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Comparing science curricula in Myanmar and Japan: Objectives and content covered in lower secondary textbooks

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Abstract

An analysis of textbooks can lead to a comparison of the curricula in two nations and how curriculum standards determine the textbook content in a developed and developing country. Deductive content analysis was employed to analyze and compare objectives mandated in science curricula in Myanmar and Japan, and the articulation of science textbooks' content on science curricula's objectives including approaches to learning and learning of content taught at grade-6 in Myanmar and grade-7 in Japan. The results show that both countries' curriculum objectives are clearly mandated to cultivate students' scientific knowledge, skills, and attitudes. The exchanges of knowledge between the two contexts are the analyzed Japanese science textbook's employment of a step-by-step and detailed scientific inquiry-based approach for the students to learn light and sound concept, and Myanmar's science textbook's description of some technical scientific terms in both mother tongue (Burmese) and English.

Keywords: content, objectives, science curricula, lower secondary textbooks

INTRODUCTION

A curriculum comprises three forms: the intended curriculum, implemented curriculum, and attained curriculum (Cai, 2014; Schmidt et al., 2001). The intended curriculum encompasses the official syllabus and prescribed textbooks. Textbooks can be defined as potentially implemented curricula (Valverde et al., 2002) because many teachers typically rely on them as a primary resource in classroom teaching (McDonald & Abd-El-Khalick, 2017), usually in conjunction with supplementary material such as teachers' guides and editions, lesson plans, worksheets, and workbooks. At the secondary level textbooks influence the planning and implementation of the curriculum (Gericke et al., 2013; MacDonald, 2015). Moreover, they can bridge the gap between the intended and implemented curricula, revealing learning opportunities for students (Schmidt et al., 2001). In the current study, the conceptual framework is guided by tri-partite model developed by Valverde et al. (2002) in which textbooks have been argued to play a mediating role between the intended and implemented curriculum, serving as links between what is required to be taught and what is taught in the classroom as learning experiences. They are regarded as essential for achieving curriculum goals. A frequent mismatch is observed between the three forms of curriculum: intended, implemented, and attained curricula (Cuban, 1993). Therefore, investigating how textbooks are organized based on curriculum objectives is crucial.

An analysis of textbooks can lead to a comparison of the curricula in the two nations and how curriculum standards determine the textbook content in the selected contexts––a developed and a developing country. In Myanmar, Ministry of Education (MOE) has full authority in formulating curriculum standards, textbooks, and teachers' employment. The learning content and activities are based on curriculum standards and prescribed in the national textbooks. Myanmar's education system is centralized and follows a strict top-down approach (Lwin, 2019), and only one national textbook is used throughout the country. The curriculum development team in Myanmar is committed to the successful implementation of basic education curriculum (KG+12) and ensuring the timely delivery of textbooks and teachers' guides.

In Japan, Ministry of Education, Culture, Sports, and Technology (MEXT) is responsible for setting and implementing the course of study as the national

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Contribution to the literature

- Although textbooks influence the planning and implementation of the curriculum and can bridge the gap between the intended and implemented curricula, it is yet to be investigated how curriculum standards determine the textbook content in the selected contexts- a developed and a developing country. It was found that science curriculum objectives in both countries aim to cultivate students' scientific knowledge, attitudes, and skills, and both textbooks were systematically and comprehensively designed to articulate the curriculum standards and the course of study.
- In Japan, to learn the light and sound topic, students are encouraged to learn and think scientifically and in-depth by engaging in step-by-step discussions and experimentation on specific topics with a reflection to review their hypothesis, rather than a general approach to learning in Myanmar, and Myanmar's science textbooks can be improved by following Japan's example.
- Conversely, Japanese science textbook authors and publishers should learn from Myanmar's science textbook's description of some technical scientific terms such as reflection and incident ray in both Burmese and English, and such terms in Japanese science textbook should be written in both Japanese and English.

curriculum standards at all levels (from kindergarten through upper secondary levels) for all types of schools (MEXT, 2017a). When organizing the curriculum, MEXT (2017a) shares responsibilities––including necessary guidance, advise, and assistance––with prefectural and municipal boards of education. All textbooks are based on the course of study and published by private companies after authorization by MEXT (2017a). The major reason for this is to ensure and maintain the minimum level of attainment throughout the country. Consequently, while all five Japanese textbooks are similar––due to the textbook authorization system and based on the course of study (national curriculum standards)––every textbook is unique in reflecting the authors' ideas. They demonstrate uniqueness in terms of policy and ideas reflected by the editors because they are allowed to display their uniqueness within the scope of the course of study. The local boards of education make a choice on the textbook to be used.

In Myanmar, science at the lower secondary level is taught as science, and includes physics, chemistry, geology or earth science, space science or astronomy, zoology, and botany. In Japan, science at the lower secondary level is taught as general science and includes physical science, chemical science, biological science, and earth science. In both contexts, science is the compulsory subject at elementary and lower secondary levels; grade-1 to grade-9 in Myanmar and grade-3 to grade-9 in Japan. The language of instruction for science is the mother tongue (Burmese and Japanese). The authors analyzed the curriculum standards because they are policy instruments for articulation of the vision, framework, and subject-matter in the educational system (Schmidt et al., 2005), and specify the knowledge and skill sets students are expected to acquire in school (La Marca et al., 2000). We focus on the topic of light and sound––as it is one of the basic science concepts taught both in Myanmar and Japan––and explore how the curriculum determines the textbook content.

This study analyzes and compares the reformed science curricula of Myanmar and Japan in terms of curriculum objectives, including the course of study in Japan and textbook content in both countries for the following reasons. First, Japan is among the top-performing countries in terms of educational achievement based on international assessments such as trends in international mathematics and science study (TIMSS) and program for international student assessment (PISA). Additionally, there has been no participation by Myanmar in these tests till date. Therefore, the Japanese education system is considered a benchmark in the global education system. In addition, both countries' education systems are centralized and follow the top-down approach. However, the Japanese local board of education, a local authority, has the right to recruit teachers and choose the textbook that follows the course of study, which is similar to the national curriculum standards. Myanmar has many different ethnic groups and states and could benefit from a less centralized system with different approaches to implement the curriculum, which includes the choice of an appropriate textbook for a specific context, which is the inspiration for this research.

