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The Concept of Ocean Sustainability in Formal Education—Comparative Ocean Literacy Coverage Analysis of the Educational Standards of India and the USA

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Abstract: The concept of marine environmental sustainability is essential, and ocean literacy is currently at the core of its development. Comparing ocean literacy principles in curriculum standards is an important thing to do. Ocean literacy (OL) is a key and emerging topic, and its study has adopted a qualitative approach and follows the content analysis approach. It was observed that, on average, OL concepts covered in the educational standards of the USA (Next Generation Science Standards, NGSS) are higher than those of India (Indian National Standards, INSs). The study revealed that the 6th principle is highly accentuated in both countries' educational standards out of the seven essential principles. Moreover, the results indicate variation in OL alignment across India's grade bands and the USA's educational standards. Based on the results mentioned above, the proposed study intends to provide references to marine education researchers, curriculum developers, and educational policymakers in India to suitably adjust OL coverage concepts in schools to cultivate ocean-literate citizens.

Keywords: ocean literacy; educational standards; coverage analysis; ocean sustainable; marine education; NGSS

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1. Introduction

The ocean encompasses two-thirds of the earth and plays a vital role in defining our planet. Hence, many consider the earth as a planet of the ocean. The ocean is one of the most significant resources as it has significant impacts on climate change, weather change, and oxygen levels. Moreover, the ocean is the habitat of various aquatic species, and it provides an excellent transportation model [1]. However, water bodies across the countries need regular attention to maintain quality. In [2], it is specified that the water quality of Indian rivers is poor as per the water quality monitoring data. Discharge of domestic sewage and industrial effluents are considered the primary source of water pollution in India. Domestic sewage and industrial effluents constitute organic pollutants, chemicals, heavy metals, and runoff from land-based activities such as agriculture.

In [3], the impact of mass bathing and religious activities is assessed on India's leading water bodies' water quality index (WQI). It was found that religious activities and mass bathing contribute to poor water quality and lead to severe contamination depending upon the size of water bodies and pilgrimage loading. Similarly, the lakes and reservoirs of India are suffering from a varied level of environmental degradation. Apart from releasing pollutants from the fixed point source and non-fixed point source, cultural scenarios such as immersion of idols during specific annual festivals have been sources of severe pollution [4]. The Indian Ocean also contains such contamination. Oil pollution is a problem, as several million tons of oil and its products are transported through the Arabian Sea and Bay of Bengal, resulting in severe pollution [5]. According to the Indian Ocean Experiment

(INDOEX), the Indian Ocean is severely polluted by plastic debris [6]. India's water bodies (seas, rivers, and lakes) are significantly contaminated, influencing the entire planet, as all water bodies are ultimately interconnected. In [7], it is proposed that formal school education positively impacts knowledge regarding the ocean and coastal issues.

Marine education includes learning regarding the global sea's relationship with all world systems and society's influence upon that sea. Marine education is an umbrella term that includes oceanography, marine science models, coastal zone management, and aquatic studies [8]. Among multidisciplinary aspects, ocean literacy has been highlighted as an essential component considering its essentiality in the era of global climate change. Ocean literacy (OL) implies the transmission of knowledge about the ocean and its importance and responsible behavior towards the seas, oceans, and resources [9]. Developing more ocean-literate people, enhancing marine citizenship, and developing ocean education are pre-requisites and represent a logical step [10]. OL has been identified as one of the essential predictors of environmental behavior and education.

The USA is one of the countries taking the initiative and promoting OL. One of the USA's initiatives towards OL is developing the Next Generation Science Standards (NGSS). The NGSS are apex science standards outlined to revolutionize conventionally addressed science standards in the USA [11]. The objectives and development sources of the NGSS represent the USA's educational standards and are considered for comparative analysis after reviewing across the target criteria, OL.

The Indian education system is very diverse. The National Council of Educational Research and Training (NCERT) is an autonomous organization of the government of India. It provides academic support in improving the quality of school education in India [12,13]. As per the National Curriculum Framework 2005, NCERT has made environmental education (EE) a compulsory subject at all school levels. EE is a mandatory part of the syllabus in schools throughout the country [14]. The environmental education curriculum touches on very minute aspects of marine education through various environmental studies (EVS), science, and social studies (geography) [13]. Marine concepts are learned through various subjects without a particular subject dedicated to it in India.

Knowledge plays a significant role in forming an individual's perception of the ocean and its importance. Effective environmental and ocean-related policies can be attained with proper knowledge through formal education [7]. As the global climate and environment change, ocean sustainability continues to be a concern [15]. Students' development of the concept of marine environmental sustainability often needs to be conveyed through textbooks. Curriculum standards guide the direction of textbook writing [16]. Therefore, it is crucial to understand the curriculum standards' scope to understand marine environmental sustainability. It is crucial to access the scope and depth of fundamental OL concepts in Indian education for attitudinal change and sensitivity towards the ocean. In [16], the level of fundamental concepts addressed in Indian education is addressed. Additionally, the Indian National Standards (INSs) are compared to the USA's Next Generation Science Standards. The comparison determines the different levels of ocean literacy, and the results can be regarded as a reflective tool or benchmark for improvement in addressing OL concepts.

In this work, our goal is to determine the similarities and variations among the INSs and ICGTs (Indian Central Government Textbooks) in the context of OL. The outcome demonstrates the uniformity of ICGT content with INSs. The results can also be a guideline for the Indian Ministry of Human Resource development regarding the correspondence between INSs and ICGTs, which is expected to comply.

Overall, our study expects to yield relative analysis of USA standards and INSs and ICGTs in the context of OL to present an overview to stakeholders and enhance OL levels among students and the public. We aim to contribute to marine education and OL by proposing an output for Indian curriculum developers and marine educators worldwide.

2. Purpose of the Study

To present a comparative framework regarding the extent of OL concepts in the standards USA and India.

To verify commonalities and differences between NGSS and INSs and INSs and IGCTs in respect to OL.

2.1. Marine Education (ME)

Since the 1980s, marine education (ME) has caught the attention of several scientists, educators, and responsible citizens towards the sea. ME deals with imparting knowledge and enhancing the educational experiences regarding the relationship between the global sea and world systems formally or informally [17,18]. ME is relatively new terminology and is crucial to raise awareness among citizens regarding marine issues. Historically, ME was associated with and regarded as marine science. It was taught as a specialty under several course titles, such as marine science, the science of the sea, oceanography, oceanology, etc. Recently, ME has expanded beyond marine science. Several marine materials are incorporated in distinguished aspects of the curriculum. At present, infusion modules using oceanic or aquatic concepts and examples are inserted into the existing curricula. These compatible marine education formats enable teaching under any subject, such as language, arts, home economics, physical education, and physics. ME represents a new segment in the curriculum [17]. ME encompasses various concepts and issues and can be labeled as an umbrella term. Overall, it can be stated that ME is characterized as an interdisciplinary approach.

According to [18], ME is taught informally beyond the school environment. Television and news media educate and enlighten audiences regarding the sea's wonders, and some organizations and corporations provide educational/recreational marine-related activities. In [17], it is emphasized that marine educators are not restricted to only scientists and science teachers but also includes historians, artists, naval captains, scout leaders, and public aquariums, which suggests that marine education is a segment of everyone's life and that it is for everyone. The subsequent section explains the concept of OL, one of the aspects of ME.

2.2. Ocean Literacy (OL)

The ocean encompasses two-thirds of our planet earth. Covering approximately 70% of the earth's surface, the ocean plays an essential role in defining our planet. Hence, many consider the earth as a planet of the ocean. The ocean is one of the most significant resources as it has significant impacts on climate change, weather change, and oxygen levels. Moreover, the ocean is the habitat of various aquatic species, and it provides an excellent transportation model [1]. For a helpful understanding of geography, topics are studied such as seafloor bathymetry, plate tectonics, the ocean's role in climate variability and cycles, productivity without marine photosynthesis and chemosynthesis, and biodiversity marine ecosystems [19]. In short, understanding the ocean is of utmost importance and necessary for safeguarding and protecting our blue planet.

In the opinion of authors [19], OL is inherent to scientific literacy. OL is a relatively newfangled terminology termed by dedicated formal and informal educators, scientists, government professionals, and others interested in promoting ocean science education [20]. Ocean literacy is defined as *"an understanding of the ocean's influence on you and your influence on the ocean"* [1].

Apart from understanding, an ocean-literate person must communicate about the ocean in a meaningful way and make informed and responsible decisions regarding the ocean and its resources. According to [19], an ocean-literate person is expected to possess a certain level of content knowledge, understand how attitudes and values impact the topic, and be empowered to participate. It can be suggested that OL is about understanding the ocean and taking appropriate steps and actions towards its protection. OL accounts for

the development and attainment of several components: knowledge, behavioral change, awareness, responsibility, attitude, value, and sensitivity towards the ocean.

Since 2004, scientists and educators worldwide have developed seven essential principles and forty-five fundamental concepts of OL [21]. Organizations, such as the National Marine Educators Association (NMEA), the National Oceanic and Atmospheric Administration (NOAA), the National Geographic Society, and the Centers for Ocean Sciences Education Excellence (COSSEE), collaborated with scientists and educators to draft the framework of the Essential Principles and Fundamental Concepts of Ocean Literacy [20]. Table 1 presents OL's seven essential principles, which are accessible at http://oceanliteracy.wp2.coexploration.org/ (accessed on 18 August 2020).

Table 1. The seven essential principles of ocean literacy (OL).

Sr. No.	The Seven Essential Principles of Ocean Literacy
1	The earth has one big ocean with many features.
2	The ocean and life in the ocean shape the features of the earth.
3	The ocean has a significant influence on weather and climate.
4	The ocean makes the earth habitable.
5	The ocean supports a great diversity of life and ecosystems.
6	The ocean and humans are inextricably interconnected.
7	The ocean is largely unexplored.

Source: (Strang and Tran, 2010).

