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Issues of Bhutanese Science Curriculum: A View from the Exploratory Study

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Abstract

Bhutanese science curriculum witnessed several rounds of reforms to improve the quality of science education. The growing body of research, however, reports that the Bhutanese science curriculum is affected largely by several issues and challenges. Therefore, an exploratory study was carried out to document the issues and challenges of the Bhutanese science curriculum. Twenty-one (N=21) Bhutanese science teachers took part in the study. Data were collected through one-on-one interviews. The data collected from interviews were analyzed based on thematic analysis. The findings suggested that the Bhutanese science curriculum is largely voluminous, content-laden, high in lexical density, or prescriptive. Moreover, findings also inferred that the Bhutanese science curriculum largely lacks scientific inquiry, logical progression, and developmental appropriateness of concepts, or attributes of contextualization. Overall, compared to the science from fourth to sixth grade, seventh to 12th-grade science appeared largely plagued by issues and challenges. Findings from this study have some practical implications for Bhutanese science teachers and science curriculum developers.

Keywords: Bhutanese science education, Bhutanese science curriculum, exploratory study

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Introduction

Bhutanese science education started with a curriculum borrowed from India. In 1986, the Royal Government of Bhutan (RGoB) replaced foreign borrowed primary science curriculum by implementing a localized curriculum founded upon the principles of the New Approach to Primary Education (NAPE) (Johnson et al., 2008; Tshewang, 2016). The localized primary science curriculum is intended to promote the art of scientific inquiry through Bhutan's social and environmental contexts (Royal Education Council [REC], 2012; Tenzin & Maxwell, 2008).

However, by the early 2000s, the Bhutanese science curriculum became the hotspot of public debate (Johnson et al., 2008; REC, 2012). Many Bhutanese felt that the science curriculum is fragmented, largely content-driven, and lacks the quality to prepare students for the world of work. As a follow-up, the Ministry of Education (MoE) conducted a needs assessment of the science curriculum in 2007 (REC, 2012; Tenzin & Lepcha, 2015). Based on the findings from the needs assessment, the reformed science curriculum for fourth to sixth grade was implemented in 2013, while the reformed science curriculum for 10th and 12th-grade was implemented in 2017 (Wangdi, 2016a).

At the core, the reformed science curriculum aimed to provide a clear statement of what learners are expected to achieve as a result of science education. It desired to provide well-coordinated, consistent, and coherent learning experiences (Tenzin & Lepcha, 2015); or learning content that is enriching, challenging, and relevant to learners' developmental appropriateness (REC, 2012; S. Tshewang, 2019). During the nationwide orientation program on the reformed science curriculum in 2013, many Bhutanese science educators remarked that the reformed science curriculum is mainly designed to upscale the spirit of scientific temper ("Science Reform Curriculum", 2013; Tenzin, n.d.; Wangdi, 2016a). Many of them also opined that the reformed science curriculum is not only concise, experiential, inquisitive, and developmentally appropriate but also contextualized to suit Bhutan's emerging needs (Wangdi, 2016b).

Overall, it could be seen that the overwhelming majority of studies just report issues and challenges of the Bhutanese science curriculum from a numerical point of view in terms of frequency or severity. Moreover, most of the recent studies that make a case on issues and challenges of the Bhutanese science curriculum report merely in isolated or shallow form. As a result, there are not many reports that offer insight on issues and challenges of the Bhutanese science curriculum in a detailed qualitative fashion. Considering these accounts, it looks compelling that there is a need to carry out a study that can provide an in-depth view concerning issues and challenges of the Bhutanese science curriculum. Therefore, this exploratory study was carried out to ascertain the issues and challenges of the Bhutanese science curriculum in a rich, in-depth, and narrative fashion. The findings from this study are expected to inform Bhutanese science teachers and curriculum developers regarding the issues and challenges; and implications of the Bhutanese science curriculum. The study was carried out to answer the following questions:

1. What are the issues and challenges of the Bhutanese science curriculum?
2. What insights may be derived based on the results of the study?

Review of Literature

A growing body of research reports on issues and challenges of the Bhutanese science curriculum (Tenzin, 2019; Wangdi, 2016a, 2016b). Indeed, many delineate that the science curriculum, especially in higher grades, is largely inappropriate for both students and teachers. For instance, the recent report of Childs et al. (2012) delineates that the Bhutanese science curriculum, particularly from seventh to 12th grade, contains many concepts featured loosely in either a disconnected manner or fragmented manner; or removed either wholly or partially from certain grades and presented abruptly in other grades. Consistently, the nationwide cross-sectional survey conducted by REC (2019) also reports on a similar issue of discontinuity or fragmentation of the content, especially across the seventh to the 12th-grade science curriculum.

