

Language Analysis of Science and Technology Textbook in Nepal: A Semiotic Perspective

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ABSTRACT

This article has analyzed the semiotic aspects of grade 10 Science and Technology subjects' textbook implemented in Nepal. The main objective of this study was to explore the kind of figures, pictures, symbols, graphs and other signs used in science textbook. It examined how the figures and signs used in the book effect on science learning. It has been carried out in a qualitative design because it is developed on critical logic and argumentative analysis. Theoretically, this work believes on Peirce's semiotics. Figures, pictures, symbols, graphs and other kind of signs used in this subjects' textbook act as data in this study. The meaning-making process includes qualitative and critical analysis. It combines signs from several contexts, meaning, abbreviation including the verbal semantics of speech, and the operational system. And, its result was summarized in overall synopsis of content related aspect and pedagogical techniques and practices correspondence with relevancy and misconception. The result show that the use of visual materials, such as graphs, symbol, pictures, figure, etc. in science textbooks can serve as semiotic signs that induce argumentative reasoning and contribute to the structure of scientific arguments in science classroom. It provides good insights into the representation of multiple mode of representation, scientific influences, and the use of visual materials to enhance scientific literacy however it needs to uplift.

Keywords: *textbook, semiotic, symbols, relevancy, misconception*

Introduction

In today's world, there is a growing emphasis on improving science education and promoting effective learning in the field of science along with deeper understanding, gain insights, and open the possibilities for meaning-making process of students. Like other subjects (literature, social study, geography, etc.), language plays a crucial role in science learning because it provides the opportunities to practice the multiple language of science. It focuses, in particular, on the nature of conversation in science classrooms and the

various ways in which teacher-learner interactions enhance the effective scientific learning process (Sardag et al., 2023). Furthermore, it is essential for knowledge construction process and better educational environment setting. In the science classrooms, dialogic conversations and discussions act a language lab itself because it should be encouraged to enhance students' learning through multiple ways of languages. Tang (2019) argues that language skills serve as scaffolding tools, enabling classroom interaction, knowledge construction, and science meaning-making (316-317). And, it is vital for scientific and technological



literacy (STL), and it supports the development and transfer of scientific knowledge and ideas. In my opinion, while analyzing the language perspective in Nepalese science learning scenarios, semiotics perspective is seen as the dominating aspects and world academic scenarios shows it is an important research area. Hence, I have realized that the semiotic analysis of our science learning textbooks is very important to engage students in meaning making process. Semiotic analysis is the study of signs and symbols and how they function within a society (Zadeh et al., 2016). By applying semiotic analysis to science learning textbooks, educators and researchers will be able to gain a deeper understanding of how meaning is constructed and conveyed through texts. I think, it is very important to analyze the meaning aspect of the textbooks used in Nepali context because our science textbook also seems as combo of symbol, picture, figure, models, etc. As a researcher, I have attempted my best to condense the entirety of all semiotics aspect of science and technology textbook into this paper which are included in 19 chapters of the textbook. While attempting to connect, some semiotic means are missed because this field itself is a field of extensive study. It shows the delimitation of study. However I have explored and connected my arguments regarding semiotic perspective with science and technology textbook of grade 10.

Science Textbook and Semiotic Perspective

Science is a compulsory subject at secondary level in Nepal. It is the combination of integration of scientific skills, physics, chemistry, biology, environment, technology, geology and astronomy. It means that science is seen as a multidisciplinary integration of natural sciences. For this study, I have chosen grade 10 science textbook of Nepal. The textbook is published by Curriculum Development Center (CDC) of Nepal. It is developed based on National Curriculum Framework (NCF) 2076 BS (2019 AD) and named as Science and Technology which has been implemented since 2080 BS (2023 AD). Hence, this study has been carried out to analyse the semiotic aspects of this textbook in

Nepal. This subject has been introduced only recently in grade 10. The main objective of this study was to explore the kind of figures, pictures, symbols, graphs and other kinds of sign used in science textbook and to examine how they could affect science learning through semiotic perspectives. The language adopted in school science is mirrored in textbooks, so this analysis has been made. The focus of secondary science course of Nepal has largely been on science as a combination of content and practical activity, but it is less compare with social science and language art (Parajuli, 2023).