The seven essential principles and forty-five fundamental concepts portray the significant concepts that a school graduate should learn and apprehend regarding the ocean and its importance in the earth systems [20]. These seven essential principles and forty-five fundamental concepts must be integrated into educational practices, research curricula, textbooks, and assessments to accomplish an ocean-literate society [19]. It can be concluded that the abovementioned seven essential principles and forty-five major concepts corresponding to principles are crucial and must be incorporated in the general education system to spread literacy among the masses.

In addition to scientists and educators, the abovementioned organizations continued to work regarding the development principles and concepts. Their prolonged work resulted in the formation of a scope and sequence that explain how the ocean literacy principles should be taught at various grade bands (K–II, III–V, VI–VIII, and IX–XII). Developing scope and sequence for grade K–XII was initiated in 2002, but it began in 2006. Several scientists and educators from the ocean literacy community decided to develop conceptual flow diagrams to provide the community with a more detailed and helpful tool for understanding each concept [21].

The ocean literacy scope and sequence for grade K–XII document had undergone multiple revisions and public reviews since 2006 to strengthen its validity and reliability. Finally, in the year 2010, the final draft of the ocean literacy scope and sequence for grade K–XII was published in the NMEA Special Report #3. The Ocean Literacy Framework constitutes the essential principles of ocean sciences K–XII and the complementary ocean literacy scope and sequence for grades K–XII documents [21]. In brief, the ocean literacy scope and sequence from grades K–XII represent ocean science concepts' interconnectedness and assist the ocean's teaching-learning. In [21], among the index topics of conceptual flow diagrams from the ocean literacy scope and sequence for grades, K–XII was selected for ocean literacy review criteria.

Several research studies have been undertaken to trace marine education and ocean literacy in respective countries with specific samples. The following section reviews the findings in the area of ocean literacy and marine concepts. In [7], it was observed that the USA's masses are not knowledgeable about environmental terms and ocean issues. Residents of the coastal area are more acquainted with environmental and ocean issues. Further, the [7] suggested that newspapers and the Internet positively influence citizens' knowledge of ocean issues. On the contrary, television and radio have a negative influence.

In [20], the ocean and environmental literacy levels of public school students in the USA was examined. The study indicated a similarity in American adults' and student participants' knowledge levels by exhibiting a low initial ocean literacy level. Moreover, it was also discovered that general education and university education involve minimal ocean literacy and environmental literacy concepts. Moreover, engagement in OL programs raises OL. The [20] indicated that participation in OL programs is beneficial. Thus, such programs should be developed at various levels of education and can be one of the approaches to increase OL levels among the masses.

In [22], public school students from grades 7–12 (ages 12–18) from Nova Scotia, Canada were evaluated for ocean valuation, knowledge, interaction, and interest. The [22] revealed a low level of ocean science knowledge and a positive relationship between knowledge and value. It also suggested that intensifying interactions with the ocean can improve OL through practical learning. Hence, [22] argued that interactive and experimental learning may lead to higher knowledge levels, which might positively influence the ocean's value.

In [19], the level of OL was measured for Greek pre-service teachers. The result revealed that pre-service teachers had an average level of OL and positive attitudes towards ocean stewardship. Greek pre-service teachers regarded the Internet and mass media as more essential information sources than formal education, books, and nongovernmental organizations. TERC, the center for Earth and Space Science Education and NOAA, conducted research that analyzed earth science education standards of fifty states in the USA. Ocean literacy was one of the target criteria and essential standards of the 21st century [23].

In [24], the authors developed a four-component model (moral sensitivity, moral judgment, moral motivation, and moral character) to examine the factors influencing young people's thinking regarding ocean environmental dilemmas. Likewise, various studies have been conducted to access OL and attitudes towards it. After reviewing specific papers, it became evident that society has a moderate to low level of OL with a positive attitude towards its protection. The primary source of information is the Internet and newspapers rather than formal education and the school settings. The majority of the studies above revolve around the seven essential principles of OL. Most of the tools used to measure OL were based on the seven essential principles and fundamental concepts. Similarly, in our proposed study, the seven essential principles and fundamental concepts are the evaluation criteria.

2.3. Next Generation Science Standards (USA)

The Next Generation Science Standards (NGSS) are internationally benchmarked science standards developed to combat traditionally approached science standards in the USA. One of the main objectives behind drafting the NGSS was to prepare students for college and career readiness in science [11]. In other words, the NGSS represents a substantial shift from past approaches to a new dimension of science education.

Previously, to develop their science standards, each state in the USA followed either the National Science Education Standards (NSES) by the National Research Council (NRC) or the Benchmarks for Science Literacy by the American Association for the Advancement of Science (AAAS). Earlier state science standards reflected the mere transmission of knowledge a learner had to surpass at a given course and grade level. The inquiry was part of state standards but remained a separate standard and required independent testing [11]. The inquiry was considered a pedagogical method rather than a scientific habit of mind. There was an urge to address loopholes of existing science standards by integrating inquiry with content.

The year 2010 is marked as the beginning of the NGSS development process [25]. The development process, which constitutes two major steps, is represented in Figure 1.

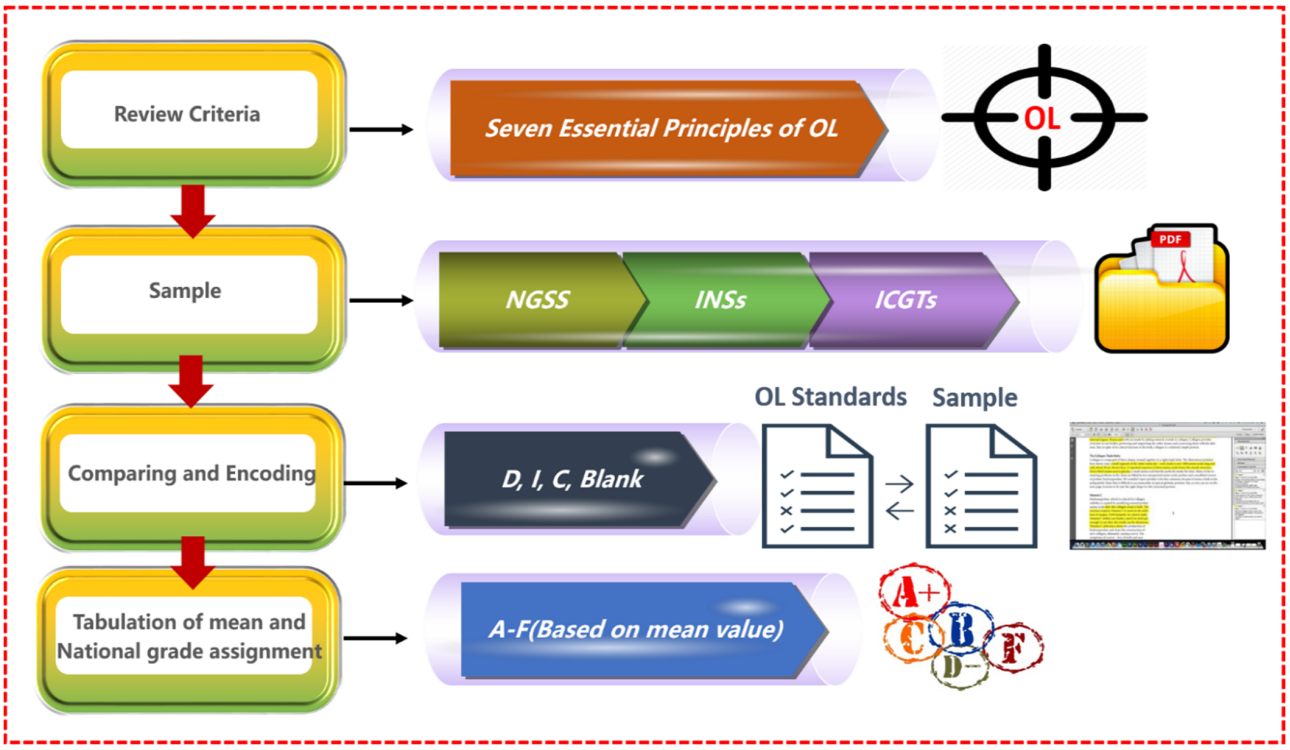

Figure 1. The conceptual framework.

The first step was led by the National Research Council (NRC), the National Academy of Sciences' operational arm. The framework is known as the NRC framework for K–XII science education. NRC authored practices, crosscutting concepts, and core ideas. The NRC framework was developed by a committee of 18 nationally and internationally recognized experts: practicing scientists, including two Nobel laureates; cognitive scientists; science education researchers; and experts in science education standards and policy. As depicted in the figure, the NRC framework describes the three dimensions for standards: practices, core ideas, and crosscutting experts. The NRC framework was designed to provide the blueprint for developing NGSS [25]. The NRC framework offers guidance and direction in the development process of standards.

The second phase constitutes a state-led effort. Each state out of twenty-six states formed a broad-based team comprising K–XII representatives, including science teachers, scientists, engineers from the business community, employers, and education leaders. The final version of NGSS was developed through the collaborative effort of twenty-six states partnering with stakeholders in science, science education, higher education, business, and industry [25]. After the development of the final draft, it went through various review procedures. Two publicly released drafts provided an opportunity to inform all interested and involved individuals and groups about the proposed content, practices, and NGSS structure. The final review was undertaken by the original NRC committee and other experts who were acquainted regarding the NRC framework and the NGSS. The reviewer considered the vision and content of the framework as a reference point to evaluate the NGSS. The draft of NGSS was evaluated on the lines of consistency with the NRC framework. After completing the final review, the National Academies Press published the final document in 2013 [25]. The development process of the NGSS was systematic and comprehensive and was authored and revised by renowned organizations and stakeholders associated with science education.

In April 2013, the NGSS was released, which marked educational reform at the national, state, and local levels. Transformations focus on teachers' professional development, school programs, assessments, and accountability [25]. The NGSS is regarded as a far-reaching step towards establishing modern, national K–XII science education standards.

The NGSS is regarded as a body of knowledge and is intended to revise and refine knowledge continually.