Although not in detail, many reports opine that the Bhutanese science curriculum, particularly in the higher grades, is loaded with heavy content (REC, 2018b; Wangchuk, 2019). As per the nationwide survey conducted by REC (2016, 2019), the Bhutanese science curriculum, especially from seventh to 12th grade, is both contents overloaded and high in lexical density coupled with a heavy focus on trivial facts and figures. A previous study carried out by Dema and Macleod (2015) reports that the science curriculum for these grades is not only overly thick but also difficult in completing a syllabus on time. Therefore, in line with this, most reports widely acknowledge that the teaching-learning in science is either forced to take place in fast pace mode with a lecture dominant style or remains situated within the classroom setting only (Rinzin, 2018, REC, 2019; Sherab & Dorji, 2013).

Concurrently, there is a consensus that the Bhutanese science curriculum is conceptually challenging (Rinchen, 2003). In this aspect, many reports increasingly explicate the Bhutanese science curriculum, especially from ninth to 12th grade, as developmentally age-inappropriate to both students and teachers (BCSEA, 2017; MoE, 2014; REC, 2016, 2019). For instance, recent studies highlight that the concepts of genetic entities and genetic phenomena are seemingly difficult and counterintuitive (Dorji et al., 2017; Dorji et al., 2017). Concepts belonging to these two areas of genetics, especially from ninth to 12th-grade biology, are highly sophisticated which makes learning often challenging. Correspondingly, Dorji (2016) in his narrative inquiry on "Mole Concept", exclusively labels mole and its associated concepts, featured in ninth and 10th-grade chemistry, as way beyond students' intelligible realm of understanding. Comprehensively, the recent study conducted by REC (2019) and Tenzin (2019) widely explicates the challenges faced by both students and teachers as a result of hierarchically intricate numerical problems, particularly in ninth to 12th-grade physics and chemistry.

One of the perennial aims of the Bhutanese science curriculum is to augment the spirit of scientific inquiry through everyday classroom teaching (REC, 2012). Many reports, however, maintain that the implementation of scientific inquiry in Bhutanese science classroom teaching is certainly challenging. According to Dema and Macleod (2015), the vastness of the Bhutanese science curriculum is one of the typical constraints that impede teachers' capacity to deliver curricular intentions through inquiry-based learning. If ever inquiry-based learning has to be implemented effectively, as per Dema and Macleod (2015), the Bhutanese science curriculum must be reduced to a manageable size. This finding was supported by the nationwide studies carried out by REC (2016, 2019). Recently, the Programme for International Students Assessment Development (PISA-D) test conducted by Bhutan Council for School Examinations and Assessment (BCSEA) (2017, 2019) found out many Bhutanese students are considered poor in solving inquiry-related questions. In its report, BCSEA (2019) explicitly points out this issue as one of the results of a typical science curriculum that is wholly or partially void of scientific inquiry.

Materials and Methods

Study Design

This study chose to explore issues and challenges of the Bhutanese science curriculum. Crowe et al. (2011) opine that an exploratory study is chosen when the study "lends itself well to capturing information on more explanatory … *what*… questions" (p. 4). The study captured up-close views of Bhutanese science teachers by talking directly to them in the natural school setting. The study allowed the teachers to use either English or *Dzongkha* as the medium of communication to express their perceptions and opinions spontaneously (Fabregues & Fetters, 2019). The study employed a qualitative-exploratory approach to understanding the issues and challenges of the Bhutanese science curriculum in the form of meanings or themes using logical inductive reasoning (Crowe et al., 2011).

The Context

This study was conducted in the fall of 2020. A letter of approval for data collection was sought from Chief District Education Officers (CDEOs). Based on the approval letter, one lower secondary school (LSS), two middle secondary schools (MSS), and one higher secondary school (HSS) were selected as the study sites in the first phase. In the second round, one primary, two LSS, one MSS, and one HSS were consecutively selected as the additional study sites. One LSS, one MSS, and two HSSs situated in the semi-urban area catered to both boarder and day scholar students, while other schools were day schools located within the vicinity of the urban center. To ease data collection, the principals of selected schools were given prior information regarding the study. The information related to the type of school, grade range of students, or the geographical locations of schools were collected.