Japan is widely recognized as the first industrialized and technologically advanced country in East Asia and provides one of the most advanced science and technology education among developed countries (Isozaki & Pan, 2016). In Japan, science education, which is a science, technology, engineering, and mathematics (STEM), is regarded as an important and primary economic driver in the 21st century. In addition, a 1999 TIMSS video study reported that Japanese science lessons included few ideas, with each idea being treated in-depth alongside multiple sources of supporting evidence (Australian Council for Educational Research [ACER], 2006). Myanmar, which has been reforming its education systems, and learning how developed countries like Japan, with its high levels of educational success and achievements as mentioned above, educates its students and is prudent of it. This comparative study, therefore, could help Myanmar contemplate how the science content in its curriculum and textbooks could be organized and reformed.

Research Questions

This study analyzes and compares curricula objectives and textbook content and organization in Myanmar and Japan. The following research questions are framed:

1. What kind of objectives are mandated in lower secondary science curricula in Myanmar and Japan?
2. How does the science textbook content articulate the science curriculum objectives in each country?

LITERATURE REVIEW

When comparing the education systems of different countries, a comparative analysis of the textbooks used can be particularly revelatory (Howson, 2013). Previous research has shown differences in textbook size, length, sequencing, and complexity in presenting topics such as science (Valverde et al., 2002). Science textbooks of different countries that participated in TIMSS, including Japan, were analyzed, and the analysis covered the entire textbooks in terms of

(1) physical features,

(2) structure including schematic representation, patterns in content sequencing,

(3) content presentation,

(4) expectations for performance, and

(5) a holistic view of lessons (Valverde et al., 2002).

Best practice conveys the importance of comparing and analyzing aspects of curriculum and textbooks from different countries. Unfortunately, Myanmar has not yet participated in any international tests, including TIMSS.

Curriculum objectives are a key player in the teaching and learning process and are articulated in the textbook content in the way in which the learning experiences should be designed (Gericke et al., 2013; MacDonald, 2015). Given the importance of curriculum standards/objectives and textbooks' content, several studies have analyzed the science textbooks in local contexts and at cross national level. For example, Yu et al. (2022) investigated the alignment between high school biology curriculum standards and five editions of biology textbooks in China. Similarly, You et al. (2019) analyzed the alignment between national curriculum and assessment of school textbooks in Korea to reform Korean textbooks. To the best of our knowledge, analysis of science curriculum standards and textbooks has not been undertaken for Myanmar in comparison with Japan.

Textbooks play a crucial role in the teaching and learning process, holding a central position in students' learning with high-quality learning opportunities (Silver, 2009). In addition, textbooks impact teaching because they influence what is taught and how it is taught in the classroom (Chiappetta & Fillman, 2007; Nirode & Boyd, 2011). Despite their importance in school education, few investigations into how curriculum standards are aligned with textbooks have been conducted (Sun & Li, 2021; You et al., 2019). The previous results on the alignment between these two components––curriculum standards and textbooks show that the misalignment or low alignment between the two is not uncommon (Polikoff, 2015; Sun & Li, 2021; You et al., 2019). Consequently, this highlights the need to investigates their alignment and how textbooks' compilation meets the curriculum standards.

Few studies have explored Myanmar's previous science curriculum in terms of the education and achievement of a particular group of students (Aung & Khaing, 2018; Kyaw & Khaing, 2018). However, to the best of our knowledge, no study has investigated the current science curriculum implemented by Myanmar at the lower secondary school level, especially comparisons between Myanmar's science curriculum and textbooks with those of other countries. Therefore, it is worth analyzing the science textbooks used in Myanmar and comparing them with those used in Japan.

In the Japanese context, numerous researchers–both Japanese and international–have examined various aspects of the Japanese education system, including curriculum transitions and reforms (Komatsu, 2002; Sato, 2019; Yamanaka & Suzuki, 2020) and conducted comparative studies on science curricula with other countries such as Laos (Khanthavy et al., 2014; Phouttha, 2005), Philippines (Pawilen & Sumida, 2005), and America (Wiecozrek, 2008). These studies specifically focused on elementary science curricula in the Philippines and Japan, educational systems, common standards in America and Japan, and elementary science curricula and textbook productions in Laos and Japan. Sun and Li (2021) conducted a comparative study on primary school science textbooks and curriculum standards in China and Japan recently. Hu et al. (2016) pointed out that Japanese elementary science textbooks pay attention to

(1) basic knowledge, skills, and their relation with practice,

(2) environmental protection,

(3) cultivation of the abilities involved in inquiry,

(4) expression, communication, and layout, and

(5) cultural issues.

However, previous studies (Hu et al., 2016; Khanthavy et al., 2014; Pawilen & Sumida, 2005; Phouttha, 2005; Wiecozrek, 2008) have neither analyzed

Table 1. Description of data sources & unit of analysis

Country		Myanmar	Japan
Curricula	School level	Lower secondary	
	Number of objectives/competencies	Five objectives	Three competencies under one main objective
	Units of analysis	Phrases & words in sentences	
Textbooks	Grade level	Grade-6 (lower secondary level)	Grade-7 (lower secondary level)
	Authors/publishers	Curriculum Development Team, (MOE), Excellent Printers Group Publishing	Shimoda et al. (2021)
	Topic of analysis	Light & sound	
	Units of analysis	Unit headings, subheadings, written sentences, front pages, steps in activities & experiments, figures, tables, pictures, examples, questions, reflections, summaries, & exercises	
	Focus of analysis	How textbooks content & organization of activities articulate curriculum standards	

the latest version of the lower secondary science textbooks nor focused on specific topics.

Previous comparative studies have focused on the comparison between developed countries and developing countries, which participate in TIMSS or PISA. However, to the best of our knowledge, attention is lacking on comparisons between a country with high academic achievements, such as Japan, and a developing country, such as Myanmar, which has no experience in participating in such international assessments. In addition, the articulation of the curriculum objectives on the content of the science textbooks has not been explored, which is important, given the alignment between the components of the intended curriculum (curriculum standards) and the materials used (textbooks). Specifically, the presence of the aspects of light and sound in science curricula, and their representations in textbooks, have not been studied yet. To address this research gap, the current lower secondary science curricula focusing on light and sound topics of Myanmar and Japan are analyzed and compared.