The NGSS present three dimensions: practices, core ideas, and crosscutting. The practices describe the meaning of "inquiry" in science, which is essential in cognitive, social, and physical practices. The term "practices" in the NGSS replaces the term "skill". The crosscutting concepts explain "cause and effect" to students, which further facilitates developing a coherent and scientifically-based view of the world. Moreover, crosscutting concepts help students explore connections across the four domains of science mentioned under the core ideas: physical science, life science, earth and space science, and engineering [26]. The two dimensions mentioned above facilitate investigation and involve the association of the four science domains, respectively. This leads to the augmentation of a learner's scientific knowledge level.

The third dimension, disciplinary core ideas (DCI), is categorized into four domains: life sciences, earth and space sciences, engineering technology, and science applications. The DCI represent a significant science concept that has broad importance within and across multiple sciences and engineering disciplines. These core ideas are progressive and evolve through grade levels [26]. DCI are the most significant aspects of science as they have the strength to influence curriculum, instruction, and assessments.

The author stated that the NGSS presents major shifts from traditional approaches, with the number of performance expectations in earth and space science roughly equal to that of both life and physical sciences [11].

The earth and space science standards are developed by joint research and education community efforts that encompass earth science literacy principles, essential ocean literacy principles, essential principles, and fundamental concepts of atmospheric science literacy, as well as essential climate science principles [11]. Ocean literacy, the key element of [11], is a content development source for the earth and space science domain. Hence, out of the four DCI disciplines, earth and space sciences (ESS) were selected for comparative studies and considered a benchmark. Besides ESS, the life science discipline was also chosen for analysis considering its biological content referring to the principle five concepts of ocean literacy.

The NGSS are coherent and present a progression from grade band to grade band that builds understanding and abilities throughout a student's K–XII science education. The NGSS are extensive and influence various levels of the educational systems. Curriculum, teacher development, and assessment and accountability are the key channels that the NGSS have an impact on [25]. The NGSS are comprehensive and progressive. The concrete structure and development process of the NGGS have to lead to the development of a rigorous framework. The significant influence of the NGSS on various channels has led to the NGSS becoming a prime document. Hence, these standards were selected as a benchmark for comparative analysis in our proposed study.

3. Methodology

3.1. Research Method

Educational research has two primary approaches to study social and individual work such as quantitative and qualitative. In the proposed work, we have adopted both qualitative and quantitative approaches. The qualitative method is an "*emergent, inductive, interpretive, and naturalistic approach to the study of people, cases, phenomena, social situations, and processes in their natural settings to reveal in descriptive terms the meanings that people attach to their experiences of the world*" [27]. According to [28], qualitative research deals with data analysis obtained from direct fieldwork observations, in-depth, open-ended interviews, and written documents. Qualitative researchers inductively generate rich narrative descriptions and construct case studies by reviewing real-world settings and naturalistic inquiry. However, qualitative research is not restricted to a single methodology and a single discipline [27]. Qualitative paradigms encompass a wide range of approaches and methods found within different research disciplines.

One of the widely used qualitative research techniques is the content analysis. According to [29], content analysis compresses several text words into fewer categories based on explicit code rules. Content analysis is the methodological examination of extensive volumes of data with relative ease. It is a creative technique that enables us to explore and elucidate the focus of individual, group, institutional, or social attention. The proposed work uses content analysis as the methodology to examine the NGSS, INSs, and ICGTs for OL by following defined procedures.

On the contrary, quantitative approach includes data analysis, objective, numerical, and statistical measurement by collecting data through various approaches such as questionnaires, surveys, and so on [10]. After analyzing the content and coding the samples under consideration, OL mean value of the samples under consideration was calculated, representing a quantitative approach.

3.2. Conceptual Framework

The conceptual framework represented in Figure 1 is the unification of two approaches inspired by [21,23].

3.3. Sample Selection Description

This section explains the background and rationality behind determining the target criteria and samples, which are verified against target criteria.

3.3.1. OL Standards

Seven fundamental principles present a general overview of OL. To measure grade-wise INSs, detailed investigation of OL principles need to be considered, setting them as target standards. NME Special Report #3 is a consensus document drafted from several scientists and educators' collaborative work. It represents the ocean literacy scope and sequence for grade K–XII. NMEA Special Report #3 presents seven essential principles of OL in 28 conceptual flowcharts. Based on the 28 conceptual charts, a matrix representation of index topics for OL is designed. The index topics' matrix represents seven essential principles, a major branch topic, and a subtopic for several grade bands [23].

3.3.2. Next Generation Science Standards (NGSS)

The NGSS are science content standards for grade K–XII. They represent a consortium effort of twenty-six states, the National Science Teacher Association, the American Association for Advancing Science, and the National Research Council to draft new standards by integrating inquiry with content [11]. The NGSS represent three dimensions that are integrated into instructions at all levels. The three dimensions of the NGSS are as follows:

1. Disciplinary core ideas (DCI);
2. Science and engineering practices;
3. Crosscutting concepts.

DCI involve specific content and subject areas across multiple sciences or engineering disciplines. The core ideas are grouped into four domains, namely, physical science, life science, earth and space science, and engineering [26]. Earth and space science and life science disciplines were selected for analysis, as OL concepts are inherently integrated into school areas such as science, environmental education, geography, and oceanography [30].

3.3.3. Document Selection for Analysis

The motivation for selection of NGSS science standards is briefly described in Section 3.3.2. On the contrary, to analyze the educational standards for India, the curriculum developed by the National Council of Education Research and Training (NCERT) is considered due to the following reasons. NCERT is an autonomous organization of the government of India established in the year 1961 on September 1. The central and state government are guided and assisted by the NCERT on several academic matters related to school education. The NCERT is constantly engaged in improvising and upgrading the quality of education in India

by various academic programs like development of curriculum, textbooks, supplementary books, educational kits, teacher's handbooks, manuals, e- resources, and capacity building of Key Resource Teachers, Teacher Educators, State Functionaries [31]. At present, the books drafted by NCERT is used in around 9000 "central schools" of India and is regarded as model textbook [32]. As claimed by [33], NCERT crafts and publishes textbooks of all subjects for grade I-XII in Hindi, English, and Urdu. This implies that the NCERT and its curriculum and textbooks has wider influence on the education system in India and holds significant position.

3.4. Analysis Procedure

Earth and space science standards, one of the DCI of the NGSS, was downloaded from the following website: http://www.nextgenscience.org/overview-dci (accessed on 13 April 2021). As per the american education system, standards were in a grade band format. Earth and space science standards for each grade band level were segregated. Subsequently, INSs from grade III–XII for subjects such as EVS (environmental studies), social science, and science were downloaded from the NCERT website (http://www.ncert.nic.in/, accessed on 13 April 2021). Similarly, EVS and social science ICGTs from grade III–XII were purchased. All statements in standards and textbooks that dealt with review standards, i.e., OL concepts, were underlined and bookmarked grade-wise and subject-wise. Successively, depending on the nature of coverage, a unique rating was assigned to each grade's subject standards content to align it with the respective principle, index topics, and concepts of OL's index topics. In the proposed work, we have inherited three rating criteria from [23], as explained in Table 2. In addition, new criteria symbolized as "C", indicating a collective representation of direct and indirect parameters, were also incorporated into the existing rating model. Additionally, criterion "C" applied to a situation where one and only one of the index topics' concepts was directly represented in the sample. The coding procedure was demonstrated for the educational standards of both the countries under consideration.

Table 2. Rating model description.

Rating	Measure
Directly (D)	Standards or content directly mention two or more major components of the specific review criteria.
Indirectly (I)	Standards or content indirectly mention or closely refer to one or more components of the specific review criteria.
Collective (C)	The collective representation of direct and indirect conditions.
Blank	Standards or content fail to address the concepts of review criteria.

Different countries have different curriculum objectives. Hence, the OL concepts under each index topic might not fall under the NMEA's respective grade band range. Therefore, the NMEA OL concepts were not strictly adhered to grade band-wise, and they were relaxed by up to one educational grade band. For example, let us consider OL principle 3. Under the index topic "water cycle", the OL concept "runoff" appears in the grade band III–V. However, if the same OL concept was traced in the sample standards of grade band VI–VIII, it was rated as per the rating of the above model.

After determining the mean value for NGSS, INSs, and ICGTs, a national ocean literacy grade was assigned to each of the samples mentioned above for comparative analysis. To assign a national ocean literacy grade, we adopted an interval-based method inspired by the study [23]. The number of intervals was reduced from seven to six, as in the proposed work, we have considered 30 OL review criteria (Index Topics) instead of 35, which were equally grouped into five grades. Table 3 presents the group ranges for OL concepts that were addressed and their corresponding national grade.

Table 3. Class intervals of national ocean literacy grade.

Number of Fundamental Concepts Directly, Indirectly, or Collectively Addressed in Sample (Real Limits)	Grade
30–25	A
24–19	B
18–13	C
12–7	D
6–1	F

Assigning a national ocean literacy grade can be confusing in mean values with a decimal point. For example, if the mean value of any of the samples above was derived from 12.5, then allocating the national OL grade would be unclear. To avoid unclearness, the class intervals (real limits) from Table 4 were relaxed with decimal values leading into the formation of apparent limits. Apparent limits were derived concerning real limits and considering the floor and ceiling of the values. Concerning our example mentioned above, the national OL grade "D" was assigned to any of the samples with a mean value of 12.5. Table 4 shows the apparent limits derived from Table 4 for assigning national ocean literacy grades.

Table 4. Apparent class intervals of national ocean literacy grade.

Number of Fundamental Concepts Directly, Indirectly, or Collectively Addressed in Sample (Real Limits)	Number of Fundamental Concepts Directly, Indirectly, or Collectively Addressed in Sample (Apparent Limits)	Grade
30–25	30–24.6	A
24–19	24.5–18.6	B
18–13	18.5–12.6	C
12–7	12.5–6.6	D
6–1	6.5–1	F

For reliable analysis, Cohen's kappa coefficient (κ), a statistical measure for inter-annotator agreement, was evaluated. Two domain experts conducted the inter-annotator agreement analysis. Two annotators were assigned with the responsibility of identifying and classifying the OL concept coverage into direct (D), indirect (I), and collective (C) groups. The OL concepts identified and coded by both annotators were considered. Our analysis results show that the inter-annotator kappa coefficient $\kappa_1 = 0.88$, $\kappa_2 = 0.81$, and $\kappa_3 = 0.85$, where $\kappa_1, \kappa_2, \kappa_3$ represent the inter-annotator agreement values for the analysis of NGSS, INSs, and ICGTs, respectively. $\kappa \in \{\kappa_1, \kappa_2, \kappa_3\} \in [0.8, 1.0]$ indicates that the outcome of the annotators was positively correlated.