Participants

Thirteen male and eight female science teachers took part in this study. They specialized in teaching: general science (*n*=5), biology (*n*=7), chemistry (*n*=4), and physics (*n*=5). Upon pre-service bachelor's degree (B. Ed) or a post-graduate diploma in education (PGDE, 11 science teachers had master's degrees either in education or a specific science discipline. While nine of them taught science from fourth to eighth grade, 12 of them taught ninth to 12th-grade science. Moreover, in addition to teaching seventh and eighth-grade science, six of them also taught 10th-grade chemistry and physics. Two teachers taught in primary school, five in LSSs, seven in MSSs, and the rest in HSSs. The demographic profile of the participants is outlined in Table 1.

Table 1: *The Demographic Profile of Teachers*

	Variables	**Frequency**	**Percentage**
Sex	Male	13	62
	Female	8	38
Subject of Specialisation	Science	5	24
	Biology	7	33
	Chemistry	4	19
	Physics	5	24
Qualification	B.Ed	6	29
	PGDE	4	19
	Master	11	52
School	Primary	2	10
	LSS	5	24
	MSS	7	33
	HSS	7	33

According to Patton (2002), participants are drawn into the study largely based on certain "pre-predetermined criteria of importance" (p. 238). Therefore, participants of this study were recruited purposefully based on the five inclusion criteria. First, all the teachers teaching science in the nine selected Bhutanese public schools were assumed to the "information-rich cases" (Suri, 2011, p. 66) or "will illuminate the questions understudy" (Patton, 2002, p. 273). Second, teachers with teaching experience of more than five years formed the new list of potential participants. Third, preference was given to teachers experienced in teaching the fourth to the 12th-grade science curriculum. Further, the preference was given to teachers who could expressively communicate experiences and opinions. Lastly, teachers were recruited based on their willingness and availability to participate in the study.

Data Collection

This study collected data from one-on-one interviews carried out with 21 Bhutanese science teachers. Each interview session lasted for more than 25 minutes approximately. Participants were informed about the rationale and procedures of the interviews. Informed consent was sought from each teacher participant after explaining the rationale and the procedures of the interview. The interviews were carried out in classrooms, the school library, or science laboratories after school hours based on the wishes of the participants. The interviewees were provided anonymous nomenclature T1 to T21 to maintain the confidentiality of their identity. Each interview session was audio-taped using a mobile phone voice recorder. Based on the wishes of the participants, the audio-taped interviews were deleted after the transcription and analysis. The interviews were carried out using a semi-structured interview protocol that contained four open-ended questions. The interview protocol was adapted from the protocol developed by Kvale & Brinkmann (2009).

Data Analysis

The interview transcripts were analyzed based on Braun and Clarke's (2006) approach to thematic analysis. The audio-taped interviews were transcribed into transcripts. Two researchers independently read and re-read the transcripts. At the end of the reading, two researchers discussed the impression of the data and developed a few initial ideas about the codes. Each researcher then set about coding at least five transcripts separately. Two researchers carried out line-by-line manual coding taking note of something that seemed relevant or interesting. In the end, two researchers compared the codes, discussed them, and modified them wherever appropriate before moving on to other transcripts. When difficulties were faced, the two researchers discussed the issues and resolved coding discrepancies until the 90% inter-coding reliability agreement was reached. The researchers used open coding and did this manually using a pen and highlighter. A list of codes was generated without pre-conceived coding frames as the researchers worked through the coding process. The codes were then collated into seven themes. The researchers defined and named the themes based on the focus and what each theme implied about the perceptions of the participating teachers. Table 2 shows seven themes and their corresponding definitions:

Table 2: *Themes and their Corresponding Definitions*

Themes	**Definitions**
The scientific inquiry	The prevalence of scientific inquiry in terms of the level of inquiry (verification, structured, guided, or open inquiry) and proportion of the inquiry-based learning experiences.
The Contextualisation	The prevalence of concepts and learning activities drawn from the immediate local environment.
The Developmental Appropriateness	The nature of concepts and learning activities in correspondence to the cognitive or psycho-social maturity of the learner.
The Conceptual Progression	The arrangement of concepts and learning experiences logically or progressively from lower grades to higher grades.
The Thickness	The size of the vastness of concepts in the form of activity, concepts, or facts and figures in relation to the length of the instructional hour.
The Content and Lexical Density	The quantitative representation of concepts and active learning activities in terms of the facts and figures, terminologies, and words.
The Choices and Flexibility	The nature of concepts and learning activities allow the development of content and instructional practices based on the needs and choices.

Member checking was carried out to establish the validity and credibility of the findings. Both data and interpretation were handed over to a few participants to check the information and the narrative accounts.

Findings

The findings from one-on-one interviews with nine science teachers are reported in the following seven themes.

