RESEARCH PAPER

Relationship between Conceptual Transition and Learning of Chemistry in Bhutanese Secondary Schools: A Case Study in Samtse District

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ABSTRACT

This study explored on conceptual transition of students from grade VII integrated science to grade IX chemistry and its impact on learning of grade IX chemistry in Bhutanese secondary schools. The study employed convergent parallel mixed method design and the data were collected through survey questionnaires, semi-structured interviews and document analysis. A total of 321 participants comprising of students both males and females (n=296), teachers (n=25), participated in the study. The quantitative data were analysed using SPSS and thematic analysis for qualitative data. The result of the study revealed that, about 59% of the students under study face difficulties in the learning of grade IX chemistry because around 50% of the concepts introduced in grade IX chemistry were totally new for the students which were not introduced and familiarized in grade VII and VIII integrated science. The study confirms that the students specifically face learning difficulties on the topics like organic chemistry, chemical bonding, mole concepts, thermodynamics and stoichiometry due to their poor foundation and the conceptual knowledge on such topics in grade IX chemistry. The study also, revealed that there is significant relationship between the transition of chemistry concepts from grade VII and VIII integrated science and learning difficulty of grade IX chemistry. Therefore, based on findings, the study recommends that the introduction and familiarization of IX chemistry concepts should start from grade VII itself in order to have strong conceptual foundation towards enhancing the learning of IX chemistry.

Keywords: Learning difficulty, Concepts, Bifurcated Science, Basic Foundation, Progression

1. INTRODUCTION

Science education in Bhutan was introduced in 1960s with the inception of a modern education system. Since then, the science curriculum has undergone number of changes with time. The organized and aligned concepts of subjects across various levels of grades in the sequential nature are a means towards smooth conceptual transition of the students [1]. One of the main purposes of science curriculum is to maintain the smooth conceptual transition of contents

and concepts in seamless nature across different level of grades [2]. In order to affirm smooth transition of students conceptually across various level of grades, the nature of learning should be from a part to a whole learning process where a bit of information be grasped before other bits can be comprehended [3]. The discontinuity of concepts across different level of grades hinders the smooth transition of students conceptually [4-5]. Further, the teaching of science in a spiral approach had a great significance in conceptual transitions of students particularly in an area of science like physics, chemistry, biology and earth science [6-7].

In mid 1980s, education department started Bhutanizing of the science curriculum by making it more innovative within a Bhutanese context. Moreover, in 1986, with an introduction of new approach to primary education system, an innovative curriculum that required teachers to adapt new approach of teaching and learning required. It focused more towards child centered learning Bhutan, began to develop her own science curriculum [4]. In the initial phase, the primary science curriculum for classes IV-VI were introduced taking more account on teaching and learning of science based on natural and social environment of Bhutan. Subsequently, by the end of 20th century (1999 and 2000), the teaching of science through three distinctive science disciplines (physics, chemistry and biology) in classes VII and VIII was replaced by a single integrated science mainly to localized the curriculum, to discourage memorization of scientific facts and figures and to bring the curriculum in line with the classes IV-VI science curriculum. Thus, the curriculum from classes IV - VIII became an integrated science curriculum and bifurcated science for classes IX-XII and for classes PP-III, the science is studied through an integrated environmental study taught in Dzongkha [4]. However, after fourteen years of its implementation there was a growing concern among the general public on content and the delivery of primary science curriculum therefore, in 2001. The textbooks were revised mainly to add content and to make the learning activities more relevant and further, owing to such general concern over the quality of science curriculum, a major reform on science curriculum for classes PP- XII was launched during the 10th Five Year Plan, by the Ministry of Education [8]. Thus, to initiate the curriculum reform several studies were conducted on Bhutanese science curricula by different researchers. The study found that there was a lack of progression in terms of scientific concepts across grades, big jumps from grade III to IV and grade VIII to IX, the contents were overloaded particularly in higher grades. Similarly, the balance in contents of biology, chemistry and physics were required across all the level of grades and the integrated science curriculum for grade VII and VIII was more of biology focused [9-11].

Therefore, all these findings have guided the Department of Curriculum Research and Development Bhutan, to develop a science curriculum framework for grade Pre-primary (PP) to XII that brings together the environmental study curriculum for grade PP to III, integrated science curriculum for grade IV to VIII and the single science curriculum for grade IX to XII. Simultaneously in 11th five-

year plan, based on the science curriculum framework the Royal Education Council Bhutan, brought a major reformation in the science curriculum for grade PP to XII. The reformed general science curriculum for grade IV to VI were implemented in 2013 and the science for grade VII to VIII in 2014 and 2015 respectively. Similarly, the newly developed bifurcated science curriculum for grade IX and XI in 2016 and for grade X and XII in 2017. However, the science curriculum for PP to grade III is taught as integral part of environmental science in Dzongkha [12].