There can be different barriers in the understanding of textbook contents. The very little knowing of symbol, lack of vocabulary and language issues, and communication are the main obstacles and sources of misconception (Mccartney 2002; Allen, 2014). Furthermore, signs, formulas, mathematics, equations, chemical reactions, pictures, etc. are mixed, so it is difficult to get good achievement. And it seems as a science is the language richness subject. Hence, almost science teaching and learning activities of our context take place multimode of linguistic using the medium of language, verbal and non –verbal (Zedeh, 2014). The analysis of Secondary Education Examination (SEE) result also supports this argument in the sense that many students feel the greatest obstacle in learning science due to the intermixture of multiple semiotic conditions. Therefore, this study focused on beyond the medium of language, mother tongue, etc., it has studied various signs, pictures, photographs and other aspects used in science learning specially used in science textbook of Nepal.

Semiotic Aspect of Science Learning : Connection of Theory and Literature

Barthes (1986) argues that semiotics offers a method for studying communication that focuses on all forms of communicative signals or "signs," as opposed to just spoken or written language (Sharp, 2002). Like Barthes' argument science includes natural sign, artificial sign, logical relation of scientist, set of different terms, acronyms,

figure, picture, graphical representation, and so on. It means that the semiotics of science learning is not only exposed in spoken or written medium but can also be seen in figures and symbols. These signs are the combination of “signifier” and “signified” together. Like linguistic analysis, in science language also signifier is the material form of the sign and signified is the mental concept or meaning associated with corresponding sign. The science textbook also acts as a multimodal resources, with combination of sign, formula, three-dimensional models, drawings, diagrams, graphs, and photographs, etc. (Poizzer & Roth, 2019). Furthermore, it is an integrated form of language with pictures, diagrams, charts, tables, graphs and other specialized scientific and mathematical symbols (Wellington and Osborne).

While integrating the Poizzer and Roth and Wellington and Osborne, arguments, the major semiotic aspect in our Science and Technology textbook has included mathematical expression, shapes, drawing, symbol, wave signals, electric circuit symbol, right hand thumb rule, symbol of elements, drawing of atomic structure, molecular formula, color of indicator, different arrows (chemical reaction, electron transfer, gain, loss, precipitation.), painting, model, photo, figure, concept map. Hence this study also focused on the semiotic analysis is the study of symbols, verbal and non-verbal aspects, and gestures of science learning scenario of Nepal through the examination and interpretation of various signs and symbols used to convey meaning within the context of scientific concepts, principles, and experimental. Theoretically, this study was believed in Peirce’s semiotics theory (social semiotics) and it is connected with the involving the sign and its interpretation (De Silva, 2022) which develop and stabilize the alignment between the phenomena and a system of models, e.g. empirical models, data models and explanatory models (Manz et al. 2020).

Hence in science learning, a semiotic perspective is very important because it entails comprehending the function of signs and symbols

in communication as well as the various semiotic resources that are used to construct meaning. This viewpoint acknowledges the multimodal character of science education, where meaning is expressed through the use of words, images, models, and symbols (Bezemer & Kress 2019). It also takes into account the interactions between teachers and learners, with the teacher assuming the role of an environment creator. In the science teaching learning context semiotic act as a parts of scientific language which helps researchers and educators to communicate and can learn more about students' content knowledge and scientific communication skills by examining the way of learning activities designed through how semiotic resources are used.

Methods and Methodology

This study has been carried out in a qualitative design because it is developed on critical logic and argumentative analysis. The grade 10 science and technology textbook recommended by CDC has been purposively selected as a sample because it is new text book and recently applied. The data are generated by textbook and content analysis. Discussion and meaning making process is guided by critical logic and argumentation skill (Parico & Layco, 2020). In fact, there are many domains where learning or acquiring knowledge in a certain way relies on the power of logic and logical argumentation to create a rational explanation system (Mirjani, 2011). Therefore, like Parico and Layco, and Mirjani’s arguments, this study also based on critical logic and argumentative analysis.