Theme 1: The Scientific Inquiry

Participants remarked that science from fourth to eighth grade is focused on scientific inquiry. In addition to confirmation and verification inquiry, participants revealed that fourth to sixth-grade science holds a high level of inquiry, such as guided and open inquiry-based learning. They remarked that the learning experiences in fourth to sixth-grade science stimulate students to engage in the process of scientific inquiry. On the contrary, participants claimed that scientific inquiry in seventh to 12th-grade science is scanty and negligible. They also opined that the level of inquiry in seventh to 12th-grade science is confined either to confirmation or structured inquiry. Teachers posited that the prescriptive experiments, theory-driven concepts, and experiments conducted just to support and confirm the theoretical concepts demean the whole emphasis of scientific inquiry and scientific attitude in higher grades. Given below is the section verbatim from one of the participants:

T8. *"Class four to six science is good … it is focused to explore through experiments. Children can make guesses, design their experiments, and write their findings. Children get stimulated to conduct experiments. On the other hand, science from class seven to twelve is content-based … there are not much of experiments or learning through experiments. Moreover, experiments are focused on either proving a theory or finding the answer with ready-made procedures"*.

Theme 2: The Contextualisation

Significantly, the participants felt that fourth to sixth-grade science is contextualized considerably in Bhutanese settings. They acknowledged that concepts in fourth to sixth-grade science are built mostly using examples drawn from the Bhutanese socio-economic environment. Moreover, it emerged that seventh to eighth-grade science is also contextualized in the Bhutanese setting. However, participants maintained that the level of contextualization is not as robust as that of fourth to sixth-grade science. Conversely, participants agreed that the degree of contextualization from ninth and 10th-grade science is shallow and scanty. They commented that the trace of contextualization is visible only in biology with a few examples from the study of ecology. One of the participants maintained that:

T6. *"Class four to six science contain many examples of plants, animals, buildings, and materials required to learn taken out from Bhutan's environment and surrounding ... culture, etc. To a certain level, class seven and eight science also contains some examples drawn from Bhutan ... but the level of contexts and examples outlined is not as many as we find in class four to six science. To be very frank, science for higher grades … I mean physics, chemistry, and biology do not focus much on Bhutan's scenario. One would find a few chapters and topics written based on Bhutan's environment … that too in the chapter of ecosystem and biodiversity".*

Theme 3: The Developmental Appropriateness

Participants admitted that fourth to eighth-grade science is quite easy for students to understand. On the other hand, they revealed that many concepts from ninth to 12th-grade science are not developmentally appropriate to students' cognitive maturity. They acknowledged that there is a considerable number of numerical problems in physics and chemistry that are increasingly challenging to both students and teachers. Further, they pointed out that “Mole Concept” in the ninth and 10th-grade chemistry, “The Earth and Beyond” in ninth and 10th-grade physics; “DNA Replication”, “Central Dogma of Molecular Biology”, “Glycolysis and Krebs Cycle”, “Electron Transport System”, “Calvin Cycle”, and “Hatch and Slack Cycle” in 11th and 12th-grade biology are hierarchically abstract in nature. Participants expressed that these concepts make learning exhaustive and increasingly stressful. Given below is an excerpt from one of the participants.

T3. *"Numerical problems in physics and chemistry are challenging … I was told even teachers find it difficult to solve. The mole concept in chemistry and earth and beyond in physics needs to be made simple. Moreover, I have come across several concepts in class 11 and 12 biologies difficult. Forget about students when a teacher like us finds concepts challenging. We need to make concepts like DNA replication, central dogma, glycolysis and Krebs cycle, Calvin cycle, and C4 pathway simple".*

Theme 4: The Conceptual Progression

Participants agreed that there is not much of an issue in the flow of concepts from the fourth to eighth-grade science. However, they believed that ninth to 12th-grade science contains concepts without much progression. Participants claimed that “Mole Concept” and “The Earth and Beyond” in ninth and 10th-grade physics and chemistry have no progression from seventh and eighth-grade science. Further, they expressed that 11th and 12th-grade biology contains both “DNA Replication” and “Central Dogma of Molecular Biology” presented exhaustively without much basic from ninth and 10th-grade biology. It came out explicitly that “Human Reproductive System”, “Human Skeletal System”, and “Human Muscle System” presented in seventh to eighth-grade science are not at all featured in ninth and 10th-grade biology. Following are the extracts from two participants:

T6. *"Both mole concept and earth and beyond in ninth to10th grade physics and chemistry have no link with any topic in class seven and eight science. Concepts of DNA replication and central dogma are given in full length in class 11 and 12 biologies but with no foundation from class 10 biology"*

T3. *"Human Reproductive System", "Human Skeletal System", and "Human Muscle System" are given classes seven and eight sciences but not classes nine and 10 biology. I think there is a need to feature these things as well in class nine or 10 biolog*ies".

