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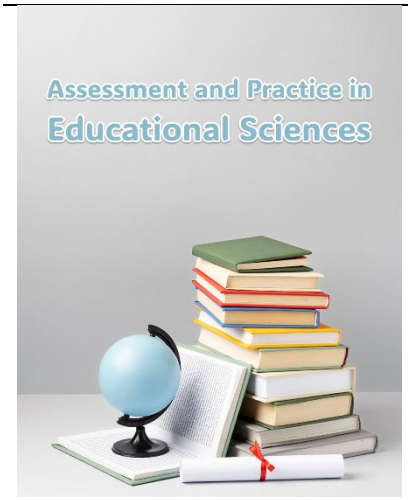

Examining and Comparing the Degree of Attention to Phenomenological Identity Components in Upper Secondary Biology Textbooks Based on Shannon Entropy Method

1. Hakimeh. Hatami: PhD Student in Curriculum Planning, Department of Educational Sciences, Mara.C., Islamic Azad University, Marand, Iran
2. Hossein. Baghaei: Assistant Professor, Department of Educational Studies and Curriculum Planning, Mara.C., Islamic Azad University, Marand, Iran (Email: 198416959@iau.ir)
3. Seyyed Abdullah. Hojjati: Assistant Professor, Department of Educational Studies and Curriculum Planning, Bon.C., Islamic Azad University, Bonab, Iran

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ABSTRACT

Learning and teaching biology in schools is a cultural necessity for the modern world, and with the help of phenomenology, we can gain a more precise view of the aspects and moments that occur within the teaching process. The present study was conducted with the aim of examining and comparing the degree of attention given to phenomenological identity components in upper secondary biology textbooks. This study is applied in terms of purpose and falls under the category of content analysis research in terms of data collection. The method employed was content analysis using the Shannon entropy approach. In this technique, the frequency of each of the 29 components of phenomenological identity in upper secondary biology textbooks was first determined, after which the frequencies were normalized. Based on these normalized data, the information load and importance coefficient for each phenomenological identity component were calculated. The analysis of upper secondary biology textbooks showed that the component related to challenge acceptance had the highest frequency with 109 instances, while the lowest frequencies were observed for the components of being directional, being strong, being profound, guidance and leadership, self-esteem, satisfaction, and pluralism, each with a frequency of (0). Furthermore, the highest importance coefficient among the phenomenological identity components in the textbooks was related to the components of life in the classroom and communication skills with a value of 0.215. The lowest importance coefficient was related to the components of being directional, being profound, being strong, pluralism, guidance and leadership, open-mindedness, self-esteem, and satisfaction, each with a value of (0). In the content of the 10th, 11th, and 12th-grade biology textbooks (taking into account the number of chapters), a relatively balanced and uniform distribution in terms of attention to phenomenological identity components was observed. However, each of the textbooks did not equally address all components, and some components received no attention or very little attention. In the 10th- and 12th-grade biology textbooks, the highest frequency was related to the component of challenge acceptance, while in the 11th-grade biology textbook, the component of practicality had the highest frequency.

Keywords: Phenomenological identity, content analysis, Shannon entropy, biology textbooks, upper secondary education

Introduction

Biology as a fundamental branch of science education plays a pivotal role in shaping students' scientific literacy, fostering inquiry skills, and preparing them to face the challenges of modern society. In the contemporary world, biology is not only concerned with the study of living organisms but also with equipping learners with the capacity to think critically about pressing

global issues such as health, environmental sustainability, and biotechnology (1, 2). The importance of biology education is increasingly emphasized as societies aim to cultivate scientifically literate citizens who can navigate the complexities of technological change and ecological crises (3, 4). In Iran, as in many other countries, secondary school biology textbooks serve as the central source for transmitting knowledge, values, and skills to learners (5, 6). Thus, analyzing the content of these textbooks provides a valuable window into how curricula align with educational objectives and respond to broader societal needs (7).

Textbooks remain a dominant instructional medium in many educational systems and act as the primary resource that bridges curriculum standards and classroom practice (8, 9). They encapsulate pedagogical decisions, curricular emphases, and cultural values embedded within educational programs (10, 11). In the context of biology education, textbooks not only convey biological facts but also structure students' ways of reasoning, approaching problems, and engaging with science as a discipline (12, 13). Hence, their analysis is critical to determining whether intended curricular goals are met and whether students are being prepared for higher-order cognitive skills (14).

Phenomenology has emerged as a valuable approach for understanding the deeper dimensions of curriculum and education (15, 16). This perspective emphasizes lived experiences, meaning-making, and subjective interpretations, offering a nuanced framework to explore how educational materials shape identity and awareness (10, 11). When applied to biology education, phenomenology allows researchers to investigate how textbooks address components of identity, personal growth, and scientific understanding beyond mere factual transmission (17, 18). By engaging with phenomenological identity components, such as responsibility, critical thinking, creativity, and open-mindedness, educators can evaluate how textbooks cultivate holistic learners equipped to participate meaningfully in modern society (15, 16).

Several studies in Iran and abroad have highlighted limitations in the design and implementation of biology textbooks. Research shows that textbooks often emphasize rote memorization over inquiry and problem-solving skills (19, 20). Moreover, analyses indicate a lack of coherence between curriculum objectives and textbook content, as well as insufficient alignment with students' lived realities (21-23). For instance, studies analyzing Iranian biology textbooks have found uneven attention to scientific competencies, critical thinking, and interdisciplinary connections (24, 25). Such gaps can hinder the development of higher-order skills that are increasingly required for university education and professional fields (4, 7).