MATERIALS AND METHODS

Research Design

This study employed a case study research design using the technique of content analysis to provide an in-depth understanding of the case and a comparison of several cases (Creswell & Poth, 2018). This study aims to make replicable and valid inferences from the existing data in context, to provide knowledge and new insights, and a representation of facts (Krippendorff, 1980). Content analysis is "a research technique for the objective, systematic, and quantitative description of the manifest content of communication" (Berelson, 1952, p. 18). This definition matches our purpose to analyze and compare the content in the curriculum standards and textbooks' content systematically. The authors analyzed and compared two data sets, which are explained in the next section. Deductive content analysis was specifically employed to analyze and compare the science curricula and textbooks of Myanmar and Japan, e.g., one textbook from each country in terms of the content and organization of science textbooks determined by the curriculum's objectives.

Data Sources

The data sources were the science curriculum standards and science textbooks in Myanmar and Japan. To analyze and compare the science curricula of Myanmar and Japan, national science curriculum, which is the latest reformed curriculum, was selected from both countries. Specifically, the science curriculum in Myanmar was framed by MOE in 2019 as part of the basic education reform. For Japanese science curriculum, the course of study for lower secondary science, which is the updated science curriculum standard mandated by MEXT (2017a) was selected. One textbook was selected from each country for comparison. The national textbook used for science at grade-6 in Myanmar was examined because it is used by all public schools in Myanmar (MOE, 2019), and was developed by the curriculum development team. In Myanmar's educational system, MOE selects the content and activities for the textbook based on the curriculum objectives and prescribes it as the national textbook. For Japan, a science textbook (Shimoda et al., 2021) published by Gakkotosho, *Chuugakkou Kagaku 1*, which in Japanese, means lower secondary school science *grade-1*, (lower secondary school science grade-7) was selected. The reason for selection of grade-6 in Myanmar and grade-7 in Japan is because these are the first grade in the lower secondary level. Japan has five publishing companies.

Units of Analysis: Sampling Units & Coding Units

This section explains the units of analysis: the sampling units and the coding units used in the study. The sampling units are the science curricula at the lower secondary level and science textbooks from Japan and Myanmar (**Table 1** and see *note 1* in **Appendix A**).

These are instrumental texts, different from ordinary literary works (Yu et al., 2022). The coding units are the

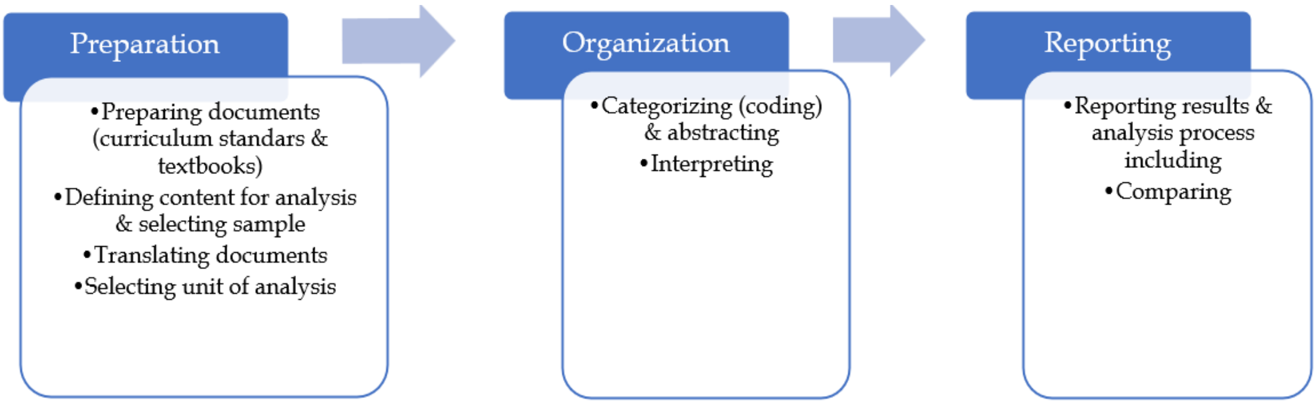

Figure 1. Deductive content analysis procedure (Adapted from Elo et al., 2014)

curriculum standards and the selected content from the textbooks (i.e., light and sound). The sentences in curriculum standards were chosen as coding units following Porter (2002). A letter, word, or sentence portion of pages can be the meaningful unit for selecting a suitable unit of analysis (Robson, 1993, as cited in Elo et al., 2014). Therefore, in the current study, unit headings, subheadings, written sentences, front pages, steps in activities and experiments, figures, tables, pictures, examples, questions, reflections, summaries, and exercises in the textbooks were selected as coding units.

Data Analysis

Data analysis was performed to answer the research questions: what is mandated in the science curriculum standards, and how textbooks content articulate these standards. Therefore, a three-phase analysis procedure was used (**Figure 1**) for deductive content analysis adapted from Elo et al. (2014): first phase: preparation; second phase: organization; and third phase: reporting.

First phase: preparation includes gathering official curriculum standards and selecting science textbooks; defining content to be analyzed; translating documents from Burmese and Japanese into English; and selecting units of analysis (sentences, phrases, words, etc.).

Second phase: organization includes conducting categorization and deductive coding to examine how the curriculum's objectives are articulated in the content and organization of the textbook; and interpreting categories and codes to confirm representation. Thus, in this phase, the unit of analysis contained in the content of the textbooks (i.e., sentences, questions, figures, tables, pictures, comments and steps in activities) were carefully coded and categorized to see how they articulated the specific curriculum standards. This implies what content and type of organization in the textbook articulated, which aspect (i.e., knowledge, skills, and/or attitudes) of the curriculum standards.

Third phase: reporting includes reporting results, which helps the readers comprehend the results in a useful and meaningful way (Holdford, 2008), presentation of a detailed report in a systematic and logical manner for clarity and understanding (Elo et al., 2014), and comparison of the results.

For the reliability of data in terms of reproducibility, the two authors analyzed the same content, made the same judgements, which means producing the same coding patterns (Potter & Levine-Donnerstein, 1999). After coding, the authors discussed the interpretation jointly to confirm its accuracy (one author is a native speaker of Burmese and the other of Japanese). In the case of discrepancies in coding and interpretations of the data, the authors negotiated till a consensus was reached. The results from each context were then compared. Coding was employed for the manifest content, which means the surface information and the latent content, which is beneath these surface elements.

