Pedagogical Practices: Triggering and Sustaining Students’ Interest and Engagement in Bhutanese Science Lessons

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Certificate of Original Authorship

I, Bijoy Kumar Rai declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Education, Faculty of Arts and Social Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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List of Abbreviations

AoI	Action of Interest
BCSEA	Bhutan Council for School Examination and Assessment
CoE	College of Education
FPMID	Four-Phase Model of Interest Development
GNH	Gross National Happiness
GoI	Government of India
HoL	Hands-on Learning
IL	Interactive Lectures
MoE	Ministry of Education
NAPE	New Approach to Primary Education
NEP	National Education Policy
NNSCF	New Normal Science Curriculum Framework
OECD	The Organisation for Economic Co-operation and Development
PISA	Program for International Student Assessment
POI	Person-Object Theory of Interest
REC	Royal Education Council
RGoB	Royal Government of Bhutan
SCF	Science Curriculum Framework
SGD	Small Group Discussion
SPP	Signature Pedagogical Practices

STEM	Science, Technology, Engineering, and Mathematics
UTS	University of Technology Sydney
VMSS	Vajra Middle Secondary School

Abstract

Securing future generations of scientists and scientifically literate citizens is vital for the economic development of Bhutan. But, the current teaching and learning of science does not seem to inspire Bhutanese students to take up science as they progress along the grades. Consistently, the benchmarking assessment in grade 10 has revealed that students' performance in science has been one of the lowest of all the subjects, while the performance in science in grade 6 is one of the highest. This study, pedagogical practices in triggering and sustaining students' interest and engagement in science, attempts to understand the current classroom practices in teaching school science despite many challenges. It was aimed at identifying those pedagogic practices that trigger and sustain students' interest and engagement in the Bhutanese school science lessons.

This study was guided by the conceptual framework of the Action of Interest (AoI) from Krapp's Person-Object Theory of Interest (POI). The relational construct between person and the object was adapted to identify interest being generated as students engaged with the science content during the lesson. In order to generate relevant data to enable the intended contribution to knowledge, the study adopted cross-sectional ethnographic case study design to elicit valid and justifiable meanings on the topic.

Data was generated from a middle secondary school in Bhutan through non-participant observation and semi-structured interviews. A class from each grade 6, 8 and 10 was identified. From each grade, four students and their science teacher(s) were recruited for the study. Following a two-part data generation process, the researcher spent initially two weeks in each grade video recording the lessons, audio recording the group discussions, and taking still photographs beside the note-taking, and this procedure was repeated for the second round. Each student participant was interviewed once a week focusing on the lesson they found most interesting and the teacher participants were interviewed twice (beginning and end) in the entire duration of the fieldwork. NVIVO 12 was used to organise the data, and a multi-stage progressive process with an in-built iterative approach was undertaken to analyse them.

The findings indicate that three approaches (interactive lecture, small group discussions and hands-on learning) were used in the teaching and learning of science in the school. These approaches in themselves were not found to be associated with triggering and sustaining students' high interest and engagement in science lessons. Rather, it was specific pedagogic practices embedded within each of them. Questioning technique in interactive lectures, variations and scaffolded autonomy in small group discussions, and distributed responsibilities in hands-on learning were key to triggering and sustaining students' interest and engagement. This was accomplished despite the constraints and challenges of teaching science in Bhutanese schools.

The findings have implications for practising teachers, teacher educators and the curriculum developers to enhance the teaching and learning to foster students' interest and engagement in Bhutanese science lessons. Furthermore, the study opens up new avenues for research building on these key findings. The first of its kind in Bhutan, this study contributes original knowledge, revealing how students' interest and engagement in science lessons can be triggered and sustained.

Chapter 1: Introduction

This thesis investigates the pedagogical practices that trigger and sustain students' interest and engagement in Bhutanese school science lessons. The National Education Framework: Shaping Bhutan's Future (Royal Education Council, 2012a), the National Education Policy (Royal Government of Bhutan, 2019), and the Science Curriculum Framework (Royal Education Council, 2012b) require that teachers foster interest and engagement to secure a generation of scientists and scientifically literate citizens. Despite challenging conditions in the Bhutanese education system, teachers use a range of pedagogical practices with varying degrees of success to connect students with these learning outcomes and keep them interested and engaged in science lessons. In addition to identifying the predominant pedagogical practices used in the observed lessons, this thesis brings out their features responsible for triggering and sustaining students' high interest and engagement.

Section 1.1 introduces the background to the study, highlighting the research questions, approaches to data generation and analysis, and the key findings. Section 1.2 presents the professional, international and Bhutanese context of the study. Section 1.3 highlights the critical literature and the knowledge gap on which the study is based. Section 1.4 discusses the theoretical background used in the study. Section 1.5 elaborates on the overarching research question and the three research sub-questions, and Section 1.6 details the research methodology used in this study. Section 1.7 briefly discusses the study's findings, contribution to knowledge and implications. Section 1.8 outlines the structure of the rest of this thesis.

1.1 Study background

Securing a future generation of scientists and scientifically literate citizens is vital for the socio-economic development of Bhutan. His Majesty, King Jigme Khesar Namgyel Wangchuck, in his Royal Address to the teacher graduates of two colleges of education on 17 February 2009 said, "In all the countries where progress has been strong in the areas we strive to develop, the strength of education system has been in math and science, and Bhutan's weakness has been on these two subjects" (Royal Education Council, 2012a, p. v). The Royal Edict for The Educational Reform issued on 17 December 2020 mandates that science, technology, engineering and mathematics (STEM) be made part of the everyday language to prepare the current generation of Bhutanese students for the future world. Further, in the Royal Edict for the Educational Reform, His Majesty asserts:

> "It is time to give renewed life to reform processes by reorienting our school structures … we must revisit our curriculum, pedagogy, learning process, and assessment to transform or rewrite them given the challenges and opportunities of 21st century."

Such statements are evidence of the pressing need to revitalise science education in Bhutan. Achieving scientific literacy and developing a pool of competent scientists crucially depends on the triggering and maintaining of students' interest and engagement in school science lessons (Archer et al., 2010). Therefore, this study explored how the interest and engagement of a cohort of Bhutanese science students were fostered by their teachers' pedagogical practices.

The overarching research question for this study was:

> *What pedagogical practices trigger and sustain students' interest and engagement in Bhutanese science lessons?*

Three sequentially organised research sub-questions were used to respond to the overarching research question:

1. *What are the main pedagogical practices enacted in Bhutanese science lessons across grades 6, 8 and 10?*
2. *What are the patterns in terms of how high and sustained interest and engagement relate to these signature pedagogical practices? and*
3. *How is each of these signature pedagogical practices enacted in the Bhutanese science lessons in ways that trigger and sustain students' high interest and engagement?*

The literature review for this study revealed conceptual and methodological gaps in the pedagogical practices needed to trigger and sustain students' interest and engagement in science. Further, only a limited number of earlier studies had looked into interest and engagement simultaneously. In terms of the methodological gap, most of these studies had relied on survey questionnaires and interviews but did not look into the classroom practices. This classroom-based study contributes to the literature by providing a landscape view of classroom practices incorporating findings from three different grades (6, 8 and 10).

This classroom-based qualitative study investigated interest and engagement during science lessons by describing events as they occurred. Data were generated from an urban middle secondary school in Bhutan. Four student participants from each of the three grades and their science teachers were recruited to participate in this study. Data generation was divided into two 2-week phases, separated by a month. Action of Interest (AoI) within the Person-Object Theory of Interest (POI) (Krapp, 1993, 2002, 2007) was used as the theoretical lens to analyse students' interest and engagement as they emerged during the lessons. A multi-stage progressive process (Creswell, 2014) with an in-built iterative approach (Srivastava & Hopwood, 2009) using themes and synoptic notes were used to analyse the data.

The data analysis revealed the deployment of three signature pedagogical practices in the teaching and learning of science in these Bhutanese classrooms. When it was found that these signature pedagogical practices themselves did not explain the patterns of interest and engagement, a granular dissection of each practice was carried out. The prominent indicators of interest and engagement observed were focused attention, concentration, enjoyment, and cognitive activation (Krapp & Prenzel, 2011), while the triggers varied from one practice to another. The detailed dissection of each pedagogic practice supported by the AoI of the participants led to the discovery of the specific practice within each pedagogical approach that was key to the triggering and sustaining of the students' high interest and engagement.

This study makes a significant contribution to science education and to the classroom practices that foster interest and engagement, not only in Bhutan but also in other low-income countries identified as the Global South (Dados & Connell, 2012) in the region.

It is the first study of interest and engagement using AoI and POI in the Bhutanese context and one of the few from the Global South, which at the moment is dominated by studies from the world's affluent countries. By using classroom observations, it offers new ways to explore the links between pedagogical practices and widely used lesson formats to understand the generation of interest and engagement.

The methodology of this study limits the generalisability of its findings across times, situations and contexts. The sampling involved high-achieving students from classes in three grades only. Hence, the concluding Chapter of this thesis suggests further ways to explore and extend the findings.

1.2 Professional, international and Bhutanese contexts of the study

This section first outlines the professional motivation and experiences that brought me to the study. It then considers the declining interest and engagement in science in an international context, and briefly presents the history of education in Bhutan before focusing on the contemporary issues related to science education in that nation.

1.2.1 Professional motivation and experience

As a product of Bhutanese education system, I was always fascinated by science and numbers during my school days. My destiny led me to complete my bachelor degree in education in 1994 as a secondary physics and mathematics teacher. In my first year of teaching, I was struck by my students' apparent disinterest in these subjects. I taught these two subjects for most of my first 13 years as a high school teacher, often wondering how to foster interest and engagement in science in students. Looking back, I realised I had been teaching the content laden subject (Dukpa et al., 2019) instead of fostering students' interest in science. By contrast, when I became an educator of primary science teachers in 2008, I found that the primary curriculum was more hands-on and its limited content (Childs et al., 2012) made it easier to generate interest and engagement in science among students. I began to see that the fostering of interest and engagement in science at this age could provide a strong base for the students to continue in high school, and this has since been my priority. This study has materialised my lifelong quest to examine more closely the pedagogical practices that trigger and sustain students' high interest and engagement in science lessons.

My positionality as an inbetweener (Milligan, 2016), or both insider and outsider provided opportunity in making sound interpretation of the cultural context, behavioural cues and relating them to indicators of interest and engagement, and at the same time, having a distinctive research agenda. I was an insider to the school system and the cultural context while being an outsider to my participants.

1.2.2 International context

From a global perspective, the decline in the proportion of students pursuing science for higher studies is a common concern (Hidi et al., 2015). The causes cited include science classroom practices that are perceived as fact-oriented, male-biased, primarily for 'smart' students, and generally of low personal value (Lyons, 2006; Osborne et al., 2003). Studies have focused separately on students' interest (Anderhag, 2014; Jack & Lin, 2014; Krapp & Prenzel, 2011; Pressick-Kilborn, 2010) and engagement (Ainley & Ainley, 2011; Ateh & Charpentier, 2014; OECD, 2007).

The conceptual framework of this study links the two key concepts of interest and engagement in a distinctive way. Some studies have even suggested that maybe the interest in learning science never emerges (Anderhag et al., 2016), although most research tends to assume a decline from grade 9 onwards. Other studies have suggested relationships between student engagement and student interest, but these have not been sufficiently developed (Ainley, 2012; Renninger & Bachrach, 2015). A further limitation is that while many researchers have focused on either the primary or middle secondary levels, very few have looked at student interest and engagement across these levels (Archer et al., 2013; Lindahl, 2003; Potvin & Hasni, 2014a). This is the gap that this study addresses. It adds new knowledge by being the first of its kind in the Bhutanese science teaching context.

In summary, this study looks at classroom practices in Bhutan by adopting the distinctive theoretical approach of POI to address the gaps in knowledge about the relations between students' interest and engagement and teachers' pedagogical practices in school science.

1.2.3 Bhutanese context

The modern education system in Bhutan is relatively young. Formal school education was introduced in 1959 with just 11 schools and some 400 students (Phuntsho, 2013). In 2020, there were 704 schools, 24 tertiary institutes and 185,757 students across the country (Royal Edict, 2020). The schooling system in Bhutan comprises 7 years of primary education (PP–6), including a year in pre-primary that starts at the age of 6 years, followed by another 6 years of secondary education (grades 7–8 as lower secondary, 9–10 as middle secondary, and 11–12 as higher secondary). The first 13 years of education are considered basic education and are free. The provision and promotion of free education have been part of Bhutan's successful efforts to make education accessible to all its citizen (Phuntsho, 2013).

Science as a separate subject is taught only from grade 4 onwards. The science curriculum initially used in the Bhutanese schools from 1959 was borrowed from India (Childs et al., 2012), as were the teachers of the subject (Rinchen, 2014). Then, with the support of Canadian consultants, the "New Approach to Primary Education (NAPE)" was developed and introduced in 1986 (Royal Education Council, 2012b). This connected the learning of science in grades 4 to 6 to Bhutan's natural and social environment by emphasising the development of investigative skills through inquiry. Since then, the textbooks and the manuals were revised in 2001 and 2012 to add content and update the learning activities.

In grades 7 and 8, the three sciences borrowed from India – physics, chemistry and biology – continued to be taught until 2000. However, to maintain progression and benefit the students of the revised curriculum in the primary grades, the Ministry of Education (MoE) decided to replace these grades 7 and 8 science subjects with "Learning Science through Environment" subjects (Royal Education Council, 2012b). The Royal Education Council (REC) has continued to update the textbooks and manuals to meet the demands of Bhutan's changing society.

In summary, from grades 4 to 8, science is taught as a single subject, and from grade 9 it is taught separately as biology, chemistry and physics. From grades 4 to 10 it is a compulsory subject that uses the English language as the mode of delivery.

In terms of students' deteriorating interest and engagement in science, there are three main issues associated with the current Bhutanese science curriculum. The first is that it is a subject grade 4 students are not prepared for. Second, while grades 4 to 6 science has limited content and is mostly activity-based, students are challenged with extensive content in grades 7 and 8, which continues to grow in terms of abstraction in grades 9 and 10. Third, the pedagogical approach has been observed to change from student-centric to teacher instruction in the process of trying to complete the syllabus (Childs et al., 2012). Therefore, this study on triggering and sustaining students' interest and engagement in science lessons is important for securing future generations of scientists and scientifically literate citizens for Bhutan.

1.3 Key literature and gap in knowledge

This section focuses on the key literature and gap in knowledge. The review of key literature (see Chapter 2) revealed that many countries have reported a significant declines in students' interest and engagement in science, with increasing numbers abstaining from participating in science-related fields (OECD, 2008; Potvin & Hasni, 2014b; Tytler et al., 2008b). Researchers have recommended looking more closely into classroom practices to understand how students' interest and engagement could be assessed and supported (Ainley, 2012; Anderhag et al., 2015; Renninger et al., 2019). This study does this from the Global South and Bhutanese perspectives.

The literature review found a number of relevant studies in the Bhutanese context: students' attitudes and perceptions towards science (Das et al., 2017; Zangmo et al., 2016); choice in science-related careers (Rinchen, 2003); and the effectiveness of some pedagogical practices such as cooperative learning strategies (Rabgay, 2018). However, most of these studies did not consider students' interest and engagement. Therefore, this study will extend the existing literature on science education in Bhutan by adding the interest and engagement to the repertoire of knowledge.

Furthermore, the limited research in the Global South has pointed out lack of resources, untrained teachers, and overcrowded classrooms as causes for the decline in students' interest and engagement in science (Choudhury, 2009; Diwakar, 2017; Faikhamta et al., 2018; Laad, 2011). However, these studies did not look into classroom practices. Hence, by including the Global South in a field dominated by the affluent nations, this study contributes to the limited literature of the region.

The literature review also found that researchers have looked at interest and engagement from a generalised perspective (Ainley, 2012; Tsai et al., 2008) and from teachers' perspectives (Anderhag et al., 2015; Xu et al., 2012). Others have focused on the primary level (Agranovich & Assaraf, 2013; Pressick-Kilborn, 2010; Tröbst et al., 2016); middle school (Blumenfeld et al., 2005; Swarat, 2009); and high schools (Hulleman & Harackiewicz, 2009). While many of these researchers did not look into classroom practices, they strongly recommended future researchers do so.

Only a limited number of international studies have covered both interest and engagement simultaneously or provided a landscape view of them across grades and levels of schooling, particularly the primary–middle school interface. This study's conceptual exploration of the symbiotic relationship between interest and engagement adds to the existing literature on the subject.

Finally, most of the related studies relied on self-reporting mechanisms, using surveys and interviews to generate data (Potvin & Hasni, 2014a). According to Baumeister et al. (2007), such hypothetical behavioural responses can be inaccurate. To get an authentic result, actual behaviours need to be observed. This study has combined both interviews and field observations to generate a better understanding of the interplay of triggering and sustaining student's interest and engagement in Bhutanese science lessons.

In summary, the review of literature revealed extensive concern for both the decline in students' interest and engagement in science across the globe and the significant reduction in the numbers of students opting to pursue science in higher grades. In addition, most of the studies of how interest and engagement can be fostered among school students have been carried out in Western countries using self-reporting mechanisms. This study aims to fulfil this gap in the literature.

1.4 Theoretical background for the study

Among the recent theories of interest investigated for this study, the Person-Object Theory of Interest (POI) (Krapp, 1993, 2002, 2007) was found to be the most suitable for taking it forward. This theory consolidates previous theories of educational interest to provide a more stable construct of interest. According to POI, interest is seen as a relational construct between a person and an object, where the individual has the potential to control what they do (Krapp, 1993). Based on self-determination theory (Ryan & Deci, 2017), POI states that an individual undergoes constant change to meet basic needs and to cope with social and physical environments. In an educational setting, this is conceptualised as an Action of Interest, which is used by someone (the teacher) to establish the relationship between a person (the student) and an object (the science learning outcome) in an intentionally designed situation or context (by using a pedagogical approach).

This study used POI for three reasons. First, it aimed to identify the features of pedagogical practices that triggered and sustained students' interest and engagement within science lessons; it did not aim to understand changes in interest over time. Had this study been about the progressive development of interest, the Four-Phase Model of Interest Development (Hidi & Renninger, 2006) would have been more appropriate. Instead, my study focused on moments in the classroom – of excitement or enjoyment during a lesson, of intense engagement in a discussion, or of being lost in the moment of carrying out activities – and tracing out what caused them.

Second, POI covers all the key concepts used in this study. Interest is seen as a relationship between an object and a person; and engagement, or object engagement, refers to the transaction between a person and an object. POI provides a space for the theoretical claim that interest and engagement having a symbiotic relationship (see Section 3.5.1). Besides, in terms of AoI, pedagogical practices are used to create contexts or situations for students to interact with the object (lesson outcomes). The main concepts for the meaningful outcome of this study – interest, engagement and pedagogical practices – are well suited to POI.

Third, this study intends to contribute to the overall science education in Bhutan by highlighting those practices that facilitate the triggering and sustaining of students' interest and engagement in science. It also entails bringing out the current practices of teaching and learning of science in the resource-limited and overcrowded classrooms of the Global South and contributing to the literature on interest and engagement that is currently dominated by the more developed countries. It takes the view that classroom organisation, task features, and attributes of activities support the development of interest and engagement among students (Anderhag et al., 2015; Tsai et al., 2008).

1.5 Research questions

To generate a deeper understanding of how students' interest and engagement might be triggered and sustained in a science lesson, previous researchers have strongly recommended looking into classroom practices (Anderhag et al., 2015; Renninger & Bachrach, 2015). In line with this, my over-arching research question is:

> *What pedagogical practices trigger and sustain students' interest and engagement in Bhutanese science lessons?*

This overarching question was further divided into three research sub-questions.

1. *What are the main pedagogical practices enacted in Bhutanese science lessons across grades 6, 8 and 10?*
2. *What are the patterns in terms of how high and sustained interest and engagement relate to these signature pedagogies?*
3. *How is each of these signature practices enacted in the Bhutanese science lesson in ways that trigger and sustain students' high interest and engagement?*

These sub-questions were classroom focused and sequentially arranged to respond to the overarching research question. Responding to the first research sub-question required close examination of the pedagogical practices deployed in teaching and learning science in Bhutanese classrooms and of the terms used by the teachers in planning their lessons. It then took a step back to look at the commonalities among the practices to categorise them for deeper analysis.

The second research sub-question was designed to identify patterns among signature pedagogical practices in terms of intensity and duration of interest and engagement. These were based on the indicators exhibited by the participants during the lessons. The findings were used to map the lessons as being of low/high or brief/sustained interest and engagement, and to identify the key lessons for sub-question 3. The overall findings in response to research sub-question 2 are presented in Chapter 5.

The third research sub-question was used to investigate in granular detail each of the signature pedagogies. One lesson from each pedagogical practice was identified for further scrutiny. An AoI under the POI (Krapp, 1993, 2002, 2007) was used to reveal the layers of pedagogic practices that were responsible for triggering and sustaining students' high interest and engagement in the observed Bhutanese science lessons. The findings for the research the sub-questions are presented in sections 6.3, 7.3 and 8.3, respectively.

1.6 Methodology

An ethnographic case study approach allowed exploration of the actions and events that took place during science lessons in grades 6, 8 and 10 in one Bhutanese middle secondary school for a duration of one month each. The policy documents used were up to December 2020, except for the Bhutanese New Normal Science Curriculum Framework introduced in 2021.

Four students (two boys and two girls) from each grade and their science teachers –a total of 17 participants – were recruited for focused observations and interviews. There was a month's gap between two periods of data generation from each grade. While the teachers were interviewed at the beginning and at the end of the fieldwork, the student participants were interviewed once a week to discuss the lesson while it was fresh on their minds.

A total of 86 lessons were observed, generating 86 field notes, 86 video recordings, 83 discussion audio recordings, and 538 still photographs as data for analysis. The lesson durations were between 35 and 50 minutes. In addition, 48 interview records were produced from the weekly students' interviews, and 10 interview records from two rounds of teachers' interviews. While the student interviews were between 15 and 30 minutes long, the teacher interviews lasted from 33 minutes to more than an hour. The interviews were transcribed verbatim before the fieldwork ended and were given to participants for member checking to confirm and validate the accuracy of the data.

A five-stage approach to data analysis was undertaken by adapting the data analysis spiral (Creswell & Poth, 2018) and using the concurrent flow of activity (Miles et al., 2014) and an iterative framework (Srivastava & Hopwood, 2009). In the first stage, key information from the field notes was formatted into a Microsoft Excel spreadsheet to get a broad landscape view. Additionally, memos were written to identify the unique contributions of the particular lessons.

Stage 2 focused on the interview data. All 58 interviews were transcribed verbatim and transferred to QSR NVIVO 12. Before coding, the transcripts were read repeatedly to understand the emerging codes and themes. Open coding was used, with new codes added when they emerged from the data. A total of 71 codes were created, which were condensed into five themes. There was sufficient substantial information on interest, engagement and pedagogical practices to take the study forward. But the themes on Gross National Happiness and curriculum and policy were thinner and not coherent with this study; hence, they were dropped. In this stage, the number of lessons for analysis was reduced to 78, and the following three signature pedagogies were identified: interactive lessons (IL) in grade 10; small group discussions (SGD) in grade 8: and hands-on learning (HoL) in grade 6 (see Section 5.4.4).

In stage 3, the focus was on identifying and finalising the indicators of interest and engagement and tracing their triggers. The entire 78 lessons were categorised into four groups according to whether the students' interest and engagement in them was low or high and their persistence was brief or sustained. Critical friends were used to validating the findings.

Stage 4 saw the video lessons reduced to 12 (three high, and one low and briefly interesting and engaging lessons from each grades) for transcription and detailed study. Taking stock of the findings and based on the recurrence of a practice in a grade (IL in grade 10, SGD in grade 8 and HoL in grade 6 – as already mentioned), one lesson per grade was identified for more granular and synoptic analysis using the Action of Interest from POI (Krapp, 1993, 2002, 2007). These required revisiting the data and synoptic units multiple times to extract finer details and generate deeper understanding to support the findings. This led to the revealing of another layer of pedagogic practice within each signature pedagogical practice. Last, stage 5 explored the representation of the findings that foregrounded the key concepts in the analysis through AoI.

The entire process of strategizing the study and generating and analysing the data saw the researcher adhering to the ethical considerations set by the University of Technology Sydney. The rigour with which the data analysis was carried out confirmed the dependability and validity of the findings.

1.7 Findings, contribution to knowledge, and implications

This section presents the findings, the contribution to knowledge, and the implications of this study.

1.7.1 Findings

The responses to three research sub-questions constitute the findings of this study. The first finding is that all the pedagogical practices used in the teaching and learning of science in the observed Bhutanese classrooms could be categorised into three signature pedagogical practices: Interactive Lectures, Small Group Discussions and Hands-on Learning. The second finding is that these signature pedagogical practices in themselves do not trigger and sustain students' high interest and engagement in school science lessons. It is not possible to say specifically that one pedagogical practice is better than the others in terms of triggering and sustaining students' high interest and engagement in these school science lessons. All pedagogical practices have the equal potential to trigger and sustain students' interest and engagement in school science lessons. Finally, the study found that the layers beneath the signature pedagogical practices were responsible for triggering and sustaining the students' high interest and engagement: In the Interactive Lecture lessons it was classroom questioning; in Small Group Discussion lessons it was variations and scaffolded autonomy; and in Hands-on Learning lessons it was distributed responsibility.

1.7.2 Contribution to knowledge

The findings of this study contribute to knowledge in four ways. The first contribution is new empirical insight into the layers of specific detail under three signature pedagogical practices that can promote students' interest and engagement in science lessons. The second contribution pertains to the addition to the literature on science classroom practices in the Global South, which is dominated by quantitative research into the perceptions and attitudes of students and teachers towards science. My study brings the Global South into the limelight in a field of study led by Western perspectives. Third, my study adds the pedagogic practices scaffolded autonomy and distributed responsibilities, including nuances to classroom questioning, to the existing literature on triggering and sustaining students' interest and engagement in resource-constrained and crowded classrooms. Fourth, the study points out the cyclical symbiotic relationship between interest and engagement in the AoI. The conceptual framework asserts that the intentional engagement of a person with an object can influence the development of interest in that object. A person already interested in an object will find ways and means to engage with it. This accounts for the cyclical symbiotic relationship between a person (student) and an object (science).

1.7.3 Implications of the study

This study has three implications for teachers and teacher educators, curriculum developers, and other relevant stakeholders. First, Bhutanese teachers of science should consider using classroom practices such as questioning during Interactive Lecture lessons, variations and scaffolded autonomy during Small Group Discussion lessons, and distributed responsibilities during Hands-on Learning lessons to promote students' interest and engagement. Teacher educators should also consider building these skills among future teachers. Second, the study recommends that due consideration may be provided by curriculum developers while recommending pedagogical practices in teaching particular content in designing the curriculum documents. Third, the study appeals to education policymakers and other relevant stakeholders in the Global South to deliberate on the significance of students' interest and engagement in science as they formulate policy documents.

1.8 Thesis structure outline

This thesis has nine Chapters. Chapter 2, the literature review, identifies the gap in the literature on the pedagogical practices that trigger and sustain students' interest in science. It provides a landscape view of existing research on the topic in terms of origins, key moments or changes, the emergence of consensus, and current debates. It also identifies the studies relevant to Bhutanese education researchers and to scholars of interest and engagement in science more widely. Through critical analysis, the Chapter distils the key findings, methodological trends, strengths and limitations from existing research in terms of relevance to the current topic.

Chapter 3 describes the theoretical background and conceptual framework used in this study. It justifies the use of POI and AoI to draw out the relationship between interest, engagement and pedagogical practices. This relationship provides the roadmap for studying the pedagogical practices that triggered and sustained the participating students' high interest and engagement in the observed Bhutanese science classrooms.

Chapter 4 details the research methodology used in planning, generating, analysing and presenting the findings of this study. Beginning with the choice of research questions and how they are linked to each other, it then presents the reasons for choosing an ethnographic case study approach and how this directed the sampling process. It describes how data were generated in compliance with ethics requirements and then analysed using a multi-stage progressive process. The final section of this Chapter brings out the limitations and benefits of the methodology.

Chapter 5 presents the general findings of this study, responding particularly to the first and second research sub-questions. It starts with a brief introduction of key participants and then provides a general overview of all the science lessons observed during the fieldwork. It then discusses the key findings pertaining to the patterns of interest and engagement related to the signature pedagogical practices observed across 86 lessons.

Chapter 6 responds to the third research sub-question in relation to Interactive Lecture lessons using POI. Using a vignette and an AoI of a key student, it identifies classroom questioning as a key pedagogic practice that can trigger and sustain high interest and engagement in Bhutanese science lessons.

Chapter 7 similarly presents findings for the third research sub-question in terms of Small Group Discussion lessons using POI. Following a similar structure to Chapter 6, the triggers of interest and engagement observed in SGD lessons are presented. This Chapter identifies variations and scaffolded autonomy as key pedagogic practices that can trigger and sustain high interest and engagement.

Chapter 8 brings out the key pedagogic practice associated with Hands-on Learning lessons, namely, distributed responsibility. Again, using a vignette and an AoI of a key participant, it describes the features of distributed responsibility that can contribute to fostering students' interest and engagement.

Chapter 9 concludes the thesis by restating its key findings and arguments. It summarises the responses to the research questions and the reasons for downplaying the thin findings on GNH. Finally, it outlines the limitations and implications of the study and recommends directions for future research.

1.9 Chapter conclusion

The first Chapter shared the background of this study, highlighting the research questions, key literatures and the gap in the literature of students' interest and engagement in school science, conceptual background, approaches to data generation and analysis, and key findings and contribution to knowledge. Chapter 2 will focus on relevant literature in greater depth, examining research on science education in Bhutan, on interest and engagement in school science, and on pedagogical practices in science education, identifying an important and urgent gap, which this study addresses.

Chapter 2: Literature Review

2.1 Introduction

How science is taught in the classroom profoundly effects how students perceive and make choices to interact with science knowledge (Tytler et al., 2008a; Vartuli, 2016), irrespective of whether they pursue higher studies in the subject (OECD, 2008; Wickman, 2006). Science plays a vital role in modern society, fostering science- and technology-driven economies and cultural and democratic views (Sjøberg & Schreiner, 2010). It is more important than ever that school students develop an understanding of scientific concepts and theories, along with mathematics and technology subjects, in this technology-based era (OECD, 2007).

According to OECD (2008), a large number of scientists should be required, but relatively few adolescents aim for professional qualifications and careers in this field. Many countries around the world have reported a decline in students' interest and engagement in science during their school years (Potvin & Hasni, 2014b). Many studies have been carried out and intervention strategies put in place to foster students' interest and engagement in science (Archer et al., 2013; Renninger et al., 2019; Tytler et al., 2008a). Researchers still strongly recommend looking into science classroom practices to understand how students' interest and engagement can be assessed and supported (Ainley, 2012; Anderhag et al., 2016; Potvin & Hasni, 2014b). This review attempts to discern the gaps in the literature and establish the need to further explore the pedagogical practices that trigger and sustain students' interest and engagement in school science, particularly in Bhutan.

The Chapter is arranged in seven sections. After this introduction, section 2.2 presents the scope and search strategies used to identify the key literature. In section 2.3, the research findings of science education in Bhutan are discussed. Section 2.4 considers the broad landscape of research on interest and engagement in school science. Section 2.5 focuses on the pedagogical practices in school science. To situate this thesis, section

2.6 highlights the important and urgent gap in the existing research. Finally, section 2.7 summarises and closes the Chapter.

2.2 Scope and literature search strategies

This section highlights the scope and search strategies deployed in this literature review. This scope sets the cut-off date and the criteria for exclusion and inclusion of the literature relevant to this study, while the strategies include how the various databases were explored and the storage of articles and documents.

This review focuses on three different fields of literature: science education; interest and engagement in science in general; and the pedagogical practices that trigger and sustain students' interest and engagement in science. While the science education analysis emphasises the Bhutanese context, the literature review on interest and engagement and pedagogical practices covers research from both developed and developing countries around the world (Awan & Sarwar, 2011; Reuveny & Thompson, 2008; Sjøberg & Schreiner, 2010). Looking at these three fields of literature will help identify features of Bhutanese school science pedagogical practices that trigger and sustain students' interest and engagement and thereby contribute further to the existing literature.

This study was bounded by a cut-off date, grade levels and the specific literature related to students' attitudes and perceptions towards science. First, the cut-off date for the literature review of this study was set to December 2020, the exception being the Bhutanese science curriculum framework updated in 2021. Second, the grade level considered for this study were from primary to secondary levels. As mentioned in Chapter 1, the teaching of science as an independent subject starts from grade 4 in Bhutan, and this study collected data from grades 6, 8 and 10. Third, to understand what pedagogical practices trigger and sustain students' interest and engagement in science, this study also looked into attitudes, motivation and perceptions of students, and the perceived decline in students' interest and engagement in science.

The search strategies focused on identifying the key studies and policy documents related to pedagogical practices that trigger and sustain students' interest and engagement in science. First, the initial reference list of main articles in the doctoral research proposal and suggested readings from university supervisors were used to identify additional readings. A snowballing effect then led to more articles, government documents and published books. Second, Google, Google Scholar, and University of Technology Sydney (UTS) library databases search engines led to numerous articles, books and other documents in the field of interest and engagement. Key search terms such as "interest and engagement in science", "decline in interest in science", "promoting interest in science", "situational and individual interest in science" and "students' engagement in science" were used. The specific country name was added at the end of these terms, especially for the global south. These searches led to various databases, in particular, EBSCO Host, ERIC, JSTOR, OECD Library, ProQuest, Routledge, SAGE, Science Direct, SCOPUS, Springer, Taylor and Francis, and Wiley. Finally, a Google Scholar alert was set up for articles on "students' interest and engagement in science".

The Bhutanese government websites and institutional journals were also searched, and the policy documents and other articles were obtained from these sources (see Table 2.1). While the publications in government websites provided the policy and curricular documents, the journals in the institutional websites provided access to the peer-reviewed journals in the Bhutanese context. Besides the internationally published Bhutanese articles, the researcher accessed all the publications related to teaching and learning of science in the Bhutanese context in the two peer-reviewed journals of the Royal University of Bhutan and Paro College of Education.

All the relevant literature were retained in electronic and print form using EndNote, UTS OneDrive, external hard drives, and physical file folders as precautionary measures to avoid losing the documents. For literature review purposes, they were categorised as "Bhutanese science", "Global South", "Interest and Engagement", "Pedagogical practices for interest and engagement", and "Students' interest and engagement".

2.3 Science education in Bhutan

This section focuses on the literature related to the teaching and learning of science in Bhutan, extending the basic information provided in Chapter 1. This literature is discussed in terms of the three categories: policy and science curriculum; research findings of the science curriculum in Bhutan; and general attitudes and perceptions of students and teachers towards science in Bhutan. These discussions highlight the implications of the pedagogical practices used in teaching and learning science in Bhutanese classrooms. The associated findings will be discussed in greater detail in section 2.5.

Science education holds a special place in the Bhutanese education system. According to the Royal edict issued on December 17, 2020, His Majesty Jigme Khesar Namgyel Wangchuck reminded citizens that to prepare the current generation of students for the future world, STEM should be a part of the everyday language. At the heart of science education lies this excerpt from His Majesty's address to the nation: "In all the countries where progress has been strong in the areas we strive to develop, the strength of the education system has been in Math and Science" (Royal Education Council, 2012a). Like other developing countries, Bhutan must rely on the potent force of science, math and technology for the economic development of the country (Ministry of Education, 2014).

2.3.1 Policy and science curriculum

While the National Education Policy (NEP) provides an overarching framework and direction for building and nurturing the education system in Bhutan, the policy and science curriculum framework (SCF) guides the selection of learning experiences, outcomes, standards, and assessment for all learning areas (Royal Government of Bhutan, 2019). The framings of the curriculum and policy documents are based on the Constitution of the Kingdom of Bhutan and His Majesty's address to the nation, mentioned above. Article 9 (Clause 15) of the Constitution states: "The state shall endeavour to provide education to improve and increase knowledge, values, and skills of the entire population with education being directed towards the full development of the human personality" (Royal Government of Bhutan, 2008, p. 19). The document titled The National Education Framework: Shaping Bhutan's Future was published after His Majesty's Royal address during the 3rd Convocation of the Royal University of Bhutan for Paro and Samtse Colleges of Education on 17 February 2009. The National Education Framework outlines the national vision and overarching goals of the Bhutanese Education System (Royal Education Council, 2012a), on which the recent policies and curriculum documents were finalised (e.g., The National Education Policy

2019; The Bhutan Education Blueprint 2014-2024; The Science Curriculum Framework: PP to XII; and the National Education Assessment Framework 2019). These documents provide the roadmaps for systemic education reforms in Bhutan. This section discusses the policy and curricular findings of science education in Bhutanese context that are grounded in both His Majesty's wisdom and the Constitution. The discussions draw upon many of the government documents listed in Table 2.1.