Recent scholarship has underscored the need to reconsider how textbooks incorporate pedagogical methods that engage students more actively. Innovative strategies such as role-playing (26), local wisdom–based learning models (3), and laboratory-centered approaches (18) have demonstrated significant promise in enhancing student engagement and conceptual understanding. However, these methods require curricular space and emphasis, which textbooks may or may not adequately provide (27, 28). A phenomenological lens helps reveal whether the identity-related aspects of such approaches are represented in the textbooks, thereby shedding light on their capacity to foster well-rounded education (29, 30).

Globally, studies have investigated the extent to which textbooks align with standards and intended learning outcomes. Yu et al. (7) showed that biology textbooks in different countries vary widely in their adherence to curriculum standards, highlighting the critical role of alignment analysis. Similarly, Ahmad and Mehmood (4) identified inconsistencies between curricular objectives and assessment in Pakistan, raising concerns about how textbooks prepare students for examinations. In the Iranian context, research has pointed out misalignments between intended and implemented curricula (6, 21), and questioned whether textbooks adequately reflect the goals outlined in the Fundamental Transformation Document of Education (25). Such concerns highlight the necessity of systematically analyzing textbooks with rigorous methods such as content analysis and entropy modeling (31, 32).

From a phenomenological standpoint, identity formation through textbooks is an essential but often neglected dimension of curriculum analysis. Previous research has emphasized that education should not only aim to transmit knowledge but also to cultivate values, dispositions, and reflective capacities in learners (11, 15). For example, Ghadousi et al. (16) argued that phenomenology provides a pathway to understand curriculum as a lived experience rather than a static plan. This resonates with international discussions on how science education can better integrate cognitive, affective, and social dimensions (8, 10). Analyzing textbooks for phenomenological identity components—such as motivation, responsibility, creativity, and classroom life—can therefore provide insights into the extent to which curricula foster holistic education (22, 30).

Despite valuable contributions, there remain persistent gaps in how Iranian biology textbooks are studied. Much of the existing literature has focused on individual chapters, specific topics such as genetics (22), or laboratory practices (18), without providing a comprehensive analysis across all secondary grades. Other studies have centered on cross-disciplinary connections (24) or on creativity and innovation (13), yet few have examined identity formation systematically across the curriculum. Moreover, many studies adopt descriptive approaches and fail to apply robust quantitative techniques such as Shannon entropy, which allows for weighting components and determining their relative importance (27, 31). This methodological gap underscores the significance of employing advanced analytical frameworks to evaluate the textbooks more rigorously (29, 32).

The question of how textbooks address or neglect phenomenological identity components has broader implications for student outcomes. International research indicates that when students' needs, interests, and lived experiences are neglected, motivation and engagement decline (9, 12). Conversely, curricula that integrate values, critical thinking, and active learning foster deeper understanding and stronger identity development (3, 10). In the Iranian context, challenges such as exam-oriented teaching (28), inadequate attention to laboratory work (18), and gaps in creativity and innovation (19, 33) exacerbate the problem. Therefore, understanding the degree to which phenomenological identity components are embedded in textbooks is crucial for aligning educational practice with national and international goals (5, 14).

The present study, therefore, seeks to fill this gap by systematically examining and comparing the degree of attention given to phenomenological identity components in 10th-, 11th-, and 12th-grade biology textbooks of Iranian secondary schools.

Methods and Materials

This study is applied in terms of purpose and, in terms of data collection, falls under the category of content analysis research. The statistical population of the study consisted of all upper secondary biology textbooks in the field of experimental sciences that were published by the Ministry of Education in the academic year 2023–2024. This included three volumes of biology textbooks (10), (11), and (12), comprising 387 pages in total. Considering the nature of the research and due to the limited statistical population, sampling was disregarded, and the entire statistical population was considered equal to the sample; therefore, the sample consisted of all pages of the biology textbooks (10), (11), and (12).

Table 1. Frequency distribution of upper secondary biology textbooks by number of chapters and pages

Grade	Number of Chapters	Number of Pages
Tenth (Biology 1)	7 chapters	111 pages
Eleventh (Biology 2)	9 chapters	152 pages
Twelfth (Biology 3)	8 chapters	124 pages
Total	24 chapters	387 pages

To analyze the content of upper secondary biology textbooks, the following stages were carried out:

Pre-analysis stage (preparation and organization): In this stage, the list of phenomenological identity components, which had been extracted from the literature and theoretical foundations of the study, was prepared. Using these components

(indicators), the frequency of occurrences in the content of the textbooks was examined. For validity determination, expert judgment was used. In the indicator development stage, opinions from curriculum planning and biology professors were utilized, and finally, 29 indicators (components) were confirmed by supervisors and consultants and used in the content analysis.

For reliability assessment, consistent with content analysis, the test–retest method was applied. In this method, the content is analyzed twice by the researcher at two different times, and items with discrepancies are reviewed. In this study, the first chapter of upper secondary biology textbooks was analyzed twice within a two-month interval, and the discrepancies were reviewed. To determine reliability, Holsti's formula was used:

$C.R = (2M) / (N1 + N2)$

M = number of agreements

N1 = number of components in the first study

N2 = number of components in the second study

A reliability coefficient of 90% was obtained, which indicates acceptable reliability in this study.

Material (message) analysis: In this stage, the frequency of phenomenological identity components in the form of text, images, and activities of the upper secondary biology textbooks was identified.