The science curriculum in Bhutan is said to be a spiral in nature and the current science curricula of grade VII and VIII is said to have both concepts and content link to the secondary science curriculum where the subject is taught bifurcated to biology, physics and chemistry [8]. However, the Review Report on Quality of Education (2016) reported that, the students find it difficult in comprehending the main idea, scientific concepts and principles in science when they go to higher classes [13]. Similarly, a study conducted by Wangdi and Dema (2020) also, concluded that the learning of integrated science in grade VII and VIII develops less foundations and conceptual understanding towards learning bifurcated science from grade IX onwards [12]. Further, when students reach to grade IX, the chemistry teachers observed that, the students are facing with numerous difficulties in comprehending the chemistry concepts, scientific terms, laws and principles introduced in grade IX chemistry. The similar issue is raised by many other chemistry teachers in the field. This observation is based on researcher‘s experiences of teaching classes VII and VIII science and IX chemistry for nearly a decade. The current study is first of its kind in Bhutan.

The intend of present study was to find out the both teachers and students’ opinion on learning difficulty of grade IX chemistry and the relationship between transition of chemistry concepts from grade VII and VIII integrated science to grade IX chemistry with learning difficulties of grade IX chemistry.

2. METHOD AND MATERIAL

2.1. Research Design

The convergent parallel mixed method design was employed in this study where both quantitative and qualitative data were collected simultaneously. The quantitative data were collected by administrating survey questionnaire to teacher participants teaching grade IX chemistry and VII and VIII integrated science likewise, student participants of grade X from four selected secondary schools in the current study. Similarly, the qualitative data were collected through interviews from teachers teaching VII and VIII integrated science and IX chemistry and grade X students. Furthermore, to find out the transition of chemistry concepts from grade VII and VIII integrated science to grade IX chemistry, content analysis of VII and VIII integrated science textbook and IX chemistry textbook were reviewed.

2.2. Research Site

The study was conducted in four secondary schools under Samtse District of Southern

Bhutan. The site for the study was selected based on the convenient of the researcher.

2.3. Sample and Sampling Technique.

Purposive sampling technique was used to have sample representative of grade X students and teachers teaching grade IX chemistry [14]. The reasons for taking only grade X in the current study was because these students are the one who have just completed studying grade IX chemistry after studying the integrated science in grades VII and VIII. Moreover, the timeline to collect data from the field was right after the re-opening of new academic session 2020.

The sample size is calculated from the total population of 1145 grade X students using Yamane's (1967) [15] formula as follows:

$$n = \frac{N}{1 + Ne^2}$$

Where:

n= sample size,
N= population size
e= acceptable sampling error (0.05)

2.4. Data Collection Tools

2.4.1. Survey Questionnaire

Two sets of survey questionaries were used one for the students and another for the teachers. The survey questionnaires included 5-point Likert-Scale items that ranged from strongly disagree (1) to strongly agree (5) measuring the students and teachers' opinions on the learning difficulties experienced by grade IX students in Bhutanese secondary schools.

2.4.2. Interview

Both structured and unstructured interviews were used both closed and open-handed questions. The respondents were given opportunity to elaborate or provide more relevant information. For the focus group interviews, 16 students consisting of 8 males and 8 females were included and 7 teachers were employed for face-to-face interviews. Different questions were administered for teachers and students interviews.

2.5. Document analysis

In this study the integrated science textbooks of grades VII and VIII and grade IX chemistry textbook were analysed to find out the introduction of IX chemistry concepts in VII and VIII integrated science curriculum and also to examine the progression of chemistry concepts from VII and VIII integrated science to grade IX chemistry.

2.6. Reliability and Validity of the Tools

The reliability of the interview questions was confirmed through expert review and peer review and the validity of the tools was established by triangulating the data collection methods and responses from the participants.

Table 1. Criteria for interpreting the overall means scores obtained

Mean scores	Interpretation
1.00-1.80	Very Low
1.81-2.60	Low
2.61-3.20	Moderate
3.21-4.20	High
4.21-5.00	Very High

2.7. Data Analysis

The quantitative data were analysed using Statistical Package for Social Sciences (SPSS) version 22 through simple descriptive analysis by taking mean, standard deviation, percentage and inferential statistics like simple correlation. The mean score interpretation table adopted from Moidunny (2009) was used to analysed the survey [16] (table 1).