Table 2.1 *Key government documents related to Bhutanese education system*

Title of document	Document type	Agency	Website
The Constitution of the Kingdom of Bhutan	Government	National Assembly of Bhutan	www.nab.gov.bt
Bhutan Education Blueprint National Education Policy	Policy	Ministry of Education	www.education.gov.bt
GNH	Proposal for GNH education	Centre for Bhutan Studies	www.bhutanstudies.org.bt
Bhutan at a glance	Government	National Statistics Bureau of Bhutan	www.nsb.gov.bt
Bhutan Journal for Research and Development	Articles	Royal University of Bhutan	www.rub.edu.bt
Rabsel: the CERD Educational Journal	Articles	Paro College of Education	www.pce.edu.bt
National Education Framework: Shaping Bhutan's future Science curriculum framework: PP to XII Textbook and Teachers' Manuals	Curriculum	Royal Education Council	www.rec.gov.bt
Pupils' performance report Education in Bhutan: Findings from Bhutan's experience in PISA for Development	Annual Assessment Report	Bhutan Council for Student Evaluation and Assessment	www.bcsea.bt

Policy and goals of science education in Bhutan: According to the Royal Government of Bhutan (2019, p. 8), the policy statement for science curriculum states, "School curriculum shall strengthen Science, Technology, Engineering, and Mathematics (STEM) education to promote creativity and innovation, and prepare students to participate meaningfully in a society and economy that is increasingly reliant on information and communication technologies" (p. 8). Similar to the aspirations of science education globally, Bhutan aims to make its citizens scientifically literate and able to make informed decisions, evaluate policy matters, and judge scientific evidence (Royal Education Council, 2021).

The overarching goal of education in Bhutan is to achieve Gross National Happiness (GNH) (Royal Education Council, 2012a). The specific goals of science education are borrowed from and align with goals of science education prescribed by UNESCO, the Next Generation Science Standards (USA), and the National Research Council (Canada). They emphasise equipping students with the knowledge, skills, and values and attitudes that nurture them to become socially and economically productive citizens who can respond and cope with emerging global challenges in their daily lives (Ministry of Education, 2014), while fulfilling the GNH aspirations of citizens.

The science curriculum framework (SCF): According to Royal Education Council (2012b), the earlier SCF provides an overview of science education in Bhutan. It intends to:

- Generate an understanding among stakeholders of what to expect of science education at various stages of schooling;
- Maintain coordination, consistency and coherence in science curriculum;
- Guide textbook developers in designing a meaningful learning experience for students; and
- Provide developmentally appropriate science education throughout primary and secondary schooling. (p. 2)

According to the new SCF (Royal Education Council, 2021, pp. 3-5), the specific goals of science education in Bhutan are to provide learning experiences that enable students to:

1. Understand the characteristic nature of science and scientific knowledge;
2. Acquire fundamental scientific knowledge at the level appropriate to their developmental stages;
3. Develop and apply the skills of scientific inquiry;
4. Develop and apply problem-solving skills in the scientific world;
5. Explore digital resources to manipulate and handle ICT related tools to solve current issues;

6. Make students scientifically literate to be able to participate in critical and informed debates on global issues;
7. Prepare learner for higher studies in STEM and or provide a smooth transition into jobs;
8. Inculcate healthy habits and lifestyles; and
9. Inculcate the love of learning science (STEM) throughout their lives. (pp. 3-5)

Dukpa et al. (2019), agrees that the science curriculum is more contextualised, exploratory and with better conceptual progression compared to past curricula. This finding is further substantiated by a study that found grades 4 to 6 science offered more learner-centred pedagogies and a significant focus on contextualisation (Childs et al., 2012). The New Normal Science Curriculum Framework PP–XII (Royal Education Council, 2021) features the increased role of technology caused by the COVID-19 pandemic. The following section outlines the structure of schooling and the content of the Bhutanese science curriculum.

The structure of schooling: The Bhutanese education system follows five key stages of schooling. Table 2.2 shows the key stages with justification on developmental stages.

Table 2.2 *Key stages in Bhutanese school system.*

Key Stages	Grades	Justification
1	Pre-primary to Grade 3	Period of symbolic mastery
2	Grade 4 to 6	Capable of mental operations and logical thinking
3	Grades 7 & 8	Abstract thinking and problem solving
4	Grade 9 & 10	Abstract thinking and problem solving
5	Grade 11 & 12	Creative thinking and problem solving

The structure of schooling through the key stages is expected to provide a developmentally appropriate curriculum through constructivist approaches and maintain continuity (Royal Education Council, 2021). It is intended to match the needs of developmental stages of children as they grow (Royal Education Council, 2012a, 2012b). Currently, science is not taught separately in key stage 1, and it is anticipated that some concepts will be covered during literacy and numeracy lessons. No study has yet been done to assess how much science is taught through English, math and

Dzongkha in this key stage. As mentioned in Chapter 1, science in this stage was introduced as a part of environmental studies taught in Dzongkha, but this subject was withdrawn from the school curriculum in the academic session of 2017. The presence or absence of basic knowledge in science in this key stage could affect how students perceive the subject in higher key stages.

Science in current key stages 2 and 3 (grades 4 to 8) are taught as a single integrated science. According to Sherpa (2007), integrated science is an attempt to create a truly Bhutanese science, which would enable students to see the fundamental unity of science. The course aims to not only make science learning interesting, relevant and more purposeful but also provide a foundation for secondary science. In key stages 4 and 5 (grades 9 to 12), science is taught as separate subjects – Biology, Chemistry and Physics.

The four strands: To achieve the key learning outcomes of science across each key stage, the SCF is divided into one process strand and three conceptual strands. Each of these strands maps out the subject knowledge, skills and values the learners are expected to develop as they progress along the developmental key stages (Royal Education Council, 2021). A summary of the strands of SCF and its expectations are given in Table 2.3 on the next page.

Table 2.3 *The four strands of science curriculum framework.*

Strand	Specific details – pupils must…,
Working scientifically (Process)	Explain the nature of science as a human activity – how science works Investigate following the due process of scientific inquiry to find answers about the natural and technological world – investigation and experimentation
Life Processes (Conceptual)	Describe the diversity and interdependence of life in terms of the biology of humans and the biology of other living things. Explain the impact of humans on their environment and how we can live sustainably with our environment. Exhibit good health and hygiene
Material and their properties (Conceptual)	Describe the particle structure of materials and how they are formed, and their properties. Explain and verify the different types of chemical reactions Justify the environmental impact of some material leading to environmental issues
Physical processes (Conceptual)	Describe key scientific concepts (e.g., force and motion, energy, earth and universe) and their impact on our daily lives Relate energy use to environmental issues and assess the emerging technologies to study space science.

Adapted from (Royal Education Council, 2021)

Science and GNH: The science curriculum uses the principles of GNH to educate for GNH in science lessons (Royal Education Council, 2021). Childs et al. (2012), asserted that GNH will be vital to the future implementation of the science curriculum. The four pillars and nine domains of GNH are as given below;

The four pillars:

1. Sustainable and equitable socio-economic development,
2. Conservation of the environment
3. Preservation and promotion of culture, and
4. Good governance (Ministry of Education, 2010; Ura, 2009)

The nine domains are:

1. Good governance
2. Psychological well-being
3. Community vitality
4. Education

5. Health
6. Cultural diversity and resilience
7. Ecological diversity and resilience
8. Time use, and
9. Living standards (Ura et al., 2012)

The GNH values and principles comprise deep knowledge and understanding, critical and creative thinking, ecological literacy, the country's profound culture and rich heritage, genuine care for nature and for others, and a holistic understanding of the modern world for right livelihood (Ministry of Education, 2014). The old SCF considers itself a vital medium for disseminating the values and principles of GNH through conceptual and pedagogical means.

However, the only study on the Bhutanese science curriculum and GNH (Childs et al., 2012) points out four concerns about incorporating GNH values and principles in Bhutanese science education. First, it cautions on the harmonious co-existence of the nature of science with the Bhutanese culture and traditional beliefs as a Buddhist country and the need to find a balance between them. Second, since science is a worldly knowledge, contextualising or localising it to the Bhutanese context might dilute the academic rigour of the curriculum. Third, the geographical terrains of the country and the remote locations of community primary schools pose a challenge to supporting the principles through teacher resource centres. And fourth, there is still a need to consult all stakeholders in ensuring that the curriculum achieves a certain level of consensus among them. Understanding such gaps is therefore relevant to my current study of pedagogical practices in the Bhutanese context.

2.3.2 Research on the Bhutanese science curriculum

As an evolving document, the Bhutanese science curriculum has undergone a series of revisions, with New Normal Science Curriculum Framework being the latest version implemented in the academic session of 2021. Prior to these curriculum revisions, assessment standards mostly involved the content included for each level, balance among the three sciences (Biology, Chemistry and Physics), alignment across grades as a part of the spiral curriculum (Bruner, 1960), and teaching-learning practices at each grade level. The 2015 version of the SCF was more contextualised, exploratory and participatory, with better conceptual progression compared to the past curriculum (Dukpa et al., 2019). This section discusses research findings across content, balance and alignment of the Bhutanese science curriculum documents, leaving the teaching-learning aspect for detailed discussion later in the Chapter.

The content covered across each grade was found to be one of the main issues in the Bhutanese science curriculum. In the past, the content was neither relevant nor contextualised, as the textbook was borrowed from India (Phuntsho, 2013). Childs et al. (2012) found that not only was the amount of information given in the textbook too little for students to learn basic concepts on their own at primary level (grade 4 to 6), it did not adequately prepare students for the content knowledge of grades 7 and 8, and that the thinning of the curriculum was occurring in the Bhutanese science curriculum for grades 7 to 10. The SCF was found to be prescriptive and rigid, examination driven, and less connected to real-life situations. The learners with lower abilities were overstretched while high ability ones were underutilised. The science curriculum in these grades was criticised for having too much content and insufficient time to teach it. "The science curriculum is said to be prescriptive and rigid, with significant more content than the time allocated for teaching, examination driven and less connection to real life situations (Dukpa et al., 2019, p. 39).

Childs et al. (2012), found that the teachers and stakeholders in the study criticised the locally developed integrated science curriculum from grades 4 to 8 for not maintaining the balance among the three science subjects (See Table 2.4). The contents focused on biology or chemistry or physics. Bhutanese students preference to biology subject (Zangmo et al., 2016) could be attributed to broader foundation in their encounter with the subject besides being personally relevant. On the contrary, unbalanced integrated science did not adequately prepare students in physics and chemistry to motivate them to take up science in higher grades (Sherpa, 2007). Moreover, the nature of content for each subject is observed to affect the pedagogical practices adopted to deliver the particular lesson (Dukpa et al., 2019; Rabgay, 2014).

Table 2.4 *Syllabi analysis result*

Grade	Major content
4	Biology (42.5 %)
5	Biology (40 %)
6	Physics (44.2 %)
7	Chemistry (40 %)
8	Biology 44 %)

Adapted from Childs et al. (2012)

The curriculum document review revealed the mismatch between the instructional time allocated by the REC and time given in the textbook for grade 10 sciences. According to REC (2019), 3600 minutes (60 hours) is allocated per science subject, but the instructional time required to teach the subject content as per the current Chemistry and Physics textbooks was 4320 minutes (72 hours) (Dorji et al., 2017; Gyaltshen & Subba, 2015). Dukpa et al. (2019), also claim that science content in higher grades usually requires significantly more than the time allocated to teaching it.

In terms of alignment, Childs et al. (2012) pointed out the fragmentation and discontinuity in the science curriculum. Science as an independent subject starts from grade 4, and it is assumed that science content in grades pre-primary to 3 is taught along with literacy and numeracy subjects. In the past, these grades were taught in Dzongkha as separate environmental studies that provided some basic content of science. However, facing some criticism, that subject has been recently withdrawn, which could impact the students' interest and engagement, as they now begin to study science from grade 4 onwards. This means there is a big leap with the introduction of science as a separate subject in grade 4 along with social studies. Another jump in terms of lack of contextualisation and heavy content was seen when student progress from grade 8 to grade 9. At this stage, integrated science divides into Biology, Chemistry and Physics. According to Childs et al. (2012), such fragmentation and discontinuity have resulted in a lack of basic knowledge of these three sciences.

2.3.3 Attitudes and perceptions towards science in Bhutan

Research in Bhutanese science learning had mainly focused on attitudes and perceptions of teachers and students. According to Ashaari et al. (2011), attitude is seen as person's mental condition shaped by experience that influences his or her reaction towards an object or phenomenon. Students' attitudes towards science are crucial to their learning and performance (Osborne et al., 2003). There is evidence that students who possess favourable attitudes toward science look forward to science classes and laboratory experiments (Perkins et al., 2005). According to OECD (2008), young people generally have a positive view of science and technology, and maintaining positive contact with it at an early age can have a long-lasting impact, while negative experiences will be detrimental to future choices. However, this study did not venture into assessing students' attitude towards science, rather the focus was on understanding the pedagogical practices that generated active participation, captivating the students momentarily with the future possibilities of returning to the task. In this section, I present the findings of research into Bhutanese students' attitudes to and perceptions of science to establish the need for this study.

Bhutanese students' attitudes towards science have been found to be high and positive (Rabgay, 2018; Zangmo et al., 2016). Two studies looking specifically into the use of cooperative learning (CL) structures (Jurmey, 2018; Rabgay, 2018) found that the use of this pedagogical approach improved students' attitudes towards science. Rabgay's (2018) study revealed that the use of CL structures increased students' academic scores in Biology in grade 10, which resulted in an improved attitude towards the subject. Jurmey (2018) found that students' attitudes towards the use of CL structures increased with their grades. High-achieving students had slightly higher positive attitudes than the low achievers in the class, and in terms of gender, female students exhibited higher positive attitudes.

Zangmo et al. (2016), found Bhutanese students' attitudes towards science increased along with grades but recorded no gender difference. Their findings indicated that students who loved science looked forward to continuing science in the future and were aware that the subject provided a broader career scope. Boys preferred mathematics and engineering, whereas girls were more interested in biology-related fields. Further, the finding on ethnicity, though inconclusive, strongly recommended parental support, which would motivate students to pursue science.

There is limited literature on perception studies in the Bhutanese science learning context. The literature search revealed a study on girls' perception of science (Rinchen, 2003), a teacher's perception of integrated science (Sherpa, 2007), and students' views about the nature of science (Das et al., 2017). Rinchen (2003), found that girls in lower grades generally shared a positive experience with science, despite resource constraints and negative influences from cultural and social beliefs. Further, the girls who liked and were interested in science had been positively influenced by elders in the family who had a science background. In contrast, Sherpa (2007) found that teachers had a negative perception of integrated science that had more biology content compared to physics and chemistry. These teachers felt that integrated science did not sufficiently build the base of their students' science knowledge to prepare them for higher grades. Other studies have shown that Bhutanese students perceive biology to be easier compared to physics and chemistry in grade 10 (Rabgay, 2018; Zangmo et al., 2016). Such findings are relevant for understanding the mindsets of students and the choices they make to engage and stay interested in science lessons.

2.4 Research on interest and engagement in science

This section critically analyses and synthesises the research on interest and engagement in school science across primary to middle school stages to identify prominent trends, key findings, and significant gaps in their findings. The findings are presented under four sub-headings: overview of research on interest and engagement; decline in students' interest and engagement in science; promoting students' interest and engagement in science; and studies on interest and engagement in the Global South. These findings will contribute to establishing the need for this study.

The conceptual understanding of interest and engagement, and their relationship are discussed in depth in the next chapter. For now, interest is individual's psychological state of being momentarily captivated, and the motivational disposition to explore further or re-engage later (Renninger & Hidi, 2011) as they interact with an object. Ainley (2012) asserts that both interest and engagement influence students' learning achievement positively. Engagement is the active involvement or participation of an individual with the object or goals (Christenson et al., 2012). While some focus on interest and regard engagement as a sub-concept, and the others the opposite, this thesis follows those who understand that interest and engagement are both initiated when something catches the attention of learner (Hidi et al., 2015). Accordingly, this study focused on how students responded to classroom pedagogical practices, demonstrating more or less interest and engagement, rather than their perceptions of those practices, general attitudes to or feelings about learning science.

2.4.1 Overview of research on interest and engagement in science

This section presents the historical development of interest and engagement, with attention to the teaching and learning of science. As a prelude to the next Chapter and to establish the gap in previous studies, this section couple the construct of interest and engagement with the person-object theory of interest. This overview is critical for establishing the need to study the pedagogical practices that trigger and sustain students' interest and engagement in Bhutanese science classrooms.

Historical development of interest and engagement: In the fields of education and educational psychology, the study of interest can be traced to scholars Johann Friedrich Herbart (1776–1841), Thomas Arnold (1795–1842), William James (1842–1910), John Dewey (1859–1952), and Edward Thorndike (1874–1949). According to Herbart (1776-1841), interest development is influenced by existing knowledge especially when it is accommodative of new ones. And, Dewey (1913) in his book Interest and Effort in Education, "Interest is not some one thing; it is a name for the fact that a course of action, an occupation or a pursuit absorbs the powers of an individual in a thorough, ongoing way" (p. 65). Both scholars believed that education programs should be designed to accommodate students' interests. Their definitions call for the action of an individual and the presence of either physical or subjective objects to interact with. These early discussions on 'interest' were later sidelined due to the emergence of other motivational concepts (e.g., attention and curiosity) that could be easily studied. Hence, relatively few studies were done on interest until the last two decades of the 20th century (Hidi et al., 2004).

The study on interest in science was revived in the 1960s and 70s when science curriculum developers looked at attitudinal objectives (Berlyne, 1960). The first review on attitudes to science (Gardner, 1975) indicated the decline in students' interest in science. The late 20th and early 21st centuries further studies established the relationships between interest, learning and achievement at different levels of education, with a greater focus on the development of interest (Hidi et al., 2004).

During this time, the person-object theory of interest was proposed (Krapp, 1993). Initially, researchers focused more on younger students in pre-schools and elementary schools (Krapp & Fink, 1992; Renninger & Leckrone, 1991). As the level of school progressed, these studies exposed the decline in students' interest in school subjects as they moved up the academic ladder. The decline in students' interest and engagement in science was found in all the countries where the study was conducted (see Section 2.4.2). A systematic review of 12 years of educational research, most of which used surveys and interviews, confirmed the decline in students' interest and engagement (Potvin & Hasni, 2014a). The self-reported data in the form of interviews and surveys were found to be apt for studies of attitudes and perception, rather than for understanding students' interest and engagement (Anderhag et al., 2016). Further, according to Renninger and Bachrach (2015), experiences that trigger interest are often unexpected and ephemeral, and participants may not be aware enough to provide a self-report. Suggestions have since been made to look into school cultures that could contribute to developing and sustaining students' interest and engagement in subject content (Ainley, 2002; Renninger & Hidi, 2002).

Such studies in interest were extended to the development of interest over time and led to the four-phase model of interest development (Hidi & Renninger, 2006). This was followed by deeper studies on understanding situational interest and individual/personal interest, and the relationship between them (Tsai et al., 2008). Recent studies have included inquiring into classroom practices that facilitate triggering and maintaining students' interest and engagement in the lesson (Renninger et al., 2019; Renninger & Hidi, 2020) and distinguishing between curiosity and interest (Renninger & Hidi, 2020). My study will extend the current findings on pedagogical practices that trigger and sustains students' interest and engagement in Bhutanese science classrooms using the person-object theory of interest.

The choice to take up interest and engagement simultaneously: The literature search revealed that interest and engagement are often mentioned simultaneously in the literature. According to Renninger and Bachrach (2015), these two terms are often used to refer to the same phenomenon despite having distinct characteristics. 'Engagement' in the form of 'focused attention' or 'concentration' on the activity task has been described as the indicator of interest (Krapp et al., 1992), whereas 'interest' has been related to emotional engagement along with values (Fredricks et al., 2004) and cognitive engagement (Christenson et al., 2012). For Ainley (2012), approaching interest and engagement in classroom activities can provide direction for further investigation into understanding the dynamics of interest and its related processes.

Furthermore, while interest is always engaging and the presence of a developing interest ensures that engagement is meaningful, the presence of engagement does not necessarily indicate that a person has an interest or that engagement is meaningful. According to Azevedo (2013), having an interest sustains one's engagement in the task, and when students are constantly engaged in science lessons that appeal to their affective domain, they are likely to develop an interest in science, enhance their performance, and pursue science-related careers. If educators or the environment provide support for continued and deepening engagement through triggers that are aligned to learners' present understanding, they optimise the likelihood that interest will develop. The process of triggering interest and supporting learners to make connections should enable them to develop enough knowledge about the content being studied to lead to engagement. The development of interest heightens understanding and sustains engaged work, resulting in positive performance outcomes and further enrolment (Renninger & Hidi, 2020).

Furthermore, while the study of interest focuses in classroom practices, the literature review revealed that often, the study of engagement are related to school engagement in general to minimise school dropouts. According to Fredricks et al. (2004), student engagement is mostly studied in terms of schooling rather than classroom activities. Therefore, interest and engagement in this study are taken up simultaneously in my study to understand their intrinsic benefits.

The theories of interest: With its popularity gaining in the past century, the study of interest in learning and development has been theorised in many ways by educational psychologists. Based on the cultural theory, interest has been related to motivation in drive theory (Hull, 1943); to intrinsic motivation in self-determination theory (Deci & Ryan, 1985); to purpose or outcome of the task in achievement goal theory (Ames, 1992); and concentrating on one's skills and energy in flow theory (Csikszentmihalyi, 1997). According to Vartuli (2016), recent leading theories or models that focus on what makes learning interesting are the person-object-theory of interest (Krapp, 2002) and the four-phase model of interest development (Hidi & Renninger, 2006). Understanding these theories and how they developed can help classroom teachers increase student interest in learning. This study uses the person-object theory of interest with some crossover to the four-phase model of interest development to understand the current stage of interest development.

2.4.2 Decline in students' interest and engagement in science

This section explains the research on the prevalence, timings and causes of the global decline in students' interest and engagement in science as they progress along the grades from primary to middle school. This will establish the need for research into classroom practices in order to understand which aspects of the teaching and learning of science promote students' interest and engagement with the subject.

Numerous worldwide studies have reported a decline in students' interest and engagement in science as they progress along the grades. Examples are: Australia (Ainley, 2012; Tytler et al., 2008a), Bangladesh (Choudhury, 2009), Canada (Potvin & Hasni, 2014a), Germany (Krapp & Prenzel, 2011), Hong Kong (Cheung, 2013), India (Garg & Gupta, 2003), Israel (Baram-Tsabari & Yarden, 2009), Nepal (Diwakar, 2017), Sweden (Anderhag et al., 2016), Taiwan (Chang Chun-Yen & Cheng, 2008), UK (Osborne et al., 2003), and USA (Tsai et al., 2008; Xu et al., 2012), .

These studies argue that children in primary schools are usually interested in science, but the interest declines as they progress along the grades. Some studies claim that the decline in students' interest and engagement are more prominent across the primary-middle school interface (Tytler et al., 2008a). Others point across ages 14 to 16, when a rapid decline in interest occurs (Azevedo, 2015; Krapp & Prenzel, 2011; Potvin & Hasni, 2014b). According to Osborne et al. (2003), children entering secondary education are usually interested in science and technology and very positive about learning more or even choosing it as a career, but this interest declines as they grow older, and by age 15, it would have declined sharply. However, few studies have indicated that this interest may not have been inherently constituted during primary schools (Anderhag et al., 2016; Archer et al., 2013) and the findings from secondary data sources do not confirm the decline. Hence there is a need to research classroom practices to understand how interest and engagement is generated and promoted in science lessons.

Various causes have been attributed to the decline in students' interest and engagement in science lessons. These include science classroom practices that are perceived as fact-oriented, male-biased, primarily for 'smart' students, of low personal value, and lacking relevance to students' lives (Logan & Skamp, 2008). Other reasons include the move from activity-based teaching to transmissive approaches, and primary teachers' lack of confidence in teaching science resulting in minimal science being taught to students during initial formative years (Tytler et al., 2008a). In developing countries, the most common factors deemed responsible for the decline in students' interest were inadequate resources and the incompetency of teachers (Choudhury, 2009; Garg & Gupta, 2003). These studies have recommended more research into classroom practices to better understand the nature of the interaction or see the prevalence of situations in various settings.

In the Bhutanese context, the Ministry of Education (2014) similarly reported concern over the dwindling performance of students in science and math. Since then, there has been a further steady decline in students' achievement in science over the three years 2018 to 2020 (see Table 2.5). This could be attributed to the decline in students' interest and engagement in science as positive relation was established between interest and academic achievement in standardised test scores (Jansen et al., 2016).

Table 2.5 *Students' performance in science (Grade 10)*

Year	Science pass percentage
2018	94%
2019	91%
2020	88%

Source: Bhutan Council for School Examinations and Assessment (http://bcsea.bt)

2.4.3 Promoting students' interest and engagement in science

Interest has been found to positively affect learning processes and outcomes, with students who express the most positive views of school science being the most likely to aspire to science-related careers (Archer et al., 2013). According to Renninger and Hidi (2020), interest is malleable and can develop at any age and in a range of contexts. The current review of the literature on the promotion of students' interest and engagement has revealed two broad categories of intervention strategies: (a) projects initiated by departments or ministries of education, and (b) findings and recommendations from independent studies.

a) Projects initiated by departments or ministries of education: A number of schemes have been proposed to encourage students' interest and engagement with science across various countries (e.g. Canada, Japan, Korea, Netherlands, and Sweden) by their respective ministries or departments of education. According to OECD (2008), the projects were categorised into three broad schemes to encourage students' participation in science: bottom-up and top-down action plans; acting on science and technology interest and literacy for all; and addressing future science- and technology-based professionals. These schemes were implemented across various countries around the world to involve young people both in schools and outside schools to engage in science. Some of these projects have expanded over several countries and are still being implemented such as MEXT (Science Literacy Enhancement Initiative) in Japan and SciTech in Sweden (OECD, 2008).

b) Findings and recommendations from independent studies: The factors that were responsible for promoting students' interest and engagement in science were found to be the teacher; the pedagogy or instructional strategy; novelty and transformative experience; timings; and family 'science capital'.

Teacher: The teacher plays a critical role in promoting science interest (Aschbacher et al., 2010). A genuinely interested teacher invests in caring and trusting relationship with students, scaffolds student learning, and offers multiple standpoints for students to learn the content (Xu et al., 2012). Teachers' autonomy-supporting behaviours were found to generate more engagement and effort among students (Reeve & Jang, 2006). Teachers can influence students' post-compulsory school choice on science (Anderhag et al., 2015) and whether students might like or dislike science courses (van Griethuijsen et al., 2015). Harackiewicz et al. (2016), recommends policy action to design a pro-active teacher preparation program on the principle of interest theory to trigger and maintain students' interest. These studies recommend observing variations in interest in authentic classrooms across a wide range of topics and activities.

Pedagogy or instructional strategy: Three different classroom pedagogical practices or instructional strategies were identified from the literature: inquiry-based or hands-on learning (Braund & Driver, 2005; Palmer, 2009); class discussions (Agranovich & Assaraf, 2013); and engaging students in either physical or intellectual activities using varied approaches, rather than have them be passive recipients (Swarat, 2009). Lessons that make an authentic connection to the everyday lives of students foster their interest and engagement.

Novelty and transformative experience: Instructional episodes that allow students to gain new knowledge are the most effective for enhancing interest (Swarat, 2009). One way to do this is to actively engage students in applying the knowledge they gain to their everyday activities and to let them experience the world in meaningful and transformative ways (Pugh, 2011). Further, students with individual interests had a higher appreciation of most science lessons (Tsai et al., 2008).

Timings: According to Maltese and Tai (2010), science interest is shaped and developed at a relatively young age. Most primary school students find the topics studied in science class interesting (Agranovich & Assaraf, 2013) and have high aspirations for science (Archer et al., 2013). It is therefore imperative that more science is taught in primary school than currently occurs.

Family 'science capital': Archer et al. (2013) found that families exert a considerable influence on students' aspirations. Students with family members having a science background are more likely to look forward to careers in science or STEM-related fields. Palmer (2015), asserts it is crucial to support students' perceptions and abilities when they are in grade 10 so as to motivate them to pursue science in higher grades.

Due to the recent manifold advancements in the field of technology and data science, studies are being carried out to better understand how interest and engagement in science can be fostered, developed, or promoted among school students. Many strategies have been suggested, but large-scale interventions have mostly been are carried out in developed countries (e.g., Smart Kids founded in Canada and Joint promotion of mathematics, science and technology in Norway). In the Bhutanese context also, the evidence suggests that students' achievements in science have been declining (see Table 2.5). Therefore, it is apt that this study explores what can be done to trigger and sustain students' interest and engagement in science in the current scenario of limited resources and teacher constraints.

2.4.4 Studies on students' interest and engagement from the Global South

There are relatively few research articles in the international arena that discuss the interest and engagement in science of students from the Global South. Most studies have pointed out that students in developing countries exhibit a positive attitude towards science (Awan & Sarwar, 2011; Koul & Fisher, 2005; Zangmo et al., 2016). Similarly, students from developing countries have reported higher levels of interest in science than students from developed countries (Awan & Sarwar, 2011; Bybee & McCrae, 2011). This has been attributed to strong schooling often being perceived as a good way to be spared from poverty (Potvin & Hasni, 2014b) and to students in these developing countries believing that science could solve many problems faced by the world (van Griethuijsen et al., 2015).

In the Global South, embracing new technologies would improve motivation and enhance students engagement with STEM (Barakabitze et al., 2019). National articles and media reports that have expressed concern over the decline in students' interest and engagement in science; for example: India (Garg & Gupta, 2003; Padmanaban, 2008); Bangladesh (Ashraf, 2008; Choudhury, 2009); Nepal (Acharya et al., 2019; Diwakar, 2017); and Thailand (Faikhamta et al., 2018; Klainin, 2012). All these studies stress the importance of science for the overall development of countries that have witnessed the decline in students' interest and engagement in the subject over the last few decades.

The main causes for the decline in students' interest and engagement in these countries were the lack of resources, large class sizes, and untrained teachers (Choudhury, 2009; Diwakar, 2017; Faikhamta et al., 2018; Laad, 2011; Padmanaban, 2008). According to Laad (2011), low or non-use of audio-visual aids, poor infrastructure, and ill-equipped laboratories can seriously affect the quality of lessons. The inability of teachers to further relate learning to everyday life, and their use of transmissive and exam-oriented teaching-learning have contributed to students losing their attraction to science. Science education is regarded as difficult and therefore attractive only to the top students in schools and colleges (Choudhury, 2009).

These studies suggest that inquiry-based or hands-on learning would promote learning by ensuring real-life applicability (Gorowara & Lynch, 2019). Further, they recommend reverting the trend by properly equipping school laboratories, recruiting and training qualified teachers, and improving the confidence and skills of existing teachers. In the Global South, embracing new technologies will improve motivation and enhance students engagement with STEM (Barakabitze et al., 2019).

2.5 Pedagogical practices in school science

This section presents the literature findings on pedagogical practices used in teaching and learning of school science. It extends the brief mention of pedagogy or instructional strategy in section 2.4.3. This is done to generate a broad understanding of the kinds of studies that have been done in terms of pedagogical practices in science lessons to promote students' interest and engagement. I will first discuss the findings of research on pedagogical practices around the world and then present those from studies in the Bhutanese context.

Furthermore, I would like to highlight that in the literature, the use of terminologies for pedagogies, pedagogical approaches, pedagogical practices, strategies and activities were found to be not consistent. In light of this, in this thesis signature pedagogies or pedagogical practices refer to the broad teaching/learning approaches adopted by the teachers whereas, pedagogic practice refers to the key practices used underneath the pedagogies or pedagogical practices in the lesson.

2.5.1 Research findings on pedagogical practices around the world

The pedagogical practices within school communities can generate feelings of either engagement, empowerment, satisfaction, or of stress and anxiety (Krapp, 2005). The literature on pedagogical practices in science lists many approaches that can be broadly categorised as student-centred and teacher-centred (Mascolo, 2009). Student-centred approaches include, for example, hands-on, project-based, cooperative, collaborative, problem-based, inquiry-based, discovery, and role-play, whereas teacher-centred approaches include storytelling, lectures, and questioning.

While many scholars have looked into inquiry-based learning in science (Abrahams, 2009; Cheung, 2008; Wilson et al., 2010; Zhai et al., 2014), others have studied questioning practices (Chin, 2007; Gayle & Preiss, 2008; Yang, 2017), group work (Shimazoe & Aldrich, 2010), classroom interactions (Chin, 2006; Leshner & Obando, 2017), practical work (Abrahams, 2009; Hattingh et al., 2007) and multiple practices (Smart & Marshall, 2013). In summary, such studies suggest that the pedagogical approaches to teaching science should: (1) actively engage students in the practices of science (inquiry processes); (2) teach them to question to build sophisticated understanding and practices; and (3) engage them in collaborative practices (Good & Lavigne, 2017).

Inquiry practices in science, including in terms of fostering interest and engagement (Palmer, 2009), have been studied more extensively than inquiry-based or hands-on teaching and learning. The following sections will look more closely into each of these practices to identify the gaps in previous studies.

Inquiry-based and hands-on approaches: According to the nature of the science topics taught, hands-on, inquiry-based approaches to teaching and learning have been highly recommended for delivering science lessons (Logan & Skamp, 2013; Palmer, 2009). Hands-on learning generally means learning by experience (Holstermann et al., 2010), while inquiry-based learning requires students to undertake specific steps to develop scientific skills.

Hands-on and inquiry-based lessons require students to be equipped with inquiry skills that are often found lacking in high school students (Palmer, 2009). In the absence of inquiry skills, students may be confused and not interested in hands-on lessons (Holstermann et al., 2010). However, students' interest in science lessons can be greatly enhanced by teachers creating the right conditions and providing them with opportunities to interact with the materials (Logan & Skamp, 2013; Swarat et al., 2012). For Palmer (2009), the factors responsible for triggering interest in hands-on and inquiry-based lessons were the opportunity to learn, choice, novelty, physical activity, and social involvement; for Logan and Skamp (2013), they were classroom climate, hands-on opportunities, clear instruction and explanation, challenge, relevancy to everyday life, and use of ICT; and for Swarat et al. (2012), they were hands-on opportunities, and engagement with technology. However, these studies recommended exploration of other aspects of science lessons to verify their claims.

Teacher-directed approaches: The research into teacher-directed approaches has looked more closely into how teachers use questioning techniques to develop investigative skills and keep students engaged and interested in science lessons. Science teaches us to ask questions, yet, in the traditional transmissive classroom, teachers tend not to ask questions that require students to immerse themselves in deep cognitive engagement by elaborating on and moving beyond the materials provided (Benedict-Chambers et al., 2017). If asked at all, questions have often been found to only require students to recall discrete bits of knowledge. This inadequacy on the teacher's part has a cascading effect on students, leaving them also less able to ask good questions and thus develop their inquiry skills (Palmer, 2009).

Teachers' questions act as a stimulant and activate students cognitive abilities (Dos et al., 2016). Effective questioning can help students engage in classroom activities quickly (Yang, 2017). Morris and Chi (2020), recommend that in order to increase students' participation and to challenge them to foster interest and engagement in science, teachers should make lessons more interactive by asking more constructive questions. Some of the strategies to enhance teacher questioning are: preparing the questions in advance with a mixture of high and low-level questions; timing the questions based on the lesson timetable, distributing the questions to the whole class, allowing adequate wait-time, and providing feedback (Yang, 2017).

Collaborative (or group work) approaches: Collaborative (or group-work) approaches orchestrate students' interactions with each other so they can learn from their own activities and with peers (Shimazoe & Aldrich, 2010). Coming in the form of inquiries, debates and informal conversations, they provide opportunities for participation, promote higher-order active learning, and engender student autonomy and self-regulation (Nussbaum, 2001). According to Shimazoe and Aldrich (2010), group work occurs in three stages: a design and development stage; an operation stage; and output and disbanding stage. The design and development stage requires the group to establish goals, check group compositions and participate in the social process to develop social skills. The operation stage focuses on designing a task, implementing it and monitoring group performance. Finally, the output and disbanding stage requires the group to discuss and present the output. The whole process to be effective, teachers need to be aware what is happening in each group.

2.5.2 Research findings on pedagogical practices in Bhutanese science classrooms

This section presents the findings from the literature on the pedagogical practices in Bhutanese science lessons. It focuses mainly on primary-middle grade levels (grades 4 to 10), with the exception of few studies that were part of needs analysis of the curriculum framework or that were carried out to revise education policy documents. While most of this literature is from peer-reviewed journals from Bhutan, it also includes few international publications.

Sherab and Dorji (2013) observed the following pedagogical practices used by teachers in Bhutanese primary schools: questioning; discussion; presentations; demonstrations; inquiry learning; cooperative methods; explanations; group work; inductive and deductive strategies; field trips; project method; role plays; simulations; and lecturing (p. 22). They categorised these practices as student-centred, semi-student-centred and traditional (teacher-centred) approaches to teaching and learning. Childs et al. (2012), also observed student-centred teaching and learning in grades 4 to 8, where students were engaged in hands-on activities (e.g., litter picking up and bouncing ball experiment) during their fieldwork. However, in the higher grades, they found a shift to pedagogical approaches that were more teacher-centred, where students were mostly engaged in listening to the teacher, copying notes from the chalkboard, or working from the textbook.