On latent content (Potter & Levine-Donnerstein, 1999), subjective interpretations were provided based on coders' own mental schema, which increases the importance of judgment making as intersubjective, which is subjectively derived and shared across coders, and helps to reach out to readers. Thus, apart from how the textbook content explicitly articulates the curriculum standards, we also subjectively explored the unique organization of content in the textbooks (e.g., how the activities in practical work are organized). In addition, we interpreted how the curriculum standards are mandated based on the unique tradition of the context (e.g., value and the love of nature in Japan), the relationship between "science and technology (S&T) and humans", and sustainable development goals (SDGs). In Myanmar, for example, S&T is considered useful and important to humans and there is awareness of its misuse or harmful effects. For the validity of the data, a coding scheme was developed to deduct code and analyze curriculum objectives and textbook content as described in **Figure 2**. The content was analyzed based on articulation of textbook contents on curriculum standards (Potter & Levine-Donnerstein,1999).

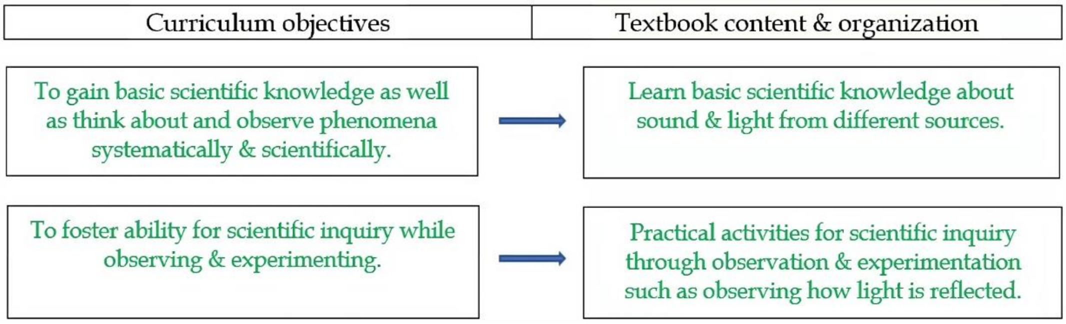

Figure 2. Sample coding scheme for deductive content analysis (Source: Authors' own elaboration)

Table 2. Comparison of science curricula's objectives at lower secondary level in Myanmar & Japan

Myanmar	Japan
1. To gain basic scientific knowledge & think about & observe phenomena systematically and scientifically. 2. To develop science process skills & apply them in daily life. 3. To understand abilities & efforts of scientists & develop a desire to explore science. 4. To understand & value scientific development & findings. 5. To encourage scientific exploration of one's environment.	1. To foster following three competencies to enable students to perform scientific investigations on natural things & phenomena, while enabling them to take an active interest in above, using scientific ways of looking & thinking by carrying out observations & experiments with predictions. 2. To enhance students' understanding of natural phenomena, cultivate skills necessary to understand natural things & phenomena, & nurture basic skills required for scientific inquiry. 3. To foster ability for scientific inquiry while observing & experimenting. 4. To cultivate an attitude to engage in scientific inquiry with an inclination toward natural things & phenomena.

Note. Translated from Burmese & Japanese into English by the authors

RESULTS

Objectives Mandated in Lower Secondary Science Curricula in Myanmar and Japan

The curriculum objectives mandated in lower secondary science curricula in Myanmar and Japan are compared in **Table 2**.

The results from comparison of the objectives of the science curricula in Myanmar and Japan revealed similarity in objectives in terms of basic scientific knowledge and science process skills in Myanmar; and basic science skills and abilities required for scientific inquiry in Japan. However, differences were noted as Myanmar's science curriculum focuses on appreciating scientific development and findings important for the development of society.

Meanwhile, in Japan, the focus of the curriculum is on encouraging students' interests and engagement in natural things and phenomena through scientific inquiry, thereby realizing and appreciating the importance of nature in their society. Therefore, the primary objectives had different emphasis, namely, the importance of scientific exploration and development in Myanmar and that of natural aspects focusing on natural things and phenomena in Japan.

The Articulation of Science Textbook Content on the Curriculum Objectives in Each Country

Case of Myanmar

The objectives of the Myanmar science curriculum were found to be well articulated, and the content of the textbook was clear and explicit. For example, a description of what and how the students are going to learn as well as the personal skills (i.e., collaboration, communication, critical thinking, etc.) they will develop appears at the beginning of the textbook. When teaching the content, the teacher employs the introduction, teaching, practice, review (ITPR) approach. The textbook is arranged in a way that is best suited to students achieving the objectives prescribed in the curriculum.

An interesting finding in the Myanmar textbook is that, in the introductory chapter, students learn the nature of S&T and its importance in real life. Particularly, students learn how S&T is applied in different fields such as physics (electricity, heat, and light), chemistry (production of food, drugs and fertilizers), biology (producing various vaccine and drugs), geology (exploring fossils and studying natural disasters), and space science or astronomy (forecasting the weather). In addition, students compare S&T to its usage in different scientific concepts (e.g., gas, medicine, electric charges, growing crops without lands, and sending information or data by using the Internet). Students discuss the advantages and disadvantages of materials used in agriculture, health, and food.

These discussions are important for them to comprehend the usefulness of the scientific investigations in improving the standards of human beings and that they can also be harmful to people depending on application and usage. This highlights how the textbook is designed to educate students not only to develop knowledge and skills, but also its application in an effective, meaningful and harmless way. However, the use of S&T and its real-life importance are not explicitly described in the national science curriculum standards.

In learning light and sound topic in the textbook, first, to understand basic scientific knowledge, as well as think about and observe the phenomena systematically and scientifically, students must learn about sound and light from different sources including the propagation of sound in a medium, its speed, and the sources, as well as the speed of light. For example, they are required to observe how different forms of sound come from vibrating objects. Second, to develop science process skills as prescribed in the curriculum, students are required to observe how reflected rays appear pointed at a mirror. In terms of classification, students must classify object depending on the amount of light transmitted as

(1) a transparent object that allows light to pass through it completely,

(2) an opaque object that does not allow light to pass through it, and

(3) a translucent object that allows light to pass through it only to a certain extent.

The textbook contains activities that require students to observe and infer the nature of light reflection, such as normal and mixed reflection. For example, students fill cups two-thirds full of water and put them under lightbulbs; and note their findings when the water is stable and unstable; and finally, they have to infer the nature of the reflection of light.