The audio recordings of interviews were transcribed, allowing sufficient time for the transcription process. After categorizing the text segments under similar categories, repeated reading was carried out to identify the codes and the codes were merged together to generate the themes.

2.8. Triangulation

In study, the findings from interviews and survey questionnaire were triangulated with the findings from content analysis of grade VII and VIII integrated science and grade IX chemistry to validate and solidify the results.

3. RESULTS AND DISCUSSION

The quantitative data were presented in the form of tables and graphs for easy interpretation and reading. In case of qualitative data, anonymity of the interview participants was maintained using pseudonyms like T_01, T_02 … for teachers and SFG_01, SFG_02 for students' focus group interviews. The findings from survey, interviews and document analyses were triangulated to validate and solidify the results.

3.1. Findings from qualitative results

About 80% of student focus group interviewees expressed that they encountered challenges in learning of grade IX chemistry. They were with the view that lack of smooth conceptual transition from integrated science to secondary chemistry made difficulties in learning of grade IX chemistry. Majority of the students believed that they have not received adequate basic IX chemistry foundation in lower secondary science. Interviewees explained that grade IX chemistry consists of many new concepts which they have not learnt in grades VII and VIII integrated science. For instance, (SFG_02) unanimously expressed that: When we reached grade IX, we find that chemistry subject is a difficult subject because, in grade VII and VIII integrated science we did not studied the basic concepts of many topics like stoichiometry, thermodynamics, chemical bonding, green chemistry, organic chemistry and mole concepts which are introduced only in grade IX chemistry.

Face to face interviews with teachers also discovered consistent views with that of students. From the total of 7 teacher participants about 70% of those interviewed teachers felt that majority of the students

Table 2. Mean score of response on learning difficulties of grade IX chemistry by student participants (N:296)

Items	Mean	SD	Rating
In grade IX chemistry, many new concepts are introduced which are not embedded in VII and VIII science.	4.06	1.24	High
I find many new terms and terminologies in IX chemistry which I have never learned in VII and VIII science.	3.94	1.29	High
I came across few new topics while learning grade IX chemistry which I have not learned in grade VII and VIII science.	2.01	1.09	Low
I came across many topics while learning IX chemistry, which I have not learned in grade VII and VIII.	3.84	1.17	High
I find chemistry is the most difficult subject in grade IX.	3.53	1.36	High
Overall Mean Score	3.48	1.23	High

Table 3. Mean score of response on learning difficulties of grade IX chemistry by teacher participants (N: 18)

Items	Mean	SD	Rating
My students are not able to cope up with new concepts, terms and terminologies introduced in grade IX chemistry.	3.89	0.90	High
I find students perceive grade IX chemistry as an easy subject after studying VIII science.	2.39	0.98	Low
I came across many topics while teaching IX chemistry which they have not learned in VII and VIII science.	3.56	1.04	High
I find students perceive grade IX chemistry as difficult subject after studying VIII science.	3.72	1.07	High
I came across few new topics while teaching IX chemistry which they have not learned in VII and VIII science.	2.17	0.99	Low
Overall Mean Score	3.15	1.00	Moderate

Table 4. Relationship between the transition of chemistry concepts from grade VII and VIII integrated science and learning difficulty of grade IX chemistry

Learning difficulty of IX chemistry		
Progression of chemistry concepts from grade VII and VIII science to grade IX chemistry	Pearson Correlation	-.324**
	Sig. (2-tailed)	0.001
	N	296
**Correlation is significant at the 0.01 level (2-tailed)		

experienced difficulties in learning grade IX chemistry because about 50% of the concepts introduced in grade IX chemistry are new for students which are not familiarized in grades VII and VIII integrated science thus, lack smooth conceptual transition. This statement is evident from the view explained by teacher participants as follows:

Just 50% of IX chemistry concepts are introduced in VII and VIII integrated science but rest are totally new for our students in grade IX chemistry (T_07). The participants were also with the opinion that, there is a lack smooth progression of chemistry concepts from grade VII and VIII integrated science to grade IX chemistry thus, students face difficulties in understanding and comprehending of concepts introduced in grade IX chemistry. This is clear from the views expressed by 70% of the participants during interview. For example, I think there isn't a smooth progression, because many IX chemistry concepts are not embedded

in grades VII and VIII integrated science, so our students are not feeling that they are smoothly sailing in their learning process of IX chemistry (T_01). Similarly, student focus group_ 03, expressed that, very few topics and concepts have progression from VII and VIII integrated science to grade IX chemistry, like balancing chemical equation, periodic table, acid and base, physical and chemical changes, but most of the topics and concepts are new in grade IX chemistry.