Childs et al. (2012) also found the pedagogical practices used for delivering science lessons in the Bhutanese context heavily reliant on the textbook recommended by the Royal Education Council and, more specifically, on the guide for teaching science in grades 4 to 8, the instructions of which the science teachers followed strictly. This guide was considered both boon and bane by the teachers. On the one hand, it prescriptively facilitated the happenings in the classroom, making the teacher’s life easier, but on the other hand, it did not provide adequate content to develop key scientific ideas among the students (Childs et al., 2012; Zangmo et al., 2016). Moreover, the textbooks and teachers’ guide from grades 4 to 8 were designed to be hands-on and more contextualised to the local community, but due to limited resources, large class sizes and the limited inquiry skills of the teachers, the lessons were often delivered using the chalkboard accompanied by the teacher’s explanation (Sherab & Dorji, 2013; Tenzin & Maxwell, 2008).

The generalist teachers of science in the primary grades said, "they felt that they needed support with developing their subject knowledge because they were not specialists" (Childs et al., 2012, p. 384). Tenzin and Maxwell (2008), observed that such teachers had themselves only studied science until grade 10 and then taken arts or commerce in higher grades before joining the education colleges. In addition, the teachers of grades 7 and 8 had been trained to handle only one or two specific science subjects, and they expressed difficulty in teaching the subject portions for which they were not prepared (Sherpa, 2007).

In the absence of a teachers' guide from grade 9 onwards, the teaching and learning of science were primarily teacher-led, focusing on lecturing. Science learning was heavily content-based and examination-centred, with students mostly engaged in extensive homework and writing responses to questions that were given at the end of each textbook chapter (Childs et al., 2012; Zangmo et al., 2016). Rabgay (2014), confirmed that lecturing was the popular approach to teaching the subject based on his study on teacher-student verbal interaction in grade 10 biology lessons. Other scholars have also found the dominance of teacher-centred teaching in Bhutanese science classrooms (Dorji, 2005; Royal Education Council, 2008; Sherab & Dorji, 2013).

However, according to the most recent SCF, the teaching and learning of science in Bhutanese classrooms are anchored on two beliefs: (i) learners already bring considerable understanding about the natural world to the classroom, which may or may not be consistent with the conventional scientific understanding, and (ii) learners' understandings are deeply held and resistant to change (Royal Education Council, 2021). The SCF and the teachers' guide recommend the teachers use the following key principles of effective pedagogy to achieve effective learning of science:

i. *Active, hands-on learning:* The use of investigative-led or inquiry-led approaches is recommended; these involve questioning, designing investigations, constructing explanations, testing and communicating ideas to make students critical and creative thinkers as well as scientifically literate.
ii. *Assessment for learning:* The focus of formative assessment is on feedback to promote students' learning.

iii. *Classroom environment:* Besides creating a safe and conducive learning environment for the students, the creation of a scientific environment is also recommended to foster interest and engagement in science.

iv. *Effective use of information and communication technology (ICT):* The use of ICT promotes cognitive acceleration among students, enables a wider range of experiences, increases learners' self-learning management, and facilitates data collection and presentation (Webb, 2005).

v. *Gender-sensitivity:* The suggestion here is for teachers to provide equal opportunities for both boys and girls to participate in all aspects of the science learning process, avoiding competitive approaches and the use of sexist language. Teachers should deploy activities, materials and resources that appeal to both girls and boys and are relevant to their lives. (Royal Education Council, 2021)

Thus, the findings from the literature suggest that most of the lessons in science across the primary–middle secondary schools are teacher-centred and lecture-based, even though the curriculum framework recommends the teachers adopt varied pedagogical approaches in teaching science. To understand this gap, there is a need to look further into Bhutanese pedagogical practices.

2.6 An important, urgent gap in the existing literature

This review of the literature on science education in Bhutan has revealed research on attitudes and perceptions towards science (Das et al., 2017; Zangmo et al., 2016); science-related careers (Rinchen, 2003) and cooperative learning practices (Rabgay, 2018). However, no research has specifically looked at pedagogical practices that trigger and sustain students' interest and engagement in science in Bhutan. The current study will address this limitation by introducing a repertoire of interest and engagement to the existing literature on science education in Bhutan.

There is evidence of concern about the decline in Bhutanese students' performance in science (Ministry of Education, 2014) and, as Table 2.5 illustrates, there has been a the decline in students' performance in science over the three years 2018 to 2020. This concern has been made explicit in the Educational Reform (Royal Edict) (December 17, 2020), which commands that STEM be made part of students' everyday language.

Studies across other countries reporting a decline in students' interest and engagement in science have indicated that the interest of students needs to be considered in the context of ongoing activities in the classroom (Pressick-Kilborn, 2015). Hence, it is timely that this study has explored classroom pedagogical practices to understand how students' interest and engagement in science can be triggered and sustained in school.

A further limitation is that most of the international studies were conducted in either primary level or middle secondary level grades (Anderhag et al., 2015; Lindahl, 2007; Potvin & Hasni, 2014a; Pressick-Kilborn, 2010), with very few looking into student interest and engagement across grades from primary to middle secondary level. There is evidence from longitudinal studies (Archer et al., 2013; Childs et al., 2012; Osborne et al., 2003; Potvin & Hasni, 2014a) but this is limited and mostly in non-science disciplines such as mathematics (Ebert, 2011). A more thorough understanding of the pedagogical practices in science across these grades will ensure students are provided with adequate support to sustain their interest and engagement as their schooling progresses.

From a methodological perspective, most of the studies used self-reporting mechanisms such as survey questionnaires and interviews (Potvin & Hasni, 2014b), given that hypothetical behavioural responses can be inaccurate, actual behaviour needs to be observed (Baumeister et al. (2007). In the Bhutanese context, many of the attitude studies were also conducted through questionnaires and interviews, seeking perspectives but not actually looking into classroom pedagogical practices. In line with the recommendations of , the current study combines observations with interviews to get a better understanding of interactions in Bhutanese science classrooms and their consequences in terms of the generation of interest and engagement with science.

Finally, most studies were completed in countries with western perspectives, for example, Australia (Logan & Skamp, 2008), the UK (Archer et al., 2010), Sweden (Anderhag et al., 2016), and the USA (Vartuli, 2016). As reported earlier, there is limited literature from the less developed countries, including Bhutan. This study will contribute to the repertoire of existing knowledge from the perspective of the Global South.

2.7 Chapter conclusion

This literature review has established that most of the studies on interest and engagement in science in Bhutan and elsewhere have been carried out through self-reporting rather than by looking at classroom practices. In the Bhutanese context, no prior observational research has been conducted into the triggering and sustaining of students' interest and engagement in science. The current study contributes to filling this gap.

This literature review provides a landscape view of research on Bhutanese education research in particular and interest and engagement in science more widely. It has critically analysed the methodological trends, strengths and limitations of the existing research and distilled key findings that are relevant to the current study. The next Chapter will discuss the conceptual framework of this thesis.

Chapter 3: Conceptual Framework

3.1 Introduction

Chapter 2 reviewed the literature on students' interest and engagement in school science and established an important gap in the limited number of studies of relevant classroom pedagogical practices. For example, there were relatively few studies from the Global South and none from the Bhutanese context. Therefore, this study aimed to contribute to the existing research on students' interest and engagement from the perspective of more detailed classroom practices, bring the Global South into the limelight, and promote the overall development of science education in Bhutan.

This conceptual framework Chapter operationalises the concepts of interest and engagement and links them to the pedagogic practices observed in the data. The research questions were addressed using the Person-Object Theory of Interest (POI) and the related educational construct, Action of Interest (AoI). This enabled an approach that maintained close proximity to what happened in the classroom, identifying the pedagogical practices that were used to trigger and sustain students' high interest and engagement in the observed science lessons.

Underpinning the focus on interest and engagement are two assumptions. The first of these recognises children's curious nature and expects that all children are interested in some things (Bulunuz & Jarrett, 2015). The second holds that teachers' pedagogic practices can support the development of student's interest and engagement in particular classroom activities (Turner & Silva, 2006).

This Chapter comprises another five sections. Section 3.2 introduces and explains POI as the broad theoretical basis for this study and how I conceptualised "interest" in this study. Similarly, section 3.3 conceptualises "engagement". In section 3.4, I outline how the relationship between interest and engagement was conceptualised. Section 3.5 adds pedagogic practices to the conceptual framework through the idea of an Action of Interest. Finally, section 3.6 recapitulates how the conceptual framework was used in this study.

3.2 The Person-Object Theory of Interest (POI)

In this section, I introduce and explain POI and justify why it aligns strongly with the current study. I also explain how I conceptualised “interest”.

3.2.1 Introducing POI

The Person-Object theory of interest (POI) is one of two widely used theories of interest, the other being the Four-Phase Model of Interest Development (FPMID). POI is an attempt by Andreas Krapp in 1993 to unify the previous educational theories of interest [e.g., educational theories of interest (Schiefele et al., 1983); the person-environment model (Holland, 1985); and interest-oriented learning (Dewey, 1913)] to build a more reliable and convincing theory of interest. POI is a theoretical model of the educational-psychological construct of interest, which considers interest a relational construct (Krapp, 1993). POI is based on two fundamental assumptions in combination with Deci and Ryan (1985) self-determination theory. The two basic assumptions are: (1) the person-environment relationship makes interest a relational construct – as a specific person-object relationship, and (2) every individual has reflexive competence in action – the ability to control rationally and intentionally what one does (Schiefele et al., 1983). According to self-determination theory (Ryan & Deci, 2017), an individual is characterised by his or her distinct capacities, knowledge, attitude and goals. An individual undergoes constant change based on basic needs and to cope with the constantly changing social and physical environment (Deci & Ryan, 1985). POI was initially proposed by Krapp in 1993 and later revised in 2002 and 2007 as *an educational-psychological conception of interest* to promote interest-based learning in the school setting.

POI describes a *person* or an *individual* as the potential source of action and the environment as the object of an action (Krapp, 2002). An individual’s learning and development happens within the environment, and through these interactions they realise their strengths and weaknesses, which then influence their knowledge base and future courses of actions. As a unique entity having distinct personal characteristics, an individual may act differently when motivated by basic psychological needs (competency, autonomy and social relatedness) and influenced by their immediate environment (e.g., culture). POI postulates that an individual develops an interest in a small number of areas, and this interest is malleable in the sense that it can be triggered at any time. Social influences play an important role in the development and sustaining of interest. In this study, each participating student was assumed to be unique in terms of their background, and the abilities and values they brought to the science classroom. POI postulates that the basis for individual, social, and societal development is the constant interaction between an individual and the objects in his or her environment.

The *object* of interest can be a concrete thing, a topic, a subject matter, an abstract idea or any cognitively represented "life-space" (Krapp, 2002). The significance of the object varies from one individual to another and is described in terms of a person's store of knowledge (Krapp, 1993). This is because interest is a relationship between a person and an object; what looks like the same object (e.g., an activity that all students do in a class) can actually be a very different object in the POI sense, as the relationship between different individuals can be different. One of the reasons this can be different is that individuals might encounter that object as part of their environment from different positions, values and prior knowledge. The object can exist either cognitively in an individual's mind as a 'schema' or objectively in concrete form. It can be anything from inanimate to living things, general conditions, changes, events, contexts or facts in the environment of a person about which knowledge can be acquired and exchanged (Krapp, 1993).

3.2.2 Why POI

POI was chosen as the framework in this study for three reasons. First, the model was appropriate for the aim of this study, which is to understand which features of the pedagogic practices triggered and sustained the students' interest and engagement in science, rather than just the current stage of interest among the participants. The attention is on classroom practices, with the "person" being the Bhutanese students, and the "object" the science they were learning. There are other theories, such as the FPMID (Hidi & Renninger, 2006) but my focus was more immediate, rather than on the periods or phases of interest development. Besides, the nature and duration of the study did not favour looking at longitudinal changes over time. POI was the most suitable way of responding to the research questions as it dealt with the person's interest in the object/content and not just the person, which has been identified as a flaw in previous theories of interest (Krapp, 1993). The intention of the current study was to establish the features of pedagogical practices in teaching science within a constrained environment would allow students to stay interested and engaged in the lessons.

Second, POI is the culmination of research by educational psychologists committed to improving educational practice, which is also the intention of this study. The POI model takes into account the concrete activities that teachers might take up (Krapp, 2007). The proponents of theories of interest have noted the importance of interest in encouraging effort, focused attention, and persistence to understand the lesson content and that the design and sequencing of tasks are likely to promote learners' interest in content to be learned (e.g., Dewey, 1913). Many of the previous theories on interest have suggested that classroom organisation, task features, and attributes of activity can support the development of interest.

Finally, POI is used in this study because it is a theory of interest that attunes very closely to engagement (see section 3.5). It uses interest and engagement simultaneously. Interest is referred to in terms of the relation between person and an object, while engagement is the transaction between the person and the object. POI presents as a theory with the most potential to guide and frame this study.

3.2.3 What is interest?

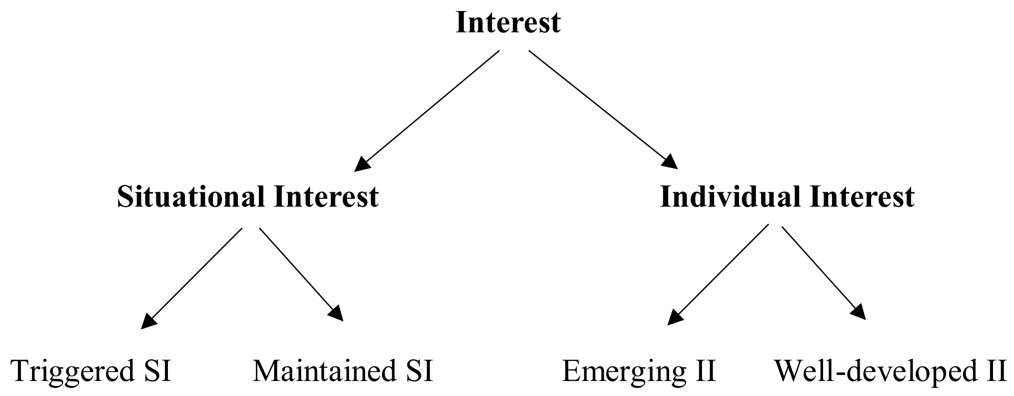
Interest is the phenomenon emerging from an individual's interaction with his or her environment (Krapp, 2002). In this study, it is conceptualised as students' meaningful participation with particular science lesson content in the classroom context, their psychological state during that engagement, and the likelihood of voluntary or independent re-engagement with it over time. Interest emerges when students interact with the subject content during science lessons. It represents a more or less enduring specific relationship between students and the science they learn. Interest is described in terms of a student's psychological state and the motivational disposition the student brings into the lesson (Renninger & Hidi, 2011). The psychological state is determined by the student's momentary experience of being captivated by the lesson, while the motivational disposition is the more lasting feelings that the student brings to the lesson or seeks to explore further by re-engagement with the content. Since the momentary experience and more lasting feelings relate to situational and personal/individual interest, they are discussed later in this Chapter under the types of interest. However, the focus of this study was more on the students' momentary experiences of being captivated (their psychological state) during the lessons than on the predispositions they brought to them.

According to Renninger and Hidi (2011), conceptualisation of interest was based on five considerations pertinent to the study of science. First, as students learn science, they engage with the object (concrete resources), events (in the discussion, observation or simply listening) or ideas (concepts or reflection). Second, interest is characterised by the cognitive, emotional and affective qualities exhibited by students: the learning they bring to or take from the lesson; their enjoyment expressed as excitement or curiosity during the lesson; and the value they attach to the lesson as they interact with its content. Third, interest is malleable; hence, support from knowledgeable others (teachers and fellow students), materials and opportunities plays a key role in interest development. It is believed that interest can be triggered and developed irrespective of age, gender, personality or previous experience (Renninger & Hidi, 2016). Fourth, students may or may not be aware of what triggers their interest; either they express so little interest that there may be no expectation of interest or they will be caught up in the experience of the interesting activity. Fifth, interest has been shown to have a neurological basis; learners are hardwired to want to re-engage and develop their understanding of the contents of interest over time. As students become interested, engaging with the content itself can become its own reward.

3.2.4 Types of interest

According to POI, the characterisation of interest in the form of the cognitive, emotional and affective states of an individual is used to distinguish between two levels of interest: a behaviour-oriented level and a more general level. The behaviour-oriented level of interest is categorised as situational interest (SI) and the more general level as the individual or personal interest (II or PI) (Hidi & Renninger, 2006; Krapp, 2007). SI is further divided into emerging situational and stabilised situational interest under POI, and into triggered situational and maintained situational interest under FPMID. While II or PI is maintained as the status quo in POI, it is further divided into emerging individual and well-developed individual interest under FPMID (See Figure 3.1).

Figure 3.1 *Types of Interest*



(*Adapted from Hidi & Renninger, 2006; Krapp, 2007*)

This study focused more on SI, with due consideration to II/PI, depending on the participants. These two types of interest will now be elaborated on.

SI refers to the momentary or current engagement of students in the interest-based activity. It describes the ongoing process of interest and the processes related to the engagement with the object of interest (Krapp, 2007). SI is generated by features of specific situations such as novelty, ambiguity, opportunities for collaboration, exploration, and challenge (Ainley, 2012). For SI, the triggers are mostly external and self-generated, based on a person's curiosity (Renninger & Hidi, 2011), focused attention, cognitive activation, persistence, and enjoyment (Hidi, 2006). SI is conceived as usually caused by external factors that are transitory or may provide the basis for individual interest in the long term (Krapp, 2007). In other words, interest relevant to learning in the classroom exists only for a limited period and is often triggered by external incentives, but repeated engagement will generate more stable interest.

Individual interest (II) or personal interest (PI) refers to the individual's stable preferences for a specific content matter – a stable tendency to occupy oneself with the object of interest (Krapp, 2007). Individuals with II or PI re-engage with the activity because they have already accrued knowledge and they value and enjoy the activity. In the classroom setting, the II or PI brings out individual differences (Krapp, 2002). For example, a student interested in human anatomy would be especially likely to be in a state of PI during a lecture on the composition of blood, whether the lecture was entertaining or not. II or PI is analysed in terms of a generalised willingness to act or the characteristics of a person where the influence of school plays a major role. PI or II is used in the explanation of various effects in the context of learning and development (Krapp 2002).

My study was more about SI, even though the participants might have had II in the science subject. It focused more on observing students being engaged, engrossed or entirely taken up with some activity because they recognise its worth (Dewey, 1913). It was intended to observe participants as they became involved in the lesson activities, the analysis would focus on identifying the indicators of interest that were used to trace out the triggers of interest and ultimately bring out the pedagogical practices. The findings would be substantiated through semi-structured interviews that captured the II that the participating students brought to the science lessons.

3.3 Conceptualising engagement

This section explains how engagement was conceptualised in this study. It describes the various types and levels of engagement used to identify the students' participation in the lessons and to categorise the lessons for analytical purposes.

3.3.1 What is engagement?

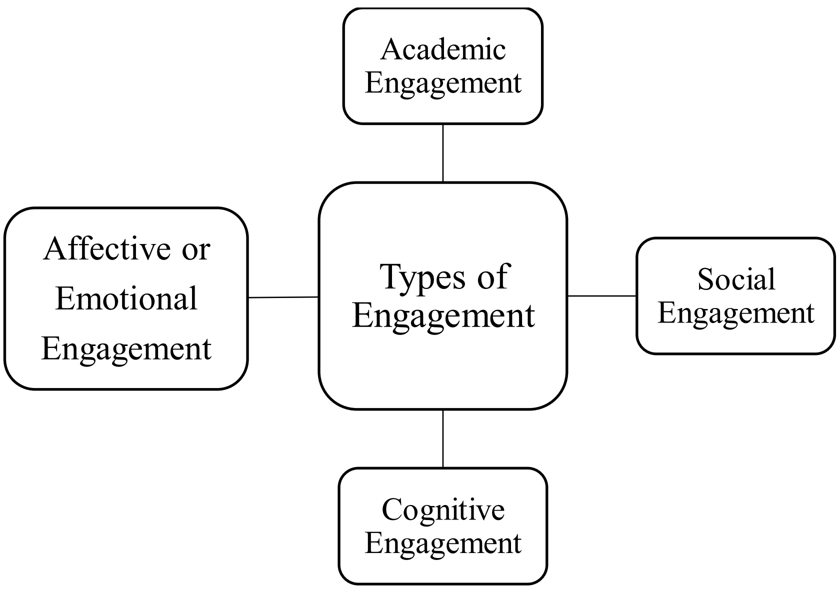
According to POI, engagement is conceptualised as transaction or object engagement. It refers to the context of participation, which incorporates how a person interacts with an object (e.g., how students interact with the science content during lessons). According to Krapp (2007), engagement "refers to concrete, hands-on engagement with the object as well as abstract cognitive working on the specific problem and to occupy oneself with certain ideas without conscious control" (Krapp, 2007, p. 8). In an education context, engagement is also defined in terms of learners' active involvement, or participation, in school or extracurricular activities and their commitment to related goals (Christenson et al., 2012). For Newmann (1992), it is "the student's psychological investment in an effort directed toward learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote" (p. 12).

The focus of the current study is in terms of learners' active involvement during science lessons as they interact with the content. When the content of learning activities pertains to something being valued or perceived as enjoyable, students choose to engage and often re-engage given the opportunity (Ainley, 2012). The transaction connects the students to the science content being taught in the lessons.

3.3.2 Types or models of engagement

This section introduces the four types or models of engagement used in the analysis of data in this study. According to (Krapp, 1993), he does not in specifically in POI mention the types or models of engagement, but acknowledges the contribution of Fredricks et al. (2004) and Appleton et al. (2006), compiled by Finn and Zimmer (2012). However, the distinction between SI and II is characterised by cognitive, emotional and affective components. Similarly, the four types of engagement that repeatedly appear across various models of student engagement are academic, social, cognitive and affective (Finn & Zimmer, 2012) as given in Figure 3.2 . The conceptualisation of each type will now be discussed.

Figure 3.2 *Types of Engagement*



(Adapted from Finn & Zimmer, 2012)

Academic engagement refers to the students' behaviours exhibited as they attempt to meet the learning outcome of the lessons, for example, being attentive during the lesson;

completing the assigned task, including the homework; trying to find responses by looking through the available resources; and volunteering to respond to the teacher's questions on the lesson topic. Academic engagement is conceptualised as the transaction between the student and the science learning outcome of the particular lesson. According to Finn and Zimmer (2012), academic engagement corresponds to the behavioural component of the participation-identification model and relates directly to the learning process. This study acknowledges the requirement of academic involvement for learning but focuses on classroom learning only, not on extracurricular activities.

Social engagement is the transaction between students and knowledgeable others (teachers and peers) that can help the student achieve the lesson's learning outcome. It refers to the interpersonal skills a student uses to facilitate his or her learning and is a behavioural component of the engagement that can be identified through observation. Examples include interacting appropriately with teachers and peers, engaging actively in contributing ideas during group and whole-class discussions, providing opportunities for others, and not exhibiting antisocial behaviours such as dominance, aggression, or disrupting the work of others. A high degree of social engagement may facilitate more significant learning and a low degree of social engagement usually interferes with learning; in other words, there is a connection between academic engagement and achievement (Finn & Zimmer, 2012).

Cognitive engagement refers to how much students are invested mentally in learning new material. According to (Finn & Zimmer, 2012, p. 102), "It is the expenditure of thoughtful energy needed to comprehend complex ideas in order to go beyond the minimal requirements" (p. 102). Some of the behavioural indicators of cognitive engagement are asking clarification questions, contributing ideas in the discussions, persisting with difficult tasks, looking for more information, cross-checking with previously learnt materials, and using self-regulatory and metacognitive strategies to enhance learning. If the students exhibit high levels of cognitive engagement, it makes their learning of complex material much easier (Finn & Zimmer, 2012).

Affective engagement incorporates both the emotional and the value components of the lesson. It refers to how students feel about the content or their emotional response to the material being learnt. (Finn & Zimmer, 2012, p. 103) define affective engagement as the level of emotional response characterised by feelings of involvement in school as a place and a set of activities worth pursuing. Students' affective engagement can be observed in terms of their emotional involvement in the lesson and by how much they persist in their learning, and it can be confirmed through interviews. Further, Finn and Zimmer (2012) assert that affectively engaged students exhibit a sense of belongingness and value their learning accomplishments. Many studies in the Bhutanese context have attributed students' interest and engagement in science to career and social status. As pointed by (Zangmo et al., 2016), Bhutanese students often aspire to become either engineers or doctors for a decent living and hence associate the value of science with these careers.

3.3.3 Levels of engagement

Engagement can be conceptualised not only in terms of types but also in terms of levels, that is, the degree of engagement. This was particularly important in my study because it was analytically necessary to distinguish highly engaging lessons from those where evidence suggested engagement was lower. For the purposes of this study, Schlechty's (2011) five levels of student engagement were used to specifically identify the types or models of engagement, which in turn were used to distinguish between the behavioural or situational interest and the general or individual interest that students might bring to the lesson. These five levels of engagement will now be briefly described.

Authentic engagement describes the highest level of attention and commitment exhibited by students during a lesson. According to Schlechty (2011), some of the indicators of authentic engagement are focused attention, persistence, and commitment. Student exhibit focused attention when the task is personally meaningful to them and they value the task assigned. They persist with the task in the face of difficulty and do not compromise the quality of work. Finally, students place a moral obligation on themselves to complete the task by committing their time, energy and effort. In the current study, the lessons that triggered these behaviours were categorised as being of high and sustained engagement.

Ritual compliance occurs when students exhibit close attention, but their commitment is up to the point where they receive an extrinsic reward for the assigned task. The students still find the task worthwhile, but only because of extrinsic rewards attached to it, such as marks, grades or recognition from teachers or peers. They see the task personally less meaningful and abandon it after achieving the reward. The indicators include focused attention, persistence, and investment in the task up to the point of getting the reward or whatever is desired by the student (Schlechty, 2011). In this study, the lessons stimulating ritual compliance were categorised as highly but briefly engaging because they were still able to support students' future engagement and trigger their interest.

Passive compliance occurs when students have low attention and little to no commitment. According to Schlechty (2011), such students see little or no meaning in the assigned tasks but will persist with them only to avoid negative consequences; they pay minimal attention, are easily distracted during the activity, and often seek alternative activities to pursue and thus to avoid the task altogether. They focus only on those things that are directly supervised by the teacher. Lessons resulting in passive compliance were categorised as being of low but sustained engagement.

Retreatism describes situations where students are disengaged and make no attempt to comply with an assigned task but at the same time avoid disturbing others. Such students are emotionally withdrawn and exhibit indications that they do not understand what they are supposed to accomplish. They have no persistence and often try to conceal their lack of involvement. If forced to do the task under teacher supervision, they either engage in ritual compliance or rebel (Schlechty, 2011). Lessons resulting in retreatism were classified as low and briefly engaging.

Rebellion refers to situations when students openly refuse to be involved in the assigned task, are disruptive, and engage in other activities. Such students reject a task, try to sabotage it, and build opposing coalitions of other students involved in it. According to Schlechty (2011), the indicators of rebellion include overt refusal to carry out the task, cheating, and influencing others to not do the assigned work and instead rebel. This type of behaviour was not anticipated to occur in this study as Bhutanese children are culturally brought up to respect their teachers (Rinchen, 2014), and acknowledge the teacher's authority during the lesson (Utha et al., 2016) but if it was observed, the associated lessons would also be classified as low and briefly engaging.

The conceptualisation of engagement and its types and levels facilitated the video/audio recording during the lesson observations and the subsequent analysis of the data. While the focus was on recording those moments that triggered and sustained high interest and engagement, contrasting episodes were also noted to highlight the flipside of science lessons. It was postulated that lessons in which students exhibited more authentic engagement and ritual compliance would further increase the students' interest in science. For consistency of data analysis, the categorisations of engagement just mentioned were strictly maintained.

3.4 Conceptualising the relationship between interest and engagement

The relationship between interest and engagement was of particular significance to this study. As discussed in Chapter 2, some earlier studies focused only on or mostly on either interest or engagement (Renninger & Bachrach, 2015). However, other researchers noted the similarity or possible overlap between interest and engagement while also recognising the need to distinguish between them analytically (Ainley, 2012; Renninger & Bachrach, 2015). Among the theories of interest, POI is distinctive because it explicitly incorporates concepts of engagement (see Section 3.2.2) and of interest as a relationship between a person and an object; thus a learner engages transactionally with an object of interest. Furthermore, as will be described in sub-section 3.4.2, the model of engagement used in this study explicitly links interest to notions of cognitive and affective engagement. Thus, rest of this section explains how this complex relationship was conceptualised in this study. It also provides details of how indicators and triggers of interest and engagement were coupled in the analysis.

3.4.1 A symbiotic relationship

For this study, interest and engagement are conceptualised as symbiotically related. This implies that engagement develops students' interest, and once interested, students will find ways to further engage with the object of interest. According to Krapp (2007), repeated engagement with a specific object stabilises this relationship, creating a disposition or willingness to re-engage with the content, and thus developing further interest. Likewise, according to POI, interest is the outcome of an individual's engagement with the object (transaction) in his or her environment. While Christenson et al. (2012) state that engagement includes both interest and self-regulation to achieve desired academic, social and emotional learning outcomes, both interest and engagement are malleable, responsive to the environment, and influenced by personal characteristics (Skinner & Pitzer, 2012). Further, interest and engagement are both initiated when something catches the attention of a learner (Dewey, 1913; Hidi, 2006)). Interest is a key psychological process that energises students' active participation in classroom activities, and it is one of the variables that powers their decisions to maintain engagement with classroom activities (Ainley, 2012).

In summary, the triggering of interest establishes engagement (Renninger & Bachrach, 2015) and repeated engagement strengthens the synapses leading to development of interest (Hidi, 2006). According to POI, prolonged engagement tends to generate interest in an individual, and an interested individual will always find ways to engage or re-engage with his or her object of interest (Krapp, 2002; Renninger & Hidi, 2011). Further, the studies by Krapp, and Renninger and Hidi on interest and engagement each point to the environment and to educators as crucial to whether and how learning occurs. Both studies agree that interest and engagement can be developed in individual students, and educators and knowledgeable can support their learning. However, it is argued that students can be interested and not engaged and vice-versa (Ainley, 2012).

My aim in this study has been to observe and record sequences of actions and reactions in real-time to address the research question: "What pedagogical practices trigger and sustain students' high interest and engagement in Bhutanese school science lessons?" Looking at interest and engagement in a symbiotic way has allowed me to explore the psychological processes interacting and combining with interest to influence students' engagement with classroom activities. Ainley (2012), asserts that the relationship between a student's interest in and engagement with science consists of networks of psychological processes related to learning such as value, enjoyment, and existing knowledge of science. Both interest and engagement tend to influence learning achievement positively. Rather than understanding how pedagogical practices trigger and sustain engagement or interest separately, this study's holistic approach to examining science classroom practices through the dual lenses of interest and engagement makes it unique.

3.4.2 Indicators and triggers of interest and engagement

This sub-section describes the conceptualisation of the indicators and triggers of interest and engagement based on the symbiotic relationship established above. Given the substantial overlap between indicators and triggers, I operationalised them by coupling them together in the analysis. This study does not analytically distinguish indicators or triggers; they are closely linked despite their conceptual differences. Consistent with POI, the indicators and triggers of interest and engagement are treated as a linked couple.

Indicators of interest and engagement: The indicators of interest and engagement were initially adopted based on the observed behaviours. They were confirmed and extended after the participants' interviews to their cognitive, affective, and emotional status of interest-based transaction or object engagement. Some of the pertinent observable indicators of interest and engagement were focused attention (energy directed to the activity), concentration (persistence and being lost in the moment), enjoyment (including positive stress), and cognitive activation (questioning and active participation in group discussions).

These indicators are consistent with POI and previous studies on indicators of interest and engagement. According to Krapp et al. (1992), behavioural indicators are focused or intense facial expression and bodily gestures such as persistence and volunteering; cognitive indicators are verbal communication, which includes sharing of rich and profound scientific knowledge on the topic, questioning, and bringing in arguments; and emotional indicators are expressed bodily using high-five gestures or fist pumps, facially through smiles and brightened faces, and verbally by voicing out excitement, surprise and enjoyment. Further, according to Sansone and Morgan (1992), students indicate interest by freely engaging in the activity, and demonstrating persistence, energy, and intensity. Ainley (2002), also found that persistence, attention, concentration and feeling of surprise, excitement and enjoyment are indicators of interest.

According to POI, the presence of these indicators determines a student's level of engagement. If students persist in the learning activity with rigour and energy, exhibiting positive emotion and increased willingness to learn, they are authentically engaged and hence their lessons are considered to have high and sustained interest and engagement.

Triggers of interest and engagement: Triggers of interest and engagement were conceptualised based on the pedagogic practices deployed during the science lessons. These were traced after identifying the indicators of interest and engagement in the lessons using the video recordings and observation notes. The triggers were the opportunities the teachers created to capture and sustain students' attention using interesting and engaging phenomena. Based on the broad three approaches to teaching science observed during the lesson, the pedagogic practices that triggered and sustained students' interest and engagement in the lessons were questioning, scaffolded autonomy and distributed responsibility. These pedagogic practices provided an opportunity for participants to learn new things – novelty (e.g. turmeric or making their indicators), decided on what they want to pursue – autonomy, interact with others – socialise, find solutions – challenge, and chance to manipulate or work on embodied objects – hands-on.

The findings were expected to be consistent with POI and previous studies on triggers of interest and engagement. Renninger et al. (2019), studies on triggers for SI found 11 indicators of interest in science lessons: affect, autonomy, challenge, character identification, computer (technology), group work, hands-on activity, instructional conversation, novelty, ownership, and personal relevance. Mitchell (1993), in his mathematics classroom observed meaningfulness, involvement, puzzles, computers and group work to trigger interest among students. Bergin (1999), identified hands-on, discrepancy, novelty, social interaction, food, modelling, games and puzzles, content, fantasy, humour and narrative as triggers of interest. And Palmer (2009) found choice, physical activity, novelty, suspense or surprise, variety, social involvement to trigger interest. Additional triggers included experiencing heightened positive emotions, being taken by surprise, discrepancy or cognitive dissonance, prior knowledge or personal relevance, and experiencing support from knowledgeable others (Ainley, 2012). A combination of triggers of interest would contribute to sustaining interest over time unless it was a hands-on activity. According to Dewey (1913), educational activities should awaken and excite the immediate needs of the individual. Berlyne (1960), identified task features (collative variables) that led to increased attention, arousal and interest, namely, novelty, complexity, surprisingness, and incongruity of visual stimuli.

3.5 Conceptualising pedagogical practice in relation to interest and engagement: Action of Interest (AoI)

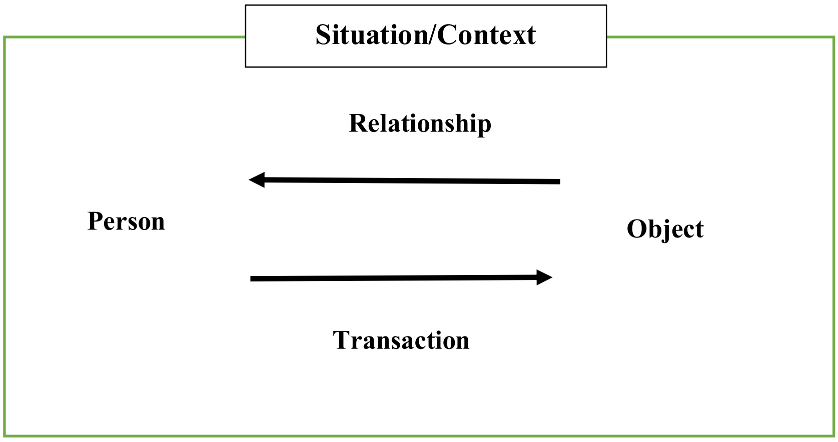
This section conceptualises pedagogic practices in relation to interest and engagement through the notion of Action of Interest (AoI). It first introduces AoI, then it conceptualises pedagogic practices as either situational or contextual within AoI, and finally it presents the operationalisation of AoI to bring out the relationship between interest, engagement and pedagogic practices as used in this study. This conceptualisation is crucial for presenting the findings of this study (see Chapter 9). AoI is concerned with particular instances of deliberate attempts by someone (usually a teacher) to facilitate others' learning (usually students) by creating a situation that promotes the learners' interest and engagement (Krapp, 1993). The sequence of events or learning environment intentionally planned comprises the pedagogic approach undertaken by the teacher to facilitate learning and achieve the desired outcome of the lesson. The concrete situation or context is perceived as a pedagogic practice consciously and intentionally planned by the teacher.

3.5.1 Introducing Action of Interest (AoI)

AoI is the educational conception of the POI that establishes the relationship between a person and an object in a concrete situation. According to Krapp (1993, 2002, 2007), an AoI is the special case of an interest-oriented pedagogic practice deployed by the teacher to engage students with the lesson content. An AoI establishes the immediate relationship between the student and the lesson outcome in the classroom context – where the teacher orchestrates the happenings in the classroom. Therefore, AoI is used as the means to bring pedagogic practices into this conceptual framework. There is no separate concept of pedagogy, but instead, the approaches adopted by the teacher comes in through AoI.

The AoI is presented in Figure 3.3. As derived from the POI, the five components of AoI will be described briefly.

Figure 3.3 *The Action of Interest as a current relationship between a person and an object (Krapp, 1993)*



Person: According to POI, a person is conceptualised as the part of the environment that is aware of itself, and the object of awareness is the person's individual "self" (see Section 3.2.1). The individual self constantly changes to satisfy one's needs and to cope with the requirements of social and environmental changes. As the person learns and develops, s/he is characterised by a distinctive structure of capacities, knowledge, attitude and goals (Krapp, 1993, 2002). The cognitive representation and emotional-motivational aspect make up the personal identity. POI suggests that in the process of maintaining a coherent image, a person sometimes cannot identify completely with thoughts, actions, task, and strivings in a certain context.