Theme 5: The Thickness

Teachers acknowledged that fourth to sixth-grade science and ninth and 10th-grade physics, chemistry, and biology are not vast in the syllabus. They expressed that teaching fourth to sixth-grade science; and ninth and 10th-grade physics, chemistry, and biology gets completed within the predetermined time frame. In contrast, they were of the view that both seventh and eighth-grade science; and 11th and 12th -science are overly thick and voluminous in structure. Predominantly, participants expressed that teachers teaching seventh and eighth-grade science, and 11th and 12th-grade science get burdened heavily with the anxiety to complete the syllabus. They explicitly stated that teachers adopt tactics, such as accelerating the pace of teaching, adopting theory-driven lecture methods, or conducting extra classes both on weekends and after school hours. Moreover, participants stated that teachers focus on certain portions and leave out some concepts deliberately. One of the participants stated that:

T9*. "Like science for lower classes, class nine and 10 physics, chemistry, and biology are quite easy to complete syllabus on time. However, it is really difficult to complete the syllabus for classes seven and eight science and classes 11 and 12 physics, chemistry, and biology. To be frank many take extra classes even on Sundays … some teach at a fast pace, some do lecture method … and many give importance to certain topics and leave others".*

Theme 6: The Content and Lexical Density

Participants expressed that seventh to 12th-grade science is plagued substantially by the heavy content. They maintained that seventh to 12th-grade science is dominated largely by a large proportion of facts and tidbits, terms and nomenclature, and trivial conceptual knowledge. Moreover, they made a loud call that science for these grades is also marred severely with high lexical density. Considering these issues, participants posited several problems faced by both teachers and students. They acknowledged that both students and teachers feel taxed and weary to complete the syllabus on time. They also agreed that teachers, on most occasions, carry out dominant use of the lecture method. A participant stated that:

T7*. "I think class seven to 12 science … I mean physics, chemistry, and biology from class nine to 12 … Science textbooks for these subjects contain a lot of content expressed with lots of words. I think such a curriculum makes teachers and students tired. Teachers use lecture method to complete syllabus on time".*

Theme 7: The Choices and Flexibility

Participants felt that fourth to 12th-grade science is rigid and prescriptive in nature. They commented that teaching and learning are encouraged neither to situate beyond pre-determined scopes nor based on one's choice, creativity, and innovation. Surprisingly, they agreed that the prescriptive nature of the science curriculum is linked largely to the examination system. They acknowledged that classroom instruction is done merely to score high marks in examinations to get admitted to higher grades or to get absorbed into job markets. Therefore, participants made a loud call to move away from the year-end paper-pencil test to a performance-based assessment. The extract below is verbatim of one of the participants:

T8. *"Our science curriculum is rigid and prescriptive. We do not have the freedom to choose our learning courses ... you know it's quite frustrating that we have to stick to what is defined in the curriculum. There is no scope for innovation and creativity ... no choice ... I think it's high time that we focus to assess what students perform in the action ... not always exam ... examination makes everything rigid to score marks".*

Discussion

Theme 1: The Scientific Inquiry

Fourth to sixth-grade science is focused largely on high levels of inquiry, such as open and guided inquiry. This finding mirrors the aspiration of the Bhutanese science curriculum. Bhutanese science curriculum envisages "to develop in the learners the notion of a scientific temper which is the spirit of inquiry" (REC, 2012, p. 8) or to provide learners with the avenues to develop the scientific temperament through a plethora of investigation-led activities (REC, 2018a). In contrast, scientific inquiry in seven to 12th-grade science is either shallow or scanty with just low levels of inquiry, such as structured or confirmation inquiry. This finding implies that there is a gradual decline in scientific inquiry from fourth to 12th-grade science. The study conducted by Dema and Macleod (2015) also reports the lack of inquiry in ninth-grade biology. This finding, of course, explains why Bhutanese students performed poorly in inquiry-based competency questions in the PISA-D test conducted BCSEA) (2019). Against this backdrop, Tenzin (n.d.) and Tenzin and Lepcha's (2015) claim that the prevalence of scientific inquiry in the Bhutanese science curriculum seems quite contrary to what is present in the real setting. This must be one possible reason why the reports from the preliminary PISA-D test conducted by BCSEA have suggested focusing school science upon the foundation of scientific inquiry (BCSEA, 2017).