Third, to understand the abilities and efforts put in by scientists and develop a desire to explore science, the introductory content of the textbook encourages students to explore science by using the scientific method, such as descriptive, comparative, and experimental investigation. Fourth, students learn about the employment opportunities offered by the scientific discipline, including careers in physics, chemistry, engineering, astronomy, geology, and medicine, thereby enhancing their desire to explore science. They learn about recent scientific discoveries to understand the abilities needed and efforts involved in these investigations. This content also encourages them to understand and value scientific development and findings, which is the curriculum's fourth objective.

Fifth, to encourage scientific inquiry into the nature of one's environment, students are guided to recognize how certain phenomena occur in their environment, such as different types of sound, the sun as a source of light, and natural and artificial luminous objects such as fireflies and electric bulbs, respectively. **Table 3** summarizes how curriculum objectives are articulated by the textbook content and its organization in the light and sound topic in Myanmar. The curriculum objectives were found to be well articulated by science textbook content.

Case of Japan

The objectives of the Japanese science curriculum well determine each content unit of the science textbook. Moreover, the major topics and subtopics are selected carefully and organized to implement the curriculum objectives laid out by the course of study. Textbooks comprise of comprehensive and step-by-step explanations, reviews, and reflection activities, allowing students to engage in scientific exploration effectively and efficiently.

The Japanese course of study emphasizes scientific inquiry and three major objectives/competencies:

(1) understanding natural things and phenomena,

(2) acquiring basic skills such as the ability to conduct practical activities, e.g., observations and experiments; and

(3) developing an attitude of willingness to take an interest in natural things and phenomena and inquire about them scientifically.

"Knowledge," "ways of thinking," and "attitudes" are crucial aspects of scientific study and can help achieve some of the goals pertaining to global problems, as mentioned under the United Nations SDG (Shimoda et al., 2021). Therefore, in the textbook, all activities are arranged purposefully and systematically, thereby supporting students in acquiring these three competencies.

Japanese course of study for lower secondary science introduces "S&T and humans" in the first field (contents of physical and chemical science), and "nature and humans" in the second field (contents of earth and biological science) in the last unit (see *note 2* in **Appendix A**). In the first field, students are provided with the instructions to acquire skills for making connections with daily life or society through observation, experiments in learning energy and substances and their uses, as well as the development of science and technology (MEXT, 2017b). Through this, students also recognize the importance of efficient use of energy resources such as hydraulic power and atomic energy, and that S&T enriches and enhances the human life. Consequently, they consider scientifically how to conserve the natural environment and the use of S&T to build a sustainable society (MEXT, 2017b). Thus, Japanese textbook introduces not only the importance of S&T, but also explicitly describes its relation to conservation of natural environment for sustainable development or SDGs. This proves the description of SDGs in curriculum standards of science textbooks and reflects how well the science textbooks articulate the science curriculum standards.

In the textbook, to learn the properties of light, through scientific inquiry, students learn two major concepts: the way light travels, and use of refraction. Students learn how light reflects when it hits a mirror and uneven objects (diffuse reflection), how it refracts when it travels through different objects; and how different images can be formed by using a convex lens. By learning these concepts through scientific inquiry, students understand the properties of light, which is the unit's major aim. Students learn science proactively with the awareness of the can-do list (i.e., three goals that they want to achieve:

(1) attitudes towards learning,

(2) knowledge and skills they will acquire, and

(3) how to use what they understand interactively by engaging in discussion with other students; and in-depth through views and ideas in learning tasks, reflecting, and connecting them to everyday life.

To learn the properties of sound, through scientific inquiry, students learn the way sound travels, and pitch and volume of sound. The textbook describes not only content that students understand but also how to learn it, in other words, way of learning. For example, preface/front pages of the textbook contain detailed descriptions and explanations of how to use the textbook and learning materials, the reason why science is studied, how to learn it, how to conduct scientific inquiry, how to perform observations and experiments, how to prepare for a presentation, directions on how to report the experiment, tips for taking lessons and notes, can-do list and a checklist of items regarding how to learn and the ability to learn, and most importantly, a detailed description of learning science through scientific inquiry.

First, the science textbook introduces students to content that enhances their understanding of natural things and phenomena, such as how light is reflected, the way light travels through objects, the determination of the image produced by a convex lens, and the relationship between the pitch and volume of the sound and its vibration, vibration of walls and ceiling of concert halls when the sound hits them, thereby nurturing basic skills required for scientific inquiry. Some activities also nurture students' basic skills required for scientific inquiry such as awareness; setting the task; hypothesis/prediction; practical work (observation or experimentation); results (e.g., recording data, drawing graphs and tables, sketching); discussion; and conclusion, reflection, conveyance, and awareness of the next task. Therefore, students not only learn the content but also acquire the required skills as mentioned above, making it apparent that the textbook is well organized.

Second, to foster the ability to conduct observations and experiments for scientific inquiry, activities are selected carefully, providing students with the required opportunities. Every science textbook must include practical activities required by course of study along with several others that authors of textbook want students to engage in, such as activities that foster ability for scientific inquiry through observation and experimentation. There are also observation activities in light and sound topic using a can-do list of inquiry, like

(1) recording the path of light when reflected by using a light source device and a mirror,

(2) recording the changes that occur as the incident angle is changed, and

(3) considering the relationship between the position of the light source and how it appears when light is reflected from it.

In addition, students also learn how the sound travels through experimenting and checking the transmission of sound using tuning fork. After learning these concepts through scientific inquiry, students become aware of the application and usefulness of these concepts in their environment such as using lenses of different shapes and sizes in cameras and designing the concert walls by creating real life elaborate models on the computer by investigating the sound. Learning of these applications and their utility encourages them to become more engaged in scientific discovery and phenomena.