Object: The object in AoI comprises the units in the cognitively represented environment that are delimited from one another and have individual significance for the person (see 3.2.1). These units can be described on the basis of the person's store of knowledge and are referred to as objects (Krapp, 1993). The object is either represented as knowledge about the object existing in the mind of an individual or as a concrete, existing object or symbolically represented fact, which can be conveyed through message or conversation. The significance of an object varies from person to person, having a momentary or lasting effect on each individual.

Transaction: Also referred to as "object engagement", transaction refers to a person's interaction with the respective environment units relevant to his or her experience and behaviours (Krapp, 1993, 2002, 2007)(see Section 3.4.1). It includes hands-on engagement with the object (e.g., doing experimentation), abstract cognitive working (e.g., analysing a scientific problem) or occupying oneself with certain facts without conscious control (e.g., volunteering every time the teacher asks a question). The particular kind of transaction between a person and the object that has both purpose and intention (e.g., teaching and learning) is called the AoI (Krapp, 1993).

Relationship: According to POI, the person-object relationship is the relationship between a person and an object that is relatively persisting or can be generalised across different situations, in the sense of an habitual or dispositional personality feature (Krapp, 1993). When the person engages with the specific object, s/he establishes a relationship with the specific part of the environment depending on the intensity and quality of its subjective significance. Such repeated engagements can lead to habitual willingness or disposition rooted in the individual, generating the situation-specific incentives or general preferences of that individual. These are called situational interest (SI) (interestingness) and individual interest (II) (personal interest, PI), respectively (see Section 3.3.1).

Situation or context: The purposeful or intentional circumstances created for an individual to interact with the object of interest within one's environment is the situation or the context. The setting of such circumstances or environments is the norms of educational practices. According to POI, interest-oriented engagement can be stimulated to arouse interest through teaching. By designing the context of action (pedagogic practices) appropriately, new incentives may be attributed to the object, stimulating a situation-specific interest, which can be strengthened further to develop a full-fledged individual interest.

In summary, understanding the five components (person, object, transaction, relationship and situation/context) and how they interconnect in terms of the AoI are crucial for this study. The AoI establishes that when a person interacts (transacts) with an object in a concrete situation or when the context is created, this can facilitate the development of interest, especially in a controlled environment. The next sub-section builds on this understanding to operationalise the relationship between the key concepts – interest, engagement and pedagogic practice.

3.5.2 Conceptualising pedagogic practices to create situation/context for AoI

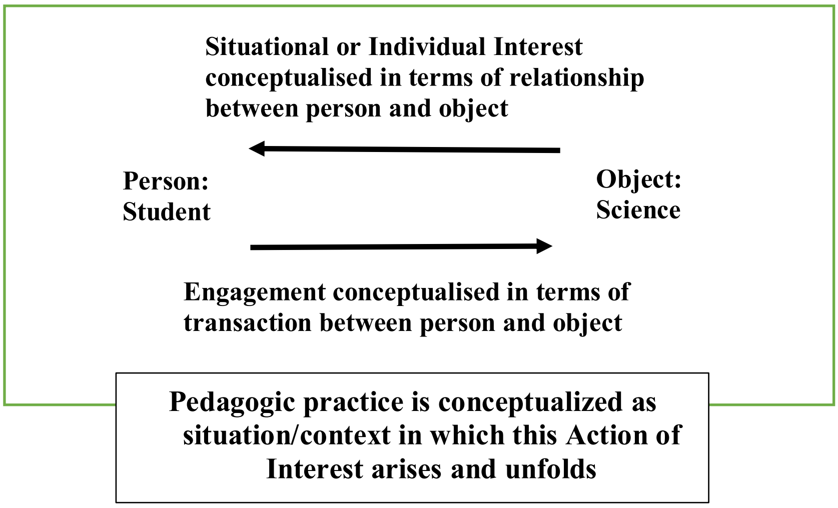
In this study a pedagogic practice is conceptualised within the AoI model as what a teacher does to create the situation or context. Teachers' intentions, decisions and actions in the classroom are all understood to significantly influence students' interest and engagement. Krapp (1993), explains how the design of the situation or context can lead to new incentives being attributed to an object, thus stimulating situation-specific interest. Pedagogic practice relates to the collective decisions made when choosing what to teach as well as how the knowledge, skills and understandings can be delivered in particular learning environments (Miller et al., 2018).

It is therefore helpful to consider how pedagogic practices in science education have been broadly described, particularly in relation to triggering and sustaining students' interest and engagement (see Section 2.5). Practices such as direct instruction, group work, inquiry-based lessons and laboratory lessons have the potential in distinct ways to establish situations or contexts that promote interest and engagement. It is particularly important to consider the Bhutanese context in relation to pedagogic practices and AoI. As discussed in section 1.2.3, Bhutan's education system faces a number of significant challenges, including large classes, limited resources, especially for practical work, and heavy curriculum content. Hence, this study aimed to understand how, within these challenging circumstances, teachers are nonetheless able to trigger and sustain students' interest and engagement through their pedagogic practices. AoI was seen as a highly suitable means for exploring this.

3.5.3 Operationalising the AoI: How the relationship between interest, engagement and pedagogic practice was applied in this study

This section explains how the general idea of AoI was applied to the particular context and focus of this study – the Bhutanese science classrooms. Figure 3.4 is a version of Figure 3.3 that shows how AoI was operationalised.

Figure 3.4 *Operationalising AoI in the Bhutanese science classrooms*



In operationalising the AoI in the Bhutanese science classrooms, the pedagogic practice is considered as the means to create the context of an action for students to engage with the lesson content with an intention to develop long-term personal interest in the subject. Each component of AoI in the Bhutanese science lessons will now be elaborated on.

In this study, the participating students represent the person; they are the potential source of action. The study explores their interactions with the science content in the context created by their teachers during lessons. The AoI of key participants were characterised in terms of the types of experience they brought into the lesson or the ways they behaved in the lesson (Krapp, 1993). This was linked to the kinds of relationships they exhibited while engaged in the lessons. Every moment of their interactions with various objects in the science lessons was recorded using field notes and video recordings, while deeper insights into their actions were sought during the weekly interviews. These behavioural actions and the general conditions the students brought into the lesson were used to determine their state of interest and engagement in the science lesson and thus to identify the effects of the pedagogical practices.

The object is the science the participating students were to learn during the lesson, and the object of interest is the subject content or subject matter. According to POI, the conception of an object is decisive for the action. The object is also seen as something that is concrete, an event or an abstract idea on which students stand invested. Krapp (2002, p. 410), states "The object of interest could be a concrete thing, a topic, a subject matter, an abstract idea, or any other content of the cognitively represented life-space" (p. 410). In other words, the achievement of the intended learning outcome would depend on the kinds of notions, knowledge and judgments the students brought into the lesson (Krapp, 2007).

Object engagement is conceptualised as the transaction between a person (students) and the object (science); it highlights the events that unfolded during the lesson as students interacted among themselves and their teachers, and with the scientific materials and their previous experiences. It describes the indicators and triggers of interest and engagement as the students interacted with the lesson content, which would form the crucial component for the data analysis.

Situational interest and individual interest are conceptualised as the outcomes of the relationship between the participating students and the science they were learning. Within the AoI, interest is seen as something generated at the moment students interact with the object (SI) or something that the students bring from their previous experiences or encounters they are invested in (II).

The design of context of action describes the pedagogical practices the teachers deployed to connect students with the science content they are learning. Interest-oriented engagement can be stimulated where no previous interest exists, and be aroused through teaching or designing the context of action appropriately, thus stimulating the situation-specific interest (Krapp, 1993).

In summary, the person is conceptualised as the students and the object of interest as the science they learn during the lesson. The object engagement or transaction is conceptualised as the engagement between a person and the object, and SI and II are conceptualised in terms of the relationship between the student and the science content they learn. All these are intentionally orchestrated through the pedagogic practice consciously set up by the teacher. According to Krapp (1993), all teaching and learning in the education context are intentional and consciously planned.

3.6 Chapter Conclusion

The conceptual framework for this study was based on POI and is conceived because of its alignment with the research questions and the recommendations of previous studies on interest and engagement in classroom practices. Here, interest is conceived as the relationship between the students and the science they study, while the engagement is the transaction or object engagement of the student. Since interest and engagement share a symbiotic relationship, the triggers, and indicators for both are coupled and discussed together. The AoI was used to explain the relationship between pedagogic practice, interest, and engagement.

Chapter 4 presents the research methodology, which is informed by this conceptual framework.

Chapter 4: Methodology

4.1 Introduction

The over-arching research question of this study was: "What pedagogical practices sustain students' interest and engagement in science across grades 6, 8, and 10 in schools in Bhutan?" To gain depth of insight and proximity to science lessons as they happened, a qualitative approach was adopted, with data generated from a middle secondary school in Bhutan. This study was unique in the Bhutanese context in its sampling from grades 6, 8 and 10. From each grade, four students (two girls and two boys) and their science teacher(s) were recruited for the study, making a total of 17 participants. Data generation in each grade was split into 2-week phases, separated by 4 weeks. In total, 86 lessons were observed, producing field notes, video records, audio records of participating students and their teacher(s). Forty-eight post lesson interviews were conducted with students, supplemented by 10 interviews with their teachers. NVIVO was used to organise the data, and a multi-stage progressive process with an inbuilt iterative process was used to generate meanings from the data.

As mentioned in Chapter 3, the study has its basis in the person-object theory of interest (POI) (Krapp, 1993). The view that behaviour is the result of the interaction between the person and the environment serves as the guiding principle of this study. It was understood that the presence of engagement in lessons does not necessarily indicate that a student has interest, or that engagement is meaningful (Renninger & Hidi, 2016). Rather, when students are constantly engaged in science lessons that appeal to their affective domains, they are likely to develop an interest in science, enhance their performance, and pursue science-related careers (Osborne et al., 2003). This study's unique contribution lies in its looking at the classroom practices that generate interest and engagement as they arise in the context of specific learning activities in the classroom, something that has not been done before.

I locate my study within the social constructivist/interpretive paradigm (Creswell, 2009; Mertens, 1998). Social constructivists do not assume any single reality and believe that empirical reality and theoretical concepts are mutually constitutive. For them, bridging between reality and theoretical concepts was narrowing the gap between concrete observations and abstract meanings using interpretive techniques (Blatter, 2008). I take the view that knowledge was socially constructed and emerges from peoples' social practices, that there are varied and multiple realities, and that I can make sense of the world through my experiences. This was a study of one school; a class each from grades 6, 8, and 10; two male and two female students from those classes; and two of their science teachers. I sought to understand the teachers' and students' perspectives and contexts and also the values, beliefs, and meanings of the social interactions they brought to the classroom practices. Adopting an interpretive constructivist stance allowed me to respond to these practices as their importance to participants became apparent in the school setting. I experienced this research as a process of interpretation and making sense of the classroom pedagogical practices that sustained students' interest and engagement in science across the identified grades.

This Chapter describe the methodology deployed and the rationale for the choice of a qualitative approach. It comprises nine sections. Section 4.2 provides an overview of the research questions posed in this study. Section 4.3 outlines the strategy adopted and the rationale underpinning it. Section 4.4 details the sampling procedures deployed to ensure the generation of data. Section 4.5 sketches the data generation strategy. Section 4.6 discusses the ethical practices adhered to in the study. Section 4.7 brings out the approaches to data analysis. Section 4.8 highlights the challenges and limitations of the study. The Chapter concludes with a summary of the key features of this methodology.

4.2 Research questions: From over-arching questions to data generation questions

Research questions lie at the heart of all research activities. Good research questions are clear, specific, empirical, interconnected, and substantively relevant (Punch, 2014). Qualitative research questions restate the purpose of the study and typically start with words such as what or how in order to explore the central phenomenon. They also provide opportunities to foreshadow the approaches to an inquiry (Creswell & Poth, 2018).

Punch (2000), states that the research questions and methods need to be aligned, and the best way to achieve this alignment is to focus first on developing the research questions, and second on the methods to answer those questions. This can be done by generating an over-arching question followed and several sub-questions (Bryman, 2012; Creswell & Poth, 2018). The overarching question, sub-questions, and interview and observation protocols for this study followed five main functions:

- organising the project and giving it direction and coherence;
- delimiting the project, showing its boundaries;
- keeping the researcher focused during the project;
- providing a framework for writing up the project; and,
- pointing to the data that will be needed (Punch, 1998).

4.2.1 The over-arching research question

The over-arching research question of this study is:

> *What pedagogical practices trigger and sustain students' interest and engagement in Bhutanese science lessons?*

This question represents the reason for undertaking the study. It was deliberately kept more general, more abstract, and thus not directly answerable because it was meant to guide how the research would be thought about and organised (Punch, 2014), synthesise the findings in response to the research sub-questions, and to identify the main substantive contribution of the study (Hopwood, 2006). Hence the question is sufficiently open-ended to evolve around unpredictable classroom practices.

Further, since the study included young student participants, it was important to ensure that the data generation methods were appropriate and that ethical issues carefully considered. As a non-participating observer, I had no control over the events happening contemporaneously in the classroom during data generation. Addressing the over-arching question required answering the following three research sub-questions.

4.2.2 The research sub-questions

The three sub-questions are:

1. *What are the main pedagogical practices enacted in Bhutanese science lessons across grades 6, 8 and 10?*
2. *What are the patterns in terms of how high and sustained interest and engagement relate to these practices?*
3. *How is each of these practices enacted in Bhutanese science lessons in ways that trigger and sustain students' high interest and engagement?*

These sub-questions took the deductive process further by dividing the more general question into specific functional questions that allowed me to take a closer look at the science classroom practices (Punch, 1998)

The first sub-question was a crucial first step towards answering the over-arching research question. It was first necessary to understand the various pedagogical practices adopted by the science teachers in the various grades. It is said that if one wants to enhance interest and engagement in lessons, it is important to examine how the lessons are conducted (Mitchell, 1993; Palmer, 2009). This question allowed me to zoom into those observable episodes or moments within the lessons and identify some 15 pedagogical approaches adopted by the teachers across grades 6, 8 and 10. Through a multi-step progressive analysis, these approaches were reduced to three signature pedagogical practices, namely, interactive lectures (IL), small group discussions (SGD), and hands-on learning (HOL) (see Section 5.4). The question also helped me identify the prevalence of these practices across grades and understand the reasons they were adopted.

Building from the first sub-question, the second sub-question explored the relationship between the identified pedagogical practices and interest and engagement. Responding to this question required identifying the indicators and triggers of interest and engagement in the lessons. Thematic analysis of the lesson videos using an iterative approach allowed me to identify these indicators and triggers (see Section 5.5). They were subsequently confirmed using critical friends. Having established the intensity and persistence of interest and engagement in the lessons, the lessons were categorised into low/high and brief/sustained interest and engagement to demonstrate their relationship with the pedagogical practices (Renninger et al., 2019).

As anticipated, the responses to this sub-question were useful for addressing the third research sub-question, which directed analytical attention to the features of the pedagogical practices that were deployed to trigger and sustain the students' high interest and engagement during the science lessons, for example, the context, content, and activities that sparked the interest that students might bring into their science classes (Krapp & Prenzel, 2011). Previous studies have strongly recommended looking into classroom pedagogical practices when it comes to interest and engagement in science (Anderhag et al., 2016; Childs et al., 2012). The conceptual framework outlined in Chapter 3 was used to generate meanings from the relationship between the pedagogical practices and interest and engagement in terms of the participants' AoI (see Section 3.6). The answers to this question are presented as separate Chapters for each pedagogical practice (Chapters 6, 7 and 8).

To generate data, the sub-questions were further sub-divided into interviews and observation protocol questions.

4.2.3 The interview and observation protocol questions

Appendices A and B show the interview and observation protocol questions used for data generation. The questions at this level were very specific and intended to confirm and give voice to the cognitive and affective interactions of students as they learned science. More than one question or form of observation was used to answer the specific research sub-questions.

The interview protocol comprised three sets of questions; two sets for the teachers were used in the beginning and at the end of the fieldwork, and one set for the students was used to guide all four interview rounds. As anticipated, some questions were added during the different interviewing stages to get as much relevant information as possible and to ensure the quality of the data.

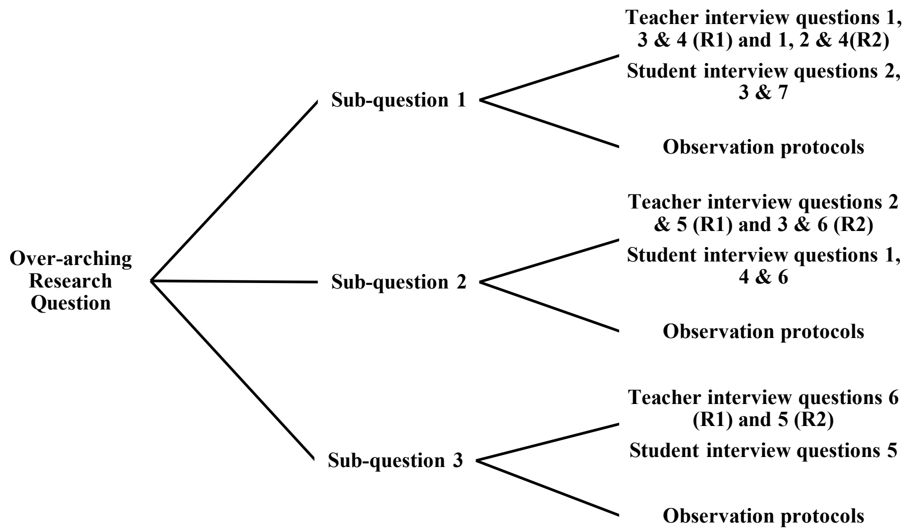
The first set of teachers' interview questions sought information about their personal experiences in teaching science and which topics their students liked. These questions also required the teachers to reflect on a recent lesson they had taught and to describe how they thought it went. They were asked if they had observed any signs of interest among students as they delivered the content, and what they considered as evidence for their statement. To validate my classroom observations, one question explored how much the teachers were aware of what they usually did during the science lessons. The second round of teachers' interview questions focused on a particular lesson to generate deeper insight into the pedagogical practices deployed by the teacher. This facilitated confirmation of the indicators of interest and pointed at the triggers. However, the question related to Gross National Happiness (GNH) resulted in thinner responses. It was unfortunate that generation of rich data from teachers detailing GNH in their pedagogy has proved elusive in prior studies as well (Childs et al., 2012).

Similarly, the interview questions for the participating students focused entirely on the most interesting science lesson of the week. They provided insights into what the students regard as key element to science learning by probing them to share more. Some questions were targeted at establishing the students' perspectives on possible indicators of interest in the lesson, and others directly tried to establish the triggers of interest. To generate understanding about their interest, the students were given opportunities to share anything about the lesson that the interview questions did not cover. Here again, the question pertaining to GNH fetched vague responses, with the participants hesitant to talk more about the subject (Childs et al., 2012) as indicated in the above paragraph.

The lesson observations focused on three key areas: the pedagogical practices, the indicators, and the triggers of interest and engagement. Field notes were used to record observations and to closely describe the events and conversations as accurately as possible. Wherever possible, reflective comments were added to aid summarising (Miles et al., 2014) or to point towards particular moments while watching the video recordings. During the lesson observations, still photographs were also taken to record students' participation in activities and facilitate analysis of the physical context. Records of materials used, handouts provided and anything written on the chalkboards during the lessons were also noted in order to analyse their impact on the development of interest (Pressick-Kilborn, 2015).

Figure 4.1 summarises how the interview questions and observation protocols were linked to respond to the research sub-questions and finally, derive response to the overarching question (see APPENDIX C and APPENDIX B for the trajectory of research questions and observation protocol respectively).

Figure 4.1 *Question and interview/observation protocol links*



4.3 Research strategy

An ethnographic case study was adopted as the research strategy for this study (Angers & Machtmes, 2005; Walters, 2007). The following paragraphs elaborate on its "ethnographic" and "case study" components.

This study is *ethnographic* in the sense that the participating teachers and students at the school formed vital components of the culture and context in which the transactions took place (Ritchie et al., 2011). The fieldwork was conducted between 18 February and 31 May 2019. During this period I entered into a close and relatively prolonged interaction with the participants in their everyday school life and actively took part in varying roles while observing and interviewing them (Creswell & Poth, 2018).

I was both an insider and outsider (Milligan, 2016) to my participants and the school system. Being a product of Bhutanese schooling, a teacher in high school for 13 years and as a faculty member in the college of education, I was an insider to the school system, the behavioural cues, and the cultural context at the Vajra MSS. Yet, I was also an outsider, neither being a student or teacher in the school, but with distinctive agenda as a researcher. Being an insider, helped me recruit participants, provided access to school, and helped me make cultural interpretations of some of the behavioural indicators and triggers of interest and engagement in the classroom teaching learning context. Further, this positionality helped with accuracy in transcribing Bhutanese forms of spoken English, and enabled me to easily understand what students and teachers meant, when local languages were used, as happens sometimes in classroom, and also happened on occasion in interviews.

In the process of exploring the classroom pedagogical practices, I paid close attention to the "subtlety, complexity, and embeddedness" (Walters, 2007, p. 97) of the classroom practices. I looked at the research situation from many perspectives and used multiple means to gather data from many sources, including the curriculum and policy documents, suspending premature judgement, and letting the data be self-explanatory.

Furthermore, the ethnographic part of this study was guided by nine attributes identified by Wolcott (2010):

1. The study has to be authentic, in the sense that fieldwork and data collection should be obtained firsthand by me.
2. The study must be conducted in its natural setting to be real.
3. I should be able to interpret the realities and make meanings of experiences by being in intimate, long term relationship with the study place.
4. I should be non-judgemental and rather seek to understand why things occur as they do within a given cultural context and how they interrelate.
5. I should focus on thick 'rich' description of events and culture.
6. The study should be specific to the local place and the people around.
7. I should be adaptive and flexible, that is, while ethnographic studies are informed by theory, the data should shape an inductively emerging theory.
8. Triangulation is important and more than one source of data is necessary to corroborate.
9. Ethnography is idiosyncratic and individualistic, so another person looking at this study might see things differently.

This study was also a *case study* of 12 students (four from each grade of 6, 8 and 10) engaged in learning of science in one school in Bhutan. Its intention was to investigate and generate an in-depth understanding of the pedagogical practices in each of these grades that sustain students' interest and engagement in science. The detailed description of each case and the themes within the grade were followed by a thematic analysis across the grades (Creswell & Poth, 2018),which in turn led to a discussion of findings and contributions of the study (Lincoln & Guba, 1985). Combining 'within-case analysis' with 'cross-case analysis' allowed for a deep exploration of emerging themes, patterns or dissimilarities (Walters, 2007).

Case studies are often used in educational settings to study pedagogy and teacher practices (Roth, 2007) within a real-life contemporary contexts or settings (Yin, 2018). I conceptualise social reality as generated and constructed by people and existing largely within people's minds (Stake, 1995). According to Blatter (2008), the understanding of case studies extends from being a specified tool in a purely positivist scientific research endeavour to being a pedagogical strategy in the education and social learning process. Furthermore, Creswell and Poth (2018) define case study as a qualitative approach in which the investigator explores a real-life, contemporary bounded system or multiple bounded systems over time, through detailed, in-depth data generation involving multiple sources of information and then reports a case description and case themes. The case study is preferred when examining contemporary events in which the relevant behaviours cannot be manipulated, and its unique strength lies in its ability to deal with varieties of evidence – documents, artefacts, interviews, and observations.

Blatter (2008), shared five advantages of the case study approach:

1. Case studies have been the major source of theoretical innovation.
2. Case study research has an affinity toward descriptive goals.
3. Case studies are often concerned with pinning down the specific mechanisms and pathways between causes and effects rather than revealing the average strength of a factor that causes an effect.
4. Case studies have a strong comparative advantage concerning the "depth" of the analysis, where depth can be understood as empirical completeness and natural wholeness or as the conceptual richness and theoretical consistency.
5. Case studies have advantages with respect to construct and internal validity.

The argument for better construct validity is based on the fact that case studies can use diverse indicators to represent a theoretical concept, and for securing the internal validity of causal inferences it depends on generating both descriptive and interpretative understanding (Maxwell, 1992).

As an *ethnographic case study*, an outcome of this study would be the sharing of processes, practices, and experiences through which classroom pedagogical practices in science can be understood within the school context. It would also provide an account of the values, practices, relationships, and identifications of participants across the grades to explain "What is going on here? How does this work? How do people do this?" (Walters, 2007). An ethnographic case study is defined as a prolonged observation in a natural setting within a bounded system (Angers & Machtmes, 2005).The use of the ethnographic case study method allowed explorations of the actions and events in the three grades in their natural setting for a period of one month each, thereby providing a deeper understanding of pedagogical practices transacted every day to sustain the students' interest and engagement in learning science.

4.4 Sampling

Table 4.1 describes the sampling related to the sites, the number of grades (three), teachers (five), and students (12) sampled for this study. The justifications for choosing actual data sources from a larger set of possibilities are discussed under each sub-topic.

Table 4.1 *Sampling*

School – Vajra Middle Secondary

Grade 6			Grade 8			Grade 10		
Teacher	*Case Student (F)*	*Case Student (M)*	*Teacher*	*Case Student (F)*	*Case Student (M)*	*Teacher*	*Case Student (F)*	*Case Student (M)*
Mr. A	Semyang	Namgyel	Mrs. B	Norbu	Samten	Mr. C	Jitsuen	Kezang
	Sonam	Phub		Dechen	Karma	Mrs. D	Yiga	Binod
						Mr. E		

4.4.1 Selection of the study school

The criteria used to identify the school were based on purposive and convenience sampling (Patton, 2001). The justification for identifying the study school has a basis in similar research on students' interest in science and technology (Pressick-Kilborn, 2010); the emotional climate of science education classes (Rinchen, 2014); and increasing high school student interest in science (Vartuli, 2016). Furthermore, an ethnographic case study requires a selection of a single site with an intact culture-sharing group having shared values, beliefs, and assumptions in which the researcher can study programs, events, processes, activities, individuals, or several individuals (Creswell & Poth, 2018).

The selection of school was based on fulfilment of the following conditions. Firstly, the school had be one of the middle secondary school having grades from pre-primary to grade 10 to observe lessons in grades 6, 8 and 10. Secondly, the school should also grant permission to conduct the study. Thirdly, to understand good pedagogical practices, the school should have a consistent record of producing a high number of students taking up science in grade 11 as indicated by performance reports (School Examination Division, 2019). Based on the above three conditions, I had identified four schools and sought prior approval from the Director General, Ministry of Education for these schools (see APPENDIX D). I formally wrote to the first two schools for permission, and both of them granted access. Upon arrival at the destination for fieldwork, I approached the school closest to where I was living, pseudonymised here as Vajra Middle Secondary School (VMSS), and the principal granted consent.

VMSS was established as a lower secondary school when it moved from its previous campus in 2004. Upon completion of additional infrastructural facilities under Government of India (GoI) funding, the school was upgraded to VMSS in 2007 as one of the 69 public middle secondary schools in the country that teaches grades from pre-primary to grade 10. The school is also one of the two public schools in the locality, which is located at 2,250 m above sea level with an area of 2.29 hectares and is close to the commercial and administrative hub of the Dzongkhag (District). It caters to the children of the local community and the civil servants working in and around the Dzong (Religious and administration building). The school teaches all the subjects mandated by the Royal Education Council (REC).

At the time of the study, VMSS employed 45 teachers (27 females and 18 males) and 13 support staff (nine females and four males) to meet the educational needs of 778 students (404 females and 374 males). The infrastructure facilities included four academic buildings that could accommodate 24 classrooms, a separate building with science laboratories (biology, chemistry, and physics), library and IT laboratory and, another multi-purpose hall for learning support. The school also had a basketball court and a football ground for recreational activities.

The students and staff come from all over the country, making it ethnically and economically diverse. The school believes in strong parental involvement for students' learning and calls parent-teacher meetings at least four times a year to provide general information about the educational needs of the child and to receive feedback on the progress of its students. Its academic reputation attracts most of the parents seeking enrolment of their children. Consistently, the school has been producing academically high-achieving graduates, especially in biology, chemistry, and physics, with the aim to enrol them in science in grade 11. The overall performance of the school in science is the highest at the district level, with the female students slightly out-performing the males in terms of numbers and mean marks.

4.4.2 Selection of the study grades

A class from each of grades 6, 8, and 10 was identified for data generation. These grades are the exit points of primary (grade 6), lower secondary (grade 8), and middle secondary (grade 10) stages of compulsory school education and have students aged 11 to 16 years. They were also suitable for investigating changes in, and the sustaining of, interest and engagement over time. Potvin and Hasni (2014a) found that students' interest in science declines across grades 5 through 11, and Archer et al. (2013) in their longitudinal study found that students' aspirations in science remain consistently low across the 10 to 14 years age range. Other decision-making factors included the curricular demand and assessment practices that have a direct implication on the kinds of teaching and learning that would happen in the classroom.

At VMSS, there were two classes for grade 6 (26 and 24 students in each), three classes for grade 8 (37, 36, and 38) and three for grade 10 (22, 31, and 31). Generating data from all the classes in each grade would not only have been unmanageable, but also lesson clashes, especially in grade 8, which has different teachers teaching different classes, would have created confusion and complications in the school's timetabling. The final selection of classes depended on the students' performances in their previous grades in terms of their classroom participation and science grades, their science teacher's recommendations, and the consent of the participating teachers and students. After receiving this consent, data were generated from the classes having 26 (grade 6), 37 (grade 8), and 31 (grade 10) students.

4.4.3 Selection of the study teachers

The selection of the teachers depended on whether they were teaching science in grades 6, 8, and 10. During the time of the fieldwork, there were 10 teachers teaching science from grades 4 to 10. Four taught science in grades 4 to 6, three in grades 7 and 8, and four taught biology, chemistry, and physics in grades 9 and 10. Of these, five teachers were invited to participate in the study using the participant invitation letter (see APPENDIX E), participant information sheet and informed consent form (see APPENDIX F) through a neutral person to keep them at arm's length and avoid coercion. Teacher participants agreed to use the English alphabets as their pseudonyms. The grades, subject the participating teachers taught and additional roles (if any) assigned to them including the grade from which the data was collected are given in the Table 4.2 below;

Table 4.2 *Grades the participating teachers taught and the grades for data collection*

Sl. No	Teacher	Grades and Subject taught	Grade and lesson Observed	Additional Responsibility (if any)
1	Mr A	6 A and B (Science)	6 A (Science)	Administrative responsibility
2	Mrs B	7 D (Science) and 8 A and C (Science)	8 A (Science)	
3	Mr C	9 A, B and C (Biology) 10 A, B and C (Biology)	10 B (Biology)	
4	Mrs D	8 B (Science) 10 A, B and C (Chemistry)	10 B Chemistry	Head of Science Department
5	Mr E	9 A, B and C (Physics) 10 A, B and C (Physics)	10 B (Physics)	

Mr. A was teaching grade 6 for the first time, whereas the other participating teachers had taught their respective grades for more than 5 years. All the science teachers had a science background and had specialised in the subject they were teaching.

In line with the University of Technology Sydney's guidelines (The National Health and Medical Research Council et al., 2007 (Updated 2018)), and based on UTS ethics approval letter (see APPENDIX G), this research was subject to the informed consent of the teachers, from whom written consent was obtained using the sample PIS and PIC. As mentioned earlier, I consulted the participating teachers when selecting the appropriate classes.

4.4.4 Selection of the case students

The decision to focus on 12 students (four from each grade) as case students has precedence in the studies cited earlier under selection of case school: Pressick-Kilborn (2010) had one teacher and six students; Rinchen (2014) had one teacher and 28 students; and Vartuli (2016) had eight teachers and 11 students. Four students (two boys and two girls) in each grade would mean the study was neither underrepresented nor unmanageable, and that the findings would not be distorted by one unusual student. As well, observing and interviewing more than four students on a weekly basis was deemed impractical (Hopwood, 2006). More than this could compromise attention to detail and result in conceptual problems for both the researcher and the reader when dealing with so many cases in depth.

The four students per chosen class in each grade (see Table 4.1) were selected through the process guided by the ethical considerations and practical requirements regarding their willingness and availability to participate using the invitation letter, participant information sheet, and participant consent forms for parents and students (APPENDIX E and APPENDIX F). An opt-out letter (see APPENDIX H) was sent to their parents. Expert opinions were sought from the teachers who had taught them in the previous year to recommend the pool of students, and since the interviews were to be conducted in the English language, the teachers' were requested to be mindful of the students' competence to communicate in English. The students' science aptitude and class participation were also considered, but not their ability and achievement in science. From the pool of potential participants, the first four students were identified using a criterion-based sampling strategy (Miles & Huberman, 1994) with random stratifying to ensure gender balance and to get consent. The selection from each class stopped when four students had given consent. However, the sampling of students could have favoured more "able" and "higher-achieving" students. Semyang and Namgyel (grade

6), Dechen and Samten (grade 8) and Jitsuen and Kezang (grade 10) had been among the top three performers from their classes during the mid-term examinations. The remaining half of the students still had good science aptitude.

4.5 Data generation strategy

The data sources in this study comprised 17 participants (5 teachers and 12 students), their observed interactions in the classroom, and the curriculum and policy documents. The tools that were used to generate data were the semi-structured interviews, the observation protocols, and the audio/visual devices used during the fieldwork. The data generated were interview transcripts, field notes, audio and video records and anecdotal records. This section describes how these data were generated.

This study is founded on *data generation* rather than *data collection*. According to Garnham (2008), “data generation refers to the theory and methods used by researchers to create data from a sampled data source in a qualitative study” (p. 192). The term *generation* is intended to capture how researchers make meaning of the data in a qualitative study. Data are not discovered but result from interactions between researchers and participants or documents or other objects (Guba & Lincoln, 1989). From the constructivist ontological/epistemological perspective, I decided what was needed for the study prior to the fieldwork and controlled what to record and how to edit and represent the conversations in and as text. Data are not considered to be “out there” just waiting to be collected; rather, data are produced from their sources using qualitative research methods. Viewing data as generated fits assumptions as they involve, at least in part, *reflection* (Hopwood, 2006). Garnham (2008), states that the decisions about the processes and techniques used to generate data are made as part of the construction of the research design. The following processes indicate the ways the data generated in this study:

1. Generating particular accounts of classroom experiences through loosely structured observation oriented towards the research questions;
2. Prompting students to articulate ideas and opinions that may otherwise have remained silent through semi-structured interviews;

3. Generating meaningful data from the science curriculum and education policy documents; and
4. Recording the details of interactions that transacted in the classroom using audio/visual equipment to extract meaning during detailed analysis to answer the research question.

"Generating" is a useful term, as I actively engaged in constructing meaning about the incidents in the classrooms and, in doing so, I abided by my ethical values, assumptions, positions and the theoretical considerations. Garnham (2008), states that the researcher constructs knowledge of the social world using research methods and techniques as s/he engages actively with the data sources. Furthermore, data generation was guided by the theoretical considerations and conceptual framework for this study, which were aimed at finding answers to the main research question. Table 4.3 given below illustrates the data generation strategy.

Table 4.3 *Data generation strategy*

Sl. No	Data Sources	Methods	Tools	Data generated as
1	Participants	Semi-structured interviews	Interview questions	Transcripts
2	Classroom interactions	Observation Video Recording Audio Recording Photography	Observation protocol Camcorder Sony Audio Recorder Mobile phone	Field notes Video Records/transcripts Audio Records/transcripts Photographs
3	Documents	Web search Physical	Electronic gadgets Manual	Memos and Synoptic Units[1]

The use of multiple methods is often cited as a strength of case study research (Stake, 1995; Yin, 2018). As shown in Table 4.3 it is a key feature of this study. The lesson observations focused on identifying pedagogical practices, triggers, and indicators of students' interest and engagement in science, whereas the interviews confirmed the observations by giving voice to the student's cognitive processes through their thinking

[1] Summaries extracted from data that relate to the study that you are interested in, written in own words

aloud. Driver et al. (1996), argue that studies based on observing and discussing classroom experiences have different strengths from those that use researcher-designed probes to generate data. The common goal of these two strategies was to identify the video lesson for in-depth analysis. According to (Punch, 1998), data from one technique can inform the interpretation of data from another technique and that data from the different techniques can corroborate each other.

4.5.1 Semi-structured interviews

Semi-structured interviews were used to complement the observations and to follow up issues that emerged during classroom activities and interactions. Interviews play an important role in exploring students' understandings and perceptions of the constraints and affordances affecting them across a range of learning settings (Pressick-Kilborn, 2010). Four interviews were conducted every week, except for the first and last weeks, when the teachers were also interviewed. Adhering to the observation schedule, I interviewed the four participants in each of the grades I observed. A loosely structured interview protocol was used to conduct the interviews (see APPENDIX A), all of which were scheduled according to the convenience of the participants and conducted in an open office space in the primary block or in the administrative block of the school. I made sure that we sat sideways along the same line rather than sitting across from each other to avoid seeming to have a more authoritative position and to create a conducive environment for the free flow of ideas. As we talked, we mostly looked at classroom pictures or moments on my laptop screen, ignoring the audio recorder that was kept some distance away. The photographs and still moments were identified during observation recording and also through initial analysis of the video recordings to confirm the indicator and triggers of interest and engagement. Other times, the moments were picked as students themselves identified the most interesting moment in the lesson. For example, the moment where Norbu asked clarification question, "What is the meaning of hypothesis?" in the SGD vignette (see section 7.2.1). This moment was observed as student's cognitive activation that indicated student's interest in the lesson.