Theme 2: The Height of Contextualisation

One of the intentions of the Bhutanese science curriculum is to make use of the examples and contexts from the immediate surrounding environment (Tenzin, n. d.; Tenzin & Lepcha, 2015; Wangdi, 2016b). Similarly, this study indicated that fourth to sixth-grade science is rooted largely to use local context as the principal source of classroom learning. This finding mirrors the report of "Reform Science Curriculum" (2013) that "all the illustrations in the textbooks are derived from Bhutanese context" (para. 2).

The use of local contexts and examples in seventh to eighth-grade science is quite shallow, while in ninth to 12th-grade science, the level of contextualization is comparatively less. The use of local examples and contexts is visible only in certain portions of biology, such as the study of plants and animals. The lack of contextualization in ninth to 12th-grade science can be explained possibly by the authorship of the ninth to 12th-grade science textbooks. Although the Bhutanese science curriculum framework per se is authored largely by Bhutanese writers, most of the ninth to 12th-grade science textbooks are authored by foreigners. As their books fail to draw concepts from the Bhutanese setting, it looks quite certain that they did not have a proper understanding of Bhutan's socio-economic environment.

Theme 3: The Developmental Appropriateness

Fourth to eighth-grade science is neither easy nor difficult. This claim by participants appears odd to the report of MoE's (2014) and REC (2016) but supports the Bhutanese science curriculum framework's intention of providing a "developmentally appropriate curriculum based on the knowledge and skills about how children develop and learn" (REC, 2012, p. 4). Conversely, many numerical problems in ninth to 10th-grade physics and chemistry are difficult for both students and teachers. This finding appears consistent with the prior research findings of the study conducted by Tenzin (2019) on Bhutanese students' conceptual understanding of physics. Significantly, "Mole Concept" in chemistry and "The Earth and Beyond" in physics are hierarchically abstract and intricate. The study conducted by Dorji (2016) found out 10th-grade Bhutanese students with little or no understanding of the "Mole Concept".

Concepts, such as "Central Dogma of Molecular Biology", "Glycolysis", "Krebs cycle"; and "Calvin cycle" are some of the examples of 11th and 12th-grade biology that are challenging considerably, counter-intuitive, or hierarchically complex and sophisticated to both students and teachers. Given this finding, the Bhutanese science curriculum framework's aim to provide developmentally appropriate learning experiences based on "Piagetian stages" looks far from having been achieved (REC, 2012, p. 8). The study by REC (2019) and Rinzin (2019) also reports similar issues associated with the ninth to 12th-grade Bhutanese science curriculum. According to Rinzin (2018), "foreign teachers from Canada, United Kingdom, and Poland remarked that our grade nine curriculum is taught in grade eleven in their countries, especially science and mathematics. Our curriculum is beyond what a child could digest and apply in life" (para.7). This could be one possible reason why the nationwide consultation conducted by MoE (2014) found science as one of the most challenging and perennially difficult subjects for many Bhutanese students.

Theme 4: The Conceptual Progression

The flow of concepts, especially from fourth to eighth-grade science, is arranged with a noticeable logical flow. This implies that concepts presented in the fourth to eighth-grade Bhutanese science curriculum are organized logically or coherently in a dovetail manner. The report by Tenzin and Lepcha (2015) also points out how concepts in the Bhutanese science curriculum are arranged in the order of logical progression. However, as their report discusses merely science curriculum in general, their inference may not imply necessarily a higher grade science curriculum.

The concepts in seventh to 10th-grade science are oriented in a mere piecemeal fashion. For instance, they mentioned that both "Mole Concept" and "The Earth and Beyond" are outlined blithely in ninth and 10th-grade science with little or no progression from lower grades. Moreover, it seemed that the seventh and eighth-grade science concepts, such as "Human Reproductive System", "Human Skeletal System", and "Human Muscle System" are presented either in a shallow, isolated fashion or not at all featured in ninth and 10th-grade biology. Further, pa concepts of "Interactions and Adaptations in its Environment" are presented repeatedly in both ninth and 10th-grade biology with little or no difference in scientific terminology, grammatical structure, or technicality of the concept. This finding appears consistent with the prior study conducted by Dema and Macleod (2015) which also explicates the issues related to the repetition of several concepts across ninth-grade biology. Therefore, the Bhutanese science curriculum's effort to bring "coordination" or "consistency and coherence" in Bhutanese science education looks certainly uncertain (REC, 2012, p. 2).

Further, concepts of molecular genetics, including "DNA Replication" and "Central Dogma of Molecular Biology" are presented blithely in 11th and 12th-grade biology without much basics from lower grades. Indeed, as is the case, the concept of "Central Dogma of Molecular Biology" is nowhere mentioned in ninth and 10th-grade biology, while it is discussed widely, both in molecular and sub-cellular processes, in 11th and 12th-grade biology. A similar issue is also reported widely in the related study conducted by REC (2019). Given that seventh to 12th-grade science is fragmented largely, the Bhutanese science curriculum framework's intention to "provide science education that … reflects a systematic and progressive approach throughout pre-primary, primary, and secondary education" seems remote and far from over (REC, 2012, p. 2).