4. Results

The following subsections discuss the analysis of the Next Generation Science Standards (NGSS), analysis of the Indian National Standards (INSs), and comparative examination of the NGSS (USA) and INSs.

4.1. Analysis of the Next Generation Science Standards (USA)

As per the defined methodology in Section 3, the NGSS were evaluated in three bands: elementary, middle, and high school. Initially, the NGSS had four bands based on the grades K–II, III–V, VI-VII, IX–XII, which were eventually converted into three bands for uniform comparison. The new bands are as follows: grade I–V as elementary school level; VI–VIII as middle school level; and IX–XII as high school level. In the proposed work, the kindergarten educational standard was not considered for analysis.

Tables 5–11 exhibit the evaluation outcome of the NGSS from OL principles 1 to 7 across the grade bands. Furthermore, these tables also reveal the number of OL concepts directly, indirectly, and collectively represented in the NGSS grade band-wise. From Tables 5–11, it was observed that a total number of OL concepts addressed directly/indirectly/collectively from OL principles 1 to 7 were 6, 8, 9, 6, 11, 14, and 2, respectively. Moreover, the mean coverage of fundamental OL concepts in the NGSS was found to be 18.7. Based on the mean value derived, a national OL grade of "B" was assigned to the USA's educational standard.

Table 5. Analysis of Next Generation Science Standards (NGSS; Principle 1).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics			
	Grade Bands	Total	Direct	Indirect	Collective	1 (A)	1 (B)	1 (C)	1 (D)
Principle 1	I–V (ESS)	2	2	0	0	D	D		
	I–V (LS)	0	0	0	0				
	I–V	**2**	**2**	**0**					
	VI–VIII (ESS)	2	2	0	0	D	D		
	VI–VIII (LS)	0	0	0	0				
	VI–VIII	**2**	**2**	**0**	**0**				
	IX–XII(ESS)	2	2	0	0		D	D	
	IX–XII (LS)	0	0	0	0				
	IX–XII	**2**	**2**	**0**	**0**				
Total		**6**	**6**	**0**	**0**				

Table 6. Analysis of NGSS (Principle 2).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics			
	Grade Bands	Total	Direct	Indirect	Collective	2 (A)	2 (B)	2 (C)	2 (D)
Principle 2	I–V (ESS)	3	2	1	0	D	D	I	
	I–V (LS)	0	0	0	0				
	I–V	**3**	**2**	**1**					
	VI–VIII (ESS)	3	2	1	0	D	D	I	
	VI–VIII (LS)	0	0	0	0				
	VI–VIII	**3**	**2**	**1**	**0**				
	IX–XII(ESS)	2	2	0	0		D	D	
	IX–XII (LS)	0	0	0	0				
	IX–XII	**2**	**2**	**0**	**0**				
Total		**8**	**6**	**2**	**0**				

Table 7. Analysis of NGSS (Principle 3).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics			
	Grade Bands	**Total**	**Direct**	**Indirect**	**Collective**	**3 (A)**	**3 (B)**	**3 (C)**	**3 (D)**
Principle 3	I–V (ESS)	2	2	0	0	D	D		
	I–V (LS)	0	0	0	0				
	I–V	**2**	**2**	**0**	**0**				
	VI–VIII (ESS)	3	3	0	0	D	D	D	
	VI–VIII (LS)	0	0	0	0				
	VI–VIII	**3**	**3**	**0**	**0**				
	IX–XII(ESS)	3	3	0	0	D		D	D
	IX–XII (LS)	1	1	0	0			D	
	IX–XII	**4**	**4**	**0**	**0**				
Total		**9**	**9**	**0**	**0**				

Table 8. Analysis of NGSS (Principle 4).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics	
	Grade Bands	**Total**	**Direct**	**Indirect**	**Collective**	**4 (A)**	**4 (B)**
Principle 4	I–V (ESS)	1	1	0	0	D	
	I–V (LS)	1	0	0	1	C	
	I–V	**2**	**1**	**0**	**1**		
	VI–VIII (ESS)	1	0	1	0	I	
	VI–VIII (LS)	2	1	1	0	I	D
	VI–VIII	**3**	**1**	**2**	**0**		
	IX–XII(ESS)	0	0	0	0		
	IX–XII (LS)	1	0	0	1		C
	IX–XII	**1**	**0**	**0**	**1**		
Total		**6**	**2**	**2**	**2**		

Table 9. Analysis of NGSS (Principle 5).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics						
	Grade Bands	**Total**	**Direct**	**Indirect**	**Collective**	**5 (A)**	**5 (B)**	**5 (C)**	**5 (D)**	**5 (E)**	**5 (F)**	**5 (G)**
Principle 5	I–V (ESS)	1	0	0	1		C					
	I–V (LS)	3	2	1	0		D	D	I			
	I–V	**4**	**2**	**1**	**1**							
	VI–VIII (ESS)	0	0	0	0							
	VI–VIII (LS)	2	2	0	0		D	D				
	VI–VIII	**2**	**2**	**0**	**0**							
	IX–XII (ESS)	2	1	1	0		D	I				
	IX–XII (LSS)	3	3	0	0	D	D			D		
	IX–XII	**5**	**4**	**1**	**0**							
Total		**11**	**8**	**2**	**1**							

Table 10. Analysis of NGSS (Principle 6).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics				
	Grade Bands	**Total**	**Direct**	**Indirect**	**Collective**	**6 (A)**	**6 (B)**	**6 (C)**	**6 (D)**	**6 (E)**
Principal 6	I–V (ESS)	4	1	1	2	C	C	D		I
	I–V (LS)	0	0	0	0					
	I–V	**4**	**1**	**1**	**2**					
	VI–VIII (ESS)	3	2	1	0	D	I	D		
	VI–VIII (LS)	2	0	2	0		I		I	
	VI–VIII	**5**	**2**	**3**	**0**					
	IX–XII(ESS)	3	3	0	0	D		D		D
	IX–XII (LS)	2	2	0	0		D		D	
	IX–XII	**5**	**5**	**0**	**0**					
Total		**14**	**8**	**4**	**2**					

Table 11. Analysis of NGSS (Principle 7).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics			
	Grade Bands	**Total**	**Direct**	**Indirect**	**Collective**	**7 (A)**	**7 (B)**	**7 (C)**	**7 (D)**
Principle 7	I–V (ESS)	1	1	0	0		D		
	I–V (LS)	0	0	0	0				
	I–V	**1**	**1**	**0**	**0**				
	VI–VIII (ESS)	0	0	0	0				
	VI–VIII (LS)	0	0	0	0				
	VI–VIII	**0**	**0**	**0**	**0**				
	IX–XII(ESS)	0	0	0	0				
	IX–XII (LS)	1	1	0	0			D	
	IX–XII	**1**	**1**	**0**	**0**				
Total		**2**	**2**	**0**	**0**				

In Table 5, principle one and its index topics out of the seven essential principles were considered for explaining the sample analysis procedure. Grade bands, total number of concepts addressed, and three different criteria's such as Direct, Indirect, and Collective were organized in successive columns. In the case of NGSS two disciplines, ESS and LS were analyzed for all the three grade bands. At each grade band level, a summation of total OL values from both the disciplines was calculated. Summation value signifies the number of OL concepts addressed in respective educational grade band level. Standards of each grade bands were rated either as D or I or C or Blank as per the rating Model (Refer Table 2). From the sample Table 5, it can be explained that the NGSS addresses total 12 concepts from principal one and its index topics directly/indirectly/collectively. Grade bands I-V, VI–VIII, IX–XII cover total 5, 3, and 4 concepts from principle one, respectively. Summation of total number of concepts addressed directly or indirectly or collectively were tabulated for each educational grade band with respect to each essential principle of OL. Analysis of the NGSS comprised of seven tables, each table corresponding to one of the seven essential principles in a numerical order. Finally, the mean value was computed.

4.1.1. Band-Wise OL Alignment in NGSS

In the proposed work, we examine the coverage of the fundamental OL concepts in the educational levels such as elementary, middle, and high school in a grade band format. Figure 2 depicts the coverage of OL concepts in the grade bands of the NGSS. Out of all the concepts aligned, the high school level, i.e., grade band, IX–XII, had the maximum number of fundamental OL concepts covered. Overall, the number of OL concepts in the NGSS throughout the whole educational grade band remained almost consistent.

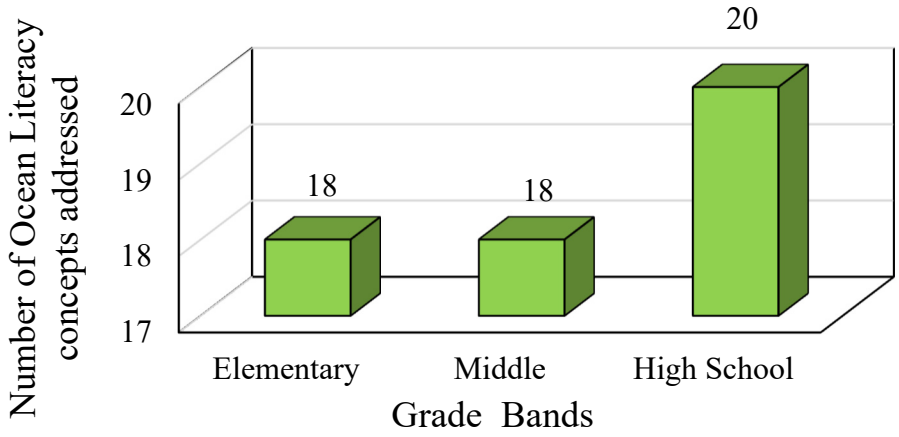

Figure 2. Band-wise Ocean Literacy alignment in NGSS.

