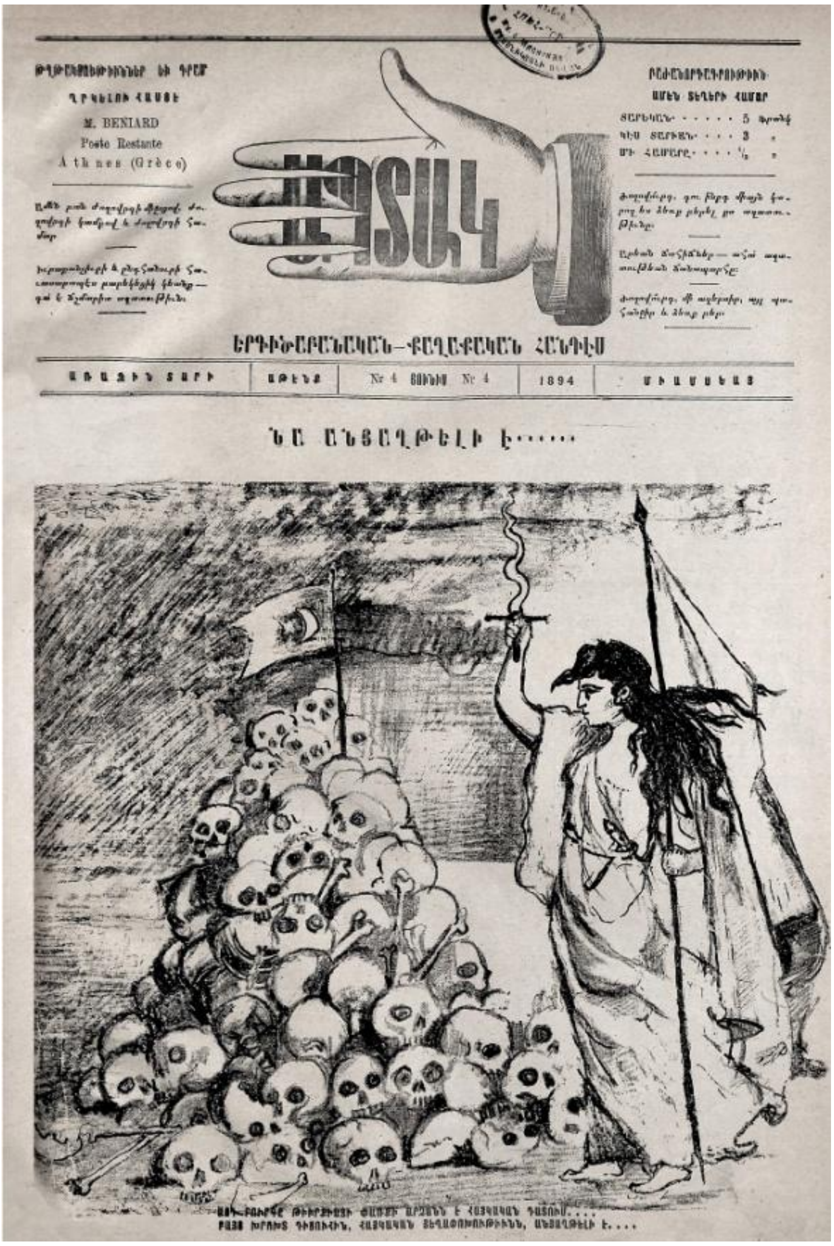

Figure 1. *Abdag* (Ապտակ / “The Slap”), 1894-1897. Archival page from EVN Report Archive Mine.

The relationship is summarized in **Table 2**. *Abdag* can function as an illustrative case of representational reasoning. It does not teach a scientific concept directly. Instead, it makes visible the transition from observation to interpretation that is also required when students work with scientific representations.

Table 2. Observation and representation from graphic narratives to science education.

VISUAL PROCESS	*ABDAG* EXAMPLE	SCIENTIFIC VISUAL LITERACY	SCIENCE-LEARNING EXAMPLE
Observe	Identify text, images, and layout	Identify visual information	Observe a scientific diagram
Select	Recognize important elements	Distinguish relevant information	Identify important structures
Represent	Interpret visual metaphor	Understand representational meaning	Interpret symbols or models
Integrate	Connect image and text	Combine information sources	Connect labels and diagrams
Explain	Explain the visual message	Communicate interpreted meaning	Explain a scientific representation

3.2. Relational Reasoning and Visual Evidence

Scientific representations frequently communicate meaning through relationships. Understanding a system diagram, model, or graph requires learners to examine how individual components are connected rather than interpret each component independently [2-5]. This process is more clearly illustrated in *Khatabala*. **Figure 2** contains multiple characters, gestures, objects, text, and spatial relationships. Facial exaggeration, body language, clothing, and surrounding objects function as signs that guide interpretation. Characters also interact within the same visual space, allowing gestures and symbolic elements to create an implied narrative.