Theme 5: The Size or Thickness

It emerged that fourth to sixth-grade and ninth to 10th-grade science is neither vast nor heavy. Teaching science for these grades is easy as the syllabus is completed often within or before the stipulated dateline. This study contradicts reports by Demand and Macleod (2015) and REC (2016, 2019) that delineate the Bhutanese science curriculum as voluminous and heavy in design. The report by Rinzin (2018) that "our school curriculum is so voluminous… teachers leave no stone unturned to complete the vast syllabus on time" also appears certainly not plausible (para. 8-9). However, the contradiction of findings of this study must be contemplated exclusively for the fourth to sixth-grade and ninth to 10th-grade science curriculum. In contrast, it came out explicitly that seventh to eighth-grade and 11th to 12th-grade science is overly thick or voluminous in design. For this, participants reported that teaching science, especially in seventh to eighth grade and 11th to 12th grade, is extremely difficult to complete on time. The prior studies conducted by BCSEA (2017), MoE (2014), and REC (2016, 2019) also report similar findings.

It appears that there are implications associated with the voluminous seventh to eighth-grade and 11th to 12th-grade science curriculum. Teachers who teach science for these grades inherently adopt dominant use of the lecture method, speed up the pace of teaching and focus more on certain portions and leave the others. The dominant use of the lecture method in most parts of Bhutanese classroom instruction is reported prominently by Sherab and Dorji (2013) in their study on Bhutanese teachers' pedagogical orientation. Overall, the finding refutes the Bhutanese science curriculum's intention to bring changes in classroom teaching methods. Therefore, it seems that the aspiration to induce a pedagogical shift from lecture-driven methods to inquiry-led activities is far from having been achieved. Moreover, teachers teaching seventh to eighth grade and 11th to 12th-grade science conduct extra classes both after school hours and on weekends. This must be one reason why MoE (2014) and REC (2016) suggest reviewing the science curriculum and the time allocated to each science subject. In the last few years, REC thinned all the school curricula. According to the official circular of REC (2018b) and Wangchuk (2019), the curriculum thinning was underpinned to downsize the school curricula by removing topics, learning activities, or assessment items, which are redundant, overlapping, irrelevant, or inappropriate. The PISA-D test conducted by BCSEA (2019) suggests the Bhutanese science curriculum focuses more on depth than breadth.

Theme 6: The Content and Lexical Density

The fourth to sixth-grade science is neither shallow nor content-laden. This remark by participants refutes REC's (2016, 2019) claim that the Bhutanese science curriculum is largely hindered by the saturation of content. Conversely, seventh to 12th-grade science is mired largely by a large proportion of conceptual knowledge, facts and figures, and terms and nomenclatures. Ideally, the Bhutanese science curriculum is intended to focus more on the scientific process with special attention to disciplinary core ideas (REC, 2012). However, as it seems, the Bhutanese science curriculum framework's intention is somewhat defeated either partially or wholly. Perhaps, this might answer why scientific inquiry is rare and scanty in seventh to 12th-grade science. MoE (2014) and REC (2016) recommend reviewing content and making the science curriculum concise and intention-oriented.

Seventh to 12th-grade science is high in lexical density. This might explain why seventh to 12th- grade science is voluminous, content-overload, or focused less on scientific inquiry. The needs assessment carried out by REC (2019) also reports a similar finding. REC carried out curriculum thinning in all school curricula, including science to reduce the lexical density in texts by minimizing heavy textual materials (REC, 2018b). Considering the findings, however, it seems that the curriculum thinning carried out by REC, especially for seventh to 12th-grade science, has still a long way to go to achieve its intention.

Regarding the content-laden curriculum, classroom teaching, particularly in seventh to 12th-grade science, is considerably challenging. Teachers feel taxed and burdened to complete teaching on time, forced to carry out theory-driven lessons, or experience frustration with excessive content to learn. According to Ndawa (2015), the content-laden curriculum poses a major hurdle for teachers and forces them to rely mostly on the "traditional lecture method" (p. 104). Lee and Willson (2017) note that students and teachers experience frustration and anxiety when overwhelmed by the excessive content that needs to be learned. Therefore, it appears apparent that teachers, especially those teaching seventh to 12th-grade science, experience more psychological and emotional pressure than the teachers teaching science in other grades.