4.1.2. OL Principles Emphasized in NGSS

Each essential OL principle embraces different index topics and concepts related to ocean and marine education. Figure 3 represents the percentage distribution of essential OL principles highlighted in the NGSS. Principle 6 (oceans and humans are inextricably linked) was accentuated in the NGSS, followed by principle 5 (the ocean supports a great diversity of life and ecosystems). OL principle 7 was underrepresented in the NGSS. There seems to be no definite pattern behind incorporating OL principles in the NGSS.

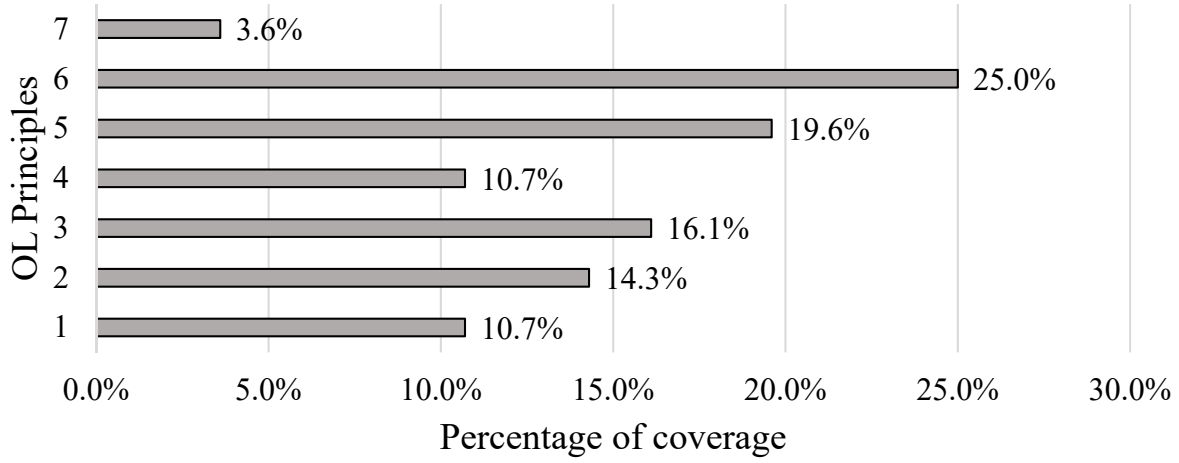

Figure 3. OL principles emphasized in NGSS.

Figure 4 shows the subject-wise bifurcation of essential OL principle alignment in NGSS. The red font in Figure 4 represents the total percentage coverage of a particular principle followed by detailed subject-wise coverage specification in black font with different color blocks. For example, of the total OL coverage, 10.7% of concepts align with principle 4 in NGSS. Of the total 10.7% of principle 4 coverage, 3.6 and 7.1% of concepts are addressed in ESS and LS disciplines/subjects of NGSS, respectively. Figure 4 displays

the subject-wise comparison of OL percentage coverage among the seven essential OL principles in NGSS.

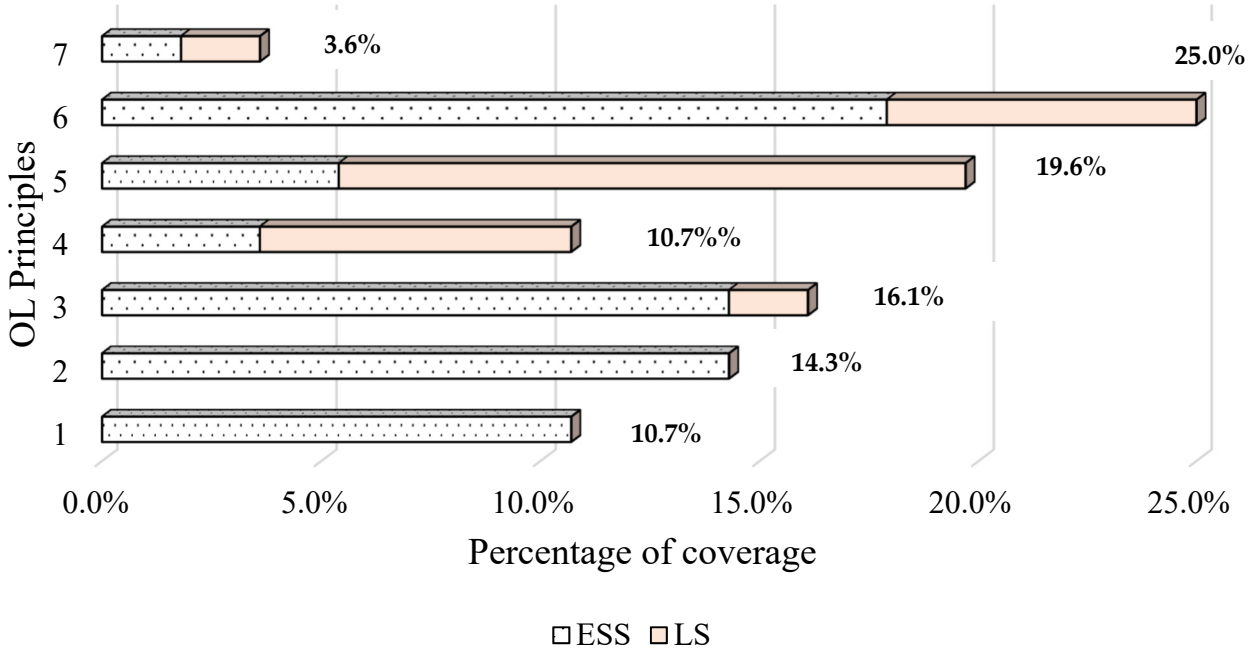

Figure 4. OL principle emphasized in NGSS (subject-wise).

4.1.3. Criteria-Wise OL Alignment in NGSS

OL alignment was labeled as per four different predefined criteria described in Figure 5, which displays the criteria-wise coverage of OL in the NGSS. Of the total coverage, many of the OL concepts were directly incorporated in the NGSS. Figure 5 indicates the superior result regarding coverage at the criteria level.

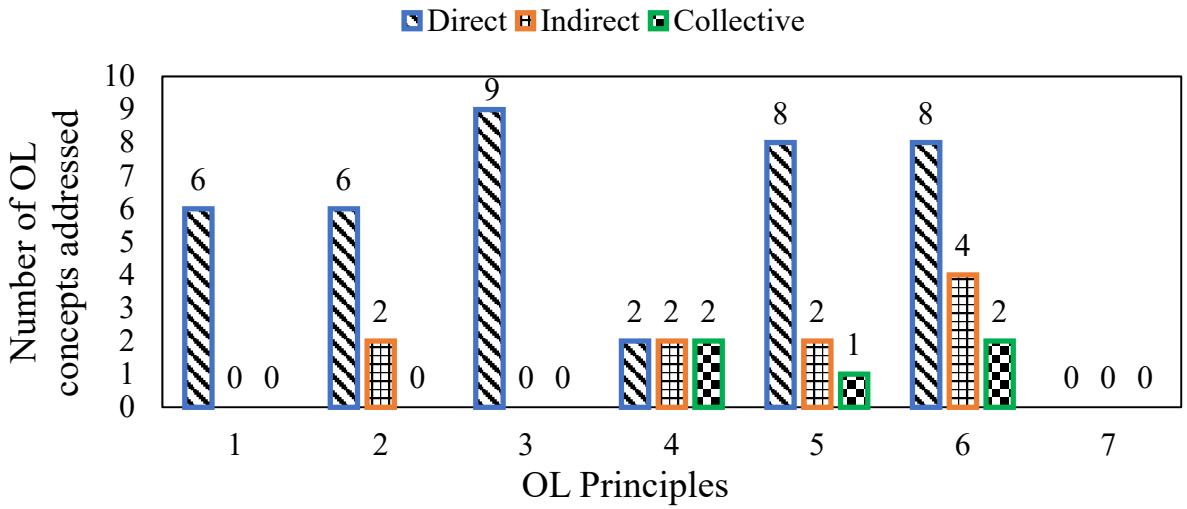

Figure 5. OL alignment in NGSS (criteria-wise).

4.1.4. OL Alignment in Multiple Subjects/Disciplines (NGSS)

As mentioned previously, ESS and LS were the two disciplines from the NGSS analyzed across all grade bands in the current study. Figure 6 shows comparative results of OL concept coverage in these two disciplines of NGSS. It can be observed that of the

total coverage, ESS aligns a larger proportion of OL concepts than LS does across all grade bands.

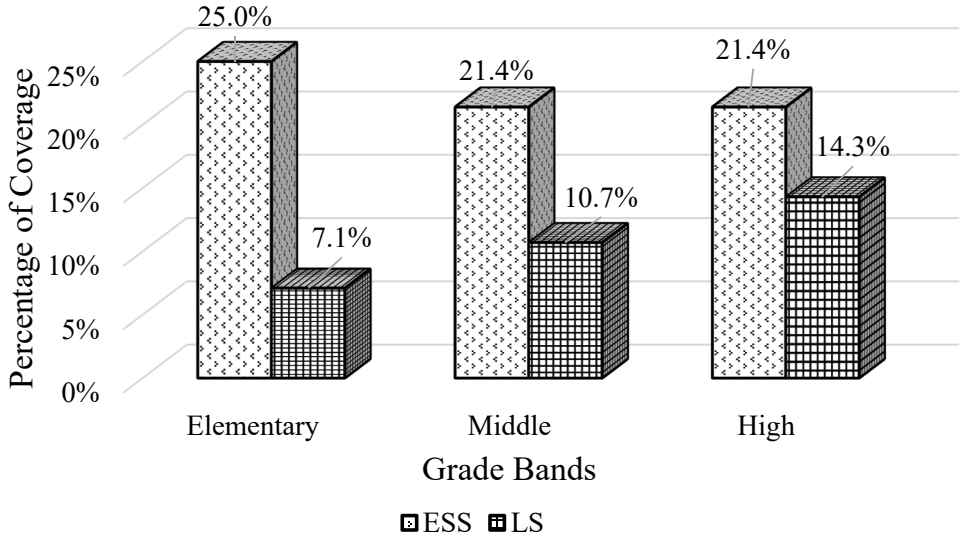

Figure 6. OL alignment in NGSS (subject-wise).