Third, to foster an attitude toward scientific inquiry, students are encouraged to engage in activities in the light and sound topic that cultivate this behavior. They are specifically required to engage in the process of being aware of the natural things and phenomena around them, setting the task, hypothesizing/predicting, planning (for testing their own hypothesis/prediction), doing practical work (observation and experiment), recording results (e.g., recording data, drawing graphs and tables, sketching), discussing, concluding (analyzing data, interpreting results, and making conclusions), and reflecting (e.g., looking back on what and how they could have done, or what and how they will do in the future). Consequently, students review their hypotheses and make a new plan and engage in scientific inquiry, as suggested in Japanese science textbooks. For instance, students become aware that diffuse reflection allows light to spread in all directions, making it possible to see a person (an object) from any position as in stage performances. Hence, students have the opportunity to inquire about the wonder of science, making them even more interested, thereby cultivating an attitude of scientific inquiry. Curriculum objectives laid out by course of study were found to be articulated

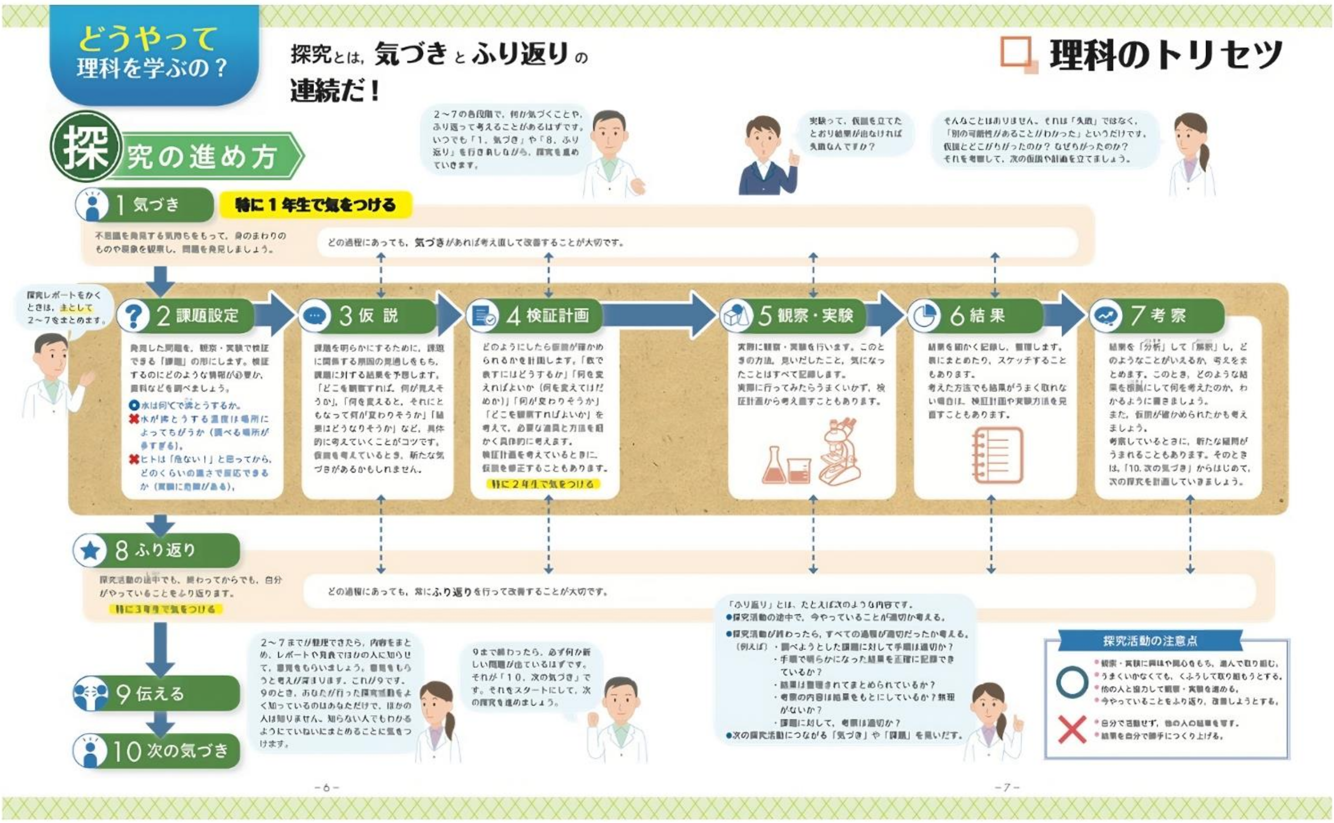

Figure 3. How to proceed with scientific inquiry presented by *Gakkotosho* ([1] students observe objects & phenomena around them with a sense of wonder & identify a problem to solve, [2] setting a topic and/or a task of lesson, [3] hypothesis or prediction setting, [4] planning a process of inquiry, [5] conducting observations & experiments, [6] Collecting data & information & obtaining results, [7] considering their hypothesis or prediction on collected data & information, [8] reflection, [9] presenting and informing finding for sharing ideas, & [10] students set inquiries & repeat process of inquiry) (Source: Shimoda et al., 2021, reprinted with permission)

Table 4. Summary of science curriculum objectives & textbook content & organization in Japan

Curriculum objectives	Textbook content & organization
1. To foster following three competencies to enable students to perform scientific investigations on natural things & phenomena, while enabling them to take an active interest in above, using scientific ways of looking & thinking by carrying out observations & experiments with predictions.	-Perform scientific investigations on properties of light & sound by learning proactively with awareness of can-do list of three goals that they want to achieve: (a) attitudes towards learning, (b) knowledge & skills they will acquire, & (c) how to use what they understand.
2. To enhance students' understanding of natural phenomena, cultivate skills necessary to understand natural things & phenomena, & nurture basic skills required for scientific inquiry.	-Learn to understand of natural things & phenomena such as how light is reflected, way light travels through objects, transmission of sound in air or other medium, & vibration of walls & ceiling of concert halls. -Engage in activities that nurture students' basic skills required for scientific inquiry such as awareness, setting task, hypothesis/prediction, practical work, etc.
3. To foster ability for scientific inquiry while observing & experimenting.	-Do practical activities for scientific inquiry through observation & experimentation such as observing how light is reflected, way light travels, way sound travels, & loudness & height of sound.
4. To cultivate an attitude to engage in scientific inquiry with an inclination toward natural things & phenomena.	-Engage in process of being aware of natural things & phenomena around them, setting task, hypothesizing/predicting, planning, etc. in learning properties of light & sound.

by textbook's content with careful selection and organization of major topics and subtopics carefully and organized. Process of scientific inquiry is one of models suggested in Japanese science textbooks (**Figure 3**).

Table 4 summarizes how curriculum objectives are articulated by the textbook content and organization in light and sound topic in Japan.