Result processing: In this stage, the obtained information was analyzed using Shannon entropy technique. The Shannon entropy method, derived from systems theory and belonging to the class of compensatory models, considers both the respondents (upper secondary biology textbooks) and the categories in analyzing and processing the obtained information, which strengthens the validity and robustness of the results (Azar, 2001). The unit of analysis in this study was the page, including text, images, tables, and activities. First, the messages related to each component were counted in terms of frequency for each respondent (chapters of the textbooks) and recorded in the relevant tables. Based on the table data, the following steps were performed sequentially:

Step 1: The frequency matrix of the tables was normalized using the following formula:

$Pij = Fij / \Sigma Fij$

P = normalized frequency matrix

F = frequency of component

i = respondent number

j = component number

m = number of respondents

n = number of components

Step 2: At this stage, the information load of each category was calculated using the following formula and entered into the relevant columns:

$Ej = -k \Sigma (Pij * \ln Pij)$

P = normalized frequency matrix

Ej = information load

i = respondent number

j = component number

m = number of respondents

n = number of components

ln = natural logarithm

Step 3: Using the information load of the categories, the importance coefficient of each category was calculated with the following formula. Any category with a higher information load has a greater degree of importance (Wj):

$Wj = Ej / \Sigma Ej$

j = component number

Wj = degree of importance

Ej = information load

n = number of components

Wj is an index that specifies the importance coefficient of each category in a message according to the form of respondents. It should be noted that in calculating Ej, the Pij values equal to zero were replaced with a very small number (0.000001) to avoid errors and infinite results in mathematical calculations.

Findings and Results

In this study, which aimed to examine and compare the degree of attention to phenomenological identity components in upper secondary biology textbooks, different sections of the books, including text, images, and activities, were analyzed. The frequency of each component in the chapters of the 10th-, 11th-, and 12th-grade biology textbooks was extracted and recorded in the relevant tables. Then, Shannon entropy method was applied to determine the importance coefficient of each component and to perform qualitative analysis.

Table 2. Frequency distribution of phenomenological identity components in Biology 1

Components (Indicators)	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7	Total
Being directional	0	0	0	0	0	0	0	0
Being strong	0	0	0	0	0	0	0	0
Being profound	0	0	0	0	0	0	0	0
Being rich	1	1	1	2	1	2	2	10
Being beneficial	4	5	2	1	2	1	1	16
Being practical	6	2	1	4	2	2	2	19
Being thoughtful	2	2	3	2	0	1	1	11
Lived experience	0	1	1	0	0	3	3	8
Consistency with applications and out-of-class instances	4	3	2	1	0	0	1	11
Being dynamic and interactive	2	3	1	1	0	0	4	11
Suitability with needs and interests	1	2	1	1	0	0	0	5
Sensory strengthening	0	1	0	3	1	1	0	6
Educating thoughtful citizens	0	0	0	0	0	0	0	0
Guidance and leadership	0	0	0	0	0	0	0	0
Communication skills	0	0	0	0	0	0	0	0
Creativity and innovation	2	1	1	2	2	1	1	10
Critical thinking	1	0	0	1	1	3	1	7
Sense of responsibility	2	0	0	0	0	0	0	2
Spirit of open-mindedness	0	0	0	0	0	0	0	0
Insight and awareness	3	3	2	3	0	0	0	11
Motivation	5	0	0	3	1	0	1	10
Self-esteem and satisfaction	0	0	0	0	0	0	0	0
Positive learning	1	0	0	2	1	0	0	4
Attention and concentration	3	2	2	2	0	0	1	10
Challenge acceptance	6	7	2	7	3	6	4	35
Conformity with realities	5	3	0	1	2	2	1	14
Pluralism	0	0	0	0	0	0	0	0
Self-leadership	0	0	0	0	0	0	0	0
Life in the classroom	0	0	0	2	1	0	0	3
Total	48	36	19	38	17	22	23	203

Table 2 shows that in the 10th-grade biology textbook, the component of *challenge acceptance* with 35 cases had the highest frequency, while the lowest values belonged to the components of *being directional, being strong, being profound, guidance and leadership, communication skills, educating thoughtful citizens, pluralism, self-leadership, spirit of open-mindedness, and self-esteem and satisfaction*, each with a frequency of 0. From a total of 203 counted frequencies, the highest value was related to Chapter 1 (48) and the lowest to Chapter 5 (17) of the 10th-grade biology textbook.

Table 3. Normalized data of Table 2 (Pij)

Components (Indicators)	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7
Being directional	0	0	0	0	0	0	0
Being strong	0	0	0	0	0	0	0
Being profound	0	0	0	0	0	0	0
Being rich	0.1	0.1	0.1	0.2	0.1	0.2	0.2
Being beneficial	0.25	0.312	0.125	0.062	0.125	0.062	0.062
Being practical	0.316	0.105	0.053	0.21	0.105	0.105	0.105
Being thoughtful	0.182	0.182	0.272	0.182	0	0.091	0.091
Lived experience	0	0.125	0.125	0	0	0.375	0.375
Consistency with applications and out-of-class instances	0.364	0.273	0.182	0.091	0	0	0.091
Being dynamic and interactive	0.182	0.273	0.091	0.091	0	0	0.364
Suitability with needs and interests	0.2	0.4	0.2	0.2	0	0	0
Sensory strengthening	0	0.167	0	0.5	0.167	0.167	0
Educating thoughtful citizens	0	0	0	0	0	0	0
Guidance and leadership	0	0	0	0	0	0	0
Communication skills	0	0	0	0	0	0	0
Creativity and innovation	0.2	0.1	0.1	0.2	0.2	0.1	0.1
Critical thinking	0.143	0	0	0.143	0.143	0.429	0.143
Sense of responsibility	1	0	0	0	0	0	0
Spirit of open-mindedness	0.143	0.143	0.143	0.143	0.143	0.143	0.143
Insight and awareness	0.273	0.273	0.182	0.273	0	0	0
Motivation	0.5	0	0	0.3	0.1	0	0.1
Self-esteem and satisfaction	0	0	0	0	0	0	0
Positive learning	0.25	0	0	0.5	0.25	0	0
Attention and concentration	0.3	0.2	0.2	0.2	0	0	0.1
Challenge acceptance	0.171	0.2	0.057	0.2	0.086	0.171	0.114
Conformity with realities	0.357	0.214	0	0.071	0.143	0.143	0.071
Pluralism	0	0	0	0	0	0	0
Self-leadership	0	0	0	0	0	0	0
Life in the classroom	0	0	0	0.667	0.333	0	0