4.2. Analysis of the Indian National Standards (INSs)

India has several educational levels, such as pre-primary (kindergarten), primary (grade I–V), upper primary (VI–VIII), secondary (IX–X), and higher secondary (XI–XII). Like the NGSS analysis procedure, the central government of India's educational bands was transformed into three bands to facilitate even comparison. INSs' transformed grade band represents grade I–V as elementary school level, VI–VIII as middle school level, and IX–XII as high school level. It is of note that some countries suggest that elementary level refers to primary level. Hence, both the terminologies, elementary and primary, are used interchangeably in the proposed work.

Tables 12–18 display the INS analysis across the grade bands in the context of OL's seven essential principles. Each table from Tables 12–18 corresponds to OL's principles following the numerical order. Tables 12–18 state the number of OL concepts covered directly/indirectly/collectively across the grade bands of INSs. It was found that the total numbers of OL concepts addressed directly/indirectly/collectively from OL principle 1 to 7 were 8, 6, 5, 0, 2, 12, and 1, respectively. The mean coverage of fundamental OL concepts in INSs was 11.3. A national ocean literacy grade of "D" was assigned to INSs by a mean value and apparent limit.

Table 12. Analysis of Indian National Standards (INSs) (Principle 1).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics			
	Grade Bands	Total	Direct	Indirect	Collective	1 (A)	1 (B)	1 (C)	1 (D)
Principle 1	**I–V**	**1**	**1**	**0**	**0**	**D**			
	VI–VIII(SS)	3	3	0	0	D	D	D	
	VI–VIII (Science)	1	0	1	0	I			
	VI–VIII	**4**	**3**	**1**	**0**				
	IX–XII(SS)	3	2	1	0	I	D	D	
	IX–XII (Science)	0	0	0	0				
	IX–XII	**3**	**2**	**1**	**0**				
Total		**8**	**6**	**2**	**0**				

Table 13. Analysis of INSs (Principle 2).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics			
	Grade Bands	Total	Direct	Indirect	Collective	2 (A)	2 (B)	2 (C)	2 (D)
Principle 2	**I–V**	**0**	**0**	**0**	**0**				
	VI–VIII(SS)	2	1	0	1		C	D	
	VI–VIII (Science)	1	1	0	0		D		
	VI–VIII	**3**	**2**	**0**	**1**				
	IX–XII(SS)	3	2	1	0	I	D	D	
	IX–XII (Science)	0	0	0	0				
	IX–XII	**3**	**2**	**1**	**0**				
Total		**6**	**4**	**1**	**1**				

Table 14. Analysis of INSs (Principle 3).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics			
	Grade Bands	Total	Direct	Indirect	Collective	3 (A)	3 (B)	3 (C)	3 (D)
Principle 3	**I–V**	**1**	**1**	**0**	**0**		**D**		
	VI–VIII(SS)	0	0	0	0				
	VI–VIII (Science)	1	1	0	0		D		
	VI–VIII	**1**	**1**	**0**	**0**				
	IX–XII(SS)	2	1	0	1	C		D	
	IX–XII (Science)	1	0	1	0			I	
	IX–XII	**3**	**1**	**1**	**1**				
Total		**5**	**3**	**1**	**1**				

Table 15. Analysis of INSs (Principle 4).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics	
	Grade Bands	Total	Direct	Indirect	Collective	4 (A)	4 (B)
Principle 4	**I–V**	**0**	**0**	**0**	**0**		
	VI–VIII(SS)	0	0	0	0		
	VI–VIII (Science)	0	0	0	0		
	VI–VIII	**0**	**0**	**0**	**0**		
	IX–XII(SS)	0	0	0	0		
	IX–XII (Science)	1	0	1	0		
	IX–XII	**0**	**0**	**0**	**0**		
Total		**0**	**0**	**0**	**0**		

Table 16. Analysis of INSs (Principle 5).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics						
	Grade Bands	Total	Direct	Indirect	Collective	5 (A)	5 (B)	5 (C)	5 (D)	5 (E)	5 (F)	5 (G)
Principle 5	**I–V**	**1**	**0**	**1**	**0**		**I**					
	VI–VIII(SS)	0	0	0	0							
	VI–VIII (Science)	0	0	0	0							
	VI–VIII	**0**	**0**	**0**	**0**							
	IX–XII(SS)	0	0	0	0							
	IX–XII (Science)	1	0	1	0		I					
	IX–XII	**1**	**0**	**1**	**0**							
Total		**2**	**0**	**2**	**0**							

Table 17. Analysis of INSs (Principle 6).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics				
	Grade Bands	**Total**	**Direct**	**Indirect**	**Collective**	**6 (A)**	**6 (B)**	**6 (C)**	**6 (D)**	**6 (E)**
Principle 6	**I–V**	**2**	**1**	**0**	**1**	**D**		**C**		
	VI–VIII(SS)	1	0	1	0	I				
	VI–VIII (Science)	2	1	1	0	I		D		
	VI–VIII	**3**	**1**	**2**	**0**					
	IX–XII(SS)	3	0	3	0	I	I	I		
	IX–XII (Science)	4	2	2	0	D	D	I		I
	IX–XII	**7**	**2**	**5**	**0**					
Total		**12**	**4**	**7**	**1**					

Table 18. Analysis of INSs (Principle 7).

Essential Ocean Literacy Principles	Type of Concept Representation					Index Topics			
	Grade Bands	**Total**	**Direct**	**Indirect**	**Collective**	**7 (A)**	**7 (B)**	**7 (C)**	**7 (D)**
Principle 7	**I–V**	**0**	**0**	**0**	**0**				
	VI–VIII(SS)	0	0	0	0				
	VI–VIII (Science)	0	0	0	0				
	VI–VIII	**0**	**0**	**0**	**0**				
	IX–XII(SS)	0	0	0	0				
	IX–XII (Science)	1	0	1	0				I
	IX–XII	**1**	**0**	**1**	**0**				
Total		**1**	**0**	**1**	**0**				

4.2.1. Band-Wise OL Alignment in INSs

Figure 7 presents the grade band-wise alignment of OL concepts in INSs. From Figure 7, it can be concluded that coverage of OL concepts progressively increased from the elementary school level to the high school level in the case of INSs. Among all of the concepts covered, the high school grade band had the highest number of OL concepts addressed, followed by the middle and elementary school grade bands, respectively. A significant proportion of the rise in the number of OL concepts addressed was observed from elementary to high school level.

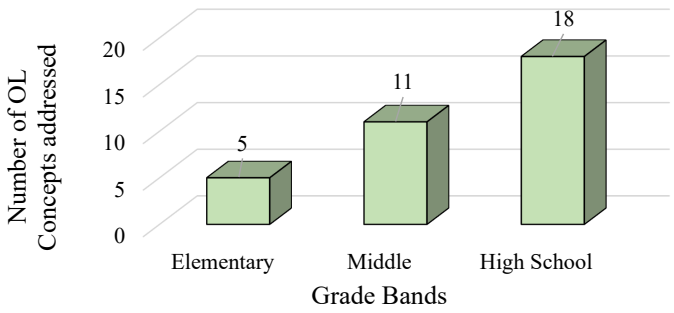

Figure 7. Grade band-wise OL alignment in INSs.

4.2.2. OL Principles Emphasized in INSs

By the total number of index topics of particular principles covered in INSs, the level of attention (e.g., emphasis) given to each principle in INSs was determined. Figure 8 makes it evident that out of the seven essential OL principles, principle 6 was highly emphasized in INSs, followed by the first and second principles. On the other hand, principles 4 and 7 had a negligible presence in INSs. INSs cover topics related to the interconnectedness of the ocean and humans in the context of OL concepts.

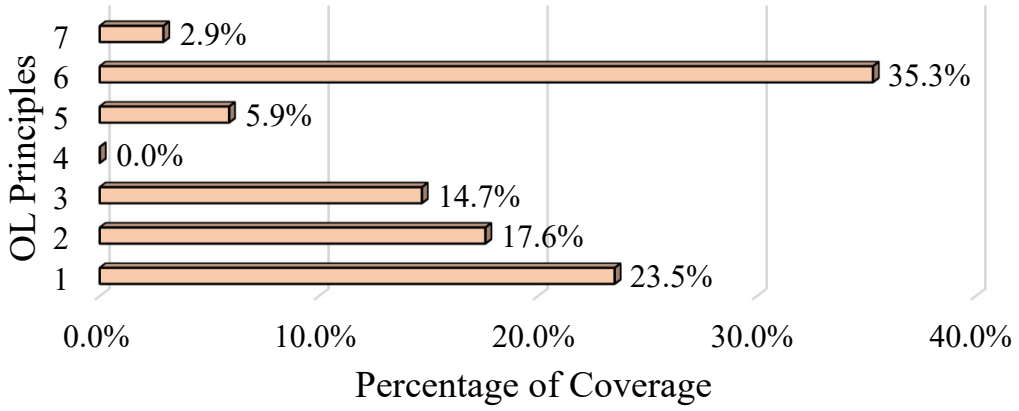

Figure 8. OL principle emphasized in INSs.

Essential OL principles emphasized in INSs are bifurcated by subject-wise percentage coverage, as shown in Figure 9. The red font in Figure 9 represents the total percentage coverage of a particular principle followed by detailed subject-wise coverage specification in black font with different color blocks. For example, among the total coverage principles, principle 6 accounts for 35.3% of OL concept coverage. Furthermore, out of 35.3% (total percentage coverage of OL principle 6), 5.9, 11.8, and 17.6% of concepts are addressed in EVS, SS, and science, respectively. Figure 9 shows the subject-wise comparison of OL percentage coverage among the seven essential OL principles in INSs.