Table 5. Comparison of approaches to "how light is reflected" in Myanmar & Japanese textbooks

Myanmar	Japan
Nature of light-reflection of light Introduction: Light is form of energy that stimulates our sense of vision. Teaching & practice: Step 1: • What is needed to see the blackboard? • What kind of properties does the light have? Step 2 • Make groups with friends and stand face-to-face. • Practice how the reflected ray appears when you point the light to the mirror. • What do you discover? • Draw picture of reflection of light in the plan mirror. Step 3 • Look at the ceiling bulb in the steady water in the cup. • After shaking the cup, look at the bulb again as before. • What difference can you find? Step 4 • Fill cups two-thirds full of water & put them under lightbulbs. • Note what they find when water is stable & unstable. • Infer the nature of the reflection of light. Review: • What do you need to be able to see objects?	How to observe reflection of light *Inquiry* • Awareness-When you are using a tablet PC, you may be bothered by the reflection of the ceiling light on the screen. If you look at the ceiling, you will see a lot of ceiling lights, but which ones are reflected on the screen? • Task-When light from a light source reflects off an object, what are the rules for how the light travels? Think about this using a model of light rays. • Hypothesis-If the light source is visible, it means that the light source is coming into your eyes, right? • Experiment plan-Let us prepare a mirror and light rays. *Observation* • Method 1) Set a mirror. 2) Record the path of light. 3) Measure the incident angle and reflection angle. 4) Change the incident angle. • Results-Record the incident angle and reflection angle. • Discussion-What is the relationship between the incident angle and reflection angle? *Results & discussion* • Results-Example of reflection • Discussion-I found that the incident angle is equal to the reflection angle. • Reflection-I wonder if the relationship would still work if I used a different mirror.

Table 5 compares how the concept "reflection of light" or "how light is reflected" is organized in Myanmar and Japanese science textbooks to facilitate students' learning and observation.

The comparison in **Table 5** exhibits that Japanese students firstly engage in the pre-observation tasks including awareness, task, hypothesis, and experiment plan observing how light is reflected. Next stage is observation, which includes method, results, and discussion. Finally, they engaged in the results and discussion stage including "reflection" activity. Meanwhile, Myanmar students engage in a step-by-step procedure (introduction, teaching and practice, and review) of observation, and they infer the concept. However, there are no detailed plans in the inquiry stage before starting the observation. Notably, they are not provided with the opportunity to reflect on what they learned.

DISCUSSSION

Comparison of Curricula's Objectives Between Myanmar and Japan

A comparison of the objectives of the science curricula in Myanmar and Japan revealed that the focus of the science curriculum in Myanmar is on scientific development and findings that are important for the development of society. Meanwhile, in Japan, the curriculum focuses on encouraging students to be interested and engaged in natural things and phenomena by involvement in practical work or scientific inquiry, thereby realizing, and appreciating the importance of nature in society. The objectives of science in Japanese schools (*traditionally* known as *Rika*) include a "love of nature," which is an important component of Japanese identity (Ogawa, 2015, p. 840; Isozaki & Pan, 2016). The Japanese science curriculum aims to nurture students' willingness to inquire about their interest in nature, which is an important factor in learning science. Additionally, as Isozaki (2014) argues, "nature" is a traditional and key concept in Japan's science education as well as in "science." Therefore, the primary objectives have different emphasis, namely, the importance of scientific exploration and development in Myanmar and that of natural aspects (focusing on natural things and phenomena) or nature herself in Japan.

Although there is a similar trend of the introduction of S&T in science curriculum standards, its importance to humans' lives, and the proper use of S&T in both countries, the way it is related to real life and SDGs in Japanese course of study is worth noting (MEXT, 2017b). Japanese science education emphasizes the importance of science in industrial development and technical innovation (Kawasaki, 1996). Moreover, it guides students' learning by encouraging them to connect what they learn to their daily lives and utilize technology, thereby facilitating the development of innovative and critical thinking leading to excellent TIMSS results (Kawasaki, 1996). Another significant finding is that Japanese course of study explicitly describes the importance of S&T in the national curriculum standards, while this is not the case in Myanmar. We, therefore, conclude that both science curricula are unique with different emphasis and Japanese course of study is more practical, which is explicitly and directly articulated in its textbook content.

Comparison of How Science Curricula Objectives Determine Textbooks' Content & Organization

Based on our comparison between the two contexts, we found that science curricula objectives are efficiently articulated in the textbook content and organization, each focusing and organizing differently, with Japan organizing its content more clearly and comprehensively than Myanmar. For example, the Japanese science curriculum emphasizes the systematic use of scientific inquiry involving experiments and observations in learning light and sound topic and the content in the textbook is well articulated. It has been argued that practical work plays an important role (Abd-El-Khalick et al., 2004; Clough, 2007; Hofstein & Lunetta, 2004), and Hodson (1993) broadly considered it, as cited in Ferreira and Morais (2014) as any kind of activity that demands students to be active. When analyzing the science curriculum and textbook, exploring the content and activities related to the practical work of how light is reflected, and establishing how these activities support science teaching and learning are essential. Regulations mandating the use of practical/laboratory work have been emphasized in Japanese science education policies since the 1880s (Isozaki, 2017). The course of study requires practical work, and therefore textbooks must include them. As the TIMSS video study (ACER, 2006) points out, in the textbook, Japanese practical work requires students to make a hypothesis or prediction before undertaking observation and experiment. Laboratory work traditionally plays an important role in teaching and learning science in Japan. As Roth and Garnier (2007) note, Japanese classes typically employ an inductive and inquiry-oriented approach, which is one of the most important activities in science lessons. This is an important finding that can be applied to Myanmar's science curriculum because even though its curriculum also focuses on practical work, it lacks detailed and systematic implementation of practical work in the textbook.

In terms of organization and content of textbooks, this study reports that textbooks' organization of various activities and practical work that allows students time for consolidation is important. This helps students improve their working memory capacity, which is essential for engaging in more complex tasks such as problem solving. This includes extensive practice, solving problems, and receiving feedback (Sweller, 1988). In this study, we found that the textbooks of both countries are well-designed to help students learn according to the expectations set in the curriculum guidelines. For example, in Myanmar's national science textbook, before participating in activities, students are first introduced to concepts in light and sound topic specifically designed to enhance their understanding; the major points are summarized at the end of each lesson. Students then review the lessons, followed by the practice questions, to ensure that they have understood the concepts. In contrast, Japanese textbooks contain activities that allow students time for consolidation, including observation, hypothesis development, discussion, reflection, and recording and reporting findings and they learn in various ways such as reading scientific findings and inquiries, learning about recent discoveries, and learning definitions of scientific terms (Osborne et al., 2016). At the end of each unit, students are required to look back at their lesson handouts and textbook, and summarize what they have learned, followed by checking the summary and basic questions by using the QR code provided in the textbook. This helps students to consolidate their learning and understanding. We can observe evidence of the policy of the course of study and the TIMSS video study showing Japanese science lessons (ACER, 2006). In TIMSS video study, Japanese students knew the questions required to make inquiries to investigate, make predictions, manipulate, organize the data, and develop conclusions. Therefore, this video study highlighted how Japanese lessons allow students time for consolidation.