Table 4. Uncertainty (Ej) and importance coefficient (Wj) of phenomenological identity components in Biology 1

Components (Indicators)	Uncertainty (Ej)	Importance coefficient (Wj)
Being directional	0	0
Being strong	0	0
Being profound	0	0
Being rich	0.97	0.006
Being beneficial	0.899	0.019
Being practical	0.922	0.014
Being thoughtful	0.884	0.021
Lived experience	0.645	0.066
Consistency with applications and out-of-class instances	0.754	0.046
Being dynamic and interactive	0.754	0.046
Suitability with needs and interests	0.685	0.059
Sensory strengthening	0.638	0.067
Educating thoughtful citizens	0	0
Guidance and leadership	0	0

Communication skills	0	0
Creativity and innovation	0.97	0.006
Critical thinking	0.759	0.045
Sense of responsibility	0	0.187
Spirit of open-mindedness	0	0
Insight and awareness	0.706	0.055
Motivation	0.6	0.075
Self-esteem and satisfaction	0	0
Positive learning	0.534	0.087
Attention and concentration	0.800	0.037
Challenge acceptance	0.961	0.007
Conformity with realities	0.839	0.03
Pluralism	0	0
Self-leadership	0	0
Life in the classroom	0.327	0.126

Table 4 shows that the highest importance coefficient among the phenomenological identity components in the 10th-grade upper secondary biology textbook is related to the component *sense of responsibility* with a value of 0.187, while the lowest importance coefficient belongs to the components of *being directional, being profound, being strong, pluralism, self-leadership, guidance and leadership, open-mindedness, self-esteem and satisfaction, communication skills, and educating thoughtful citizens*, each with a value of (0).

Table 5. Frequency distribution of phenomenological identity components in Biology 2

Components (Indicators)	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7	Chapter 8	Chapter 9	Total
Being directional	0	0	0	0	0	0	0	0	0	0
Being strong	0	0	0	0	0	0	0	0	0	0
Being profound	0	0	0	0	0	0	0	0	0	0
Being rich	2	0	3	0	1	0	1	0	0	7
Being beneficial	2	5	3	1	2	5	2	2	1	23
Being practical	1	1	2	4	1	2	2	11	4	28
Being thoughtful	4	3	0	0	2	2	2	0	0	13
Lived experience	0	0	1	0	0	0	1	3	0	5
Consistency with applications and out-of-class instances	1	1	0	0	0	2	1	3	0	8
Being dynamic and interactive	1	1	2	1	1	2	0	0	0	8
Suitability with needs and interests	0	0	1	1	2	1	10	0	0	15
Sensory strengthening	0	0	0	0	0	0	0	0	0	0
Educating thoughtful citizens	0	0	0	0	0	1	1	0	0	2
Guidance and leadership	0	0	0	0	0	0	0	0	0	0
Communication skills	0	0	0	0	0	0	0	0	0	0
Creativity and innovation	0	1	1	0	1	1	1	2	0	7
Critical thinking	2	3	2	0	2	0	1	3	3	16
Sense of responsibility	0	0	1	2	1	0	2	0	0	6
Spirit of open-mindedness	0	0	0	0	0	0	0	0	0	0
Insight and awareness	5	0	3	2	2	0	4	1	4	21
Motivation	2	1	0	1	5	1	2	1	2	15
Self-esteem and satisfaction	0	0	0	0	0	0	0	0	0	0
Positive learning	0	2	2	1	1	0	3	0	1	10
Attention and concentration	1	2	1	3	2	2	3	1	0	15
Challenge acceptance	4	5	1	1	2	2	4	2	1	22
Conformity with realities	0	2	0	0	1	2	1	0	4	10
Pluralism	0	0	0	0	0	0	0	0	0	0
Self-leadership	1	0	2	0	2	1	2	0	0	8
Life in the classroom	0	0	0	0	0	0	0	0	0	0

Total	26	27	25	17	28	24	43	29	20	239

Table 5 shows that in the 11th-grade biology textbook, the component of *being practical* with 28 cases had the highest frequency, while the lowest values belonged to the components of *being directional, being profound, being strong, sensory strengthening, pluralism, guidance and leadership, open-mindedness, self-esteem and satisfaction, communication skills, and life in the classroom*, each with a frequency of (0). From the total of 239 counted frequencies, the highest value was related to Chapter 7 (43), and the lowest value was related to Chapter 4 (17) of the 11th-grade biology textbook.