Theme 7: The Choices and Flexibility

The Bhutanese science curriculum is rigid and prescriptive in nature. It neither encourage situates learning beyond pre-determined scopes nor does it foster the spirit of innovation and creativity. Moreover, such a curriculum entails forcefully students from different learning needs to achieve the same learning standards. Studies conducted by Dorji (2015), Dorji et al. (2020), and REC (2019) report a similar finding. With these findings, one can only assume why Scheulka (2013) calls for greater flexibility and choices within Bhutanese curricular settings.

The rigid nature of the Bhutanese science curriculum appeared reasonably influenced by the assessment system geared heavily towards scoring high marks in examinations to get admitted to the next higher grades or to get absorbed into the job market. This corresponds to BCSEA (2013) and Layton and Dolkar (2010) that students from all over the country must sit for both home and national examinations to be able to gain admission to the next level of education or to get absorbed into the job market. Therefore, the report inferred by "Reform Science Curriculum" (2013) regarding the flexibility to use different assessment techniques and tools, specifically from fourth to sixth-grade science, is largely not true. For instance, students' yearlong learning in ninth and 10th-grade biology is marked out of 80 % in written examinations (Tshering, 2018; Tshering et al., 2019). Similarly, Maxwell et al. (2010) note that the year-end written examinations are the most dominant forms of the assessment system in the Bhutanese education system. Therefore, unless there is a policy that encourages the shift from home or national examinations, it looks certain that the Bhutanese science curriculum would remain prescriptive and rigid in the foreseeable future.

Conclusions

This study was carried out to examine issues and challenges of the Bhutanese science curriculum. Thirteen male and eight female science teachers took part in the study. It came out that the fourth to sixth-grade science curriculum is centered largely on scientific inquiry, contextualized to Bhutanese setting, or developmentally age-appropriate. Moreover, science for these grades appeared neither bulky nor content-laden; and contain concepts arranged logically in a dovetail manner. In contrast, both scientific inquiry and the degree of contextualization emerged considerably shallow from the seventh to 12th grade-science curriculum. Moreover, the science curriculum for these grades emerged significantly not age-appropriate, content-laden, voluminous, or high in lexical density. Overall, the Bhutanese science curriculum, from fourth to 12th grade, appeared largely prescriptive in nature influenced by an exam-dominated assessment system.

Limitations

This study recruited teacher participants based on the inclusion criteria of the purposive sampling design. As a result, the teacher participants did not have the representative nature of the whole Bhutanese science teacher population. Therefore, the findings from this study cannot be generalized or accounted for the larger population of Bhutanese science teachers. Thus, this study lacks a source of information from other strata of the education fraternity, such as school principals, students, and educators from different departments of MoE. Moreover, the study also did not take a view from documents and artifacts related to the Bhutanese science curriculum. Overall, the future study may address these limitations by drawing in a representative sample; collecting data from different strata of education fraternity, documents, and artifacts.

Implications and Recommendations

The Bhutanese science curriculum is intended largely to provide certain ideals and principles including, scientific inquiry, contextualization, logical progression of ideas; or developmentally age-appropriate learning experiences. By and large, fourth to sixth-grade science appeared better in standards, especially in realizing the goals and philosophical foundations of Bhutanese science education. Unfortunately, it emerged that seventh to 12th-grade science is mired by several issues and challenges. Therefore, it looks imperative that relevant professionals, such as Bhutanese science teachers and science curriculum developers take stock of the issues and address them accordingly wherever possible as:

1. Upscale the spirit of scientific inquiry in seventh to 12th-grade science. This may consist of developing classroom activities that entail students constructing their own questions, investigating procedures; or finding answers through their own efforts.
2. Upscale the use of Bhutanese contextual setting in seven to 12th-grade science. This may be achieved through designing a curriculum that encourages the learners to construct knowledge using examples and contexts drawn from their immediate surrounding environment.
3. Design seven to 12th-grade science developmentally age-appropriate to learners' cognitive abilities. The abstract or counter-intuitive concepts can be replaced or toned down.

4. Improve the flow of concepts from seventh to 12th-grade science. Moreover, ensure that concepts are redundant neither within nor across the grades.
5. Downsize the volume of the seventh to the 12th-grade science curriculum. This may be achieved by removing topics, learning activities, or assessment items that are redundant, overlapping, or inappropriate.
6. Reduce the content in seventh to 12th-grade science. This may be achieved by removing irrelevant conceptual knowledge, facts and figures, and scientific jargon. Moreover, use pictorial contents or info graphics in place of texts.
7. Ensure that the assessment is focused more on performance tasks than the term-end or year-end paper-pencil test.

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