In Myanmar's national science textbook, students must discuss their actions as they conduct activities, interpret the findings, compare, and contrast the concepts for light and sound topic. As such, students must use different scientific skills, such as discussion, reading, writing, and reporting. In Japanese textbooks, activities in light and sound topic are designed to increase students' awareness of natural things and phenomena around them, formulate hypotheses/make predictions, develop a plan to test their own hypothesis, perform practical work (observation and experiment), record the results, draw graphs and tables, sketch, discuss, conclude by analyzing data and interpreting the results, and lastly, reflect. These activities are part of the scientific inquiry process mentioned under the guidance of the course of study.

We found that Japanese science textbook provides students with more opportunities to engage in scientific activities and use different scientific skills compared to that of Myanmar's. Myanmar textbook provides the summary table (i.e., main concepts are summarized) and basic questions at the end of each lesson. Alternatively, in Japanese textbook, the students are firstly required to look back at the lesson worksheets and textbook to summarize what they have learned in the unit (i.e., light and sound topic). They can also check the summary and basic questions at QR code provided in the textbook. Thus, the content and organization of textbook including activities is unique. A significant point is that in the light and sound topic in Japanese textbook, students are introduced to the fact that technology has advanced in recent years and that light and images projected by projectors can be calculated and handled in details by computers. This shows the explicit description of relationship between the use of the concepts of light and sound, technology, and humans, which is mentioned in the course of study. Thus, we interpret that the science curricula are well articulated in the content of science textbooks in terms of activities and learning experiences.

According to Isozaki and Pan (2016), Japan was able to implement a modernized education system relatively quickly because the country has

(1) a highly centralized government,

(2) a unified national language, and

(3) considerable literacy among its population.

Notably, preparation and production of textbooks in Japan takes approximately four years with each stage comprising of writing/editing, authorization, adoption, and manufacturing/distribution for use, takes a year to complete (MEXT, n. d.). This process is repeated every four years. Since the textbooks must be screened and approved by MEXT (n. d.), competition is tough. Therefore, publishers create textbooks that are easy to read and understand, which makes the quality of the textbook higher. Myanmar could adapt the practice of the Japanese local board of education choosing the textbook because it has many different ethnic groups and states, requiring different approaches to implement the curriculum, including the choice of the textbook to the specific context. It has been documented and highlighted in the history of Myanmar education that the needs of local regions and indigenous people have not been met in the curriculum by the central government (Lwin, 2019).

CONCLUSIONS

Both countries seek to cultivate students' scientific knowledge, attitudes, and skills–particularly those considered critical in the 21st century–in such a way that they can apply their learnings to daily life. Along with unique and distinct contextual variations in the two contexts, content, organization, and emphasis in each country's textbook were found to be systematically and comprehensively designed to achieve the curriculum standards and the course of study in Myanmar and Japan, respectively. On the one hand, the Japanese science curriculum utilizes a scientific inquiry approach and primarily focuses on a smaller number of major topics at each grade, leaving the dissertation to the teachers so that they can teach in greater detail, utilizing a variety of learning approaches. This is one way in which's science curriculum can be improved in Myanmar to make their science teaching more effective in terms of science curriculum and textbook content. On the other hand, Myanmar's science textbook describes some technical scientific terms such as reflection, incident ray in both Burmese and English, such terms in Japanese science textbook should also be written in both Japanese and English. Thus, both countries can learn from their differences.

This study has certain limitations. First, it selected two Asian contexts and employed qualitative analysis, thereby particularizing the results rather than generalizing them. This suggests the extension of this research by employing different quantitative analysis approaches. Second, the current study analyzed two lower secondary school science textbooks focusing on the topic of light and sound. Future research is suggested to examine other topics at different grade levels (i.e., primary, lower secondary, and upper secondary levels).

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APPENDIX A

Note 1. In Myanmar science textbook, there are eight pages on the light and sound topic out of 147 pages (1.8%). The duration is six periods (each lasting 45 minutes). MOE mandates that science needs to be taught at least 200 periods out of 1,440 periods per year. Science textbook for grade-6 includes 11 chapters. In Japanese science textbook, there are 34 pages on the light and sound topic out of 233 pages (about 8%). The major difference in the weightage between Myanmar and Japan is that Myanmar science textbooks introduce light and sound topic at each grade at the lower secondary level (grade 6~9) in a spiral format. Alternatively, in Japan, light and sound topic is learned in grade-7. In Japan, the Course of Study requires teaching science in at least 105 periods out of 1,015 periods per year (each lasting 50 minutes). The actual number of lessons depends on the teachers who design the lesson plan. The selected science textbook (*Gakkotosho*) has four major chapters: classifications of animals and plants, familiar substances, familiar physical phenomena, and composition and changes of the earth, with each chapter comprising of three sections. For example, "Familiar physical phenomena" chapter consists of nature of light, nature of sound, and function of force. *Gakkotosho* textbook indicates the standard time of 20 hours which is distributed as eight hours for light, three hours for sounds, and nine hours for forces and pressure. Additional four hours are for more in-depth learning, practical work, or reviewing or to reduce if students' progress is slow. Therefore, total 24 hours are assigned for teaching that unit. Compared to other textbooks, the selected textbook's model is the minimum for spending standard time. However, *Gakkotosho* sets another eight hours available for relaxation, which can be put into teaching. In this study, not only the light and sound topics, but also the introductory chapter in Myanmar textbooks (11 pages) and front pages in Japanese textbook (27 pages) were analyzed to interpret the results.

Note 2. In the course of study, "S&T and humans" in the first field, and "nature and humans" in the second field must be taught in unit 7 (last unit) in the last grade of lower secondary level (i.e., grade-9). Therefore, science textbook includes this unit in detail in grade-9 of lower secondary level.