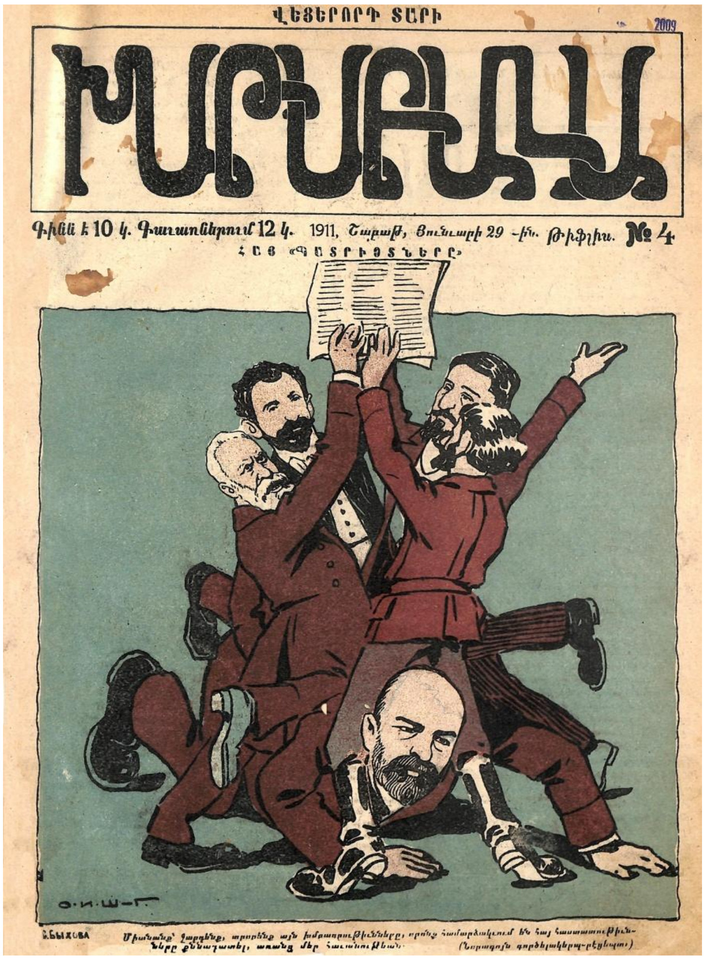

Figure 2. *Khatabala* (խաթաբալա), satirical illustration page from EVN Report Archive Mine.

The important science-education connection is relational reasoning. A learner interpreting a scientific representation similarly needs to determine how components interact. For example, identifying organisms in a food web is insufficient without interpreting their relationships. Likewise, recognizing individual components of an experimental apparatus does not necessarily demonstrate understanding of how the system operates.

Table 3 compares these processes. The comparison does not imply that interpreting caricature and interpreting scientific diagrams are identical cognitive tasks. Rather, both demonstrate that visual meaning can depend on relationships among represented elements. Readers construct meaning through structural relationships and inference [6].

Table 3. Relational reasoning in graphic narratives and scientific representations.

REASONING PROCESS	GRAPHIC NARRATIVE	SCIENTIFIC REPRESENTATION
Identify components	Characters, objects, symbols	Structures, variables, symbols
Examine position	Spatial arrangement	Spatial or functional organization
Identify relationships	Character and object interaction	Relationships among components
Use evidence	Gestures, symbols, context	Data and visual information
Infer meaning	Reconstruct implied narrative	Interpret process or mechanism
Explain	Justify visual interpretation	Construct scientific explanation

3.3. Evidence-Based Interpretation

A third important finding concerns the movement from interpretation toward justification. Scientific literacy requires students not merely to state what they think a representation means but to connect interpretations with available evidence [1]. Both visual cases require this process. An interpretation of *Abdag* depends on the interaction of text, metaphor, and historical context. Interpretation of *Khatabala* requires attention to gestures, characters, objects, spatial organization, and contextual information. Therefore, different interpretations can be evaluated by asking what visual evidence supports them.