Table 6. Normalized data of Table 5 (Pij)

Indicators	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7	Chapter 8	Chapter 9
Being directional	0	0	0	0	0	0	0	0	0
Being strong	0	0	0	0	0	0	0	0	0
Being profound	0	0	0	0	0	0	0	0	0
Being rich	0.286	0	0.429	0	0.143	0	0.143	0	0
Being beneficial	0.087	0.217	0.130	0.043	0.087	0.217	0.087	0.087	0.043
Being practical	0.036	0.036	0.071	0.143	0.035	0.071	0.071	0.393	0.143
Being thoughtful	0.308	0.231	0	0	0.154	0.154	0.154	0	0
Lived experience	0	0	0.200	0	0	0	0.200	0.600	0
Consistency with applications and out-of-class instances	0.125	0.125	0	0	0	0.250	0.125	0.375	0
Being dynamic and interactive	0.125	0.125	0.250	0.125	0.125	0.250	0	0	0
Suitability with needs and interests	0	0	0.067	0.067	0.133	0.067	0.668	0	0
Sensory strengthening	0	0	0	0	0	0	0	0	0
Educating thoughtful citizens	0	0	0	0	0	0.500	0.500	0	0
Guidance and leadership	0	0	0	0	0	0	0	0	0
Communication skills	0	0	0	0	0	0	0	0	0
Creativity and innovation	0	0.143	0.143	0	0.143	0.143	0.143	0.286	0
Critical thinking	0.125	0.187	0.125	0	0.125	0	0.062	0.187	0.187
Sense of responsibility	0	0	0.167	0.333	0.167	0	0.333	0	0
Spirit of open-mindedness	0	0	0	0	0	0	0	0	0
Insight and awareness	0.238	0	0.143	0.095	0.095	0	0.190	0.048	0.190
Motivation	0.133	0.067	0	0.067	0.333	0.067	0.133	0.067	0.133
Self-esteem and satisfaction	0	0	0	0	0	0	0	0	0
Positive learning	0	0.200	0.200	0.100	0.100	0	0.300	0	0.100
Attention and concentration	0.067	0.133	0.067	0.200	0.133	0.133	0.200	0.067	0
Challenge acceptance	0.182	0.227	0.045	0.045	0.091	0.091	0.182	0.091	0.045
Conformity with realities	0	0.200	0	0	0.100	0.200	0.100	0	0.400
Pluralism	0	0	0	0	0	0	0	0	0
Self-leadership	0.125	0	0.250	0	0.250	0.125	0.250	0	0
Life in the classroom	0	0	0	0	0	0	0	0	0

Table 7. Uncertainty (Ej) and importance coefficient (Wj) of phenomenological identity components in Biology 2

Components (Indicators)	Uncertainty (Ej)	Importance coefficient (Wj)
Being directional	0	0
Being strong	0	0
Being profound	0	0
Being rich	0.581	0.079
Being beneficial	0.934	0.013
Being practical	0.84	0.031
Being thoughtful	0.712	0.054
Lived experience	0.432	0.107
Consistency with applications and out-of-class instances	0.680	0.06
Being dynamic and interactive	0.789	0.04
Suitability with needs and interests	0.492	0.096
Sensory strengthening	0	0

Educating thoughtful citizens	0.315	0.13
Guidance and leadership	0	0
Communication skills	0	0
Creativity and innovation	0.795	0.039
Critical thinking	0.862	0.026
Sense of responsibility	0.605	0.075
Spirit of open-mindedness	0	0
Insight and awareness	0.839	0.03
Motivation	0.862	0.026
Self-esteem and satisfaction	0	0
Positive learning	0.772	0.043
Attention and concentration	0.906	0.018
Challenge acceptance	0.925	0.014
Conformity with realities	0.669	0.063
Pluralism	0	0
Self-leadership	0.71	0.055
Life in the classroom	0	0

Table (7) shows that the highest importance coefficient among the phenomenological identity components in the 11th-grade upper secondary biology textbook belongs to the component *educating thoughtful citizens* with a value of 0.13, while the lowest importance coefficient belongs to the components *being directional, being profound, being strong, sensory strengthening, pluralism, guidance and leadership, spirit of open-mindedness, self-esteem and satisfaction, communication skills, and life in the classroom*, each with a value of (0).

Table 8. Frequency distribution of phenomenological identity components in Biology 3

Components (Indicators)	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7	Chapter 8	Total
Being directional	0	0	0	0	0	0	0	0	0
Being strong	0	0	0	0	0	0	0	0	0
Being profound	0	0	0	0	0	0	0	0	0
Being rich	3	2	0	2	0	1	1	0	9
Being beneficial	0	0	1	2	0	0	3	0	6
Being practical	0	0	1	1	2	0	2	1	7
Being thoughtful	2	4	0	2	1	0	1	1	11
Lived experience	0	0	0	0	0	0	0	6	6
Consistency with applications and out-of-class instances	0	0	0	0	0	0	0	0	0
Being dynamic and interactive	5	3	0	0	1	1	1	1	12
Suitability with needs and interests	0	0	5	0	0	0	1	0	6
Sensory strengthening	2	0	0	0	0	0	2	0	4
Educating thoughtful citizens	0	0	0	4	0	0	1	1	6
Guidance and leadership	0	0	0	0	0	0	0	0	0
Communication skills	0	0	0	0	0	0	0	5	5
Creativity and innovation	0	5	0	0	0	1	4	1	11
Critical thinking	1	1	2	0	0	3	1	0	8
Sense of responsibility	0	0	0	0	0	0	1	1	2
Spirit of open-mindedness	0	0	0	0	0	0	0	0	0
Insight and awareness	3	0	2	1	6	1	2	0	15
Motivation	1	1	2	1	3	1	2	3	14
Self-esteem and satisfaction	0	0	0	0	0	0	0	0	0
Positive learning	0	0	0	0	1	0	1	0	2
Attention and concentration	4	1	0	2	0	2	3	4	16
Challenge acceptance	7	9	2	16	3	4	10	1	52
Conformity with realities	1	0	1	1	1	0	5	6	15
Pluralism	0	0	0	0	0	0	0	0	0
Self-leadership	0	0	0	0	1	1	0	1	3
Life in the classroom	0	0	0	0	0	0	0	0	0
Total	29	26	16	32	19	15	41	32	

Table 8 shows that in the analysis of the 12th-grade biology textbook, the component related to *challenge acceptance* with 52 cases had the highest frequency, while the lowest values belonged to the components of *consistency with applications and out-of-class instances, guidance and leadership, self-esteem and satisfaction, pluralism, and life in the classroom*, each with a frequency of 0. From the total of 210 counted frequencies, the highest value was related to Chapter 7 (41), and the lowest value was related to Chapter 6 (15) of the 12th-grade biology textbook.