Exploring Semiotic Aspect in Science Textbook: Data, Result and Discussion

This section of the study reveals that generation of data samples that resemble an existing Science and Technology textbook. The evaluation of data can be done visually and analytically in a tabular form, it tries to relate the data feature and comparing it with the semiotic aspects. And result and discussion were based on critical analysis and logical argumentation. And the researcher’s insight also applying through appropriate procedures, and drawing conclusions.

Data of this Study

The data collected in this study were drawn from a grade 10 Science and Technology textbook recommended by the CDC, government of Nepal. This involves reviewing of book chapter and collected major semiotic aspect chapter wise. The data have focused on the symbols, shape of structures, poster, picture, figure, chemical reaction and other sign. At the time of data generation, a

chapter wise sequence has been followed. Most often the language of used in science textbook are natural and artificial sign or symbol, acronyms, fundamental and derived units, mathematical expression, structural formula, symbols of elements and formulas units (atoms, complex substances, and other) and chemical reaction equations. Table 1 presents the data related to the semiotic aspects in chapter basis.

Table 1

Synopsis of Data Generated from Grade 10 Science and Technology Textbook

| S.N. | Chapter's Title | Some examples of semiotic aspect |
|------|--|---|
| 1. | Scientific study | Picture of catapult Symbols of units (m, Kg, s, K, mol, m/s ² , Kg/m ³ , Pa, J, W, etc.) Some velocity related equation. |
| 2. | Classification of living beings | Picture of catapult Symbols of units (m, Kg, s, K, mol, m/s ² , Kg/m ³ , Pa, J, W, etc.) Some velocity related equation. |
| 3. | Honey bee | Picture of hive, honey bee, and different stage of life cycle (egg, larva, pupa, and adult). Concept map |
| 4. | Heredity | Picture of gene, sex determination, and genetic technology. Pictorial graphical representation Model of cell division Picture of DNA Threadlike structure (combination of gene, chromosome, and protein). Sex determination Chart Pea plant character and cross charts Photos of some cross animals and plants |
| 5. | Physiological Structure and Life Process | Picture of circulatory system (full body) Photos of blood composition and blood cells structure. External and internal structure of heart. Figure of blood vessels types. |
| 6. | Nature and Environment | Graphics and photos of causes. Photos of some animal. Pictures of medicinal plants. |
| 7. | Motion and Force | Some pictures Some figure related to mass and distance, mathematical expression, formula, equations, symbols (F, G, m ₁ , m ₂ , d ₁ , d ₂ , R, α,), and scientific numbering. |

| S.N. | Chapter's Title | Some examples of semiotic aspect |
|------|--|---|
| 8. | Pressure | Pressure related photos, figures, real object or model, mathematical expression, formula, equations, symbols (F1, F2, A1, A2 W1, W2, U, etc.), arrows, etc. |
| 9. | Heat | Heat related photos, figures, mathematical expression, formula, equations, symbols (T1, T2, Q, M, K, C, m, S), arrows, etc. Graphs |
| 10. | Wave | Wave related photos, figures mathematical expression, formula, equations, symbols (, i, r, I, O, α , μ , C, C1, C2, P1, P2, R1, R2, f, 2f), scientific numbering, symbol of lenses, arrows for ray(s), object, image. |
| 11. | Electricity and magnetism | Electric appliances photos, figures, mathematical expression, formula, equations, symbols (electric circuit, Hz, Vp, Vs, Np, Ns,) arrows, etc. Current –time graphs, line graph, Right-hand thumb rule symbol, Step-up and down coil symbol, |
| 12. | Universe | Universe photos, figures, graphs, line graph, etc, |
| 13. | Information and Communication Technology | Photo, signals and signal graphs, Block pictures/ diagrams, |
| 14. | Classification on Elements | Symbol of elements, their atomic numbers, weights, groups, periods Shell (K, L, M, N), subshell (s2, p6, d10, f14) |
| 15. | Chemical Reaction | Different chemical reaction equations, arrows etc. for eg. $\text{CaCO}_3(\text{s}) + 2 \text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ |
| 16. | Gases | Electron exchange vein diagram, molecular formula, symbols (CO2, HCl, (aq), (g), (l) \rightarrow , \square , etc), figures, chemical reactions. Greenhouse 3D models and pictures, chemical reactions and their symbols. |
| 17. | Metal and Non metals | Photos of metals and their ores with molecular formula, mineral's photos, |
| 18. | Hydrocarbon and their Compounds | Ball stick model, molecular formula, condensed formula, structural formula of hydrocarbon, general formula (CnH2n) |
| 19. | Chemicals Used in Daily life | Some related photos and figures. |