3.2. Findings from document analysis

From the in-depth content analysis of grade VII and VIII integrated science and grade IX chemistry, it was found that the key concepts required to learn the topics like organic chemistry, mole concepts, chemical bonding, stoichiometry, green chemistry and thermodynamic in grade IX chemistry are not introduced and familiarized in grade VII and VIII integrated science. Therefore, many terms, terminologies and concepts introduced in grade IX chemistry are totally new for the students.

3.3. Findings from quantitative results

Based on Moidunny (2009) [16] score interpretation, students rated high level of learning difficulties of grade IX chemistry with overall mean score 3.48 (S.D, 1.23) (table 2). Further, item 5 was rated high by student respondents with the mean score of 3.53 (S.D, 1.36). This result indicates that majority of the student participant's face learning difficulty in grade IX chemistry. Based on study score interpretation, the teacher participants have rated the moderate level of students learning difficulty in grade IX chemistry with an overall mean score of 3.15 (S.D, 1.00). However, item 1 was rated high by teacher respondents with the mean score of 3.89 (S.D, 0.90). Similarly, item 4 was rated high with the mean score of 3.72 (S.D, 1.07) (table 3). This result shows that most of the teacher participants were of the opinion that the students face learning difficulty in grade IX chemistry. The total of 296 students participated in the survey, out of which 175 (59%) student participants agreed that they experienced learning difficulty in grade IX chemistry and about 79 (27%) of the student participants disagreed on having any learning difficulty in grade IX chemistry. However, 42 (14%) of student participants were of neutral views.

Table 4 shows the relation between the flow and progression of chemistry concepts from grade VII and VIII integrated science and learning difficulties of students in grade IX chemistry, determined through simple Pearson correlation computed and tested at (0.05) significance level. The flow and progression of chemistry concepts from grade VII and VIII integrated science to grade IX chemistry has a significant negative correlation with the learning difficulties of grade IX chemistry ($r = -0.324$, $P = 0.001$). In other words, organized and well maintained progression of chemistry concepts from grade VII and VIII integrated science to grade IX chemistry will reduce the challenges towards coping up with the concepts and contents introduced in grade IX chemistry however,

hapazard sequencing and disorganized progression of chemistry concepts from grade VII and VIII integrated science to grade IX

chemistry elevates the challenges towards learning of grade IX chemistry (figure 1).

3.4. Traingulation of findings

The findings from interviews, survey and content analysis are concurrent and supportive each other. About 80% of student participants and 70% of teacher participants shared a similar view that majority of students face difficulties in learning grade IX chemistry in secondary schools due to poor conceptual transition. Further, most of topics, concepts, scientific terms and terminologies introduced in grade IX chemistry are alien to the learners. Similarly, from the survey it is evident that 59% of student participants rated that they face challenges in learning grade IX chemistry in secondary schools. Likewise, majority of teacher participants have rated that they perceived students facing difficulties in learning of grade IX chemistry due to poor conceptual transition from integrated science to grade IX chemistry. Furthermore, from the deeper content analysis of grade VII and VIII integrated science and grade IX chemistry, it was found that majority of topics and concepts introduced in grade IX chemistry were totally new for students and the basic concepts of many topics were not embedded in grade VII and VIII integrated science. The transition and alignment of concepts were not spiral in nature rather it is in haphazard sequencing from grade VII integrated science to grade IX chemistry.

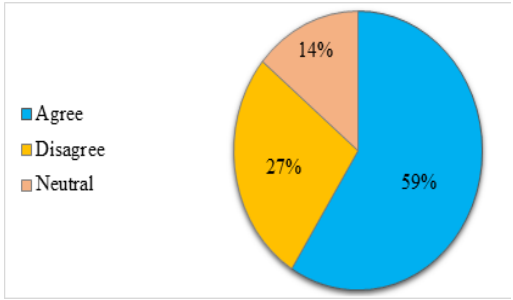

Figure 1. Number of student participants who experienced learning difficulty in grade IX chemistry

The study revealed that, most of the students lack basic concepts required to learn grade IX chemistry. Thus, majority of the students face challenges in learning new concepts and contents introduced in IX chemistry. In addition, the content analysis of grades VII and VIII integrated science and grade IX chemistry textbooks also shown that the basic concepts on organic chemistry, mole concepts, thermodynamics, chemical bonding and stoichiometry are not introduced and familiarized in grade VII and VIII integrated science. The present study confirms that when the students get graduated from lower secondary integrated science (grade VII and VIII) and steps into secondary chemistry (grade IX chemistry) majority of the students are with insufficient fundamental chemistry concepts required to learn grade IX chemistry and thus, the students face challenges in learning of grade IX chemistry. However, students encounter less difficulty in coping up with those chemistry concepts which are already introduced and familiarized in grades VII and VIII integrated science.