Active listening, sharing personal stories, and talking about my own children helped the students open up, even though some had difficulty expressing in the English language. There were instances where the interview had to be stopped mid-way and continued later or had to be rescheduled when the participant was not comfortable. Except for a few, the interviews were conducted after the school hours, ensuring nil or minimal disturbances to academic and co-curricular activities. For the student participants the duration of the interviews ranged between 15 minutes and approximately 35 minutes.

The teacher participants were interviewed twice – in the first and last weeks of the fieldwork. The first round of interviews was held in early March 2019 and the second round towards the end of May 2019. Their interviews were between 35 and 80 minutes and were held at locations convenient locations of their choice. Most of the interviews happened in the physics laboratory, the office space provided to me in the administrative building, or in the conference room. As with the students, I made sure to sit sideways with the teachers looking at either the interview questions on my laptop or the class photographs. Since the quality of data generated through these interactions would depend largely on the rapport developed, I also shared personal stories and experiences as a science teacher to ensure that the teachers were comfortable to share their views when asked. Table 4.4 shows the number of interview transcripts generated as a result of the semi-structured interviews.

Table 4.4 *Semi-structure interviews*

Sl. No	Participants	No. of participants	No. of rounds of interviews	Total interviews
1	Teachers	5	2	10
2	Students	12	4	48
Grand total				58

To conclude, all interviews were loosely semi-structured, I followed my interview guide to steer and keep relevant the participants' comments, and I actively listened to their responses in order to pose follow-up questions or to probe for further clarification (Thomas, 2011). The participants reflectively responded to the questions that I posed, thus generating ideas during the interviews or shaping their responses to what was said earlier. Hence, the data may be considered to have been generated using intellectual, analytic, and interpretive activities during the interviews. The audio recording device helped me stay attentive to the participants' responses and thus probe further. This ensured that I could later analyse the essence of each participant's responses.

4.5.1 Classroom observations

The classroom observations of the teaching and learning of science took place in the regular classroom settings (Angrosino, 2005) and in science laboratories. Field notes, still photographs, audio records, and video diaries were obtained using a camcorder, an audio recorder, and a mobile camera. Table 4.5 shows how these multiple methods were used in each classroom.

Table 4.5 *Classroom observations*

Sl. No	Data	Grade 6	Grade 8	Grade 10	Total
1	Field notes	20	30	36	86
2	Still Photographs	16	30	36	82
3	Audio Records	17	30	36	83
4	Video Diaries	20	30	36	86

The details of the data generated using each of these methods will now be explained.

Field notes: In total, 86 field notes (20 – grade 6; 30 – grade 8; and 36 – grade 10) were generated as a result of recording classroom activities during the 13 weeks of fieldwork. The observations focused on the informal recording of important facets of what happened during the formal lesson time (Thomas, 2011) and were loosely guided by the observation protocol (see APPENDIX B). The observation protocol was designed specifically to look into the pedagogical practices of the teachers, as well as the triggers and the indicators of students' interest and engagement in learning science. Basically, four indicators of interest namely; focused attention, concentration, enjoyment and cognitive activation, drawn from the literature were used to identify the pedagogic practices that triggered interest and engagement among students. The field notes were maintained in a separate notebook that recorded the participants, periods, lesson topics, dates, locations (either classroom or in the laboratory), activities, interactions, behaviours, conversations, processes, and institutional structures (Creswell & Poth, 2018; Schensul & LeCompte, 2012). During lessons, I sat at the back of the classroom, noting the teachers' and students' utterances and actions, and during the student's activities I interacted with the participants (including the teachers) and took their photographs. I attended to the non-participating students only when they asked for help or were struggling.

In the entire 13 weeks of lesson observations in each grade, I took part in all the participants' science lessons, noting their daily activities, rituals, interactions, and events to understand the explicit and tacit aspects of their routines and cultures (DeWalt & DeWalt, 2011). The observational data included both the verbal and nonverbal cues that would provide contextual knowledge of events. In conjunction with interview data, these facilitated the gaining of deeper understandings of the activities and their meanings (Hoepfl, 1997). The field notes were also intended to assist interpretation of the video recordings. During the field work the time table changed three times (see APPENDIX I) affecting the data generation plan (see APPENDIX J).

All of the 86 lessons I observed were planned and delivered by participating teachers, who also happened to teach the other grades (see Section 4.4.3). In addition to taking the field notes, I supported the teachers by arranging teaching-learning materials for the lesson or by guiding students during group or individual activities. Mostly I stayed around the participants' table supporting them or taking notes and photographs. On a few occasions, I also supported other groups.

Still photographs: Photographs complement the spoken word and enable a richer, more holistic understanding of participants' world (Keegan, 2008). In this study, I used still photographs to complement the interviews and video recordings. The photographs taken during each lesson were filed together as a set. In total, 82 sets of photographs were generated, with each set having two to 12 photographs. They were taken using my mobile phone, from different angles to those captured in the video recordings to offer visual variety. I decided to include the photographs after realising that the fixed video camcorder did not allow the activities happening at the table to be seen close-up or from different angles. These photographs were used to elicit explanations of incidences that occurred in the classroom during teaching and learning, and to prompt discussions about the meaning of content. Along with still images from the video recordings, some photographs featuring de-identified participants have been used in this thesis to elaborate the findings of this study.

Student discussion audios: In-class audio recordings have been used successfully in other studies, particularly in science (Driver et al., 1994). In this study, 83 student discussion audios were generated to capture the verbal activities at the participants' table that the camcorder could not record because it was at a fixed distance from the groups. The voice recorder was left on the participant's table during the science lessons to capture the contents and tonal variations of the group discussions, thereby adding to the richness of the data generated through other methods, especially the video recordings.

Video diaries: Researchers and teachers in science education have reported the benefits of capturing and evaluating classroom activity using videotape (Elmesky, 2003). In this study, 82 video records (20 – grade 6; 26 – grade 8; and 36 – grade 10) were generated during the fieldwork. This was researcher-generated recording, as I chose where to place the camcorder and when to record (Gibson, 2005). In every science lesson, the participants occupied the central front table in the classroom to enable me to focus the camera on them and simultaneously capture the teachers' activities both in front of the class and when using the chalkboard. Except for a couple of lessons in grade 6, all the video diaries were generated from a fixed point in the classroom using a tripod stand. These enabled me to look into the pedagogical practices and interactions among the participants while also complying with my ethics approval.

The video recordings helped me capture the conscious and unconscious acts and other non-verbal cues of the participants and their teachers in their natural classroom settings. They also provided denser information and generated more contextual data than the other data sources by enabling me to identify the speakers and see non-verbal behaviours such as posture, gestures, facial expressions, and proxemics, which helped identify the kinds of emotions the participants were experiencing. Another advantage of video recording is durability: I could store and watch them repeatedly. Replaying the event gave me more time to contemplate before drawing any premature conclusions, thus facilitating the iterative approach. However, because the camera was at a distance from the participants, it did not capture their voices, and at times some had their backs turned to the camera. I minimised this limitation by taking the still photographs and placing the recorder on the participants' table, as mentioned earlier.

Documents: The documents shown in Table 4.6 were crucial for understanding the demographic information of Bhutanese schools, the national education policies behind the development and implementation of curriculum and assessment practices, and their impact on the country's classroom practices. They form the secondary data (Schensul, 2008) and were identified using the following framework for gathering evidence (Thinley, 2009):

- The documents can provide useful information to answer the research questions.
- Public and private documents are included as the source of information.
- Access or openness is granted and permission for use is sought whenever necessary.
- The documents are of quality of in terms of trustworthy and representation.

These documents were particularly useful in developing a rich view of the education policy and curriculum framework that influenced the relationship between the students' interest and engagement in science lessons. However, an in-depth analysis of each document was not done.

Table 4.6 *Typology of documents*

Document type	Title of the documents	Authorship	Source
Policies	National Education Policy 2014 & 2019; Bhutan Education Blueprint 2014 – 2024	Royal Government of Bhutan; Ministry of Education (MoE)	Available online in MoE website
Curriculum Documents	Science Curriculum Framework PP-XII Educating for GNH	Royal Education Council (REC), MoE	Available online in REC website
Syllabuses	Textbook and Teacher's guide	REC, MoE	In print and available online
Public Exam Performance Report	Student Performance Report	Bhutan Council for School Examination and Assessment (BCSEA)	Available online in BCSEA website
Historical background and current situation	The History of Bhutan Bhutan at a glance & Population and Housing Census of Bhutan 2017	Karma Phuntsho National Statistics Bureau	Available in print and online

Adapted from Thinley (2009, p. 4)

4.6 Ethical considerations

In preparation for an ethics application, prior approval was sought from the Director General, Department of School Education, Ministry of Education, Royal Government of

Bhutan to generate data from one of the four carefully selected schools (see Section 4.4.1). After securing approval, the principals of the first two schools in the list were contacted as the potential gatekeepers for access to their schools, and written acceptance was sought. However, the principal of the second school was informed that his school would be considered in case the first school principal changed their mind. These documents were also used as supporting evidence to apply for ethics clearance. Ethics approval (see APPENDIX G) was granted for this study by the University of Technology Sydney's Human Research Ethics Committee (Approval number: UTS HREC ETH18-2605) before fieldwork began.

Informed consent: As intended, informed consent was sought from the participating teachers and students, and the parents of these students. All the conditions listed in the Participant Information Sheet (PIS) and Participant Informed Consent (PIC) approved by UTS HREC were explicitly mentioned each time an interview was conducted. This ensured that consent was based on sufficient information and adequate understanding of both the proposed research and the implications for the participants (The National Health and Medical Research Council et al., 2007 (Updated 2018)).

To elaborate on the successful deployment of informed consent, five students were nominated by their previous grade science teacher for grade 6 participation, even though only four were required. Since these students came to see me, I decided to recruit all of them despite the additional data that would be generated. I sent the PIS and PIC through them to get their parent's consent. However, the parent of one student denied consent, which left four participants as desired. In other grades, the first four students identified gave their consent/assent, so there were no recruitment issues.

No harm to participants: Research participants can be harmed physically, psychologically, or emotionally (Babbie, 2016). I was aware that all 17 participants might feel self-conscious about being observed, video recorded and audio-interviewed. They might also experience emotional distress or uncomfortable feelings as a result of being asked to share information. Hence, I avoided asking them to share anything they might not feel comfortable talking about. For example, no students were asked questions about their teachers and the school administration, and likewise, teachers were not asked to share about their colleagues and the school principal. Students did not benefit in any way in the form of assessment, and the teachers did not change their practices. To minimise intrusion, the burden of the time commitment, and concern about talking to the researcher alone, I blended in the natural environment as quickly as possible and scheduled all interviews at the convenience of the participants. As well, they were allowed to bring along a companion or request interviews in an open area. Quite often, the students brought a friend to the interviews.

Confidentiality and anonymity: Since Bhutan is a small country where everyone knows everybody, I made every effort to maintain the confidentiality and anonymity of the participants. They were allowed to choose their own pseudonyms, and information about them was de-identified after transcribing the data. The hard copy information has been secured in a locker that only I have access to, and a soft copy has been saved according to the norms of the UTS eResearch team.

Deception: After I transcribed the first set of interview data, all the transcripts were member checked to ascertain if the participants were uncomfortable with certain ideas being shared and if my understandings corresponded with those of the participants. The participants were asked to clarify what they said in the interview and to confirm the accuracy of my interpretations of the observed classroom scenes and whether my summaries were accurate. Further, in order to generate data overtly using naturalistic observation that would be relatively nonintrusive (O'Neill, 2008), I blended in the classroom environment as quickly as possible to minimise the burden of intrusion. A final report of the findings of this study for the school principal will focus on the positive aspects of the pedagogical practices that sustain students' interest and engagement in science in order to avoid any implications about the school

Accuracy: During the analysis and reporting of the research findings, I avoided fabrications, omissions, and contrivances of data and ensured that the data are accurate and have internal and external validity (Cooksey & McDonald, 2010). As a researcher working alone, it was difficult to ensure interrater reliability; however, I used member check and critical friends to provide consistent and accurate interpretive descriptions. These descriptions were generated through the use of codebook, which comprised of descriptions of codes and their inclusion/exclusion criteria, and synoptic units

(Hopwood, 2018) that summarise the actual events or as the participants described them.

4.7 Approaches to data analysis

This section describes the approaches to data analysis undertaken in this study. The study used a multi-stage progressive process to analyse data (see Table 4.7) with an iterative process built into each stage. A combination of thematic analysis (Braun & Clarke, 2006); three concurrent flows of activity, namely data condensation, data display, and verification or drawing conclusion (Miles et al., 2014); and a practical iterative framework (Srivastava & Hopwood, 2009) within an adapted data analysis spiral (Creswell & Poth, 2018) were deployed. The entire process was guided by the theoretical considerations and the conceptual framework developed in Chapter 3 and derived from POI (Krapp, 2007).

The practical iterative framework (Srivastava & Hopwood, 2009) ensured an appropriate balance between more grounded and more researcher-directed analysis. The following three questions were asked throughout the analysis:

1. What are the data telling me?
2. What do I want to know?
3. What is the relationship between 1 and 2?

These exercises ensured that the approaches to data analysis aligned with the research strategy, thereby enabling within-grade and across-grades analysis. As mentioned earlier, the data was comprised of interview transcripts, field notes, lesson video transcripts, group discussion audio transcripts, and still photographs.

Table 4.7 on the next page outlines the approaches taken in the five stages of data analysis. The ensuing sub-sections elaborate on these stages.

Table 4.7 *Approaches to the data analysis*

Stages	Key feature	Approach
1. Data condensation	Memoing and spreadsheet	Memoing during transcription of interviews and type-up of lesson observations –ongoing Summarising key information about 86 lessons in a spreadsheet for landscape view
2. Preliminary familiarisation with the interview and observation data	Preliminary familiarisation with lessons	Going back through the lessons to identify pedagogical approaches
	Preliminary familiarisation with participants	Open coding of interviews with students and teachers to get a 'sense' of who they are, how students responded to the lessons
3. Analysing lessons for interest and engagement	Identification of indicators of interest and engagement	Linking findings from interview data to field notes and video recordings
	Identification of triggers of I&E	Linking findings from interview data to field notes and video recording
	Mapping lessons according to high/low sustained/brief I&E	Linking interview findings (statement by students) with video recordings and field notes (intensity of indicators of interest and engagement) Duration of activity and the time for which the students were engaged. Support from critical friend to validate findings
4. Granular and synoptic analysis of the lessons identified as high and sustained interest and engagement.	In-depth focus on a particular lesson and a student (AoI)	Identification of key video lessons and participants for in-depth analysis Identification of patterns across high interest and engagement lessons
5. Representations that foreground key concepts in analysis through AoI	AoI for key participants	Established diagrammatic representation to show the relationship among the five components of AoI, and respond to the main research question.

4.7.1 Stage 1: Data condensation

According to Miles et al. (2014, p. 8), "data condensation is the process of selecting, focusing, simplifying, abstracting, and/or transforming the data that appear in the full corpus of written-up field notes, interview transcripts, documents and other empirical material" (p. 8). Further, it involves writing summaries, coding to develop categories and themes, and writing analytic memos.

The initial phase of data condensation focused on memoing and transferring key information from the lesson observation notes to Microsoft Excel spreadsheets. I maintained memos throughout the data analysis process. They comprised short phrases, ideas or key concepts (Creswell & Poth, 2018), or "writing descriptive summary of data in an attempt to synthesise them into higher level of analytic meaning" (Miles et al., 2014, p. 95). I wrote them for each observed lesson and for each interview to remind myself about the unique contribution that the particular lesson or interview might make to this study. In addition, I used the field observation booklet, post-it notes, my diary and the memo facility in QSR NVIVO to record memos.

To obtain a landscape view of all 86 lessons, the summary of the key information from each lesson was transferred to a Microsoft Excel spreadsheet. This provided immediate access to information such as the lesson topic, the pedagogical approaches used in the lesson, teaching-learning resources, and notes on the lesson and the participants. A sample spreadsheet is shown in Table 4.8 in the next page.

Table 4.8 *A sample of spreadsheet generated from field notes*

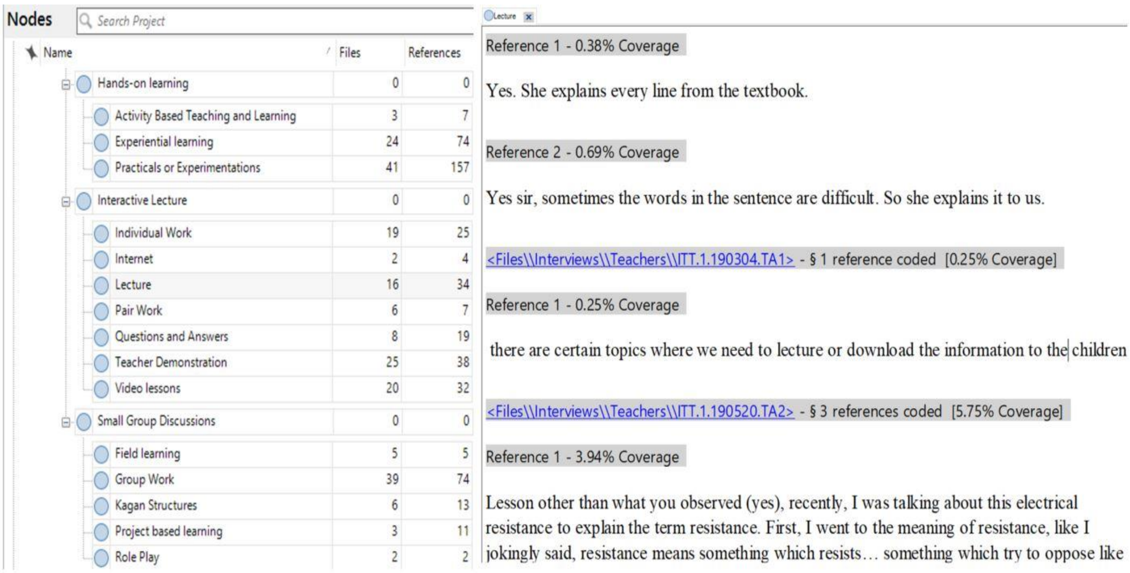
Grade 8							
Topics	Pedagogy	TLM used	Comments	Moments			
				Norbu	Dechen	Samten	Karma
Reproduction in Plants	Q&A, teacher reading and explaining individual reading (IL lesson)	Potato	Huge coverage/ Overloading of information. Can refer for heavy lesson Participants did not do the homework and get down to the task when the time was provided within the lesson.	Helped teacher in recapitulating the previous lesson by responding to questions. Prefers listening to following the teacher in the textbook while she reads and explains Initially hesitant but get back to the individual reading task	Helped teacher in recapitulating the previous lesson by responding to questions. Follows teacher on the textbook when she reads Complies to reading task	Helped teacher in recapitulating the previous lesson by responding to questions Follows teacher on the textbook when she reads Initially hesitant but get back to the individual reading task	Helped teacher in recapitulating the previous lesson by responding to questions Follows teacher on the textbook when she reads Complies to reading task

4.7.2 Stage 2: Preliminary familiarisation with the interview and observation data

This stage involved coding the interview transcripts to develop familiarity with the participants and revising the spreadsheets to advance the process of interpreting the observation data. While coding led to the development of themes, the statements from the interview transcripts provided richer insights to the observation notes by adding the cognitive dimension to what was observed. Both the coded and the spreadsheet data provided organised and compressed information for conclusion drawing and action (Miles et al., 2014).

Before the coding, I read the interview transcripts repeatedly, and wrote reflection notes alongside them to aid my memory during analysis. I then transferred the transcriptions into QSR NVIVO 12 software. Coding was done in two cycles (Saldana, 2009). The first cycle comprised the creation of nodes or codes and the linking of them to the statements, phrases or paragraphs in the transcriptions. In total, 71 codes were created, with substantial overlaps among them. Memos in the form of summaries were either transferred or added to the NVIVO software. During the second cycle, the codes were refined by adding descriptions to each code, which was useful for aligning the text with the codes (see Figure 4.2).

Figure 4.2 *Codes and texts*



After the second cycle of coding, all 71 codes were grouped to form 13 categories and five themes. For example, all activity based lessons, experiential learning opportunities provided to the students and laboratory based practical or experimental lessons were sub-categorised as Hands-on learning (see Figure 4.2). Likewise, IL, SGD and HoL lessons formed the category, pedagogical approaches or signature pedagogies under the theme teaching and learning. Table 4.9 on the next page shows the emergent themes and categories from the data.

Table 4.9 *Themes and categories*

Themes	Categories
Curriculum and policy matter	Curriculum and policy issues
Engagement	Indicators of engagement
	Triggers of engagement
	Types of engagement
Interest	Indicators of interest
	Triggers of interest
	Types of interest
Teaching and learning	Pedagogical approaches
	Assessment practices
	Teaching and learning resources
	Lesson planning
	Lesson Delivery
Gross National Happiness	Gross National Happiness

The five themes were curriculum and policy matters; engagement; interest; Teaching and learning; and GNH (see Table 4.9). Among the themes, the data on engagement, interest, and teaching and learning were rich enough to aid interpretation of the classroom lessons. At this point, I observed that an overlap between the indicators and triggers for interest and engagement, which led to the coupling of them for analytical purposes. While a theme relating to GNH was detected, this was much thinner; either the teachers and students did not respond directly to questions about GNH or they struggled to do so. Furthermore, there was little evidence of purposely led GNH-related ideas detected in the 78 lessons observations, except for the meditation practice in the beginning of the lesson; so this was not taken further as a theme. Although GNH is a key aspect of Bhutan's distinctive approach to education and had been anticipated to be a more prominent feature of the data, I decided to focus on aspects where the data was richest, namely interest, engagement and pedagogic practice. A final theme relating to curriculum and policy was identified in the transcripts of the interviews with the teachers. However, this did not connect coherently with the other themes and was again thinner, so it was noted but not taken further in the analysis.

With the new insights from the interview data, the spreadsheet was again revisited to refine the pedagogical practices and add more information about the lessons based on participants' comments. As mentioned earlier, I used an iterative framework (Srivastava

& Hopwood, 2009) to make meaning of the data and link them to the research questions. This step also involved progressive analysis of the observation data. Stage 1 of this framework focused on the question “What are the data telling me?”, taking an open approach by noting various features of each lesson. In the second stage, the question “What do I want to Know?” was taken up, specifically asking what were the main pedagogic approaches to the 86 lessons?

This analysis identified three main approaches to lessons, or “signature pedagogical practices”: interactive lectures, small group discussions, and hands-on learning. Occasional lessons devoted to tests or pre-test revision were identified and omitted from the analysis at this point, leaving 78 lessons in the analysis. Section 5.4 describes these in more detail.

In this way, the relationship between what the data were telling me, and what I wanted to know changed. Having identified the three signature pedagogies, the next step was to explore how these related to interest and engagement.

4.7.3 Stage 3: Analysing lessons for interest and engagement

Stage 3 progressed the analysis, building on the outcome of stage 2. It was not possible to focus more explicitly on interest and engagement, and to begin processes that incorporated verification and preliminary conclusions (Miles et al., 2014) – these conclusions were not endpoints, but were stable interpretations of the data that determined the next step. Three important components of the data analysis were covered at this stage: (a) identifying the indicators of interest and engagement (b) identifying the triggers of interest and engagement, and (c) mapping lessons across high/low and sustained/brief interest and engagement. The identifications of the indicators and triggers of interest and engagement were guided by readings from the literature and from observations recorded during the lessons (see Table **5.3**). The indicators were then used to trace out the pedagogic practices that triggered students’ interest and engagement in science lessons.

Identifying the indicators of interest and engagement: Data triangulation was used to finalise the identification of the indicators of interest and engagement. Triangulation is a method of confirming findings (Miles et al., 2014). The observation field notes of facial expressions during the interviews and the video recordings of behavioural indicators, verbal responses, excitements and facial expressions were used to confirm the indicators of interest and engagement. These corroborated findings were backed by the theoretical background of POI (see Section 5.5.1).

Identifying the triggers of interest and engagement: The indicators of interest and engagement were used to trace the triggers. Reflection on incidences that led to observable indicators was used to identify the triggers in the field notes that were later confirmed through interviews. I repeatedly watched these moments in the video recordings. Again, data triangulation (field notes, interviews and video recordings) and the iterative approach (Srivastava & Hopwood, 2009) were used to determine the triggers, which varied from lesson to lesson depending on the pedagogical approach used by the teacher. These findings were again supported by POI and they are discussed separately in each of Chapters 6, 7 and 8.

Mapping lessons according to their high/low and sustained/brief interest and engagement: After identifying the presence of interest and engagement and locating their triggers, all 78 lessons were categorised into four groups by placing lessons in one of the four quadrants of a matrix. The matrix had two axes. The first differentiated low and high interest and engagement and the second differentiated sustained or brief interest and engagement. In this way, the lessons were determined to be low/brief, low/sustained, high/brief, or high/sustained. The placing of lessons in the quadrants was strictly based on the intensity of the indicators (focused attention, concentration, enjoyment, and cognitive activation) and the duration or persistence of interest and engagement. All 78 video recordings were closely watched to confirm their categorisation (see Table 5.4 and APPENDIX K for mapping).

This mapping was a crucial part of the analysis because it involved interpretations that would be used as foundations for the next steps. As such, it was important to seek external input to ensure that the allocation of lessons to the quadrants was justified. I engaged two "critical friends" for this process. I gave them a sample of data and asked them to identify the indicators and triggers of interest and engagement. I also asked them to say whether they thought the interest and engagement was high or low, brief or sustained. Rather than relying on numerical indicators, this process provoked a discussion in which differences in interpretation were used to sharpen the analysis by, for example, helping to clarify how high interest and engagement were defined. This reflected the qualitative approach to validity taken up by Brooks and Hopwood (2006).

4.7.4 Stage 4: Granular and synoptic analysis of the lessons identified as being of high and sustained interest and engagement.

The analysis in this stage focused on understanding each signature pedagogical practice more closely through the lenses of interest and engagement. I needed to identify and reveal the layers under each signature pedagogical practice that were responsible for triggering and sustaining students' high interest and engagement in the lessons. After mapping the lessons into high/low and sustained/brief students' interest and engagement, I identified 12 videoed lessons (four each from grades 6, 8 and 10) for granular and synoptic analysis. Three (one each from IL, SGD and HoL) of the four videoed lessons were of high and sustained interest and engagement, and one was of low and brief interest and engagement. Both video and audio recordings were transcribed (see samples in APPENDIX L and APPENDIX M), and I repeatedly watched each videoed lesson keeping in mind the following iterative framework questions (Srivastava & Hopwood, 2009):

1. What are the data telling me?

    What is this lesson video telling me about pedagogical practices?
    What are the indicators of interest and engagement in this lesson video?
    What are the triggers of interest and engagement in this lesson video?

2. What is it I want to know?

    What are the features of the pedagogical practices that triggered and sustained students' high interest and engagement?

3. What is the dialectical relationship between what the data are telling me and what I want to know?

    What are the pedagogic practices under each pedagogy that contributed to triggering and sustaining students' high interest and engagement in the science lesson? Or, what is the hidden layer under the pedagogical practices that triggered and sustained students' high interest and engagement in these science lessons?

The mapping in Stage 2 dealt with the first of these questions: What are the data telling me? It revealed that the three signature pedagogies were not straightforwardly related to interest and engagement. Lessons categorised as being of high and sustained interest and engagement were of all three kinds. Therefore, a new version of the 'What do I want to know?' question emerged: What do I want to know about particular lessons of each kind that made them interesting and engaging in a sustained way? This required a more granular and conceptual analysis. For this purpose, the Action of Interest (AoI, see Section 3.5) became a key focus.

4.7.5 Stage 5: Representations that foreground the key concepts in the analysis through AoI

This final stage involved stepping back from the granular focus on detailed observation and video data by using visual representations to provide a more synoptic view. The chosen vehicle for representation kept the process close to the concepts that had underpinned the analysis, and maintained fidelity to the up-close approach, which favoured depth of insight rather than numerical patterns. For this reason, rather than tables or graphs, a representation adapted from Krapp's (1993) AoI was used. The representation and visualisation of the AoI for each individual participant was a useful exercise in understanding the approach to answering the research questions for this study.

In summary, a multi-step progressive process was used to analyse the data. The thematic analysis used to make meaning of data to generate responses to the research questions was accomplished through coding in the software QSR NVIVO 12. The data were analysed using the three concurrent flows of activity, namely, data condensation, data display, and verification or drawing conclusion (Miles et al., 2014), along with the practical iterative framework (Srivastava & Hopwood, 2009) within the adapted data analysis spiral (Creswell & Poth, 2018). The steps taken to make meaning from the data are shown in Table 4.10 below. Chapters 5, 6, 7 and 8 present the findings of the emergent themes using vignettes and visual representations.

Table 4.10 *Data analysis and representation*

Stages	Activity(ies)	Outcome(s)
Memoing and data condensation	Memoing during transcription of interviews and in the field notes (lesson observation) Summarising key information about 86 lessons in a spreadsheet for landscape view	Insights for further analysis and easy navigation to large volume of data
Familiarisation with participants and lessons	Preliminary familiarisation with the lessons (Going back through the lessons in field notes, making margin notes/creating spread sheet with lesson details Preliminary familiarisation with participants (Open coding of interviews with students and teachers to get a "sense" of who they are and how students responded to the lessons	Categorisation of lessons as IL, SGD and HoL – Response to Research sub-question 1 Participants' profile information, and details of lessons that student participant found interesting and engaging
Analysing lessons for interest and engagement	Identification of indicators of interest and engagement (Triangulation of student interviews, field notes and video & audio recording transcripts) Identification of triggers of interest and engagement (Triangulation of student interviews, field notes and video & audio recording transcripts) Mapping lessons according to high/low and sustained/brief interest and engagement (Student interviews, field notes memo and video & audio recordings)	List of indicators of interest (Focused attention, concentration, enjoyment and cognitive activation) List of triggers of interest (Novelty, challenge, opportunities for social interactions and Cognitive dissonance, choice) Classification of lessons as high/low and sustained/brief interest and engagement
Granular and synoptic analysis	In-depth focus on particular lessons and key student (data triangulation) Identify patterns across higher interest and engagement lessons (data triangulation)	Lesson vignette and student's AoI Response to research sub-questions 2 & 3
Representations of findings	Representations that foreground key concepts in analysis through AoI	Action of Interest for key participants

4.8 Limitations and benefits of the study

This section sets out the limitations and benefits of this study critically and transparently to help readers evaluate it in terms of its scope and applicability for future research (Cooksey & McDonald, 2010).

The first limitation relates to the limited sample size. This study focused on one school, a class each from grades 6, 8 and 10, with four student participants from each grade and their science teachers. Besides, the process of identifying student participants who could provide verbal responses in English language during the interview, led to recruiting students who were mostly high achieving and liked science subject. However, this limited sampling provided opportunities to generate rich data (see Table 4.5), making it possible to spend more quality time with participants in each grade fulfilling the intensity and rigour of ethnographic studies.

Second, the ethnographic case study adopted for this study did not permit empirical generalisation. However, the research strategy facilitated better understanding of both school and the Bhutanese culture. It provided deeper insights into Vajra MSS practices and Bhutanese etiquette and practices. For instance, Bhutanese students are bound by age-old practices that forbids them from questioning their teachers, making them submissive and accepting of whatever the teacher says is correct. Students are expected to maintain a high degree of respect for teachers by greeting them by bowing their heads and standing whenever they communicate with their teachers (Rinchen, 2014). Such understanding helps other researcher understand what works best in similar context.

Third, this study is liable for researcher's interpretation despite ensuring member check and use of critical friends during data generation and analysis respectively. Using varied approaches to data analysis, the rigor was maintained to secure trustworthiness of the findings leading to contribution to existing knowledge. Therefore, novelty in terms of how students' interest and engagement can be triggered and sustained in resource constrained science lesson is considered in this study.

4.9 Chapter conclusion

This Chapter outlined the methodology employed in this research. Starting with my beliefs and theoretical position, I outlined the different levels of the research questions, justified my choice of an ethnographic case study and why a larger scale study was not possible, and delineated the sampling procedures adopted. The sources, methods, and tools used to generate data were explicitly discussed, the ethical issues anticipated and mitigated, and the different stages of data analysis explained. The final section set out the limitations and benefits of the study.

Chapter 5 briefly introduces the participants and explores the varied pedagogical practices in teaching science in Bhutanese classroom thereby, responding to the first two research sub-questions. The findings provides rich insight into practices that promotes interest and engagement in Bhutanese science lessons.

Chapter 5: Learning Science in Bhutanese Classrooms: Pedagogical Practices and Patterns in High and Sustained Interest and Engagement Lessons

5.1 Introduction

This Chapter investigates the different teaching-learning approaches deployed in teaching science across grades 6, 8 and 10 in the observed Bhutanese science lessons. It intends to bring out the lesson patterns that triggered and sustained students' high interest and engagement in those lessons, thereby responding to the first two research sub-questions:

1. What are the main pedagogical practices enacted in Bhutanese science lessons across grades 6, 8 and 10?
2. What are the patterns in terms of how high and sustained interest and engagement relate to these signature pedagogical practices?

Responding to these two questions is critical for looking more closely at each of the signature pedagogies in the following Chapters. This Chapter explores the different ways teachers used the same practices but with varying impacts on students' interest and engagement. It thus promotes a richer understanding of the complex dynamics of interest and engagement in 'real-life' science classrooms in Bhutan.

Section 5.2 introduces the research participants. Section 5.3 provides an overview of the lessons observed in this study, highlighting the typical everyday science lesson. Section 5.4 describes the signature pedagogies in Bhutanese science classrooms and its prevalence across grades 6, 8 and 10 in response to research sub-question 1. Section 5.5 maps the signature pedagogies with regard to intensity and duration of interest and engagement in order to highlight the patterns among high and sustained interest and engagement lessons. The findings of section 5.5 respond to research sub-question 2. Section 5.6 concludes the Chapter.

5.2 Introducing the participants

This participant introduction has two subsections, one each for the teacher participants and the student participants. The introduction of the teacher participants focuses on their demographic information, teaching backgrounds, and accrued beliefs about teaching science. For the student participants, the focus is on their demographic data, their experiences in learning science and their schooling generally.

5.2.1 Teacher participants

This subsection introduces the five teacher participants of this study, focusing on their demographic information, teaching backgrounds and experiences, and their beliefs about teaching science and the use of various pedagogies. The general science subject was taught by one teacher each in of grades 6 (Mr A) and 8 (Mrs B). In grade 10, science was bifurcated into biology (Mr C), chemistry (Mrs D) and physics (Mr E). These teachers specialised in their subjects.

Mr A

At the time of the research, Mr A was 37 years old with a postgraduate teaching diploma specialising in Biology and Chemistry. He graduated from Samtse College of Education (Samtse CoE) in 2004. He participated in this study because he taught science in both classes of grade 6. In the 14 years of his teaching career, he taught mostly biology from grades 9 to 12, had a couple of years of experience teaching chemistry and environment studies, and had begun teaching integrated science in lower grades after taking up an administrative role. Vajra MSS was the fifth school where he continued his administrative position and taught science in grade 6. His other specialisations included participating in curriculum writing workshops and developing the science curriculum for grades 7 and 8, and biology for grades 9 to 12.

Mr A said, "*Students learn well when they have engaged themselves in the process of learning, they have to be engaged in hands-on activities, use all their senses to explore about themselves and their surrounding*". He described his typical science class as having "*much interaction between my students and me. I will be conducting or demonstrating experiments, facilitating group discussions, and students will be doing experiments, asking questions or sharing their ideas.*" He said that primary science teachers have a significant role in making students understand that science is about themselves, their environment, and the world around them; science learning should happen through hands-on and minds-on activities:

> "*Let them touch things, do things, and also let them make mistakes and then learn. That is very important besides the actual learning, that will help ignite the interest, and as long as they have that interest, I think when they go to higher classes, they will take up science…, hopefully, do well in science*".

He also said, "*There is a need to balance between practical work and theory classes across grades, but in reality, the practical classes diminish with an increase in grades.*" However, "*Students enjoy science in grades 7 and 8, but their interest declines when they get to grades 9 and 10.*" He attributed this change to the board examination in grade 10 and the content-heavy abstract curriculum: "*In grade 10, the content becomes more difficult, and the focus of students and teachers gets shifted to board examination, in the process, the fun of learning science is not significant.*" Furthermore, Mr A said that the pubertal changes added to students' deteriorating interest by making them more conscious of themselves: "*They do not want to ask questions unless we ask them and this trend continues in grades 11 and 12.*"

Mrs B

At the age of 36, Mrs B was in her 12th year of teaching, having graduated from Samtse CoE in 2007. She has a Bachelor's degree in primary education with a specialisation in biology and had the broadest range of classroom teaching experience among the five participating teachers. She had taught grades 2 to 9 in two schools, including Vajra MSS, a range of subjects: English, mathematics, environmental studies and Dzongkha to grades 2 and 3, science to grades 5, 6, 7 and 8, and biology to grade 9. During the research fieldwork, she was teaching science to grades 7 and 8.