Results and Discussion

Table 1 shows the brief description of the semiotic aspect adjusted in Science and Technology textbook. As seen in the data, every chapter has figures and pictures of corresponding chapter and sub-heading. While analyzing this textbook, the most pictures, photographs, are seen, followed by signs and mathematical expression, while graphs, Venn diagrams, 3-D pictures, concept maps and models are seen a little less. As a whole, pictures and signs are used to cover the chapter to provide visual non-verbal language. In the physics and chemistry related portion seen as symbol dominant portions and similarly other portions are dominated by figure, picture and model. However, in physics and chemistry sections also include a lot of figures and photos for visual representation. In the semiotic perspective, symbols or signs which are used in science textbook has a linguistic admixture of “signifier” and “signified” which extracts their signifiers (in the form of nomenclature) and names their signifiers (in the form of usages or reasons)” of perspective (Sharp, 2002).

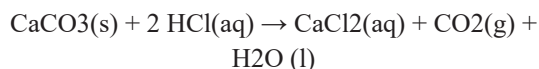
While analyzing the use of figure and picture in science learning it has been seen that using figures and pictures to teach science can significantly increase students' motivation to learn and comprehension of the subject matter. Using interactive picture and picture learning models has produced positive results, as discussed in Putri and Setiyawati's study (1097-1108). It has also been pointed that incorporating drawings and images into arts-based learning helps students learn science and develop their creative and communication abilities (Acharya & Acharya 2022). Furthermore, an image-to-writing strategy inspired by scientific visualisation techniques aids in students' development of a deeper conceptual understanding and their ability to make effective use of representations (Yeo et al., 2021). Students' science learning outcomes have also been successfully improved by the picture and picture cooperative learning model. All things considered, the data points to the possibility that using figures and pictures in science instruction can improve

students' motivation, comprehension, and learning results. Similarly, the application of hand-made 3D models in science learning can provide a fun and engaging learning situation for students, promoting a positive attitude towards learning (Keshavarz, 2023). Therefore the learner engagement through figure, picture and model aspects is widely used in the textbook which is a better aspect.

In some chapters of this book, for example in the chapter three honey bee, concept map and flow charts are included. They are used as the form graphic representation of different concepts that make relationships between different ideas (Gijlers & Jong, 2013), and try to create a significant relationship between different concepts (Novak, 2012). Novak and his colleagues first developed concept mapping from their research on learners' science learning and initially utilized it to document the conceptual understanding and development of children's science concepts. Novak (2012) argued that the Ausubel meaningful verbal learning model as the theory behind their work (pp.241–258). Furthermore, in the previous time it is used as one visual learning tools, which connect a pair of concepts with a one-way (unidirectional), and multiple arrows (bi-directional or Multidirectional), then label the arrow with a word or short phrase that describes the re-relationship between two or more than two concepts, ideas, related problems and many more. The learner can use these connected terms and graphics for reading sentences, create story and poem. Technically these sentences and terms (concept, reason, use, etc.) And, linked by an arrow and phrase—are called propositions (Vanides et al., 2005). In the present time, various software are developed to design concept maps such as Infographics, wiki, etc. However, its' traditional concept only used in it, it means that it focuses to develop the concept of learner and design with interlinking to concept in linear way. However, it can be used in a different way such as design concept map activities (collaboration), open-ended activities that allow students to construct their ideas, fostering the design thinking, dialogue creating, sharing (communication), writing a story and many more (Artistic literature)

but there is lacking to engage student in multiple ways of engaging.