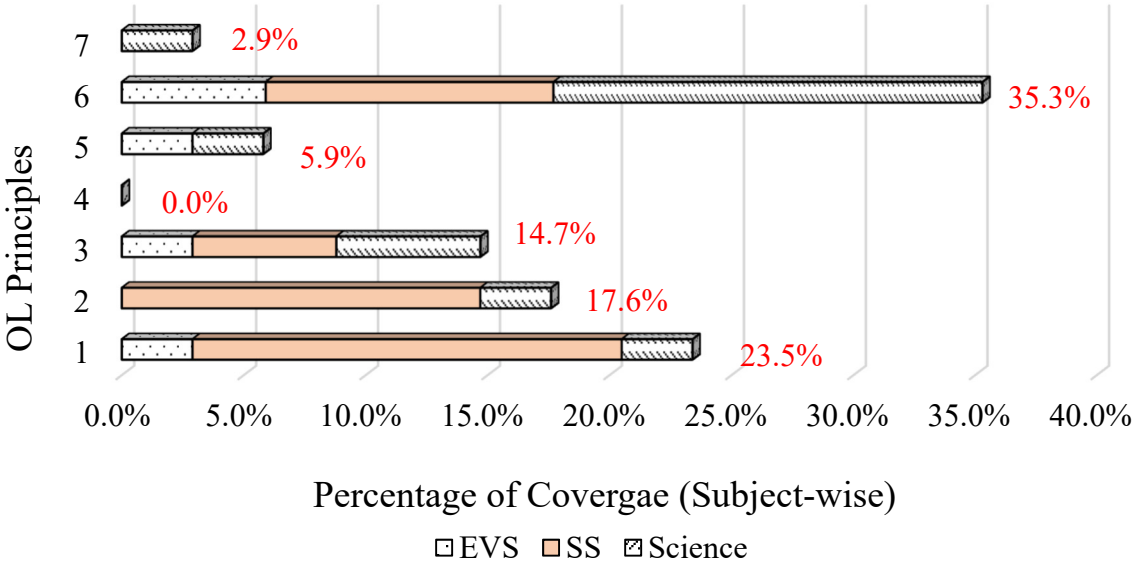

Figure 9. OL principle emphasized in INSs (subject-wise).

4.2.3. Criteria-Wise OL Alignment in INSs

The coverage of OL concepts in the studied samples was coded as per the four predefined criteria described in Table 2. Out of the four rating criteria, the blank criteria fail to address the review criteria. Hence, the blank criteria were not incorporated in the criteria-wise analysis. Figure 10 displays criteria-wise OL coverage concepts in INSs across the seven essential principles of OL. It can be concluded from Figure 10 that out of all the concepts covered in INSs, 50% of concepts were directly addressed, while 41.2 and 8.8% of concepts were indirectly and collectively addressed, respectively.

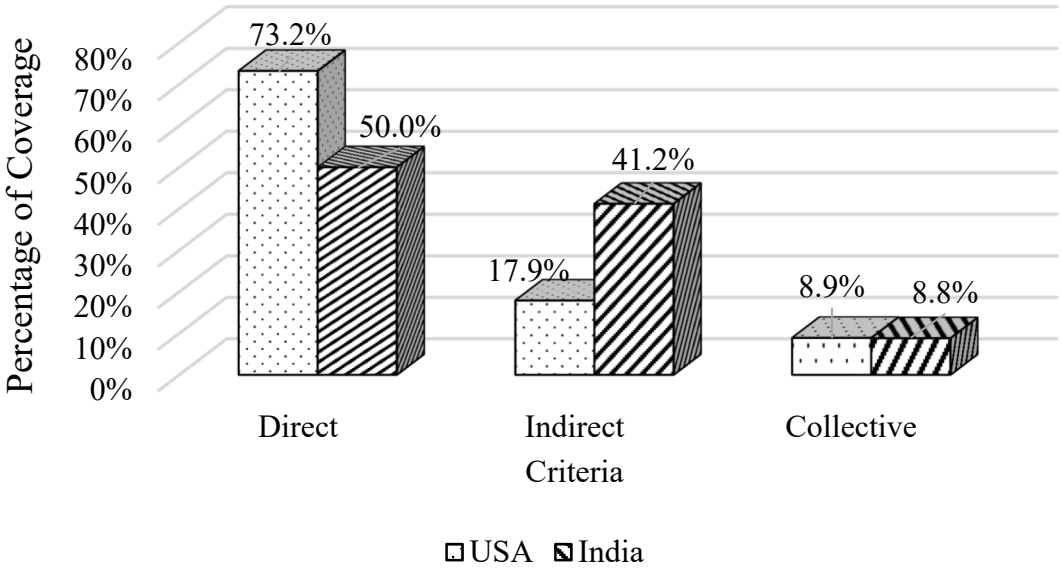

Figure 10. OL alignment (criteria-wise).

4.2.4. OL Alignment in Multiple Subjects (INSs)

As stated previously, in the case of INSs, standards of two subjects, namely, science and SS (geography), were evaluated against review criteria across two grade bands, middle and high school levels. Figure 11 shows the comparative results of OL concept coverage in two subjects, science and social science. It can be observed that the geography branch of SS has a maximum percentage of OL concepts covered compared to science across the two abovementioned grades bands.

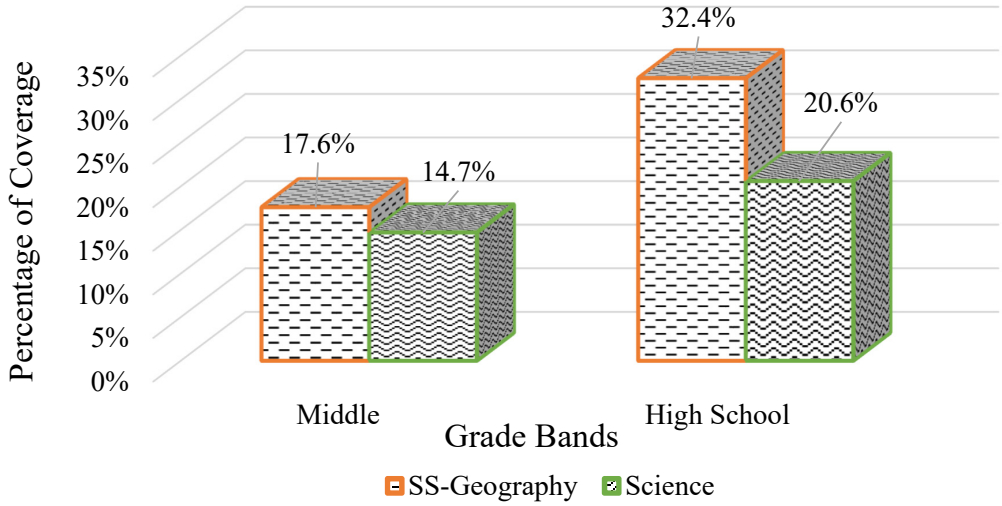

Figure 11. OL alignment in INSs (subject-wise).

4.3. Comparative Analysis of Educational Standards of the USA and India

This section evaluates distinction and resemblance in OL concepts among the two countries' educational standards under consideration. The comparative reference structure was drawn by assessing both countries' educational standards against review criteria in addition to coordination with the research objectives.

4.3.1. Comparative Analysis of OL Mean Coverage (USA and India)

Figure 12 shows the mean value for OL concepts derived after incorporating a similar assessment approach with a uniform structure. It can be seen that the mean value of the USA is greater than that of the mean value of India in the context of OL concept alignment. National OL grades of "B" and "D" were assigned to the USA and India, respectively. The assigned national OL grades to both countries indicate room for improvement in aligning an adequate number of OL concepts in the educational standards, especially in India's case.

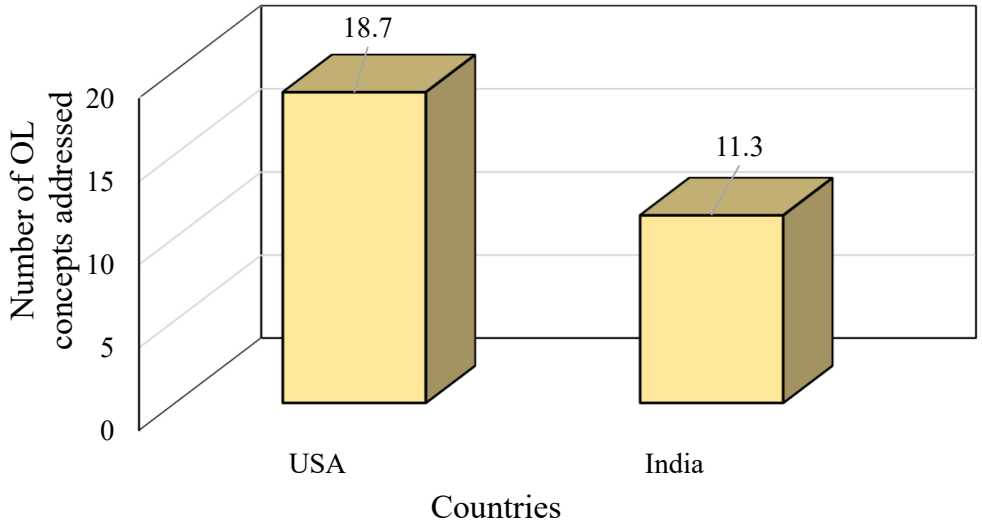

Figure 12. Comparative mean coverage of OL concepts.

4.3.2. Comparative Analysis of OL Alignment across Grade Bands (USA and India)

Figure 13 demonstrates the percentage of OL alignment out of all the concepts addressed in the two countries across the three grade band levels. It can be concluded from Figure 13 that the coverage percentage across the grade band levels remains almost consistent in the USA, with a marginal rise at the high school level, whereas a progressive increase was observed from elementary school level to high school level in the educational standards of India.

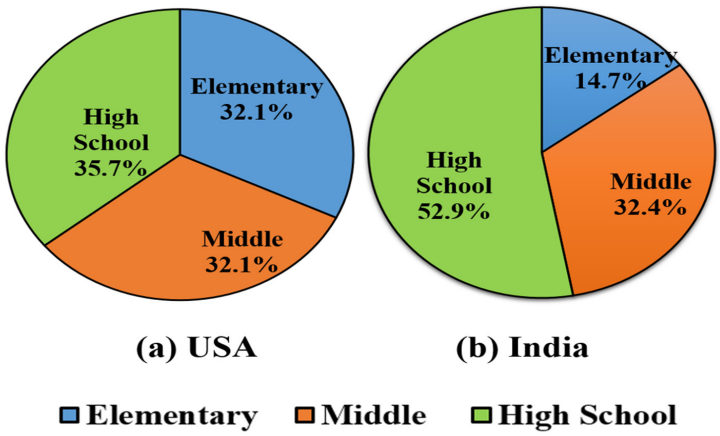

Figure 13. OL percentage across grade bands (NGSS and INSs).