According to Mrs B,

> "*It is easier to grab the attention of the smaller ones, but it is for a short duration only. And the bigger ones they tend to listen less when we compare with the smaller ones. And it is easier to reinforce the smaller ones. Because they feel happy when we reinforce or give the reinforcement works. And it does not have much impact on the higher ones*".

"*Most students who perform very well in grades 7 and 8, did well in grades 9 and 10 also, and they were getting science in 11 and 12 also. Maybe they are genuinely interested. Those who are scoring low, they end up not getting anywhere*".

Mrs B often deployed Kagan structures:

"*I mostly use that rally coach. Rally coach is guiding one another, either face partner*[2] *or shoulder partner*[3]*. When one solves the problem, the other one guides and takes the turn*".

"*And everyone, they will get time to participate, they cannot hide. Because, they are numbered 1 to 4 so, they will not know whose number will be called by the teacher so should be alert and they should be prepared*".

Her pedagogical choice would depend on the topic:

"*Whenever it is practical or experiment to be conducted on a particular topic, I take them to the lab and perform. First, I demonstrate to them, then provide the equipment and required material to the group, and let the group carry out the experiment.*"

But, she shared that in practical lessons,

"*We have to take students to the lab so in between, time is lost when we don't get enough time - especially in grades 9 and 10 they have only three periods, so it is difficult for them. For us, we have eight periods so we can perform. That also we have a bulky syllabus, so it is a bit difficult*".

Mr C

When interviewed, Mr C was 32 years old and had been teaching for the past 10 years. He graduated with a Biology/Health and Physical Education (HPE) qualification from Paro College of Education in 2009, and Vajra MSS was the second school he had taught at. He had taught science to grades 4, 6, 7 and 8, biology to grades 9 and 10, and HPE to

[2] Another student sitting in-front of you
[3] Another student sitting adjacent to you

the primary grades. For the past five years, he had been teaching biology to grades 9 and 10 students only, and he found that students liked this subject. He reasoned:

> "*Biology is a subject where we learn about ourselves, our environment, how to keep oneself healthy and all those things…, one interesting topic in biology is the reproductive system, whenever this topic comes, students are always full of doubts.*"

To make the lessons enjoyable, he said, "*I relate to stories, jokes that I put so that students love it. They don't feel sleepy in the class so, whatever jokes, funny things I remember in between, I tell them.*" He also uses meditation practices to focus the students' attention in the lesson. On the use of Kagan structures with all students participating in the lesson, he said:

> "*A person who does not get up, who's very shy in the class can even have an opportunity to share their knowledge and talk with friends. That's good! However, with the content that we presently have, we will face lots of difficulties in covering the syllabus*".

Mrs D

Mrs D was 43 years old. She graduated from Samtse CoE as a biology/chemistry teacher in 1998. Vajra MSS was her second school after getting transferred in 2007. She had once taught integrated science to grades 4, 5, 7 and 8, biology to grade 9, and had been teaching chemistry for the last eight years at Vajra MSS. She was the head of the science department and co-ordinated all the science-related, school-level professional development activities. During the fieldwork, she was teaching chemistry to grade 10 and integrated science to grade 8.

Mrs D said, "*I am hardworking…, I make sure that I do my duties on time and well*," and she attributes this quality to preparing her lessons well in advance. She was excited to teach grade 8 after a gap of almost 10 years: "*I like teaching science in lower grades. I find students in lower grades very interested in learning science. It could be because of the syllabus or the curriculum-the way they designed the textbook.*" In terms of grade 10 chemistry, she said she was satisfied with her students' performance in state-level assessment thus far:

> "*In the first five years of my stay here, students used to get good marks in chemistry. I don't know why maybe students were little matured, and they used to do well. Now we are getting students who are not interested in chemistry, but still in this Dzongkhag [district] they say that our school is doing well*".

> "*Most of them perform well in biology and physics and then I am in the safer side because all the three subjects are combined and given as science, so all of them pass*".

Mr E

Mr E was 48 years old and had graduated in 1997 as a physics/mathematics teacher. As a novice teacher in lower secondary school, he taught physics and mathematics to grades 7 and 8. He started teaching integrated science after its introduction in these grades in 1999. His initial experience was: "*I found it quite challenging, particularly with the Biology part because, I did not take Biology and Chemistry, they have put them together. That was quite challenging.*" However, a solution was available: "*Those days I think they even had prepared the teacher's manual. So, we made use of those teacher's manual.*"

Mr E had completed a postgraduate diploma in information technology (IT) through part-time study mode in 2005, which helped him get a transfer to the Vajra MSS in 2007 as an IT, physics and mathematics teacher. That was when he started teaching physics and mathematics to grades 9 and 10 students. He was once the vice-principal of this school, which allowed him to pursue a Master's degree in educational leadership and management through part-time study at the Paro College of Education. Having completed his MEd in 2016, he eventually gave up his administrative position to specialise in teaching. At the time of the fieldwork, he was teaching physics only to grades 9 and 10. He said he is more comfortable with students and enjoys being with them:

> "*I love being with children and I mingle with children more than with the adults, I go to the level of students particularly, while in the classroom and I am not that strict but, at the same time, I can be firm when it comes to the disciplines. In*

terms of academic learning, I am not that strict, because, when we are strict in the classroom, I feel that children don't understand when we are teaching".

In summary, all the teacher participants were mid-career teachers with science background. Four had graduated from Samtse CoE and one from Paro CoE. Their teaching experiences ranged from 10 to 22 years, and each had taught science in grades 7 and 8 at some point in their career. While some had been teaching the same subject in the same grade for over a decade (e.g., Mr E, Mrs D, and Mrs B), Mr C had taught grade 10 biology for last five years, and Mr A was teaching grade 6 science for the first time. All were comfortable teaching their assigned grade(s).

5.2.2 Student Participants

This subsection introduces the student participants. There were four participants (two boys and two girls) from each of the three grades. However, for analytical purposes, only two students (a boy and a girl) were identified from each grade. This subsection presents these six participants' profiles from the interview and classroom observation data.

Grade 6: Semyang

Semyang is a high-achieving student who said she wanted to become a doctor when she grows up. She turned 11 years of age during the fieldwork. She said her favourite subject was science and she preferred autonomy in learning but did not hesitate to ask for help when needed. She would lead the group work mostly, and as a result take the opportunity to handle equipment while doing experiments (see Figure 5.1). She mentioned, "*I like to do things on my own when I understand all the explanations sir says, and I would like sir, to explain it when I do not understand the things sir teaches.*" She said she was a quick learner and preferred to learn kinaesthetically: "*I can catch up immediately and prefer learning practically.*" Besides being one of the class monitors, she was a scout member and went for karate lessons twice a week. Her favourite author was the emerging Bhutanese story writer Chador Wangmo.

Figure 5.1 *Semyang volunteering to be the group captain supported by Namgyel and Phub*

Grade 6: Phub

At 10 years of age, Phub was the youngest in the class. His hobbies included reading storybooks, watching Discovery and HBO channels on television, and playing mobile games. Because science was his favourite subject, he would get to learn new things,. However, Phub was unsure about whether to become a soccer player, an artist or a scientist in the future. He did not like this quality of being indecisive. However, he did appreciate the benefits of learning science, saying, "*If we learn about them, we can become engineers and doctors.*"

Figure 5.2 *Phub and Namgyel volunteering to respond to the teacher's question*

Phub often appeared distracted during the lessons, but he was quick to share his responses. His raising of a hand to respond to the teacher's questions, which he did quite often, indicated his presence in the lesson (see Figure 5.2). During group activities, he always contributed and made sure that members adhered to the scientific procedures by providing instructions. He preferred learning science through watching and doing it practically, and attributed his excellent vocabulary to the Discovery Channel and Word Shuffle – the mobile game that he plays often. He exhibited an excellent science vocabulary among the participants and always came up with the correct term.

Grade 8: Samten

Samten was 14 years old and liked playing soccer. He was a high achieving student with no apparent ambition but was quick enough to mention that science was his favourite subject:

> "*The thing I like about science is the inventions made by the scientists and the physics, and I want to learn more about the inventions in my upcoming science class. I hope that I can do my best to learn science and importantly enjoy science*".

Samten's strategy for learning science was: "*I listen to my teacher carefully and revise what I learnt in the class when I reach home*" (see Figure 5.3). His interest in science was influenced by his science teacher in his previous school. He reiterated: "When I first started learning science, I didn't have much fun in learning science but, my first science teacher's teaching attracted me towards science. So, from then, I am enjoying science."

Figure 5.3 *Samten concentrating on teacher's explanation*

Grade 8: Norbu

At 13 years of age, Norbu was confident about reading and writing at her level, and she said she liked taking part in writing competitions: "*I am very good at reading and writing. I am writing another story. This time I am participating in the International essay writing competition on making a kinder society*" Her hobbies were singing and writing, and she aspired to become a doctor and a writer. Her favourite subjects were science and English.

Norbu frequently volunteered responses to the teacher's questions (see Figure 5.4 left). The teacher also looked at her when no one volunteered in the class. When asked what gave her the confidence to participate in the question-and-answer session, she said, "*Sometimes I can just figure out what madam is going to ask. So, I just ready my* *answers before that.*” She was appreciative of what the teacher did to enhance their learning: “*She shows us examples. Even when she couldn’t, she showed us videos so, it is easier to understand with her teaching.*” She also actively participated in hands-on learning by taking the initiative to lead the experiment most of the time (see Figure 5.4 right). She said she liked learning on her own: “*I study almost by myself.*”

Figure 5.4 *Norbu responding to the teacher's question (left) and getting the chemical for the experiment (right)*

Grade 10: Yiga

Yiga aspired to be an army doctor and liked reading during her free time. At the time of fieldwork, she was 13 years old, and she said her favourite subject was biology: “*Biology is important if you want to be a doctor.*”

Figure 5.5 *Yiga responding to the teacher’s question (left) and note-taking (right)*

Yiga was diligent in her studies. She often volunteered to share her responses during the lesson and actively engage in note-taking (see Figure 5.5). She said she liked coming to school because

> "*We get to learn certain knowledge that we cannot learn from our parents and family and we can even socialise without using the phones and other stuff. We can develop certain characteristics by coming to school and, we can also learn good things from our friends, and there are people we can look up to*".

Grade 10: Kezang

Kezang turned 15 years of age during the fieldwork. As a high achieving student in the class, he considered himself nerdy, and, as with many students of his age, he liked spending time with electronic gadgets (his current interest was "Time Machine"). He aspired to be a data analyst but appreciated his grandfather's desire for him to become a doctor. His favourite subjects were English, science and information technology (IT). His interest in science began with the encyclopaedia his parents bought for him when he was in grade four. He said:

> "*Ask me anything, there was this encyclopaedia about science. It is actually what made me interested in science. I read the book at least seven times*".

> "*It all started with physics so, it was the first real science that I read and studied about. Soon I also discovered scientists such as Albert Einstein, Stephen Hawkins…, read some of their biographies, watched some of their films and that's when I started to like science*".

Figure 5.6 *Kezang seeking clarification from teacher (left) and paying focused attention (right)*

Kezang exhibited critical thinking and sought opportunities to pursue and learn more about the topic by questioning the teachers (see Figure 5.6 left). He often used different approaches in solving numerical problems compared to the ones used by his teachers. He was always focused and attentive in lessons during the fieldwork (see Figure 5.6 right side), and Mr E complemented him for his critical thinking.

In summary, all the student participants mentioned science as their favourite subject, along with additional subject(s) for some of them (e.g., Norbu and Kezang), and most anticipated a science-related career in the future. It was evident that some chose science as their favourite subject because of their ambition, while for others it was the marks that they could score in the subject assessments, the new learning they could gain from it, or the influence of significant others such as their teachers and parents.

5.3 Overview of the lessons

In this section I provide an overview of the lessons I observed. I first describe the lesson timing changes that were implemented across the country by the Royal Education Council (REC) and how these impacted pedagogical practices. The second part provides topical information on the content covered, and the third part is an outline of the general trend in lesson delivery across the grades.

5.3.1 Timetabling issues and challenges

Timetabling and lesson duration (duration of each scheduled teaching and learning period) are vital to a teacher's pedagogy. During the fieldwork, the timetable changed three times due to teacher transfers (see APPENDIX I). The last change happened on April 18, 2019, when the REC notified schools to implement the rationalised curriculum and revised instructional time from May 1, 2019. The notice mandated the standardisation of each period for 40 minutes and specified the number of periods for each subject (e.g., science in grades 6 and 8 would have six and seven periods respectively, and there was no change in the number of periods for grade 10 biology, chemistry and physics). Each science subject would have only three periods per week. The revised timing was the outcome of the curriculum thinning executed in 2018 by the REC based on the Bhutan Education Blueprint 2014–2024 and the National School Curriculum Conference 2016. As a result, the time duration allocated to grade 6 science was increased by 5 minutes per week, grade 8 science was reduced by 100 minutes per week, and grade 10 science was reduced by 20 to 25 minutes per week.

Furthermore, there was a mismatch between the time allotted in the grade 10 chemistry/physics textbook (4,320 minutes) and the revised instructional time (3,600 minutes). Except for Mr A, the rest of the teacher participants expressed that they would complete the syllabus; however, they said that the lessons would be more teacher-centred. With the reduced time, it was observed that it would be challenging for Mrs D to complete teaching the curriculum in the remaining time unless she strategized other means to ensure it.

5.3.2 Content coverage

Included in the 86 lessons observed during the fieldwork were 34 topics within 16 textbook chapters across grades 6, 8 and 10. Table 5.1 on the next page highlights the main topics and sub-topics covered in the three grades.

Table 5.1 *Details of topics covered during field work*

Grade	Subject	Chapter	Topic(s)
6	Science	Chapter 1: Elements, Acids and Alkalis	1.1 What elements are made of 1.2 Elements and their symbols 1.3 Acid and alkalis 1.4 Indicators for acids and alkalis 1.5 Make your own indicators
		Chapter 2: Chemical change	2.3 Hard water and soft water
		Chapter 3: Separating mixtures	3.3 Density of solids in different liquids 3.4 Separating soluble solids 3.5 Separating immiscible liquids 3.6 Separating miscible liquids
		Chapter 4: Mass and Weight	4.2 Relationship between mass and weight
8	Science	Chapter 2: Human as an organism	2.5 Sense organs 2.6 Environment, lifestyle and health
		Chapter 3: Green plants	3.1 Absorption by roots 3.2 Organic and inorganic farming 3.3 Reproduction in plants
		Chapter 4: Living things and their environments	4.1 Adaptation and survival
		Chapter 5: Classifying materials	5.3 Chemical equations
		Chapter 6: Materials and change	6.1 Solubility 6.2 Chemical reaction
10	Biology	Chapter 3: Humans as organisms	3.2 Blood and Circulation 3.3 Excretion 3.4 Respiration
		Chapter 4: Response and coordination in humans	4.1 Nervous system 4.2 The hormones
	Chemistry	Chapter 2: The mole concept and stoichiometry	2.3 Percentage composition, empirical formula and molecular formula 2.4 Calculations based on chemical reactions
		Chapter 3: Metallurgy	3.1 Introduction 3.2 Metallurgy 3.3 Electrolysis
	Physics	Chapter 2: Pressure and its application	2.2 Application of Pascal's law (Hydraulic jack and its working)
		Chapter 3: Energy	3.1 Work, Power and Energy 3.2 Energy conservation
		Chapter 4: Electricity and Magnetism	4.1 Flow of electric current

Grade 6 integrated science has 12 chapters divided into 60 topics, an average of five topics per chapter. Within two months, Mr A had completed teaching the first three chapters and was into the fourth chapter. With this gain in time, he was confident about covering the syllabus before the final standardised assessment. The fieldwork recorded the teaching of 11 topics, of which only one was from physics; rest were from chemistry, which explained the frequent visit to the chemistry laboratory and the use of its equipment. The first three chapters were distinctively chemistry focused, as observed in both the teacher's manual and the student textbook. For this reason, the discussions related to classroom pedagogical practices in this thesis will be on the chemistry lessons for grade 6.

Grade 8 integrated science has three units divided into 13 chapters (37 topics), and the field observations noted the completion of the biology and chemistry portions in the curriculum document. The first round covered biology lessons, and the second round saw the completion of chemistry lessons, as per the chapter sequence in the textbook. Mrs B confirmed:

> "*Our textbook is divided into three parts; the first part is all with biology only so last time when you were there, my part was with biology only, that's why I took to biology lab. The second middle part is with chemistry, so now most of the experiments are happening in chemistry because all the middle portion is with chemistry. And the last portion will be dealing with physics so, we will be coming back in this lab only [indicating the physics laboratory]*".

Therefore, the analytical discussion for grade 8 includes both the subject (biology and chemistry) to capture the variation (if any) in classroom pedagogical practices.

Even though Mrs B lost a period per week due to the notification from the REC, she was more concerned about grades 9 and 10 and how the teacher of those grades would manage. Having completed six chapters and looking forward to covering another chapter before the mid-term assessment, she said she was comfortable with the coverage, even though she was planning to rush it.

Grade 10 biology has seven chapters divided into 21 topics, of which Mr C had almost completed 13 topics (chapter four). He said he was comfortable about completing the syllabus on schedule, despite the reduction in time, and was looking forward to taking students to the laboratory to carry out some practical lessons.

Grade 10 chemistry has nine chapters with 36 topics. Having reached just the third chapter and completed 10 topics, Mrs D said the REC notification added pressure to her existing worry about covering the syllabus. During the second interview, she said, "*I am worried now. Today, I am thinking of taking an extra class – from today. Again, children are burdened, and there is no time after the 8th period.*" However, she was willing to strategize and complete the syllabus before the final standardised assessment. It was apparent that Mrs D had no choice other than to take additional classes to complete the syllabus.

For grade 10 physics, Mr E said he was comfortable with having reached four chapters out of six. When asked if he would complete chapter 4, he said, "*Yes! I can finish it.*" It was observed and Mr E confirmed that the content in physics curriculum was reduced over time to minimise content and also avoid redundancy.

Since there were marginal variations observed in how these three science teachers taught their lessons, a lesson from each subject that had triggered and sustained students' high interest and engagement was identified for deeper analysis. Coincidently these lessons matched the dominant signature pedagogical practices of the teachers, as will be discussed later in this Chapter.

In conclusion, taking curriculum content and time allocation into consideration, it was observed that the grade 10 chemistry syllabus was too vast to be covered within an academic year, as was expected in the textbook. This was closely followed by the grade 8 integrated science syllabus. There was a need to balance the curriculum content with time allocation; otherwise, the focus would have been more on syllabus coverage than on the students' learning.

5.3.3 A general trend in lesson delivery

An emerging pattern across all five teacher participants, regardless of grade or topic, was evident in the ways they taught their daily lessons. The lessons can be divided into four phases: pre-teaching, introductory, lesson development, and lesson conclusion. The following sections briefly describe each of these phases.

In the *pre-teaching phase* it was customary for students to stand and greet the teacher as s/he entered the classroom. This was followed by the marking of attendance in the class logbook. Some teachers simply inquired about the absentees (grade 6 and 8), some counted (physics), and some made the students count themselves (biology). The attendance check was followed by a brief mindful meditation that lasted between 30 seconds and a minute. The meditation practice required students to sit up straight, gaze in front of them and focus on the air entering and leaving their lungs.

The *introductory phase* comprised the revisiting of the previous lesson by asking a few questions, such as, "What did we do in the last class?" or "Who can tell, what we learnt in the previous lesson?" This was followed by introducing the day's lesson topic, either by telling directly or asking, "What is today's topic?" The teachers mostly wrote the topic on the chalkboard. They often quickly checked the prior knowledge on the topic or related it to previous learning or personal experience using the questioning technique. In a few cases, the teacher used think-pair-share activities or group work to find prior knowledge on the topic (e.g., discuss in your table group: What is the smallest thing in the world? Where is it found?).

The *lesson development phase* occurred as the lesson progressed to generate conceptual understanding, the development of skills and procedures, or values associated with the content learning, with the teachers adopting different pedagogies depending on the content information and the curriculum instruction. In this phase, the actual teaching and learning of the content took place. Some of the varied teaching and learning approaches deployed were:

- use of the questioning technique (e.g. Popcorn method[4] or simply a question and answer session) to generate whole-class discussion as the teacher related the content to prior knowledge or previous experience of the students or summarised the learning activity,
- teacher explanation using the chalkboard or teaching-learning materials (real objects or models or charts) that included the sharing of anecdotes and storytelling,
- teacher reading and explaining the text word by word,
- teacher demonstration (an experiment or solving numerically on the chalkboard) and watching a YouTube clip or pre-recorded video clippings,
- individual problem solving (peer demonstration), reading, drawing diagrams or note-taking task/pair work (e.g. think-pair-share with shoulder partner or face partner),

[4] All students sitting in a group (group of four students) could be identified with the table number (number of table depends on the class size) and the student number (1-4). Teacher calls the table number and student number to pick a student to respond to the question.

- small group discussion (e.g. round-robin, Jigsaw, round-table discussion, rally coaching, and brainstorming); these activities usually used BINGO[5],
- teacher instruction followed by experimentation/practical work or hands-on learning (HoL).

The information inputs or the learning outcomes of the activities were again summarised by the teacher using a question and answer session. Mostly, the teacher asked questions and the students raised their hands for the teacher to select one to respond. In a few cases, students asked the teacher clarification questions.

The *lesson conclusion phase* also showed teachers taking different approaches to close their lessons. Mr A mostly stopped the teaching a few minutes before the bell (indicating the end of the period) to summarise the lesson, revisit the lesson objectives, and sometimes provide information on the following lessons. Mrs B went with the lesson's flow and did not have a particular way of closing the lesson. If the bell rang while students were in the middle of some individual activity (e.g. drawing or solving numerical), she would assign them homework. At other times, she ended the lesson with "cheers"[6] or simply mentioned that it would be continued in the following lesson. When she had plenty of time, she would also introduce the next lesson. In grade 10, Mr C, Mrs D, and Mr E often tried to summarise their lessons. However, they frequently went on teaching after the bell rang and mostly asked students to continue the task as homework. At times during this phase, Mr E made his students summarise the lesson, Mrs D talked about the next lesson; and Mr C used anecdotes, story(ies) or hand signals to end his lessons.

From this analysis of the general trends in lesson delivery, three distinctive pedagogical practices were evident across all the lessons observed. The lessons were either dominated by teacher explanation (interactive lecture, IL) or had components of small-group discussion (SGD lasting for more than 25% of the lesson duration, or involved students in hands-on learning (HoL). In this thesis, these three pedagogical practices are

[5] Students shout BINGO at the end of the activity to signal that they have completed the task. It is used as a timed group activity that pushes the students to complete the activity quickly.
[6] In the Kagan structure, to celebrate the successful completion of an activity students perform different "cheers".

collectively termed the signature pedagogical practices (SPP) used in teaching science in the lessons observed and they are described next.

5.4 'Signature pedagogical practices (SPP)'

This section responds to the first research question, "What are the pedagogical practices enacted in Bhutanese science lessons across grades 6, 8 and 10?" The three signature pedagogical practices identified in Section 5.3 were interactive lecture (IL), small group discussion (SGD) and hands-on learning (HoL). This section briefly describes each of these, as observed during the fieldwork, the intention being to bring out the unique features of teaching science in a Bhutanese classroom with limited resources. Taking one practice at a time, I will first describe it and what it encompasses. I will then explain how it is enacted in the Bhutanese classroom across the grades, and finally, I will map the practice across grades and the lessons in terms of frequency and variations (if any) to identify the emerging patterns.

5.4.1 Interactive lecture (IL)

The category IL includes lessons that involve a significant component of teacher-led pedagogy and engage students as active participants in various ways. Macdonald and Teed (2020), define ILs as those classroom interactions in which the teacher breaks the lesson at least once to have students participate in an activity. In an IL, the teacher might demonstrate using concrete materials (laboratory equipment or working models); explain using teaching-learning materials (charts, audio-visuals, chalkboard or textbook); generate whole class discussion (e.g. questioning); encourage individual problem solving (e.g. balancing chemical equations, reading text individually, or solving numerical); or initiate pair work (e.g. shoulder partner or face partner discussion). In these ways, IL lessons allow students to relate their learning to prior knowledge, build new knowledge, evoke questions and apply new learning to real-world situations. They are not entirely teacher-talk and they encourage students to be equally responsible for creating their knowledge. Some examples of IL lessons observed in this study will now be presented.

In grade 6, Mr A deployed different ways to engage students in his IL lessons. In most of these he used the chalkboard to highlight the discussion points and questions by drawing diagrams to engage the students by elaborating a point or demonstrating the solution to a numerical problem. In one lesson, he used a picture drawn on chart paper to illustrate how the separation of miscible liquids is carried-out using a distillation flask. Mr A also demonstrated the separation of immiscible liquids using a separating funnel in the laboratory (see Figure 5.7). He ensured that all students could see the demonstration and occasionally asked questions to engage and interest them. Finally, the students recorded the observations in their individual notebooks.

Figure 5.7 *Mr A demonstrating separation of immiscible liquids using a separating funnel*

In grade 8, Mrs B mostly read from the textbook and either explained the content word-by-word or elaborated on it. At times she would use the chalkboard to illustrate or build on the explanation. She kept the students engaged through questioning or leaving the last few words of the sentence for students to complete as a choral reading. The other pedagogical approaches she frequently used were "rally coaching"[7] and "popcorn questioning" from the Kagan structures. She demonstrated the experiment twice; the first time using the Bunsen burner, even though there was only one working in the laboratory. She said:

[7] Usually done in pairs with the shoulder partner. One of the partners coaches or helps the other in solving numerical or other problems, taking turns.

"*The problem is with that Bunsen burner… if it is sufficient for all the group, it will be better for them to experience themselves only. So, whenever the heating experiment comes, we have to do the demonstration only because the Bunsen burner is not sufficient*".

The second demonstration showed the solubility of sugar in ethanol, despite the limited amount of ethanol in the laboratory. A couple of times, Mrs B took the students to the biology laboratory to show video clips on sense organs and osmosis. To one of these lessons she brought a tuber to show the eye of the potato. She said, "*I felt that we need to have some activities with the lecture also because most of the students they enjoy doing the activity, whatever they learn, they can retain in their mind for a longer period.*" She often gave individual tasks to her students.

In grade 10, the teachers used the pre-written flipchart or butcher or chart paper or to elaborate on the lesson. Mr C used the flipchart, Mrs D was seen with butcher's paper mostly, and Mr E occasionally used the coloured chart paper. All of them used the chalkboard to illustrate their explanations and to note the key points of their lessons (see Figure 5.8).

Figure 5.8 *Teachers in grade 10 using flip charts and butcher's paper to vary interactions*

Mr E used a hydraulic pump model to demonstrate the working of a hydraulic machine, and a dry cell to explain the electrical property potential difference. He deployed the questioning technique and often asked students to solve numerical equations or to read the textbook individually. Mrs D also used questions to engage students and called for volunteers to share their work on the chalkboard. She also focused on individual problem solving or reading. In a few classes, she used rally coaching and think-pair-share activities. Mr C used bodily gestures and facial expressions to share stories and anecdotes related to the lesson content. Participants often found his actions and stories engaging, and as a result nominated his lessons as most interesting during their weekly interviews. He also assigned individual reading and deployed questioning skills to assess the students' learning.

For the purposes of categorising which of the lessons that had a significant component of being teacher-led or teacher-instructed IL lessons, the observation record shows that six of 16 lessons in grade 6; 11 of 26 lessons in grade 8; and 28 (9-Bio+8-Che+11-Phy) of 36 lessons in grade 10 were taught through IL. There is also evidence of Mr A using a variety of IL approaches, while Mrs B frequently read from the book, explained and asked questions to engage the student. In grade 10, Mr E, Mrs D and Mr C relied on newsprint paper or a flipchart to engage students and enhance their learning.

5.4.2 Small group discussion (SGD)

SGD describes lessons where students are involved in face-to-face discussions on a specific topic with more than two students per group for at least two minutes (Bennett et al., 2010). In this study, teachers organised SGD to access the students' prior knowledge, link learning to everyday life, or to check the students' understanding of an assigned task. These may have required more teacher-led introductions, set-ups and plenary discussions, but the key feature of the lesson was the discussion among the students. This required students to exchange ideas and consider others' perspectives, building their intra-personal and interpersonal (social) skills to foster values of interdependence and happy coexistence (Department of Curriculum Research and Development, 2012).

Most of the small group discussions occurred within the table groups, based on the proximity of seating arrangement and the difficulty level of the task. The teachers varied the interactions among the group members by following Kagan structures such as brainstorming, round-robin and rally coaching. When the teacher assigned pair work, the students took the opportunities to discuss as whole table groups. The use of cooperative learning (Jigsaw strategy) was observed in one of the grade 10 lessons; however, most of the discussion occurred as a table group discussion.

In grade 6, only three of the 16 lessons were SGDs. Mr A engaged students as a table group (four members) to discuss and come up with responses to the activity questions or to discuss the procedural steps in carrying out an experiment (e.g., separation of soluble solids). Mr A moved around, encouraging the participation of all members in each group and responding to students' queries. He was often observed listening attentively to group proceedings. After assessing the progress of the groups, he would stop the activity and proceed to consolidate each group's findings. The students shouted "BINGO" to signal the completion of the activity.

Grade 8 had nine of 26 lessons using SGDs. To facilitate SGD, Mrs B used timed "BINGO", or round table discussions, numbered head/table rally robins, or simply table group discussions. She deployed SGD as she read and explained from the textbook and encountered the activity questions. She would use one method to assign group discussion, followed by group presentation and consolidation of findings. As the students discussed a topic (see Figure 5.9), Mrs B went around the class but mostly refrained from interacting with the groups. Her interaction with the students occurred when one of them presented their group's findings. However, when some groups raised doubts, she was there to support them. Students often discussed in their group or mouthed the answers to each other, even when they were forbidden to do so.

Figure 5.9 *Participants engaged in small group discussion in grade 8*

Only five (3-Bio, 1-Che & 1-Phy) of the 36 lessons in grade 10 used SGDs. In a chemistry lesson, Mrs D used the jigsaw method, which allows students from different tables to interact, forming home and expert groups. Consolidation of the activity by Mrs D helped the students to comprehend the content of the discussion. Another variation of SGD had Mr C challenging a table group to come up with a creative presentation in the form of song, poem, or short play when they discussed "regulating glucose in the blood". After the group's presentation, Mr C highlighted the key points of the lesson. Otherwise, the remaining SGDs were table group discussions, where students complied with the assigned task (e.g., coming up with responses to the questions, recollecting past learning, or solving numerical together).

Compared to other grades, SGD was more prominent in grade 8. Mrs B used various ways to make the group members interact, even though they were mostly working in the same group. However, new variations were observed in grade 10 in terms of the jigsaw method and creative presentations.

5.4.3 Hand-on learning (HoL)

The third pedagogical practice in Bhutanese science lesson was HoL. All the lessons that allowed students to handle the scientific equipment or manipulate the materials while attempting to learn the lesson contents were classified as HoL. These lessons required students to participate significantly in the learning process by using prior knowledge and constructing the meaning of the new experiences (Holstermann et al., 2010). In most cases these lessons took place in the laboratories (chemistry and biology), and in a few instances the materials were made available within the classroom for students to interact with. Due to limited materials or equipment, most HoL lessons were group activities, and in some cases individuals were appointed by the teacher to conduct the entire practical work.

The classroom HoL lessons were done as table groups and were the lessons that had adequate equipment. By contrast, the lessons conducted in the laboratory had fewer sets of equipment and the group size was observed to be larger, with most practicals in the laboratory having a minimum group size of six students. Taking the teaching-learning materials to the classroom or visiting the laboratory for HoL excited students, triggering interest and engagement in the lesson.

Of the six HoL lessons conducted by Mr A in grade 6, five were in the chemistry laboratory, and one was in the classroom. All were group activities; three were peer demonstration, and in the other three everyone in the group had an opportunity to conduct part of the experiment. Before the experiment, Mr A provided explicit instruction to the students, checked their understanding, and allowed them to experiment completely dependent on the group leader (the captain) to ensure the smooth completion of the activity. He said, "*They take turns, but the captain ensures that the experiment is conducted properly from the start till the end.*" As students engaged in the HoL, he moved around the groups guiding and correcting them and ensuring they were on track for timely completion of the activity. After summarising the activity, he usually asked the students to complete the written component as homework.

Most of the teacher participants believed that the lower grades had more HoL activities compared to the higher grades. For example, Mr E said, "*I think from class 4 to 6, science is more practical and activity-based, content information is quite less I think – a lot of activity.*" And Mrs B said, "*But once they reach [grades] 7 and 8, there are more theories as well as practical. And in [grades] 6 and 5, there are more practical.*"

Mrs B's grade 8 also had six HoL activities from 26 lessons, five of them in laboratories (one-biology and four-chemistry) and one in the classroom. Every student had the chance to carry out part of the experiment for solubility (see **Figure 5.10**) and observe the roots, but the other HoL activities were always group work. Mrs B carried out all the experiments as a participative demonstration; she demonstrated the experiment before letting the students experiment on their own. The biology experiment was on osmosis, and student volunteers had to bring potatoes for the experiment. Two chemistry experiments were on solubility, and the remaining two were to test chemical reactions.

Figure 5.10 *Samten dissolving a spatula of sugar in lemon juice*

Only two HoL lessons were conducted for grade 10 students, both being chemistry experiments that took place in the chemistry laboratory as group activities. Only a few students from each group were involved in carrying out the first experiment, while in the second experiment, everyone had a chance to hold some part of the connecting wires (see Figure 5.11). Mrs D stayed close to the groups to ensure students adhered to the instructions, and at times she took part in the experiments along with the students.

Figure 5.11 *Chemical reaction (left) and electrolysis (right)*

Both Mr E and Mr C said that they conducted four to five experiments during the year but were yet to take the students to the laboratories to provide the experience. Mr E was planning to take the students to verify Ohm's law, which was the next topic that he would be teaching. However, it was apparent that these experiments were conducted as part of the final continuous assessment in grade 10.

As the teacher participants mentioned, HoL was more common in grade 6 compared to grades 8 and 10. While Mr A allowed his students to experiment on their own after explicit instruction, Mrs D and Mrs B were more cautious and consistently monitored their students. Furthermore, to understand the classroom pedagogical practices, one of the questions the researcher asked during the teacher interviews was, "If I were to walk into a typical science lesson you were teaching, what would I see you doing? What would your students be doing?" The following were the responses received:

> *Mr E: There are many topics where we need to lecture or download the information to the children, and there are also certain topics where there are lot of activities to be done so, it will depend on the topic. We do this experimentation then, activity-based sometimes. Activity-based, in a sense, what is given in the text where equipment is available, those we give for activities.*

> Mrs D: *I conduct the experiment, I sometimes demonstrate, I let them experiment, and okay, I try not to give lecture all the time, but in the certain lesson, it's not possible! Cannot…, sometimes, I show video clips taking my laptop to the class or bringing them here.*

Mr C: *In science what I do is, most of the time, I go with experiment. So that being in class listening to teacher sometimes make them bored, take them to sleep so most of the time, I go with experiment. Even a short experiment also. So, I encourage them to take science. Sometimes I even take them to the field trip. Sometimes I take them to hospital, BHU and sometimes I call the health officials to talk to them about health.*

Mrs B: *If the lesson that I am teaching has experiment or practical, you will be entering the lab, and you will see my students performing the experiment. I will be monitoring them strictly because having an experiment, especially in Chemistry lab, is very risky. So, I will have to monitor them closely. If it is in other, theory parts, then we can discuss in the class, Maybe shoulder partner or face partner. So, questions will be provided, and they will be discussing, so teachers have to monitor, group-wise, moving around the class, and they can have the presentation after their group discussion. So mostly it will depend on the nature of the topics.*

Mr A: *If you walk into my classroom usually you will find a lot of interaction between my students and me. I will be engaged, you know with the students, conducting a lot of experiments, particularly in class 6, 7 and 8 curricula. There are many science experiments, so either you find me demonstrating a particular experiment, or maybe you will find me you know, facilitating group discussion in the class. Similarly, students will be interacting with me, engaged in experiments and then, they will also be engaged in you know asking questions and then sharing their ideas among themselves as well as to me so, you will find a lot of interactions.*

All the teachers prioritised HoL, followed by group interactions or discussion. Other pedagogical approaches included video lessons, teacher demonstrations, fieldwork, inviting a guest speaker, questioning, and lectures. While grades 6 and 8 focused on HoL and SGD, grade 10 used other approaches.

In summary, the three signature pedagogical practices (SPPs) used in teaching science across grades 6, 8 and 10 at VMSS were interactive lectures (IL), small-group discussions (SGD) and hands-on learning (HoL). HoL was prominent to grade 6, SGD to grade 8, and IL to grade 10.

5.4.4 The prevalence of the signature pedagogical practices

This section presents the prevalence of each of the three signature pedagogical practices in grades 6, 8 and 10, as observed during the fieldwork. From a total of 86 lessons observed, four lessons in each of grades 6 and 8 were excluded because they were either revision lessons or clubbed together as block sessions. Table 5.2 shows the prevalence of these signature pedagogies in the remaining 78 lessons.