Table 9. Normalized data of Table 8 (Pij)

Indicators	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7	Chapter 8
Being directional	0	0	0	0	0	0	0	0
Being strong	0	0	0	0	0	0	0	0
Being profound	0	0	0	0	0	0	0	0
Being rich	0.333	0.222	0	0.222	0	0.111	0.111	0
Being beneficial	0	0	0.167	0.333	0	0	0.5	0
Being practical	0	0	0.143	0.143	0.286	0	0.286	0.143
Being thoughtful	0.182	0.364	0	0.182	0.091	0	0.091	0.091
Lived experience	0	0	0	0	0	0	0	1
Consistency with applications and out-of-class instances	0	0	0	0	0	0	0	0
Being dynamic and interactive	0.417	0.25	0	0	0.083	0.083	0.083	0.083
Suitability with needs and interests	0	0	0.083	0	0	0	0.167	0
Sensory strengthening	0.5	0	0	0	0	0	0.5	0
Educating thoughtful citizens	0	0	0	0.667	0	0	0.167	0.167
Guidance and leadership	0	0	0	0	0	0	0	0
Communication skills	0	0	0	0	0	0	0	1
Creativity and innovation	0	0.454	0	0	0	0.091	0.364	0.091
Critical thinking	0	0	0	0	0	0	0	0
Sense of responsibility	0	0	0	0	0	0	0.5	0.5
Spirit of open-mindedness	0	0	0	0	0	0	0	0
Insight and awareness	0.2	0	0.133	0.067	0.4	0.067	0.133	0
Motivation	0.071	0.071	0.143	0.071	0.21	0.071	0.143	0.214
Self-esteem and satisfaction	0	0	0	0	0	0	0	0
Positive learning	0	0	0	0	0.5	0	0.5	0
Attention and concentration	0.25	0.062	0	0.125	0	0.125	0.187	0.25
Challenge acceptance	0.135	0.173	0.038	0.308	0.058	0.077	0.192	0.019
Conformity with realities	0.067	0	0.067	0.067	0.067	0	0.333	0.4
Pluralism	0	0	0	0	0	0	0	0
Self-leadership	0	0	0	0	0.333	0.333	0	0.333
Life in the classroom	0	0	0	0	0	0	0	0

Table 10. Uncertainty (Ej) and importance coefficient (Wj) of phenomenological identity components in Biology 3

Components (Indicators)	Uncertainty (Ej)	Importance coefficient (Wj)
Being directional	0	0
Being strong	0	0
Being profound	0	0
Being rich	0.732	0.03
Being beneficial	0.487	0.057
Being practical	0.745	0.028
Being thoughtful	0.789	0.023
Lived experience	0	0.111
Consistency with applications and out-of-class instances	0	0
Being dynamic and interactive	0.74	0.03
Suitability with needs and interests	0.217	0.087
Sensory strengthening	0.333	0.074
Educating thoughtful citizens	0.417	0.065
Guidance and leadership	0	0

Communication skills	0	0.111
Creativity and innovation	0.559	0.049
Critical thinking	0.718	0.031
Sense of responsibility	0.333	0.074
Spirit of open-mindedness	0	0
Insight and awareness	0.763	0.026
Motivation	0.947	0.006
Self-esteem and satisfaction	0	0
Positive learning	0.333	0.074
Attention and concentration	0.818	0.02
Challenge acceptance	0.873	0.014
Conformity with realities	0.7	0.033
Pluralism	0	0
Self-leadership	0.528	0.053
Life in the classroom	0	0

Table 10 shows that the highest importance coefficient among the phenomenological identity components in the 12th-grade upper secondary biology textbook is related to the components *lived experience* and *communication skills* with a value of 0.111, while the lowest importance coefficient belongs to the components *being directional, being profound, being strong, consistency with applications and out-of-class instances, pluralism, guidance and leadership, open-mindedness, self-esteem and satisfaction, and life in the classroom*, each with a value of (0).

Table 11. Frequency distribution of phenomenological identity components in upper secondary biology textbooks

Components (Indicators)	Biology (1) Frequency	Biology (2) Frequency	Biology (3) Frequency	Total Frequency
Being directional	0	0	0	0
Being strong	0	0	0	0
Being profound	0	0	0	0
Being rich	10	7	9	26
Being beneficial	16	23	6	45
Being practical	19	28	7	54
Being thoughtful	11	13	11	35
Lived experience	8	5	6	19
Consistency with applications and out-of-class instances	11	8	0	19
Being dynamic and interactive	11	8	12	31
Suitability with needs and interests	5	15	6	26
Sensory strengthening	6	0	4	10
Educating thoughtful citizens	0	2	6	8
Guidance and leadership	0	0	0	0
Communication skills	0	0	5	5
Creativity and innovation	10	7	11	28
Critical thinking	7	16	8	31
Sense of responsibility	2	6	2	10
Spirit of open-mindedness	0	0	0	0
Insight and awareness	11	21	15	47
Motivation	10	15	14	39
Self-esteem and satisfaction	0	0	0	0
Positive learning	4	10	2	16
Attention and concentration	10	15	16	41
Challenge acceptance	35	22	52	109
Conformity with realities	14	10	15	39
Pluralism	0	0	0	0
Self-leadership	0	8	3	11
Life in the classroom	3	0	0	3
Total	203	239	210	652

Table 11 shows that in the analysis of upper secondary biology textbooks, the component *challenge acceptance* with 109 cases had the highest frequency, while the lowest values belonged to the components *being directional, being strong, being profound, guidance and leadership, self-esteem and satisfaction, and pluralism*, each with a frequency of 0. From the total of 652 counted frequencies, the highest value was related to the 11th-grade textbook (239), and the lowest value was related to the 10th-grade textbook (203).