The most striking result emerged from this study is that, there is a significant relationship between the transition of chemistry concepts from lower secondary science (grade VII and VIII) with the learning difficulty of students in grade IX chemistry. The transition in this study

refers to the alignment and hierarchy of chemistry concepts and contents in organized and advancing nature from grade VII and VIII integrated science to grade IX chemistry. The quality of conceptual transition of students from grade VII and VIII integrated science to grade IX chemistry will determines the intensity of students' learning difficulties in grade IX chemistry. The smooth conceptual transition of chemistry concepts from grade VII and VIII integrated science generally helps students to understand the concepts more easily in grade IX chemistry. On the contrary, haphazard and disorganized sequencing of chemistry concepts from grade VII and VIII integrated science causes challenges in understanding the new concepts in grade IX chemistry. Therefore, findings from this study shows that lack of smooth conceptual transition from grade VII and VIII integrated science to grade IX chemistry is one of the major factors that causes learning difficulty of students in grade IX chemistry in Bhutanese secondary schools.

Based on the background and rationale behind the study presented in the introduction, the issues to be examine is expressed in the question: Is there relationship between the transition of chemistry concepts from grade VII and VIII integrated science to grade IX chemistry with the learning difficulty of students in Bhutanese secondary schools? Based on the issues, the main objective of this research is to seek views on transition of chemistry concepts from grade VII and VIII integrated science to grade IX chemistry and its impact on learning of grade IX chemistry from teacher and student participants.

Chemistry is one of the three main branches of pure science and is important subject because the knowledge of chemistry is required in all chemical industries both in the developed and developing countries [17]. However, many students perceived chemistry as difficult subject [18]. Several previous studies found the different causes of learning difficulties in chemistry. Uchegbu *et al.* (2016) found that the bulky chemistry syllabus, numerous calculations involved in the topics, lack of the qualified chemistry teachers and students' perception of chemistry as being too abstract was some of the reasons for the difficulties in understanding of the chemistry topics by the students [19]. Further, students' poor foundation and the conceptual knowledge on subject makes students to perceived difficulty in learning chemistry [17, 20-22]. Kyalo (2016) concluded that, when students develop negative attitude towards subject, they perceived chemistry as difficult subject [23]. Gafoor & Shilna, (2015) claimed that memorization of concepts without actually understanding the chemistry concepts makes students to perceived chemistry as difficult subject [24].

Other literatures highlighted that, students perceived chemistry as difficult subjects due to other factors like, students lack of scientific literacy, poor teaching methods, non-contextualized chemistry curriculum, students lack of interest in chemistry and lack of resources like textbooks and equipped laboratory [25-29].

4. CONCLUSION

The findings from the study concluded that, about 50% of the concepts required to learn grade IX chemistry were not introduced in lower secondary integrated science. Thus, about 59% of the students under study face challenges in learning of grade IX chemistry. Further, majority of the students perceived that numerous concepts presented in grade IX chemistry are totally new for them as they were not familiarized with such concepts in VII and VIII integrated science. The coherency of chemistry concepts and contents are not appropriately aligned from grade VII integrated science to grade IX chemistry thus, transition of chemistry concepts from grade VII integrated science to grade IX chemistry is not significantly smooth.

The study also revealed that there is significant relation between transition of chemistry concepts from grade VII and VIII integrated science to grade IX chemistry with the learning difficulty of students in grade IX chemistry. The well organized and progressive sequencing of chemistry concepts from grade VII and VIII integrated science to grade IX chemistry enhances the students comprehending of IX chemistry concepts more easily. On the other hand, haphazard sequencing of chemistry concepts from grade VII and VIII integrated science to grade IX chemistry causes learning difficulty of students in grade IX chemistry.

5. ACKNOWLEDGEMENT

NA

6. CONFLICT OF INTEREST

The authors have declared that there is no conflict of interest.

7. SOURCE/S OF FUNDING

NA

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