This suggests a simple reasoning sequence: Observation → Representation → Relationship → Evidence → Explanation. **Table 4** translates this sequence into a potential science-learning framework. The sequence provides the central conceptual outcome of this study. Science education commonly uses representations to support knowledge construction and communication [1]. However, students may have difficulty interpreting scientific diagrams and coordinating visual information [2-4]. Making each reasoning stage explicit may therefore provide useful scaffolding.

Table 4. Proposed scientific visual-literacy reasoning sequence.

STAGE	GUIDING QUESTION	SCIENCE-EDUCATION PURPOSE
Observation	What is visible?	Identify relevant information
Representation	What does it represent?	Interpret symbols, diagrams, or models
Relationship	How are the elements connected?	Develop relational reasoning
Evidence	What supports this interpretation?	Use visual evidence
Explanation	How can the meaning be justified?	Construct evidence-based explanations

3.4. Implications for Science Teaching

The findings suggest a potential two-stage instructional approach. Students could first practice the reasoning sequence with a non-scientific visual narrative and then apply the same questions to a scientific representation (**Table 5**). This approach positions graphic narratives as preparatory interdisciplinary resources, not replacements for scientific representations. Their function is to make visual reasoning explicit before students encounter more disciplinary forms of representation. This interpretation is consistent with evidence that visual-literacy instruction can support comprehension and inferential interpretation of comics [7], while science-education research emphasizes the importance of explicit reasoning with diagrams and representations [1-5]. The framework also offers a practical distinction between visual literacy and scientific visual literacy. Visual literacy involves interpreting how visual forms communicate meaning. Scientific visual literacy requires these interpretive abilities to operate within scientific knowledge, evidence, representations, and explanations.

Table 5. Proposed application in a science classroom.

PHASE	MATERIAL	STUDENT TASK	EXPECTED REASONING
1	Graphic narrative	Identify visual elements	Observation
2	Graphic narrative	Interpret symbols and relationships	Representation and relational reasoning
3	Graphic narrative	Justify interpretation	Evidence use
4	Scientific diagram/model	Repeat the reasoning sequence	Transfer of visual reasoning
5	Scientific diagram/model	Explain the represented phenomenon	Scientific explanation

Table 6 summarizes this distinction. The proposed framework remains conceptual. No students or teachers participated, and no classroom intervention was conducted. Therefore, the findings cannot demonstrate improved science achievement or scientific visual literacy. Future empirical studies should test the sequence with scientific diagrams, models, or other representations and examine whether explicit transfer from general visual reasoning supports students' scientific interpretation.

Table 6. From visual literacy to scientific visual literacy.

VISUAL LITERACY	SCIENTIFIC VISUAL LITERACY
Observing visual information	Observing scientifically relevant information
Interpreting symbols	Interpreting scientific symbols and models
Recognizing visual relationships	Interpreting relationships within scientific systems
Using visual clues	Using visual and scientific evidence
Explaining visual meaning	Constructing evidence-based scientific explanations

Recent studies further support the educational importance of visual and audio-visual resources. Previous studies illustrate the broader instructional value of visual resources. Audio-visual materials have supported elementary learning in online environments [8], while dynamic visualization tools have enhanced students' motivation and engagement in biology education [9]. These studies reinforce the importance of purposeful visual representation in education, while the present study extends this discussion toward the reasoning processes underlying scientific visual literacy. Visual representations can support learning when they are purposefully integrated into instruction. In science education, their value depends not only on presentation but also on how learners observe, interpret, connect, and explain visual information. Therefore, the present framework extends previous work on educational visualization by emphasizing the reasoning processes required to construct meaning from scientific representations.. Therefore, scientific visual literacy should be considered not only as an interpretive skill but also as an instructional and accessibility issue in science education.

4. CONCLUSION

This conceptual study proposes a scientific visual-literacy framework based on five processes: observation, representation, relational reasoning, evidence interpretation, and explanation. Armenian graphic narratives provide illustrative cases for examining how visual information is identified, connected, interpreted, and justified. Their value for science education lies not in scientific content but in making visual-reasoning processes explicit before learners engage with scientific diagrams, models, and other representations. The proposed framework connects general visual reasoning with evidence-based scientific interpretation while preserving the original historical meaning of the materials. Future empirical studies should test this framework in science classrooms and examine its effects on students' interpretation of scientific representations.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper is free from plagiarism.

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