Table 5.2 *The prevalence of three signature pedagogical practices*

Grades	Interactive Lectures	Small-Group Discussions	Hands-on Learning	Total lessons	Remarks
Grade 6	6	4	6	16 (20)	4 lessons were revision
Grade 8	11	9	6	26 (30)	4 lessons were block sessions
Grade 10	28	6	2	36 (36)	
Total	45	19	14	78 (86)	

Of the 78 lessons observed, 45 lessons used IL, 19 used SGD and 14 used HoL. In grade 6, there were no significant differences in the use of these three signature pedagogies. In grade 8, IL was more prominent compared to HoL lessons. However, the use of the three signature pedagogies was more or less balanced. In grade 10, most of the lessons were delivered using IL. Six lessons saw SGD being deployed. Only two lessons in grade 10 chemistry were delivered using HoL (none in biology and physics). The rest of this section will elaborate on this finding to bring out the prevalence of the signature pedagogies.

Interactive lectures: With 45 of 78 lessons delivered through IL, this was the most prevalent signature pedagogy in all grades except grade 6, where it shared that ranking with HoL. Two of the findings associated with the high frequency of IL lessons were:

1. The inclusion of a wide range of pedagogic practices within the broad IL signature pedagogy
   IL comprised the widest range of practices, namely, teacher explanation, whole-class discussion, teacher demonstration, individual problem solving, and all those activities carried out as pair-work. Further, teacher explanation was carried

out in many ways, such as using the chalkboard, using a flipchart with pre-written information, the use of embodied objects (concrete teaching-learning materials), YouTube clippings, and reading from the textbook and elaborating. Therefore, one of the reasons for the high frequency of IL lessons was the inclusion of a wide range of practices within the IL signature pedagogy.

2. The high prevalence of IL lessons in grade 10

   With 28 of 36 lessons delivered through the use of IL, grade 10 had the highest frequency of lessons delivered using this signature pedagogy. Reasons cited by the grade 10 teachers were:

   Heavy curricula and lack of time: The primary reasons cited by the the grade 10 teachers for opting for the IL signature pedagogy were heavy curricula (content overload) and lack of time to cover the syllabus. Mr C said, "*With the content that we are presently having, we are facing a lot of difficulties to cover the syllabus.*" Likewise, Mrs D was worried and planning for additional lessons outside the normal teaching lessons to cover-up the syllabus: "*I am worried now, I am thinking of taking the extra classes from today.*" And Mr E said,

   When we conduct practical, it takes a lot of time. One period is not enough especially for this practical, especially this circuit connection, and we are not getting a proper answer, as a result, we have to do a lot of re-connection, within one period we are not able to finish up.

   Inadequate equipment and assessment practices: The next set of reasons for teachers to stick to IL lessons in grade 10 included the lack of equipment to conduct practical lessons and the current assessment practices with their high reliance on end-of-term examinations. In the absence of laboratory equipment, teachers were not able to adopt HoL approaches. Mrs D said, "*We don't have enough equipment, last year I did it, but insufficient chemicals and apparatus and that leaves us with no choice than to opt for the lecture.*" And in regard to assessment, Mr E said, "*Our mode of assessment is exam-oriented, which leaves us no option, we have to focus more on covering the syllabus and prepare students for the examination. Instructional approaches are the best options.*"

Small-group discussions: SGDs were more prominent in grade 8. Mrs B explained that it was easier for her to assign SGD tasks and get feedback on her students understanding. She would assign activity questions in the textbook for group discussions: "*Questions will be provided, and they will be discussing, so teachers have to monitor, group-wise, moving around the class and they can have the presentation after their group discussion.*" Further, as she was well acquainted with Kagan structures, she added:

> "*I mostly use that rally coach. Rally coach is guiding one another, either face partner or shoulder partner. When one solves the problem, the other one guides and takes the turn. Then, I prefer to do the number heads together. So, I did that one also, rally coach. Rally robin and rally table*".

Hands-on learning: Grade 6 had the highest percentage of lessons delivered using HoL and this was at par with the IL lessons. This was because the teachers' manual instructed teachers what to do in the lesson. Mr A, who believes that the best way to learn science is through hands-on practice, was seen manipulating equipment to fulfil the curriculum requirement. He said:

> "*I believe that students learn well when they have engaged themselves in the process of learning, so they have to be engaged in hands-on activities and maybe use all there all senses to explore about themselves and also about their surrounding*".

However, Mr A also said he felt restricted when applying creative ideas in the teaching-learning of science due to the prescriptive nature of the curriculum: "*The curriculum is very prescriptive and does not allow us to use innovative ideas.*"

5.5 Signature pedagogies, and interest and engagement

This section maps the signature pedagogies alongside intensity and duration of interest and engagement to highlight the patterns among the high and sustained interest and engagement lessons. Hence, it responds to the second research question: "What are the patterns in terms of how high and sustained interest and engagement relate to these practices?" The indicators of interest and its theoretical underpinnings are presented first. Following this is an exploration of the pattern among signature pedagogies in terms of the intensity and duration of interest and engagement that were observed in the lessons.

5.5.1 Indicators of interest

The identification of the indicators that characterise the students' interest and engagement in the lessons was primarily guided by the theoretical underpinnings of the person-object theory of interest. According to Krapp (2007) and Krapp et al. (1992, p. 7 & 9), the typical characteristics of interest are: increased attention (or focused attention), greater concentration (persistence), pleasant feelings of applied effort (enjoyment), and the increased willingness to learn. These indicators of interest and engagement are supported by other studies on indicators of developed interest, namely, frequent, deep, and voluntary and independent engagement in the task (Renninger & Pozos-Brewer, 2015; Renninger & Su, 2012; Renninger & Wozniak, 1985); perseverance (Sansone et al., 2015); and questions (Ainley, 2002).

These characteristics were listed in the observation sheet, specifically to record their presence during the lessons. The observed intensity and duration of key participants' interest and engagement were considered while noting the indicators. Moreover, during the analysis of the video and audio recordings of the key science lessons, these indicators were revisited to confirm the field observation findings. Inter-rater reliability was also carried out with two researcher colleagues to ascertain trustworthiness of the findings. The interpretation of the four observed indicators of interest are summarised in **Table 5.3** on the next page, using examples from the lessons.

Table 5.3 *The four observed indicators of interest and engagement*

Indicators	Working Definition	Observations and examples
Focused (increased/ Intense/ Undivided) attention	Ability to stay on the task for any length of time	Participants were observed carrying out the task as instructed without deviation (e.g. reading, solving numerical, staying within the topic for group discussion, and working towards completing the experiment) Samten: I give my ears to the teacher and eyes to the book when the teacher reads and explains
Greater concentration (Persistence)	Being lost in the task and not distracted	Expression of positive stress and being lost in thought or activity. Semyang: I am stressed (as she poured the last few drops of oil from the mixture)
Enjoyment	Feeling of excitement, pleasure, happiness, and surprise expressed facially, through gesture and in expressive language	Smiling (lips stretched to form smile) Thumbs-up and hi-fives Phub (after Semyang completed the separation of oil and water): Yay, pure water! Can we drink it?
Cognitive activation	Engaged in deep thinking, initiating discussions, sharing critical views and asking questions	Actively engaging in sharing, daring and asking critical questions to the teacher, volunteering to respond or take responsibilities. Norbu: Madam, what's the meaning of hypothesis?

All four indicators were found to be distinctly prominent features of those 39 lessons (see Table 5.4) that were categorised as triggering high and sustained interest and engagement. These were not limited to any one of the three signature pedagogies but were evident in classroom activities involving HoL, SGDs, and ILs. The categorisation of lessons into high/low and brief/sustained interest and engagement that was based on these indicators is presented next.

5.5.2 Patterns among signature pedagogies in terms of intensity and duration of interest and engagement

This sub-section explains the pattern among signature pedagogies in terms of intensity and duration of interest and engagement, as observed in the science lessons. Understanding this pattern was key to identifying the pedagogical practices that trigger and sustain students' high interest and engagement in science lessons to identify a key lessons each under IL, SGD and HoL for granular and synoptic analysis. The patterns are shown in Table 5.4.

Table 5.4 *Mapping patterns: SPP within intensity and duration of interest and engagement*

Intensity ⟶ Duration ↓	Low Interest and Engagement	High Interest and Engagement
All observed lessons (n=78)		
Brief	19 (24%)	12 (16%)
Sustained	8 (10%)	39 (50%)
Total	27 (35%)	51 65%)
IL lessons (n=45)		
Brief	17 (38%)	4 (1%)
Sustained	5 (1%)	19 (42%)
Total	22 (49%)	23 (51%)
SGD lessons (n=19)		
Brief	2 (11%)	4 (21%)
Sustained	3 (16%)	10 (53%)
Total	5 ((26%)	14 (74%)
HoL lessons (n=14)		
Brief	0	4 (29%)
Sustained	0	10 (71%)
Total	0	14 (100%)

The following findings were deduced from Table 5.4:

First, a significant number of lessons under each signature pedagogy triggered and sustained students' high interest and engagement. It was observed that 50% of the 78 lessons triggered high and sustained interest and engagement among the participants. Closer scrutiny reveals that in more than 70% (10/14) of HoL lessons, more than 50% (10/19) of SGD lessons, and more than 40% (19/45) of IL lessons students exhibited the four indicators of interest more prominently across the three phases of the lesson.

Second, 16% of the 78 lessons triggered high but brief interest and engagement among the participants. Numerically, the same number of lessons were found under each signature pedagogy. These were the lessons where momentary high interest and engagement were triggered as a result of comparatively shorter activities within one phase of the lesson. However, there was still a significant number of lessons present from all the signature pedagogies.

Finally, looking at the brief and sustained low interest and engagement lessons together, it was observed that no HoL lessons, 26% of SGD lessons, and 49% of IL lessons were recorded. The reason for not having any HoL lessons in these categories could be attributed to the limited number of lessons in this pedagogical practices.

In summary, these finding suggest that triggering and sustaining of students' high interest and engagement is not attributable to the signature pedagogies. The following Chapters will look more closely into each practice in order to understand which of its features trigger and sustain students' high interest and engagement.

5.6 Chapter conclusion

This Chapter introduced the research participants and identified the three broad signature pedagogies deployed for teaching science in the observed Bhutanese classrooms. These signature pedagogies – interactive lectures (IL), small group discussions (SGD), and hands-on learning (HoL) – are the prominent teaching-learning practices of science in Vajra MSS. Furthermore, there was a need to establish a pattern among these signature pedagogical practices to see if any were associated with the triggering and sustaining of students' high interest and engagement in Bhutanese science lessons in responding to the second research sub-question. The indicators obtained from literature search were found to be evident and applicable in the Bhutanese context. Although the signature pedagogical practices themselves were not found to trigger and sustain students' high and sustained interest and engagement in the Bhutanese science lessons, it provided avenue to look deeper into each of the signature pedagogical practice. This will be done in Chapters 6, 7, and 8.

Chapter 6: Understanding Interactive Lectures in Science Lessons Through the Person-Object Theory of Interest

6.1 Introduction

Chapter 5 identified the three signature pedagogical practices and the pattern for triggering and sustaining high interest and engagement in science lessons in grades 6, 8 and 10 in Bhutan. Each of the next three Chapters will analyse one of these practices more closely through the person-object theory of interest (Krapp, 1993) in order to address the research question, "*How is each of these practices enacted in Bhutanese science lessons in ways that trigger and sustain high interest and engagement?*" Chapter 6 is dedicated to interactive lectures (IL), Chapter 7 will focus on small group discussions (SGD), and Chapter 8 will cater to hands-on learning (HoL). These chapters will tease out the different ways the participating teachers used the practices, sometimes with varying impact on students' interest and engagement in learning science, thus promoting a richer understanding of the complex dynamics of interest and engagement in real-life science classrooms in Bhutan.

The findings in Chapter 5 also confirmed that while some lessons using IL, SGD and HoL were highly interesting and engaging, others were of low and brief interest and engagement. Since this study aims to develop a new understanding of the pedagogical practices that trigger high interest and engagement from the point of view of POI, it was imperative that lessons in the first category be carefully chosen for more in-depth analysis. Therefore, each of Chapters 6, 7 and 8 will discuss a lesson from the three grades that were unique to particular grade but common within the grade and, at the same time, triggered and sustained high interest and engagement in it. The practice that was more prominent in the specific grade (e.g., IL in grade 10 and HoL in grade 6) will be comprehensively analysed using a vignette and one participating student's Action of Interest (AoI) followed by an exploration of the patterns of similar practices in other grades. Vignettes offer a way to mine data by observing participants engaged in activity, reflecting and learning from it (Miles & Huberman, 1994). The study also accommodates the uniqueness and diversity of approaches the participating teachers adopted when using the same pedagogical practice, while acknowledging the idiosyncratic nature of interest development among the students (Krapp et al., 1992).

Section 6.2 introduces a lesson in grade 10 physics and justifies why this lesson was identified for deeper analysis. This is followed by the lesson vignette, Kezang's AoI, and an analysis and interpretative discussion that draws out the effective practices that triggered high interest and engagement for Kezang in this lesson. Section 6.3 compares and contrasts the significant practices of the lessons with episodes from other grades to look at the patterns across science lessons using IL. The intention of this section is to generate a new understanding of how IL is enacted in ways that help to produce and sustain higher interest and engagement in science lessons, as interpreted through POI. Section 6.4 concludes the Chapter.

This Chapter analyses the IL used to trigger and sustain participants' interest and engagement in learning science in Bhutanese classrooms. Of the two main practices of questioning and interaction variations within IL, questioning was found to be crucial in triggering and sustaining students' high interest and engagement. Therefore, this Chapter will highlight the key features of questioning practices using a vignette lesson and the AoI of the student Kezang. The findings will then be used to generate a deeper understanding of how questioning made IL lessons interesting and engaging in the Bhutanese science classroom. It will answer the third research question: "How are IL enacted in the context of Bhutanese science lessons in ways that trigger and sustain students' interest and engagement?" The response will form one of three responses to the key research question.

Almost three-fifths of the total number of lessons observed in the three grades were delivered through IL (see Table 5.2), making it a prominent pedagogical approach used by the science teacher. The popularity of this pedagogy is based on the variety of approaches (teacher demonstration, individual work, explanation, use of teaching-learning material) the teacher used to make the lessons interactive. A little over two-fifths of these IL lessons were categorised as triggering and sustaining participants' high interest and engagement, and almost the same number were categorised as being of low and brief interest and engagement. In analysing the data, the focus will be on the lessons that triggered and sustained participants' high interest and engagement.

The primary sources of data were the video recordings of the lessons, the accompanying classroom discussion audios, the field notes, and the interviews with the participating students and teachers. These data were used to bring out the similarities and differences among all IL lessons. Identified were common themes among teacher's practices, as well as patterns of interaction and meaning making that were particular to the individual students who contributed their experiences of interest and engagement in learning. The analysis used an iterative framework to optimise the output from the data (Srivastava & Hopwood, 2009).

6.2 Enactment of IL in grade 10 physics.

In order to understand the enactment of IL through POI, I will focus on a vignette from a grade 10 physics lesson that introduced a lesson for a new textbook chapter on electricity and magnetism. It focused on familiarising students with important terms associated with the sub-topic, "electric circuits". The duration of lesson was 45 minutes.

There were five reasons for choosing this lesson. First, it was one of the lessons identified in Chapter 5 as triggering high and sustained interest and engagement among the students while using the IL approach. Second, 28 of 36 lessons (79%) in grade 10 were delivered through IL (See Table 5.2), making it the most recurrent pedagogical practice in this grade across the three science subjects (biology, chemistry and physics). Third, it was representative of a common practice deployed in the particular grade, namely, heavy reliance on the use of the chalkboard. Fourth, 11 of 12 lessons (92%) in physics were taught through IL. Fifth, one of the participating students, Kezang, found the lesson interesting, thus making it possible to analyse it from his perspective to better understand interest and engagement. Therefore, this particular physics lesson was chosen to bring out the nuances that made learning science using IL trigger high interest and engagement through the lens of the POI.

6.2.1 Vignette: Some important terms under the topic "The electric circuits"

The vignette has two parts; the first column, the narrative that brings out the lesson as it progressed from introduction to the closure. Within the narrative, I have included the observable behaviours of the key participants, which are then linked to the second column, which shows the commentary on the triggers and indicators of interest (Bergin, 1999; Krapp, 2007; Pressick-Kilborn, 2010; Renninger et al., 2019; Tsai et al., 2008) and the types of engagement (Ainley, 2012; Schlechty, 2011). The narrative column illustrates what transacted in the lesson, and the commentary column identifies the triggers and types of interest and engagement being generated. Together they bring out the significant practices within the broader pedagogical practice of IL that will be compared with Kezang's AoI (see Section 6.2.2) to look for patterns in other science lessons across grades 6, 8 and 10.

Narrative	Commentary
Introduction:	
Mr E started the lesson by saying, "*In our previous lesson we were discussing the sustainable sources of energy, isn't it…, How solar energy is used to generate electricity? How is geothermal energy used to generate electricity? …, So, now today, we are going to discuss electricity and magnetism okay, electricity and magnetism. The previous chapter was how natural energy is used to generate electricity so, now today we are going to discuss electricity and magnetism.*"	Linking the lesson to previous learning - A common approach to triggering interest (Renninger et al., 2019)
Yiga flipped the pages in her textbook and briefly read it. She also opened her notebook. Kezang adjusted his sitting posture to face the teacher. His books were already open.	Authentic engagement, as it is personally meaningful to prepare for the lesson (Schlechty, 2011). Autonomy (choice or preference) as triggers of interest - (Renninger et al., 2019)
Mr E wrote the topic on the chalkboard and read it. Yiga was seen writing in her notebook, while Kezang had his gaze fixed on the chalkboard.	Use of concrete classroom object – stimulus variation (Chalkboard: Highlight the main topic, vary interaction and pace of lesson delivery) to engage and trigger interest.
Mr E then asked, "*Yes! You know what electricity is, and you know what magnetism is. Now, my question is, what is the connection between these two, electricity and magnetism?*" Mr E rephrased and repeated the question providing hints (e.g., electromagnetism) more than five times until Binod volunteered. Participants were observed discretely discussing by mouthing	Questions as the cognitive challenge and instructional conversation in terms of information input – trigger of interest (Renninger et al., 2019)

Narrative	Commentary
and whispering the answer to each other. Kezang nudged Binod to volunteer. As Binod stood up, Yiga and Kezang (Kezang during the interview said, he experienced heightened emotion when no one volunteered and relieved when Binod did) smiled. Binod said, "*From electricity, we can create magnetism, and from magnetism, we can get electricity.*" Acknowledging the response, Mr E asked, how magnetism is induced from electricity to Binod in continuation.	Authentic engagement as they validated their answers Heightened emotion – an indicator of interest (Krapp, 2007)
The next question was asked to Kezang when no one volunteered "*How does magnetism produce electricity? (A long 10-15 seconds pause)Yes! Kezang, would you like to try?*" Before Kezang's name was pointed out, he was seen discussing with Binod with a smile on his face (He was saying "*discharge of electrons*" while Jitsuen was whispering "*change in the magnetic field*" as evident from classroom discussion audio). Kezang responded, "Magnetism may allow discharge of electrons."	Questioning as cognitive challenge students thinking – Triggers of interest Authentic engagement – sharing prior learning (social interaction) and enjoyment (heightened emotion) are indicators of interest Focussed attention as an indicator of interest (Hidi, 2006) Autonomy to come up with own answers as an indicator of interest (Tsai et al., 2008)
Mr E built from the response to relate to lesson learnt in grade nine about inducing electricity using magnets, and a galvanometer to detect the presence of current. He used his hand gesture to draw attention and explain the process. Then he explained how electricity and magnetism were related. "*Wherever there is an electric current passing through a conductor, there will be a magnetic field (Indicating with hand motion), and when there is a change in the magnetic field, it will induce electric current in the circuit. Therefore, these two co-exist understood! So, that's why we say electromagnetism.*"	Relating to prior learning (knowledge) – Triggers of interest
Kezang was seen listening without changing his body posture, had a hand on his forehead at times, while Yiga looked into her textbook often.	Focused attention as an indicator of interest (Also an indicator of authentic engagement)

Narrative	Commentary
Then, Mr E brought out the main focus of the lesson, "*Now, let us see some terms related to electricity.*"	
Lesson Development: Mr E wrote 'insulator' and 'conductor' on the chalkboard diverting students' attention at the chalkboard. He then asked what an insulator or a conductor is to the whole class. When no one responded, he rephrased the question and asked one of the students for an example of 'an insulator'. The teacher was surprised when the answer was, 'copper wire'	The teacher varied the visual interaction between teacher-student to chalkboard-student (stimulus variation as a practice to engage and trigger situational interest)
and a few students giggled. Participants were observed to be discussing again (Yiga was heard saying that *copper wire is a conductor…*, their responses were rubber, wood, plastic) Mr E asked some more students to get the examples of insulator and conductor.	Incorrect response (Cognitive dissonance) triggered seeking behaviour (curiosity) (Bergin, 1999)/ Authentic engagement Curiosity and novelty (Renninger et al., 2019)in response Engaged and interested (more discussion, smiles and murmuring of answers – positive emotion) As the lesson progressed, more questions were asked challenging the students' cognition.
This was followed by getting back to the definition of 'insulator' and 'conductor'. He again asked, "*So now, what is a conductor and what is an insulator? What are the properties of these insulators and conductors?*" A student provided correct response to both the questions. More questions were asked, and each time Mr E rephrased and repeated the questions. "*What is the property that allows the current to flow? What makes the electric charge to flow?*" More explanation to understand about conductors and insulators in terms of free electrons. Kezang maintained his focused posture and time to time, smiled as he discussed responses with his friends. Yiga had started taking notes after discussing with her peer.	Repetition and rephrasing of questions (instructional conversation) provided hooks for students to cognitively engage and get interested in the lesson, as varied interpretations were provided (trigger of interest and engagement). Focused attention as an indicator of interest Autonomy as an indicator of interest
Mr E then introduced a new term 'electric current' and asked for the definition from	

Narrative	Commentary
students. Participants were seen discussing again and yet again, Binod shared his response. Mr E rephrased and wrote the definition on the chalkboard followed by the formula (I=Q/t). Students copied the definition in their notebook. More questions, "*What is the SI unit of charge?*" (Participants discuss and says 'volt' – not correct) As another student answered, the participants' face lightens up in recollection. Kezang was seen stroking his chin here exhibiting thinking	Repeated explanation (instructional conversation)– providing varied points of entry/understanding – Triggers of interest Ritual compliance in terms of participants' engagement (Schlechty, 2011) Positive emotion (smiling)– an indicator of interest
"*What is the SI unit of time?*" (Yiga said seconds)	Automatic response from prior learning (an indicator of prior disposition)
"*What is meant by one ampere (wrote "1A" on board). Okay, when do we say that the current is one ampere? If the current is said to be one ampere, what does it mean? Or when do we say that the current is 1 A? or the flow of charge is 1 A?*"	
There was another unexpected response to the question (e.g., the flow of charge is similar to the flow of water). Participants were observed mouthing response to each other. Yiga was writing again	Cognitive dissonance (subtle laughter in some sections of the classroom) or discrepancy (unable to register the response) – triggers of interest Cognitive activation as an indicator of interest and authentic engagement
Mr E provided the hint on the chalkboard. Another student volunteered and gave a partly correct response which Mr E used to write the definition on the chalkboard for students to copy.	Interaction variation/focused attention to engage and maintained interest Ritual compliance
Potential, potential difference and volt were the next terms introduced. Mr E explained the flow of electrons and the conventional flow of current. Getting back to the concept, he asked for the definition of potential again? Both Kezang and Yiga were listening attentively. Kezang was back to his focused posture and occasional turning to his peer to whisper responses, while Yiga continued on her notetaking habit.	Focused attention and positive emotion were the indicators of interest.
When no one responded, the question was rephrased to "*What does potential*	

Narrative	Commentary
determine?" and the response was, "*The direction of flow of current.*" Mr E used this cue to write the definition on the board. He asked the students to copy it, and as usual, read the definition after writing.	Ritual compliance – participants engaged in copying
Mr E then took out AAA dry cell and used it to identify the terminals providing another stimulus variation for the transaction. He further elaborated to inform students about the potential and direction of flow of current when two terminals of the cell are connected. He often used hand gestures to elaborate on the parts and functions of the dry cell.	Interaction variation (stimuli) for engagement with personal/prior knowledge as triggers of interest
Participants looked at the dry cell and responded to teacher question in the chorus. Relating to the exhaustion of the battery, Mr E asked about the potential difference. He picked Yiga for the answer, but before she could say anything, Mr E started writing the definition on the chalkboard asking everyone to copy it.	Focused observation – an indicator of interest and engagement A cognitive challenge as the trigger, and heightened emotion as an indicator of interest
He wrote, "Potential Difference (P.D): Potential difference between two points is equal to the work done in moving unit charge from one point to another point. [V=W/Q]". Participants copied the note	Ritual compliance while copying the notes from the chalkboard
Mr E also introduced the symbols associated with the potential difference (V) and work done (W) and explained the definition a couple of times before moving on to the SI unit of p.d. (V – volt). He asked for the volunteer to define volt in a similar way to ampere. *(Bell rang - end of the period – Mr E continues to teach)*	
Participants discussed and Kezang was seen again, whispering the answer to Binod with a smile on his face, which was indicative of high interest and engagement in the Bhutanese context. The 9th students outside the participants' table volunteered. Mr E reinforced and rephrased the definition and provided additional notes to the students.	Authentic engagement Positive emotion, cognitive activation and focused discussion are all evident – indicators of an interested person according to POI

Narrative	Commentary
Lesson Closure: Mr E: "*So, that's all for today (placing the chalk on the table), who would like to summarise the lesson that we have learnt today (looking at a student), Yes Jitsuen, would you like to…, so you just share what we have learnt today*".	An authentic engagement was observed for Kezang and Yiga as they focused their attention on Jitsuen to listen to her responses
As Jitsuen answered the first question, another followed till all the key concepts were covered. A total of five questions were asked. Tr: *Now, can you tell me what is current then?* Jitsuen: *It is the flow of electrons in the circuit* Tr: *Okay, the rate of flow of charge is known as the current isn't it! And, what is the difference between insulator and conductor?* Jitsuen: *In the insulator, there are no free electrons, and in conductors we have…,*	Novelty as triggers of interest (Renninger et al., 2019) was evident for both Kezang and Yiga as they confirmed their understanding of the flow of current.
Participants were actively engaged as they listened to the interaction between Mr E and Jitsuen.	Authentic engagement and focused attention (an indicator of interest)

In this vignette, the teacher, Mr E, spent a major portion of the time explaining and elaborating on some of the important terms associated with the lesson topic, as well as questioning and writing notes on the chalkboard. The video recording and the field notes show that the teacher-talk dominated the lesson, pausing only while waiting for volunteers to respond to questions or when writing and waiting for students to copy the notes from the chalkboard.

Questioning was observed to be one of the main components of the vignette. Mr E asked 17 different questions, which triggered cognitive activation, cognitive dissonance, autonomy, and novelty resulting in discrete learning interactions for the participating students. The questions had a distinctive role in different sections of the lesson, for example, the lesson introduction questions focused around linking the topic to prior learning or personal experience of the students; the lesson development questions provided the diagnostic assessment of the content taught; and the closure questions checked if the students achieved the learning outcome of the lesson. Additionally, the lesson highlighted the practice of cueing the question, asking it, and following up the response across the lesson. Embedded within the practice were other features such as repetitive questioning, downtime, and response pattern. The questioning practice was Mr E's main tool for triggering and sustaining participants' interest and engagement in the vignette lesson. A more in-depth analysis of the questioning practice will be presented in Section 6.3.

It is also evident that Mr E used various forms of stimulation to keep the students engaged. Reliance on the chalkboard – a reality of Bhutanese classrooms – was one of the distinctive features of the lesson. Other practices included the use of additional teaching-learning material (e.g., dry cell), bodily gestures to elaborate and extend student learning, repeating and explaining the content in different ways, relating to prior knowledge or personal experience of the students, informal discussion, and the brief use of humour.

In summary, the two key components used to trigger the interest and engagement of students in the lesson were questioning and stimulus variation. Both stimulated cognitive activation, autonomy, cognitive dissonance, and novelty among participants, whose interest and engagement in the lesson were exhibited through focused attention, heightened emotion and enjoyment. The emerging pattern from each of these components will be discussed further in section 6.3.

Kezang's AoI will be analysed next to explore what significant practices under IL triggered high interest and engagement for him in this lesson.

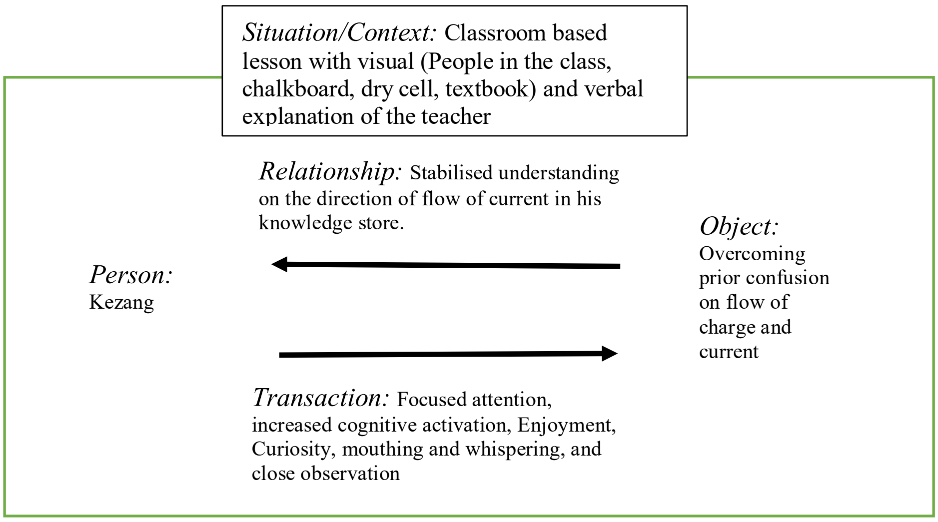
6.2.2 Kezang's AoI

Kezang found this lesson the most interesting of all the science lessons taught during the week. In the weekly interview, he was asked, "*Among all the science lessons you had this week, which lesson you found most interesting?*" He replied:

> "*If I have to choose, I guess physics for a tiebreaker. Particularly, because last year, we also learnt about electricity and magnetism but, maybe I wasn't fully attentive last year, I guess, I found it as a chance to redeem myself and get to understand more. We haven't got into the equation yet but, this time I am paying attention I guess so, it has been more of a success.*"

This response suggests that he brought his previous disposition (personal interest) and a stable preference (Krapp, 2002) "to redeem" his previous confusion on the lesson topic. The opportunity provided by the lesson to revisit "flow of charges and electrons" and to clarify his incomplete understanding made the lesson "enjoyable" for him. Enjoyment is an emotional indicator of interest (Krapp, 2007). The object of interest for Kezang in this lesson, therefore, was overcoming prior confusion, which is detailed as his AoI in Figure 6.1. The following section will show how Kezang's interest was triggered by both his situational and personal interests. It will also elaborate on the object of interest, the transaction that took place in the lesson, and the new relationship he developed as he interacted with the object of interest.

Figure 6.1 *Kezang's AoI (A figure adapted from Krapp, 1993)*



Person: Kezang

In a continuation to his personal profile (see Section 5.2.2 under grade 10: Kezang), Kezang's AoI in this particular lesson may be discussed in terms of two distinct influences – the personal and situational (Krapp, 2002) – that he brought to this lesson. The personal or actualised interest focuses on the previous stable knowledge he brought to the lesson and the associated indicators. The situational interest emphasises the triggers that were provided within the learning situation to generate interest (Krapp et al., 1992). Each of these two factors is discussed below.

The interview quotation in section 6.2.2 states that Kezang found this lesson interesting because he brought with him the intention to clarify the confusion (Bergin, 1999) he had from his previous grade: a personal interest – "*a chance to redeem myself*". Interest was fuelled by prior confusion. It also established his previous encounter with the topic. He further added that having overcome the confusion, the lesson was more enjoyable:

> "*So, when it comes to thinking about that moment when we were learning about the charge, flow of charges, electrons and there was lots of things going in my mind and eventually, there was this part where I could get to learn this, I could understand this… that actually helped and I enjoyed*."

Additionally, this quotation shows his cognitive processing, which was reflected in his observed behaviour of authentic engagement in the lesson (e.g., focused and positive emotions) to make learning meaningful. Meaningful learning is said to empower individual and sustain students' interest (Mitchell, 1993).

Furthermore, his other observed behaviours such as stroking his chin or putting a hand on his forehead were also indicators of his being involved in cognitive processing. He said:

> "*These are times when I try to focus or try to use this [pointing at his head] or when I am trying to process, I do that, or sometimes, I try to completely focus myself, close from other parts so that I don't get distracted, I do this [putting hand on his head]*".

It was apparent that his action was related to being focused most of the time in the lesson. Focused attention is another indicator of interest (Krapp et al., 1992). These behaviours are evidence of Kezang's prior disposition towards the content of the topic and his commitment to getting his confusion clarified. Besides, being a high performer, he brought his stable interest in science into this lesson.

Kezang's situational interest was triggered several times during the lesson. It was first triggered when Mr E mentioned the lesson topic, which was related to his prior learning. Kezang composed himself with focused attention "*to redeem*" his previous confusion on the topic. It was then rekindled when Mr E asked the first question providing cognitive challenge (Renninger et al., 2019). These questions also created cognitive disequilibrium when out-of-context responses were shared in the lesson, stirring subtle humour (Bergin, 1999). Kezang was seen smiling and discretely sharing his answers to his peers as is evident from the video and audio recordings (e.g., prior to Mr E asking him to respond to the third question, he was recorded saying, "discharge of electrons" to Binod). These behaviours were exhibited throughout the lesson whenever Mr E asked questions. The third time was when there was variation in visual stimuli – the people in the classroom, the chalkboard and the teaching-learning material. Finally, Kezang confided, "there was this part where I could learn, get to learn it", which indicated there was the novelty or meaningful learning for him (Mitchell, 1993). Taken together, these triggers illustrate Kezang's situational interest in the lesson.

Object: Overcoming prior confusion

As Kezang explicitly mentioned twice during his interview, the object of his interest in this lesson was to overcome his prior confusion on "*how current flows*" (see Figure 6.1). He said, Figure 6.1 *Kezang's AoI (A figure adapted from Krapp, 1993)*

> "*Back then, I had a bit of confusion on how charge (current) and electrons flow opposite to each other, I just thought maybe, electrons move in a certain direction, the charge will also follow that, but then, it goes in the opposite direction*".

He linked this to his chemistry knowledge: "*If we combine that with our chemistry lesson, maybe if we use positive ions, it also conducts electricity.*" These statements indicate that Kezang had some understanding the flow of electric current, but he had difficulty in comprehending the direction of the flow of current. Therefore, according to POI theory, Kezang's object in this lesson was overcoming the confusion over the abstract conception of the flow of current.