The next non-verbal (visual) representation included in this textbook is line graph. For example, the chapter ‘electricity and magnetism’ has included the line graph. It was created based on the current and time. It should be noted that as a symbolic representation, the interpretation of the line graph involves coordination of a different of semiotic aspects, it shows scientific concepts, comparison, numerical concept, relationship between corresponding variables, and it creates connections between the observed phenomena and conceptualizations. Moreover, in this textbook, different symbols are use like u =initial velocity, v = final velocity, s = speed, a = acceleration, F = force, m = mass, (aq) for aqueous, (g) for gas, (l) for liquid, \rightarrow for reaction, \rightleftharpoons for reversible process, and other units also included in the complied form of signified and signifiers. Moreover, in the chemistry related topics there is the use the symbol. The short form used there stands for the atom of a specific element. It has qualitative and quantitative meaning. For example O is the symbol of Oxygen, it has qualitative meaning; oxygen, and quantitative meaning: it has atomic number eight and 15.99 or 16 molecular weight. Like this symbol, the symbols of element convey the both qualitative and quantitative meaning. Similarly, the molecule of a compound by a formula (CaCO_3), and a chemical change is represented by an equation:



It means that the chemical equation is the symbolic representation of a chemical reaction mainly it has two parts; these two parts are separated by arrow head mark (\rightarrow). The first part is called reactants. They have symbols of substances which take part in chemical reaction as starting material. Usually reactants are written on left hand side. The second is product and it represents substances formed as a result of chemical reaction and they

are written on right hand side. And the Each plus sign (+) separated each reactants and products and included number represents the condition of equation in terms of balanced or not. Furthermore, (+) and (-) with symbol of element like Na^+ and Cl^- , it provide meaning as a radical. A radical with positive charge it is a cation (Na^+ = sodium ion), and with negative charge is an anion (Cl^- = chloride ion). Consequently, the language use in science is very richness in semiotic perspective.

On the other hand, the very same difference in sound in science learning related terms used in this textbook also have significance in meaning. They represent the subject- section’s context, vernacularly we do not think of “Cell in physics”, “shell in chemistry”, and “Cell in biology” as meaning three different things. Similarly in the spelling “Cell” it also different in physics’ portion and biology portion. Thus, sounds and spelling of word in science learning create difference in meanings. Although only a few examples are described here, there are many aspects of language used in science textbook which can be seen as multimodal of linguistic (Barth and Kapatsinski 203-205) and social semiotics.

Findings and Conclusion

In our Science and Technology textbook of grade 10 has several semiotic aspects. These aspects convey knowledge, perceptions of science and attitudes. In addition, the use of inscriptions, (like diagrams, figures, and models) enhance scientific concepts, their interpretation and meaning-making processes. It means that the semiotic aspect of this book plays crucial role to understand and communicate scientific information and shape students' understanding. The use of semiotic analysis in science textbook or learning has several benefits. Firstly, it helps to identify the learner’s learning culture and context that may influence the interpretation of scientific concepts. This is especially important in a multicultural classroom and multidisciplinary science subject like our textbook where students may come from different

backgrounds and have varying levels of knowledge and experience and content of textbook organize by different sections (physics, biology, chemistry, technology, etc.). By analyzing the science textbook through a semiotic lens, educators can ensure that the content is inclusive and relevant to all students.

In another side, semiotic forms and other form of language mixed in science make science textbook beautify. These help to enhance students' critical thinking and analytical skills but critically, it makes learning is more complicated and leads to misconception. However, the deep envisioning of semiotic aspect of textbook allows for the identification of any misconceptions or misunderstandings that may arise from the use of certain signs or symbols also. By examining the signs or symbols, picture, photo, figure, drawing, model, chemical and mathematical equation, used in scientific texts, students are encouraged to raise some questions. Similarly, the information presented to them promotes a deeper understanding of scientific concepts and encourages them to think critically. Furthermore, by applying this thought in science learning it helps to ensure a solid understanding in science learning.

In conclusion, the semiotic aspects regarding pictures, photo models and symbols, as used in the science textbook of grade 10, are good, but the aspects of concept map, graph, and vein-diagram require more addition. It combines signs from several contexts, including the verbal semantics of speech, the operational system of actionable meanings, the visual representational system, and commonly the mathematical semiotic system.

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