4.3.3. Comparative Analysis of OL Principle Coverage (USA and India)

Each essential OL principle embraces different index topics and concepts related to ocean and marine education. Figure 14 represents the outcome of the percentage of coverage of OL principles in educational standards of the two countries under discussion. It can be seen from Figure 14 that among the seven essential OL principles in the education standards of both countries, principle 6 (i.e., oceans and humans are inextricably linked) is significantly covered. Furthermore, both countries' educational standards reflect an almost similar trend of incorporating OL principle 2 (the ocean and life in the ocean shape the earth's features) and OL principle 3 (the ocean is a major influence on weather and climate). OL principle 7 has the least percentage coverage trend in educational standards across the two countries. Additionally, variability in percentage coverage trends is seen in the two countries' educational standards for the remaining OL principles.

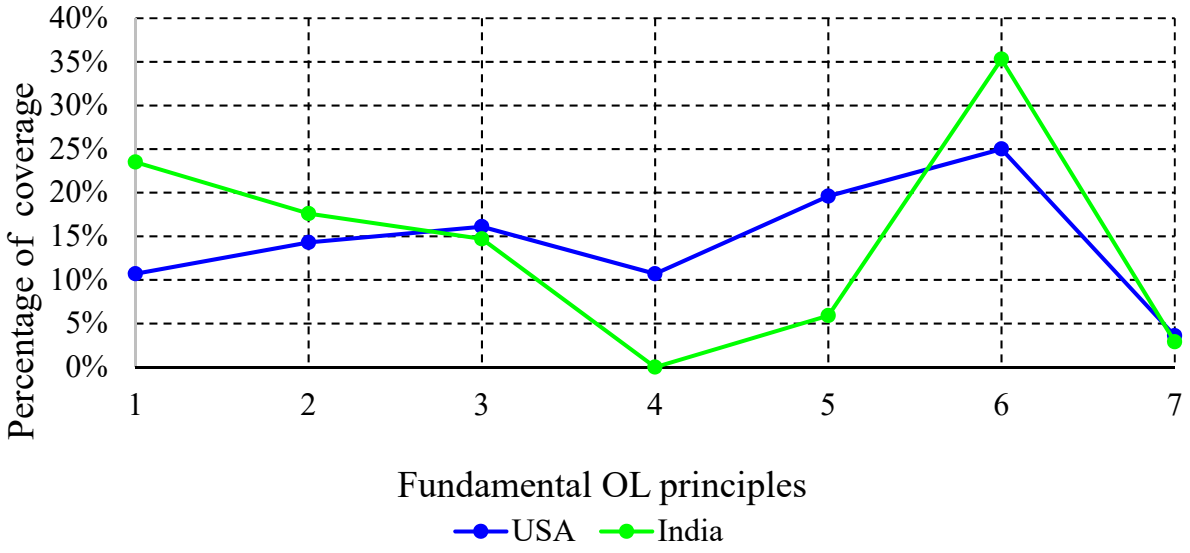

Figure 14. Coverage percentage of OL principles (NGSS and INSs).

Figure 15 presents a comparison between NGSS and INSs in the context of the seven essential principles across three educational grade band levels. After analysis, it was observed that INSs lack incorporation of OL concepts addressed in NGSS across the three educational grade band levels. At the elementary school level, concepts from principles 2, 4, and 7 are underrepresented in INSs compared to NGSS. Variation in concept alignment of essential OL principles 5, 4, and 1 was observed at the middle level, and principles 1, 2, and 5 were observed at the high school level in INSs compared to NGSS. This indicates that INSs do not sufficiently address OL principles when compared to NGSS across the examined educational grade bands, suggesting a potential scope for the enhancement of OL concepts.

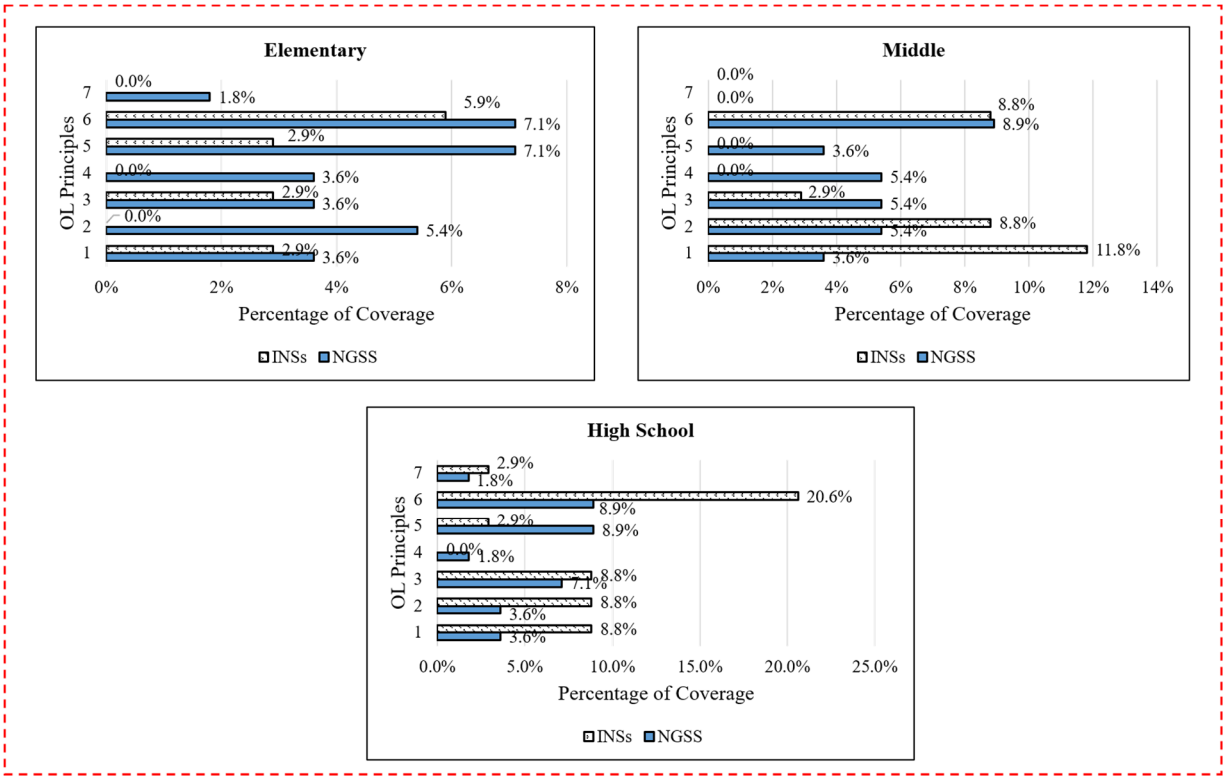

Figure 15. Comparative coverage of OL principles across grade band levels (NGSS and INSs).

5. Discussion and Conclusions

This section presents an overview of the study outcomes. It is divided into four sections: summary of research findings and discussion, suggestions, future research scope, and conclusion.

5.1. Research Findings and Discussion

The study displays OL coverage analysis results of the educational standards of two countries under consideration followed by comparative frameworks. In the following, a summary and brief discussion of the research findings are presented.

(a) It was observed that the educational standards representing the USA, i.e., NGSS, covered an average of 18.7 OL fundamental concepts from grade I to grade XII. It was found that out of the two disciplines under consideration, ESS encompasses more OL concepts than LS. Furthermore, almost 70% of all concepts covered were direct in NGSS. Out of the three grade bands, the high school band had the highest OL concept alignment. Moreover, among the essential OL principles, principles 5 and 6 had maximum OL alignment in NGSS, whereas principle 7 and its concepts were minimally addressed. As per the mean coverage value, the USA received a national OL grade of "B". From the research findings and previous related work, it can be stated that the inclusion of fundamental OL concepts in NGSS is relatively higher than the OL coverage mean value of the USA state standards. However, NGSS have ample scope to improve the national OL grade by adequately alignment with fundamental OL concepts.

(b) The national educational standards of India, i.e., INSs for school instruction, received a national OL grade of "D. This implies that INSs do not sufficiently address OL alignment with a mean value 11.3. Furthermore, the study revealed that geography, a discipline of SS, had better alignment than science across all grade band levels. Like NGSS, the educational standards of the high school band had considerable OL concept alignment. OL alignment significantly rose across the grade bands in INSs.

Of the total coverage, 50% of the concepts were directly addressed. Like for NGSS, OL principles 6 and 7 were highly and minimally emphasized in the INSs, respectively. Following principle 6, principle 1 was emphasized in INSs.

(c) The educational standards of the USA and India were compared on various parameters, such as mean OL coverage value, grade band comparison, OL principal coverage, and nature of the coverage. It was observed that the OL mean coverage value of the USA is significantly greater than that of India, indicating that the USA more successfully encompasses OL concepts than India does by a value of 7.3. Many differences and similarities were observed between the USA and India concerning OL alignment. It was found that of the aligned concepts, the majority of them belonged to index topics of principal 6 for both countries. Furthermore, it was observed that the coverage nature of the total coverage concepts remained direct for both countries under comparison. Alignment of OL coverage remained almost stable with a minor rise in OL alignment number across all grade band levels in the USA. At the same time, a substantial progressive increase was observed across the grade band levels of India.

5.2. Conclusions

The study conducted a comparative analysis of the educational standards of the USA and India. The findings reveal that the USA more successfully aligns maximum OL concepts than India does. The results of the study can serve as a reflective framework for the countries under consideration. Sample countries can determine OL levels and identify approaches to raising the percentage of OL concepts in their own country's educational standards. The currently used Indian learning materials drafted by NCERT can incorporate maximum OL concepts with strategic planning [33].

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