Table 12. Normalized data of Table 11 (Pij)

Indicators	Biology (1)	Biology (2)	Biology (3)
Being directional	0	0	0
Being strong	0	0	0
Being profound	0	0	0
Being rich	0.385	0.27	0.35
Being beneficial	0.356	0.511	0.133
Being practical	0.352	0.518	0.13
Being thoughtful	0.314	0.374	0.314
Lived experience	0.421	0.263	0.316
Consistency with applications and out-of-class instances	0.579	0.421	0
Being dynamic and interactive	0.355	0.258	0.387
Suitability with needs and interests	0.192	0.577	0.231
Sensory strengthening	0.6	0	0.4
Educating thoughtful citizens	0	0.25	0.75
Guidance and leadership	0	0	0
Communication skills	0	0	1
Creativity and innovation	0.357	0.25	0.393
Critical thinking	0.226	0.516	0.258
Sense of responsibility	0.2	0.6	0.2
Spirit of open-mindedness	0	0	0
Insight and awareness	0.234	0.447	0.319
Motivation	0.256	0.385	0.359
Self-esteem and satisfaction	0	0	0
Positive learning	0.25	0.625	0.125
Attention and concentration	0.244	0.366	0.39
Challenge acceptance	0.312	0.223	0.464
Conformity with realities	0.254	0.472	0.273
Pluralism	0	0	0
Self-leadership	0	0.727	0.273
Life in the classroom	1	0	0

Table 13. Uncertainty (Ej) and importance coefficient (Wj) of phenomenological identity components in upper secondary biology textbooks

Components (Indicators)	Uncertainty (Ej)	Importance coefficient (Wj)
Being directional	0	0
Being strong	0	0
Being profound	0	0
Being rich	0.99	0.002
Being beneficial	0.891	0.023
Being practical	0.886	0.025
Being thoughtful	0.997	0.001
Lived experience	0.983	0.004
Consistency with applications and out-of-class instances	0.619	0.082
Being dynamic and interactive	0.987	0.003
Suitability with needs and interests	0.885	0.025
Sensory strengthening	0.613	0.083
Educating thoughtful citizens	0.512	0.105
Guidance and leadership	0	0
Communication skills	0	0.215
Creativity and innovation	0.984	0.003

Critical thinking	0.935	0.014
Sense of responsibility	0.865	0.029
Spirit of open-mindedness	0	0
Insight and awareness	0.969	0.007
Motivation	0.987	0.003
Self-esteem and satisfaction	0	0
Positive learning	0.819	0.039
Attention and concentration	0.982	0.004
Challenge acceptance	0.96	0.009
Conformity with realities	0.962	0.008
Pluralism	0	0
Self-leadership	0.533	0.1
Life in the classroom	0	0.215

Table 13 shows that the highest importance coefficient among the phenomenological identity components in upper secondary biology textbooks is related to the components *life in the classroom* and *communication skills* with a value of 0.215, while the lowest importance coefficient belongs to the components *being directional, being profound, being strong, pluralism, guidance and leadership, open-mindedness, and self-esteem and satisfaction*, each with a value of (0).

Discussion and Conclusion

The analysis of the second secondary biology textbooks demonstrated both diversity and inconsistency in the attention devoted to phenomenological identity components. The findings revealed that in the 10th-grade textbook, the component of *challenge acceptance* achieved the highest frequency, followed by practicality, while components such as communication skills, guidance and leadership, self-esteem, and pluralism received no attention at all. In the 11th-grade textbook, practicality emerged as the most emphasized component, highlighting the tendency of the curriculum to prioritize functional knowledge and application. Meanwhile, in the 12th-grade textbook, challenge acceptance again dominated, while lived experience and communication skills obtained the highest importance coefficients, suggesting some degree of recognition for student-centered and interactive dimensions. Across all three grades, the aggregated results showed that challenge acceptance overwhelmingly held the highest frequency, whereas being directional, strong, profound, pluralism, and life in the classroom remained absent or marginal. The entropy analysis further confirmed that certain components, notably life in the classroom and communication skills, carried the highest weights in terms of importance coefficients, while many other identity components were systematically overlooked.

These results reflect a clear imbalance in how textbooks are designed to engage learners with identity-related aspects of phenomenology. On the one hand, the emphasis on challenge acceptance aligns with the pedagogical aim of encouraging students to approach scientific problems with perseverance, curiosity, and resilience (24, 29). This is consistent with international scholarship showing that science education should cultivate students' ability to tackle complex and uncertain challenges, an attribute critical for 21st-century skills (4, 7). However, the neglect of other components such as open-mindedness, self-esteem, and leadership is troubling, as these traits are integral to forming holistic learners who can integrate knowledge with personal and social growth (15, 16). The uneven distribution of identity components indicates that while Iranian biology textbooks encourage certain forms of cognitive engagement, they often fail to support affective, social, and ethical dimensions of learning (27, 32).

The prominence of challenge acceptance across all three grades resonates with findings by Bakhtiari and Khakbaz (23), who highlighted that Iranian biology textbooks frequently emphasize persistence in problem-solving and conceptual understanding. This pattern is also supported by studies such as Farasat and Rahimi (26), who demonstrated that role-playing activities in

biology can enhance student persistence and active participation. Moreover, Feizi's content analysis of genetics chapters (22) confirmed that the curriculum tends to promote resilience and challenge orientation. Nonetheless, the overemphasis on challenge acceptance may overshadow the importance of communication, collaboration, and critical citizenship skills, all of which are necessary for well-rounded scientific literacy (8, 10).

The findings regarding practicality in the 11th-grade textbook illustrate a curriculum orientation towards applied knowledge, particularly in the context of laboratory and real-world applications. This aligns with studies that have underscored the importance of connecting science education to students' everyday lives (2, 18). Practical components help students bridge theoretical concepts with observable phenomena, thereby increasing engagement and comprehension (1, 3). However, while the emphasis on practicality is commendable, the neglect of complementary identity aspects such as guidance and leadership suggests that the curriculum fails to prepare students for collective problem-solving and scientific leadership roles (11, 14). This reinforces the critique by Samadi (19) that biology education in Iran is overly focused on functional knowledge while sidelining creativity and innovation.

The 12th-grade textbook demonstrated a unique feature by assigning the highest importance coefficients to lived experience and communication skills. This suggests a curricular attempt to integrate experiential and interactive dimensions into the learning process. Such a focus aligns with phenomenological theories that stress the centrality of lived experience in meaning-making and knowledge construction (10, 15). It also resonates with Borahouei Moghadam and Moghadam's (30) study, which emphasized the need for active learning approaches in the biology curriculum. Similarly, communication skills, which received a high weight in the entropy analysis, are critical for cultivating collaboration, dialogue, and social learning in classrooms (9, 12). Yet, despite their importance, these components were inconsistently distributed across the chapters, indicating a lack of systemic integration into the curriculum design (24, 25).

Comparing these results with international research reveals both commonalities and divergences. Yu et al. (7) found that biology textbooks in different countries vary in their emphasis on skills such as critical thinking and practical application. Similarly, Ahmad and Mehmood (4) reported gaps between curriculum objectives and textbook content, particularly in aligning assessment with learning outcomes. These align with the current study's findings that Iranian textbooks, while emphasizing persistence and practical knowledge, neglect other identity-forming dimensions such as leadership and self-esteem. The neglect of creativity and open-mindedness further echoes the criticisms made by Kargar (33) and Kaveh (13), who underscored the need to infuse biology education with opportunities for divergent thinking and imaginative engagement.

The broader implication of these results is that Iranian biology textbooks partially fulfill their role in preparing students for scientific literacy but fail to provide a balanced framework for identity development. By overlooking critical components such as pluralism, leadership, and self-reflection, the textbooks risk perpetuating a narrow view of science education that prioritizes knowledge acquisition over personal growth and civic responsibility (16, 21). In this regard, phenomenology offers a powerful lens to critique and improve textbook content, as it emphasizes not only what is taught but also how it shapes the learners' sense of self and their relationship with knowledge (10, 15).

The uneven attention to phenomenological identity components also suggests systemic issues in curriculum planning and textbook development. As noted by Rasouli and Atashani (27), textbook design often relies heavily on descriptive coverage of content rather than integrating deeper dimensions of identity formation. Studies by Riahi Eshtehbanati and Rezaeian (31) and Saadati and Ebadi Manas (32) similarly revealed that many chapters fail to align with educational objectives that call for nurturing critical and creative thinking. This resonates with Feizi and Abyari (29), who argued that textbook analyses must go beyond factual content to assess how well they embody holistic educational principles.

Taken together, the results highlight the need for reform in biology textbook design in Iran. A more balanced approach that incorporates phenomenological identity components such as responsibility, creativity, communication, and pluralism is essential for equipping students with the capacities required in a globalized and knowledge-driven society (5, 30). Without such reform, students may excel at memorization and functional problem-solving but remain underprepared for the social, ethical, and civic dimensions of science in practice (2, 19).

The present study, while offering valuable insights, is subject to several limitations. First, it relied exclusively on the content of biology textbooks without examining classroom implementation or teacher practices, which may significantly influence how identity components are enacted. Second, the analysis was confined to three grade levels of Iranian secondary education, limiting the generalizability of findings to other subjects or educational contexts. Third, the use of Shannon entropy, though robust, may not capture the full complexity of qualitative dimensions inherent in phenomenological identity. Finally, cultural and contextual factors that shape how textbooks are written and interpreted were not directly analyzed, which may limit the interpretive depth of the findings.

Future research should expand the scope of analysis to include classroom practices, teacher perspectives, and student experiences to gain a more comprehensive picture of how phenomenological identity is addressed in education. Longitudinal studies could trace how exposure to particular textbook components influences student outcomes over time. Comparative research across different subjects and national contexts would also provide valuable insights into whether similar patterns emerge elsewhere. Additionally, integrating mixed-method approaches that combine quantitative techniques such as entropy analysis with qualitative interviews and observations could offer a richer understanding of the interplay between curriculum design and identity formation.

Curriculum developers and textbook authors should strive to design materials that balance cognitive, affective, and social dimensions of learning. In particular, textbooks should more systematically incorporate components such as communication skills, leadership, open-mindedness, and pluralism alongside challenge acceptance and practicality. Teacher training programs should emphasize how to draw on phenomenological identity components in daily instruction to foster student engagement and holistic growth. Policymakers should also ensure that curriculum reform frameworks explicitly recognize identity formation as a core educational objective. By integrating these considerations, biology education can better prepare students not only for academic achievement but also for meaningful participation in society.

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Declaration of Interest

The author of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adhered in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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