Situation or Context: Enabling environment

To interact with his object of interest, multiple opportunities were provided to Kezang to help him overcome his confusion. The questions posed and the various stimuli presented triggered his interest and engagement. For instance, the concept of the direction of flow of current was repeatedly explained using different approaches. It started with an analogy of flow of water:

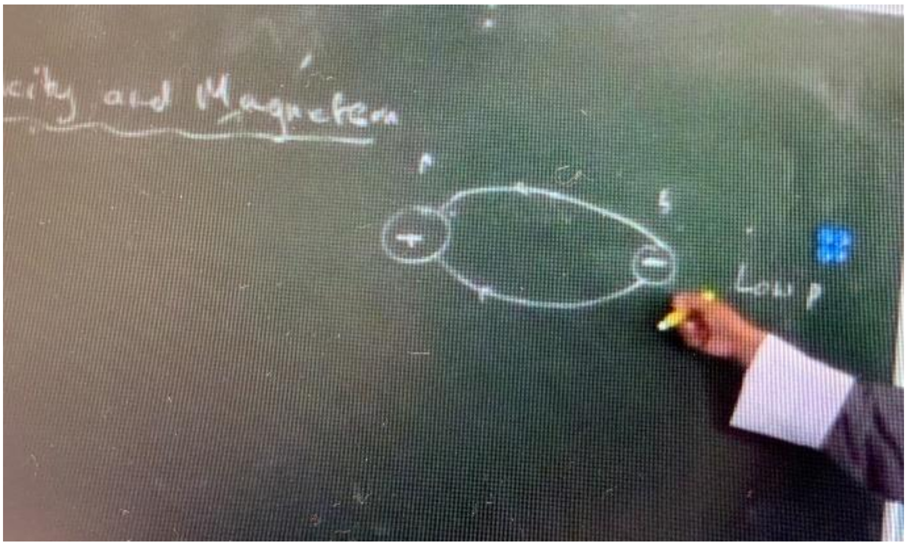
Mr E: *Can you tell us how the water flows?*

Student: *High level to low level.*

Mr E: *So, one should be at the higher level, and one should be at the low level, then only the flow will be there isn't it…, water flows from high level to low level so, similarly, the charge will also flow from (higher level)…, current will flow from high potential to low potential.*

Then, through illustration on the chalkboard (see Figure 6.2)

Figure 6.2 *Mr E's illustration of flow of the current on the chalkboard*



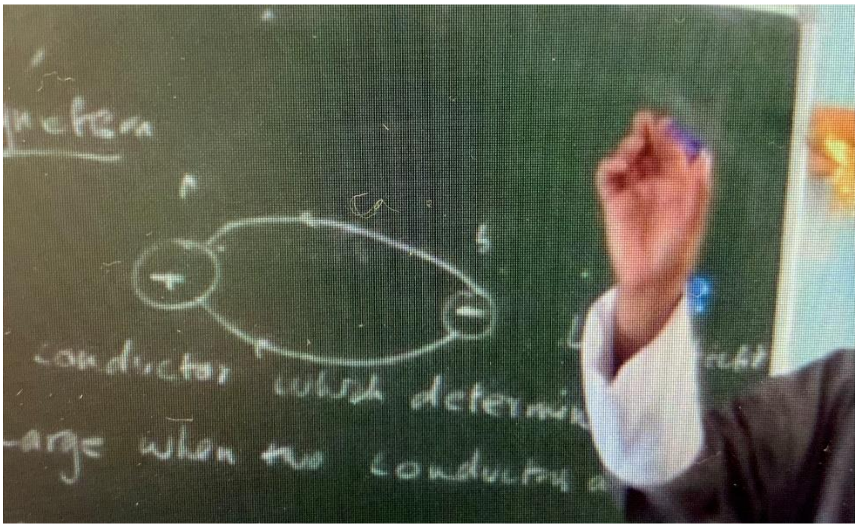
Mr E: *In which region, for example, let's say point A and B (writing A and B above + and – respectively) has more concentration of electrons?*

Students (chorus): *B*

Mr E: *Okay! Surplus of electrons that is negatively charged and the deficit of electrons that is positively charged (indicating on the chalkboard). So, the electrons flow from B to A, conventionally we say, this is at low potential (pointing at the –ve point on the chalkboard), the one which has a surplus of* *electrons is at a low potential, and this is at a high potential understood! So now, the flow of electrons and the direction of the conventional current is just the opposite. So, this is at a higher potential (pointing at the +ve point), the current flows from A to B.*

And finally, using the dry cell (see Figure 6.3)

Figure 6.3 *Mr E showing a dry cell*



Mr E: *Have you seen (pointing at the + and – sign on the cell)? So, one is positive (pointing at the dry cell) and one is negative, what does this positive indicate?*

Student: *High potential*

Mr E: *It is a high potential, isn't it! What about in terms of electrons? It has fewer electrons, isn't it! So, electron flows from negative to the positive terminal if it is connected with a conducting wire. As long as there is a difference in potential, there will be the flow of charges, similar to the flow of water.*

It is therefore apparent that multiple means were used to help Kezang understand about the direction of flow of current in this lesson.

Furthermore, as observed in the vignette, questioning was prominent throughout the lesson. Again, it was the cognitive challenge and Kezang's prior knowledge that kept him engaged and interested in the lesson. The lesson also saw a high frequency of questions being used. As mentioned earlier, 17 questions were asked in this lesson, which was comparatively high number compared to other normal lessons that had about 5 to 10 questions during a 40-minutes lesson. Additionally, the questioning also provided opportunities for Kezang and his peers to share their responses among themselves through mouthing and whispering.

Transaction (Object engagement): Clarifying the confusion

This subsection reveals how the lesson unfolded for Kezang in his venture to overcome the prior confusion over the abstract concept of the flow of current. As encapsulated under POI theory, of the three approaches to the transaction, this particular IL lesson required Kezang to mostly engage in abstract cognitive processing (Krapp, 1993) to understand how current flows. To elaborate on Kezang's transaction, I will describe his behavioural indicators of interest, and then his object engagement or transaction, as I observed them in the lesson.

Kezang's visual expression of interest was confirmed when I asked him about it during the interview. He said, "*I guess, if I am enjoying, my face would be relaxed and might even be smiling. My posture could be straighter up or bending; that is what I usually do.*" This was what Kezang exhibited during the entire lesson. His bodily posture, focused attention, responses to questions, interactions with his table group members, and the occasional smiles that lit up his face are evidence that he found the lesson interesting and engaging. He also occasionally put his Hands-on his chin or forehead to signal thinking or cognitive engagement. When I asked him, what was going on in his mind when he put his Hands-on his chin or forehead, he said, "*I was trying to process that actually like, if it did go from the higher to lower potential, does that mean, maybe the charge was a bit delayed to the flow of electrons.*" Kezang's behaviour in the class illustrates a range of conditions that triggered his interest and engagement in this particular lesson. The behaviours are used to describe the following transaction.

Kezang's object engagement in the lesson began when the teacher recapitulated the previous lesson to link and introduce the current topic, and his interest was triggered the moment, the teacher asked the first question: "*What is the relationship between electricity and magnetism?*" He was observed to be paying focused attention, occasionally nodding his head, and smiling when the teacher explained the question.

Kezang was given the opportunity to share his response to the third question (see Figure 6.4), and this attention from Mr E made him more focused and interested in the lesson. As more questions were asked, he said, he was excited and concerned; excited because Mr E "*brings in some tricky questions and entice students with that*" and concerned because "*physics teacher was prying eyes on me but, I was a bit hesitant, I felt uncomfortable…, I wish that I actually participated at that time.*" There were moments when no students volunteered to respond to the teacher's questions, making Mr E call out names and ask individuals to respond.

Figure 6.4 *Kezang sharing his answer with the class*

Questioning provided opportunities for participants to discuss answers among themselves, despite the teacher's questioning practice being ostensibly framed between him and the particular students or the class in general. It was observed that interest and engagement were sustained for Kezang and other participants through practices in which they mouthed and whispered answers to each other, and discussed them discretely (e.g., when Kezang was heard saying "*discharge of electrons*", Jitsuen was saying, "*due to magnetic field*"). Thus they were able to interact about the content, even when the more overt talk was between the teacher and another student. In general, it was observed that Kezang and his friends barely volunteered to respond, preferring instead to discuss within the group. From both the video recordings and the classroom discussion audio, it is evident that the participants at Kezang's table used the think-time to mouth, whisper, and discretely discuss the answers among themselves and nod or shake their heads to agree or disagree. Therefore, questioning gave Kezang and other participants opportunities to engage discretely in social interactions, despite the overt requirement being to discuss with the whole class or the teacher.

The vignette also highlights the moments of discrepancy when out-of-context or wrong responses were provided to questions. These moments also led participants to confirm the answers. For instance, when one of the students gave the wrong answer for "*insulator*", Jitsuen said, "*Copper wire is a conductor*", and the examples of insulator discussed were "*rubber, plastics and wood*". It was observed that participants mouthed or discussed discretely to resolve discrepancies or cognitive conflicts. People often manifest interest in resolving discrepancies (Bergin, 1999). Questioning was one of the ways that triggered situational interest in Kezang.

The other object engagement or transaction was facilitated by the provision of varying foci for interaction through the use of concrete materials such as the chalkboard and the physical artefacts in the classroom, including Kezang's peers. The chalkboard was the source of lesson notes for the students and it highlighted the key points of the lesson, with diagrams drawn to elaborate on the main ideas. The diagrammatic representation on the chalkboard showing the flow of electrons and the potentials at two ends of the terminal facilitated Kezang's understanding of the direction of flow of current. The dry cell shown during the lesson attracted the attention of Kezang and his peers and engaged them further when Mr E elaborated on the terminals and flow of current. Mr E said in his interview:

> "*They know what a cell is, and the terminals. One thing that our children they are interested in is something that they can see in their real life. If they can make connections with the day to day life then, I think they learn better.*"

Therefore, these materials played a significant role in achieving Kezang's engagement in the lesson.

Relationship: The outcome

This subsection analyses the outcome of the transaction between Kezang and his quest to understand the flow of current in the lesson. According to POI theory, the AoI or transaction results in the person either influencing the object or making new experiences and gaining new information to extend their knowledge store (Krapp, 2007). It was the latter case for Kezang, based on the discussion that took place during the lesson. The use of diagrams on the chalkboard aided by the explanation using the dry cell helped Kezang understand the justification behind the flow of current. He said, "*I thought the electrons did go through the conductor and the movement formed the current afterwards*" to justify his learning.

The repeated engagement with the object through different means, such as verbal explanation, the chalkboard and the dry cell helped stabilise the person-object relationship (Krapp, 1993) for Kezang. During his interview he said he was convinced about the convention of the flow of current: "*There was this part where I could learn, get to learn it [flow of current] and I enjoyed*". Kezang's AoI resulted in him gaining new information about the flow of electrons and the current, thus extending his knowledge structure.

In summary, it was evident that Kezang brought to the lesson a knowledge gap on the direction of flow of current that he wanted to clarify. It was his personal interest and a series of triggers of situational interest that kept him interested and engaged in the lesson. The use of questions and various stimuli ensured that he was cognitively and emotionally engaged. The triggers that generated his interest and engagement in the lesson were cognitive challenge (questions), opportunities for social interaction, autonomy, cognitive dissonance, and novelty. His interest and engagement in the lesson were demonstrated through focused attention, heightened emotion, and enjoyment. Ultimately, he strengthened his understanding that the direction of flow of current was opposite to the direction of flow of electrons.

6.2.3 Mapping IL with Kezang's AoI

Kezang's interest and engagement in the lesson were heightened by a series of questions that enabled him to link the content taught to his prior knowledge and experiences. Every time questions were asked, he was found to be cognitively engaged, excited and enjoying the opportunity to discretely share the responses among this peers. His cognitive engagement was observed in his behavioural indicator of putting his Hands-on his head or chin, and the positive emotion of excitement and enjoyment was displayed through his smile prior to sharing the response. This behaviour was consistently recorded throughout the lesson. Therefore, the questioning did trigger and maintain his interest and engagement throughout the lesson. Furthermore, questioning helped Kezang connect the learning to his prior knowledge and at times caused cognitive dissonance, which also kept him interested and engaged in the lesson.

6.3 Classroom questioning: A key component of high interest and engaging IL lessons

Classroom questioning was one of the key components in generating interest and engagement across all the observed IL lessons. It is not argued that questioning is the only and exclusive trigger of interest and engagement in the vignette above. We can also recognise the use of analogy and demonstration. My purpose is to show how questioning pedagogic practice works to promote students' interest and engagement in science lessons and not to prove that the questioning is the only practice.

During high and sustained interest and engagement lessons there were more interactions among teacher and students through the use of questioning. The number of questions asked were relatively higher compared to lessons that showed low and briefly sustained interest and engagement. Questions were used by the teachers to link to previous lessons or personal knowledge of the students, diagnose students' learning, and assess if the learning objectives for the lesson were achieved. When asked how he assessed students in the classroom, Mr E said, "*Basically, by asking questions only*". His questions generated scientific literacy, scaffolded students' thinking, and developed conceptual understanding of the topic being taught (Chin, 2006). The observations also revealed that often the teachers used simple recall questions that required students to repeat what was written on the chalkboard (Childs et al., 2012).

During IL lessons, it was not only the teachers asking the questions, students were provided with opportunities to clarify their doubts by asking questions. Classroom observations revealed students ask questions to clarify their doubts across grades. Students asking questions indicated their interest in learning the subject matter. According to Ainley (2002), question involves the situation where the person is asking for information about the object or activity, signals the seeking behaviour, and it is an indicator of interest.

Furthermore, Mr E's questions triggered cognitive challenges, provided autonomy, caused cognitive dissonance, and generated novelty through his interactions with his students and among the students themselves. By varying the levels of the questions and the frequency of opportunities to interact and pace his students, he "*enticed*" (as mentioned by Kezang during the fourth interview) them into learning science. His students also took chances to clarify their doubts by asking him questions. Other indicators of students' interest and engagement as they participated in learning science included focused attention, mouthing of responses to each other (cognitive activation), and surprise and enjoyment. It is apparent that questioning played a key role in triggering and sustaining high interest and engagement among participants in the IL lessons.

The following subsections will detail the findings on the role of questioning in IL lessons, the four prominent triggers of interest and engagement that are evident from the vignette and Kezang's AoI, and the emerging patterns of questioning as enacted in the observed Bhutanese science lessons. A summary will highlight the key features of questioning to show how they were responsible for triggering and sustaining high interest and engagement among students in the science lessons.

6.3.1 The role of questioning in generating interest and engagement in learning science.

Questions played a critical role in triggering and sustaining participants' interest and engagement in the science lessons. Teachers used questions to draw attention and interest students in learning (Dos et al., 2016) and facilitated students' cognitive engagement with the science content (Morris & Chi, 2020). In grade 6, participants volunteered by raising their hands, and in grade 10, participants engaged in mouthing and whispering answers among the group members whenever the teacher asked questions. The data analysis reveals four main sources of interest as participants interacted in the questioning process: cognitive challenge, autonomy, cognitive dissonance, and novelty. These four sources will now be elaborated.

Cognitive challenge: Questions asked during the lesson posed cognitive challenge, not only in terms of the content matter, but also in formulating an appropriate response in English, the second language of Bhutan. According to Good and Brophy (2008), questions stimulate students to think about the content, connect to their prior knowledge, and begin to explore its application. Enhancing students' active cognitive participation has been shown to foster learning and to increase intrinsic interest and enjoyment (Kunter & Baumert, 2006). Kezang acknowledged that Mr E introduced some "tricky questions" which kept them engaged in the lesson.

Autonomy: Teachers' questioning were observed to draw out students' knowledge, promote internal dialogue to lead to independent thinking. Mostly, teachers asked questions but they also created an autonomy-supportive environment for students by listening and responding to their questions, acknowledging their perspectives, allowing them to work on their own, using praise as informal feedback, and offering engagement (Reeve & Jang, 2006). Studies have confirmed that the positive effects of this type of autonomy support students' interest and engagement (Krapp, 2002, 2005). Students whose teachers are autonomy oriented show higher intrinsic motivation, positive emotion and more active involvement (Tsai et al., 2008).

Cognitive dissonance: Cognitive dissonances were created when students shared their misconceptions or unexpected responses to the teacher's question. For instance, when Mr E asked for an example of "an insulator", one of the students answered as "copper wire", which created commotion in the vignette lesson. The participants were surprised and they immediately tried to resolve the discrepancy by whispering the answers among themselves. Likewise, in grade 6, "an ant" was answered as the smallest thing in the world, which created humour and focused the students' attention in the lesson. According to Bergin (1999), "people often manifest interest in resolving the discrepancy" (p. 93).

Novelty: Questions generated novelty and created possibilities for applying newly acquired knowledge into novel situations. As teachers asked questions and students shared their responses, the novelty generated frequently triggered and sustained students' interest and engagement in the lesson. Novelty here refers to something unfamiliar or not yet experienced (Förster et al., 2010). As students volunteered to share their responses or the teacher selected individuals to respond, others were often found eager and paying focused attention to the one responding. Semyang, during her fourth interview, said, "*The questions were hard for me, someone presented the answer and I could understand better.*" Similarly, there was novelty for Kezang in the vignette lesson when his peer responded to the lesson summary questions. Throughout the lesson, Kezang was found focused and attentive to all the questions asked. Questioning appeared to trigger novelty that sustained students' interest and engagement in the lesson.

6.3.2 Patterns in questioning that trigger and sustain high interest and engagement in IL lessons

Some of the patterns in classroom questioning that were common across high and sustained interest and engagement in IL lessons were:

- Questions attuned to the lesson phases;
- Setting up for the questioning;
- The questioning process; and
- The follow-up to the questioning.

Each of these patterns will now be analysed.

Questions attuned to the lesson phases.

The lessons typically had three phases, as discussed in section 5.3.2. A clear pattern was observed in the way the teacher asked questions during the introductory, development and lesson closure phases of most of the high and sustained interest and engagement IL lessons. Across 90 per cent of these lessons, the ways interest and engagement were generated through classroom questioning appeared different in each phase of the lesson. Therefore, understanding questions attuned to the lesson phases are likely to contribute to sustained interest and engagement in IL lessons. The following paragraphs will elaborate on the types of questions asked during each lesson phase.

The teachers' questions during the introduction phase were related to assessing learning from the previous lesson or linking the current lesson to the prior knowledge or personal experiences of the students. As Binod said, "*The teachers, they come to class and ask questions about the previous lessons.*" However, according to Mrs D, the questioning was intended to build "*proper connection between the previous lesson, what they know and the lesson to be taught*". These classroom questions acted as hooks (Mitchell, 1993) to draw students into the lesson and activate cognitive interest. As the questions were asked, the class frequently became quiet, signalling cognitive activation. Some students were seen flipping pages of their books and quietly reading from them. These questions were starters and appeared to be the teachers' stimuli for students to generate novel ideas using insights from previous learning. The questions were found to elicit student thinking and probing preconceptions. Other examples of questions asked during the lesson introductions observed were:

> Grade 6 – Have you seen the universal indicator before? What could be the difference between litmus and the universal indicator?
>
> Grade 8 – Can anyone tell me two differences between taproot and fibrous roots?
>
> Grade 10 – What could be the relation between electricity and magnetism?

As each lesson progressed, situation-specific interest was rekindled by more questions asked during the information input of the lesson development phase. These classroom questions linked the lesson to students' prior knowledge or personal experiences and to the content in the textbook. They were diagnostic to ascertain students' understanding. A question such as, "*How would you define 'ampere' by looking at this relation, 'I=Q/t'?*" would assess students' ability to comprehend the equation and write the definition of ampere. These, in turn, triggered cognitive challenge (Bergin, 1999; Renninger et al., 2019). As the teacher invited students from different tables in the classroom to share their understanding, participants were observed giving undivided attention to the respondents and simultaneously mouthing answers among themselves.

At other times, the teacher posed questions related to the activity or lesson input to trigger cognitive challenge or to check students' understanding. In grade 8, Mrs B used a YouTube clip to reinforce the lesson content in the textbook. As she played the clip, she often paused to elaborate or to ask questions to ensure that students were paying attention:

YouTube clip: (As it was played) The movement of water from the root to the other parts of the plant above the ground is called the ascent of sap

Mrs B: (pausing the clip) *What is meant by 'ascent of sap'?*

Students (chorus): *The movement of water from the root.*

Mrs B (with students): *The movement of water along with the (salt) salt or minerals from the soil to the cell sap of the root and from root to other parts of the plant is known as 'ascent of sap'.*

The cognitive challenge was evident as the participants scrambled to check their textbook for the answer; they were observed trying to recollect what was said in the YouTube clip, which indicated their cognitive engagement as the teacher surprised them with the question to check their understanding of the explanation. Most of the students in the class joined the teacher in generating the responses to the questions.

During such times, students also asked questions, thus exhibiting seeking behaviour about the content being delivered. These seeking behaviours were the indicators of students' interest in the subject matter. According to Newman (2006), academic help-seeking is a self-regulated learning strategy where a student's perceived need for help is matched with a request for assistance. For instance, in one of the grade 6 lessons, Phub asked his teacher, "*Why is it called a universal indicator?*" and in another Norbu asked, "*What do you mean by hypothesis?*" Both students behaviourally indicated their genuine interest in knowing the answers in order to accomplish the task they were assigned. The responses from their respective teachers maintained the students' interest and engagement on the content being delivered.

Finally, the classroom questions posed by the teacher to summarise and close the lessons provided opportunities for students to revisit the lesson, creating possibilities for igniting interest and engagement yet again. These questions provided avenues to verify and concretise their learning. Teachers would ask, "*Who would like to summarise the lesson?*", or "*What did we learn today?*" During the lesson closure when questions were asked to highlight the main content of learning, the participants gave focused attention to the respondents and affirmed their learning by nodding their heads in agreement.

In summary, it was found that in all the lesson phases, the teacher elicited interest and engagement among participants by asking questions. In terms of the person-object theory of interest, such questioning practices appeared to trigger and rekindle interest at different points during the lesson and provide new opportunities for students to expand their cognitive engagement with or to confirm their recall of the content being delivered. This section illustrates one of the key practices of Bhutanese science IL lessons, which is that teachers attune their questioning practice to the three lesson phases.

Setting up for the questioning: Planning and cueing

The function of classroom questions to trigger interest and engagement in the lesson was developed by setting up the students or providing hints for upcoming questions. Questions can provide cognitive challenge and are considered one of the triggers of interest and engagement (Renninger et al., 2019). Setting up for the questioning generated curiosity. When curiosity was aroused, the participants exhibited seeking behaviour through mouthing and whispering to peers, to resolve the perceived ambiguity, complexity, or uncertainty (Berlyne, 1960; Lindholm, 2018), thus leading to the development of interest.

The teachers' preparation of important questions ahead of time and the pacing of them appropriately across lessons were found to be additional strategies that successfully triggered and sustained students' interest and engagement in the science lessons observed. The kinds of questions that teachers ask and the way they ask them can influence the types of cognitive processes that students engage in as they construct scientific knowledge (Chin, 2007). Evidence suggests that many of the questions used by teachers in the observed Bhutanese science lessons were planned. Divergent questions require good preparation (Epstein, 2003). The teachers would use the questions in the textbook; for example, when I asked Norbu in her interview, "*What kind of questions does your teacher ask?*" she said, "*Just the exercise questions*", replicating Samten's reply: "*Questions from the textbook*". Alternatively, the teachers would ask questions as they read and explained from the textbook; for example, when I asked the same question to Semyang, she said, "*He makes other questions by himself to make us understand more.*" Or they would use questions on a strip of paper to check students' understanding or comprehension of the science lesson (see Figure 6.5). Therefore, it seems likely that the pre-planned questions helped generate and maintain interest and engagement in the lesson.

Figure 6.5 *A sample question strip*

1. Calculate the number of molecules in 10g of sodium chloride?
2. How many moles and number of molecules are there in 50g of $CaCO_3$?
3. Find out the number of molecules in a drop of water weighing 0.08g.
4. Calculate the mass of a silver atom.

In terms of cueing, the teachers would say something to alert students to the fact that the question was coming, for example, "*Before we begin the lesson, let us recapitulate the last lesson, or, let us discuss and find out what you know about this topic before we move on.*" It was observed that the participants became alert and focused when they heard such statements. In other situations, students would simply anticipate questions from the teachers. For example, Norbu said, "*Sometimes, I can just figure out what madam is going to ask. So, I just prepare my answers before that.*" The students' focused attention and concentration were indicators of frequent situational interest being generated. Cueing appeared to be crucial to generating interest and engagement in these Bhutanese science lessons.

The questioning process

The lesson observations revealed that across these Bhutanese science classroom contexts, the teachers' classroom questioning processes comprised of rephrasing and repeating a question after stating it, pausing, and then often letting students themselves volunteer to respond, or otherwise selecting a respondent. Within these stages of questioning, the teachers created opportunities for different forms of situation-specific interest to be triggered, such as heightened affect, humour, and discrepancy leading to the instructional conversation. Each of the embedded stages of the questioning process that were observed as typical in Bhutanese science teachers' practice in this study is discussed below.

a) Rephrase and repeat: After stating the question, it was often observed that the teacher rephrased and repeated the question to provide varied opportunities for students to understand the question. Participants' faces brightened at different stages of rephrasing and repeating the questions, thus indicating their understanding. For example, Mr E asked,

> "*Do you think that there is any correlation between these two, electricity and magnetism? How are they related? Or how they are connected, this electricity and magnetism? Yes! You know what electricity is, and you know what magnetism is. And then now, my question is, what is the connection between these two, electricity and magnetism?*"

The rephrasing and repetition of questions not only provided a means to understand a question, it also gave time to make meaning of it. According to Mitchell (1993), "making the content of the learning meaningful empowers students to achieve their personal goals" (p. 426). Meaningful learning is associated with sustaining or holding interest and engagement for a considerable duration.

b) Pause: Pause is an aspect of classroom questioning that was found to support the generation of interest and engagement. The length of a pause or downtime depended on the type or difficulty level of the questions asked in accordance with their grade. The open-ended (divergent) questions or higher difficulty level questions (e.g., using Bloom's taxonomy[8]) were provided with longer pause time compared to closed (convergent) or lower difficulty level questions (Dos et al., 2016). The pause or downtime extended the time for making sense of the questions and formulating responses to them (Yang, 2017). Mrs B said, "*When we ask the class, they get that preparatory time so…thinking time is already provided so after some time only we call the table number and student number so, they already got the thinking time.*" In terms of the person-object theory of interest, pausing provides transactional time to take a person closer to their object. The teachers usually waited for a sufficient number of volunteers to raise their hands or else they identified potential individuals to respond.

It was found that the pause time was longer in higher grades compared to the lower grades, thus generating a range of student interest and engagement across grades. This difference was also observed across different lesson topics. Questions posed during abstract lessons or when introducing unfamiliar topics that potentially involved greater cognitive challenge were provided with more pause time for response than questions relating to familiar or everyday topics. The blank facial expressions and avoidance

[8] Bloom's taxonomy is followed in classifying the difficulty level of questions in Bhutanese Education System

tactics the participants showed indicated that they were confused by some questions. In such circumstances, the teachers rephrased and repeated the questions or redirected them to other students.

Also observed in the Bhutanese science lessons in this study were the characteristics of learning activities that previous research has established as possible situational triggers for students' interest: autonomy, cognitive challenge, cognitive dissonance, and novelty. The participants were often seen to flip through their notebooks or textbooks. The grade 10 participants also engaged in mouthing and whispering their responses among themselves but rarely raised their hands to volunteer. By contrast, in grades 6 and 8, the participants' reactions involved raising their hand to share their responses with the teacher, but they rarely discussed the responses among themselves. These reactions indicate that even though the behavioural objective was to confirm their answers, variation was observed in terms of whom the participants preferred to discuss their responses with.

c) Identification of respondents: It was observed that the teachers adopted two ways to identify respondents for their questions. The first was to choose a student from among those who raised their hands, and the second was to call their roll number in the attendance register or their seating position in the room. Raising of hands indicated students' willing participation and engagement and, to some extent, their situational interest in the lesson.

Voluntary participation through the raising of hands was comparatively minimal in grade 10, but in grade 6 it was often the same group of students volunteering. As Mr A noticed, "*The voluntary participation goes down as we go higher up the grades.*" The grade 6 participants were frequently seen raising their hands, and in grade 8, participants would raise their hands until picked, and once they shared their response, they would not volunteer again unless no one else volunteered. The participants in grade 10 rarely volunteered to share their responses; mostly, the teacher had to identify the respondents. According to Mr E, "*I throw to the whole class and then, if there is no response from whole class then sometimes, I pinpoint. And sometimes, I ask the children who don't respond at all.*" It was observed that the teachers consciously tried to spread the opportunity to all the students unless there were few volunteers or when they were running short of time. Mrs B said, "*Everyone, they will get time to participate, they cannot hide. Because they are numbered 1 to 4 so, they will not know whose number will be called by the teacher so they should be alert and they should be prepared.*" However, Mrs D said, "*I tend to ask questions to those people who are showing interest because I get kind of encouragement listening to those students.*" When I asked Phub how he felt when he was picked after raising his hand, he said, "*I feel great,*" and when overlooked, "*I feel bored*". Mr A, often distributed the questions to as many students as possible to engage them actively.

The second strategy used to identify the respondent included calling out the roll number as per the attendance record book, or using their table number and student number, or choosing the students directly. In this practice, it was noticed that the teachers usually informed the students that a number would be called and that they should listen attentively to the question (e.g., Mr C said, "*I will ask the question first and call out the number, so everybody listen.*"). Both Mrs B and Mrs D mostly used the table number and student number to identify the respondent. Mrs B said,

> "*When we ask for the volunteer, I feel that most of the time, the brighter ones stand up to tell the answer. And when we call table number and student number, most of them are alert may be, their number will be called. If the same person stands up for repeated times, I avoid that student and ask some new students to respond*".

By contrast, Mr E randomly selected students to respond to questions. It was observed that the different strategies adopted by the teachers allowed them to distribute the questions throughout the classroom. When the opportunity to respond was opened to the whole class, most students showed interest and engagement in the lesson.

The follow-up to the questioning: Responding and probing

This stage involved the teacher paying attention to what the respondent had to say and providing appropriate feedback and comments. It was observed that students who shared their responses and received positive comments became more interested and engaged in the lessons. During the instructional conversation, when a student responded, most often, the other students looked at him or her. Reaction from the class varied according to the response. Some responses created cognitive discrepancies that led to humour or further discussion, while others made students realise their errors or look at the teacher for confirmation.

In the following interaction, there is evidence of the focused attention, humour, disequilibrium and redirecting of questions that occasionally happen in Bhutanese science classrooms.

> Mr E: *So, what do you mean by an insulator? Can you give me some example of an insulator? Yes! S1 (Calls out a student name and points at the student), can you give me one example of an insulator?*
>
> S1: *Copper wire…*
>
> Mr E: *COPPER WIRE is an INSULATOR (Some students giggle) Okay! Is copper wire insulator? Yes! S2 (calling out and pointing at another student) Can you give me one example of an insulator?*
>
> S2: *Insulator?*
>
> Mr E: *Yes! Example of an insulator.*
>
> S2: *Rubber sir.*

The participants were found confirming their responses and correcting the errors through mouthing and whispering. The class became livelier after the incident, which could be interpreted as indicating renewed student interest and engagement in the lesson.

Depending on the accuracy of responses, the question would be redirected or reinforced by the teacher. According to Mr A, "*I ask questions, and if they are not able to answer, I ask other students to help them.*" The process was repeated until a student provide some satisfactory answer. When a student shared the correct or partially correct answer, the teachers usually reinforced the response by either repeating or supplementing the answer.

In summary, it was observed that the questions were spread across the lesson and matched the different purposes across the introduction, lesson development and closure of the lesson, thus generating situation-specific interest. The questions in the lesson introduction activated cognition to link the topic to the prior knowledge or experiences of the students. The questions during the lesson development challenged students to explore the content, relate it to life experiences, or simply assess the learning up to that point. Finally, the questions during the lesson closure assessed students' learning to see whether or not the lesson objectives were fulfilled.

6.4 Chapter conclusion

The findings in Chapter 5 revealed that IL was used in the teaching of science across grades 6, 8 and 10 in Bhutanese classrooms, and that it does not generate the same interest and engagement within the same grade; the higher grades use IL more than the lower grades because of vast curriculum content and resource constraints. In this Chapter, using the person-object theory of interest, I have highlighted questioning as one of the key practices within IL lessons in Bhutanese science classrooms that can trigger and sustain students' high interest and engagement. Features of such classroom questioning include:

- prior to asking the question, not telling who is going to be involved in sharing their responses,
- cueing that the question is coming up,
- giving students time to generate ideas or discuss possible answers with their peers before sharing with the whole class, and
- attuning questions to phases of the lesson.

Chapter 7 focus on small group discussion lessons in a similar way, drawing out features that make the lessons interesting and engaging to students when learning science in a Bhutanese classroom context.

Chapter 7: Understanding Small Group Discussion in Science Lessons Through Person-Object Theory of Interest

7.1 Introduction

This Chapter focuses on small group discussions (SGD) by using a lesson vignette from grade 8 science and drawing out the participants' actions of interest (AoI) through the person-object theory of interest (POI) (Krapp, 1993). It closely examines how the participating teachers used the SGDs to impact student interest and engagement in learning science. Similar in design to Chapter 6, this Chapter responds particularly to the research sub-question, "*How are SGDs enacted in Bhutanese science lessons in ways that trigger and sustain students' interest and engagement?*" It thus promotes a richer understanding of the use of SGDs in the dynamics of interest and engagement in real-life science classrooms in Bhutan.

The analysis will bring out patterns among the two-thirds of the SGD lessons that generated high and sustained interest and engagement among the participants (see Table 5.4). A quarter of the 78 lessons observed used SGDs. Between a fifth and a third of lessons in each grade involved SGDs (the highest proportion being in grade 8), and two thirds of these were found to be lessons where there was evidence of high interest and engagement among students. However, around one tenth of the SGD lessons were less interesting and engaging (see Section 5.4). Therefore, this analysis focuses on the two thirds of the SGD lessons exhibiting high and sustained students' interest and engagement.

The main sources of data were the video recordings of the SGD lessons, field notes, audio recordings of class discussions, the interview transcripts, and the curriculum documents. The analysis identifies common themes among the teacher's practices, as well as patterns of interaction and meaning-making that were contributed to certain students' experiences of interest and engagement in learning. When new themes were established, the data were revisited using the iterative framework of (Srivastava & Hopwood, 2009).

Section 7.2 introduces an SGD lesson in grade 8 science and justifies why this particular lesson was identified for deeper analysis. This is followed by the lesson vignette, Norbu's AoI, and an interpretative analysis and discussion to draw out the key aspects of the lesson that triggered and sustained high interest and engagement for Norbu in this lesson. Section 7.3 looks at similarities and differences across the teachers' use of SGD in their science teaching practices in order to identify key features of their lessons. This will generate new understandings of how the practices of SGDs were enacted in ways that helped produce high and sustained interest and engagement in learning science, as interpreted through POI. Section 7.4 will conclude the Chapter and pave the way for Chapter 8.

All SGD activities were organised as the part of lesson development and they comprised three stages: the instruction, the activity, and the follow-up to the activity. The instructions prepared the students for a smooth transition into the activity. During the activity, as the students interacted among themselves, the teacher monitored them by standing in front of the class or moving around from group to group while listening to the discussions or scaffolding the learning. The opportunity to discuss acted as the source of interest (Agranovich & Assaraf, 2013). Finally, the follow-up consolidated the SGD activity to draw consensual learning for the whole class.

The number of SGD activities in each lesson varied; some lessons had as many as three SGD activities within them (see vignette in Section 7.2), and in others the SGD activity took the whole lesson (e.g., grade 10 lesson 8 in chemistry and lesson 12 in biology). When there was more than one SGD activity, the rigour of the discussions was high, and the teachers generally asked the students to shout "BINGO" when they finished the activity, which added time pressure. During the SGD activities that lasted for longer durations, the participants were engaged by being assigned different tasks at different points in time or by changing the individuals with whom they interacted.

Most of the SGDs took place as table group discussions (see Figure 5.9). However, the teachers deployed strategies like think-pair-share, shoulder partner followed by whole group discussion, rally coaching, and round-robin to vary the kinds of interaction that took place. The use of the Jigsaw strategy was also observed in one of the grade 10 chemistry lessons.

7.2 Enactment of SGD in grade 8 science

The following vignette captures a science lesson in grade 8. In this lesson, Mrs B had completed teaching the topic "sense organs" and began a new topic, "environment, lifestyle and healthy habits". The activity questions provided at the end of these topics were used to engage students in SGDs. In total, there were three SGDs held within 50 minutes of the second period lesson.

The following factors were considered in identifying this particular lesson for deeper analysis of SGDs. First, this lesson was categorised under high and sustained interest and engagement category (see Section 5.4). Second, with a third of the lessons in grade 8 delivered using SGD, it was a recurrent practice of this particular grade. Participant Karma said, "*Group discussion is like our daily classes,*" and Norbu said in the weekly interview that she found this particular lesson interesting among all science lessons taught during the week. This makes it possible to analyse the lesson from her perspective to better understand interest and engagement. Therefore, this particular science lesson was chosen for close investigation to explore the nuances in the teacher's practices that made learning science through SGD more sustained and highly interesting from the POI perspective.

7.2.1 Vignette: Environment, lifestyle and health (Exploring pollutions and its alternatives)

Narrative	Commentary
Lesson Introduction:	
Mrs B started the lesson with a brief meditation. It was followed by two questions to recapitulate the previous lesson. The first question was, "*What are the two layers of the skin?*" A brief pause and an identification of student, "*Group 3, student 1*[9]". Norbu stood up, but other students pointed at her shoulder partner, who later responded. The second question was, "*What is the function of sweat gland?*" This was asked to "*Group 6, student 3*". Students were observed to be alert and engaged during the questioning. Both Norbu and Samten looked into their book and later	Ritual engagement (part of GNH practice - affective) Prior learning and challenge/task – Trigger of interest Pause (downtime) – Engagement (cognitive) (Competent and readiness – cognitive activation)

[9] All students in the class can be identified through table number and student number (each student in the table is numbered 1– 4)

made eye contact with the teacher, ready to respond. After the number was called, all students turn their head to face the identified student. When the student could not answer even after providing hint and seeking support from the table members, the teacher redirected the question to student 4 in table 5 who gave the correct response.	Authentic engagement (cognitive), Focused attention. Competency (confident) Opportunity as trigger of interest
Lesson Development: Mrs B asked students to look at page 42 of their science textbook for the end-of-topic questions. She divided the six questions among the six groups of students in the class to discuss the answers as shoulder partners. It was observed that Mrs B deliberately assigned the most difficult question to the participant's group. As she explained the question, participants were seen reading from the book too. After the teacher moved away, Norbu immediately closed-in to talk to members across the table. Her shoulder partner was still reading. They discussed the question and were stuck with the meaning for hypothesis. Norbu's shoulder partner admitted that he did not understand the question. Meanwhile, Mrs B reemphasised three minutes for shoulder partner discussion. Briefly, the members separated to discuss as shoulder partners but, Norbu returned to whole group discussion. As Mrs B walked by the group, Norbu asked for the meaning of hypothesis. The teacher's response made the group more confused. Samten was sharing his answer when one of the groups shouted "*BINGO*". After the third group shouted BINGO, Mrs B stopped the discussion. The group agreed to let Norbu share what she feels is correct. Norbu was still trying to figure out the answer as table 1 presented their response. Both Norbu and Samten were concerned and continued to discuss. As the third group presented their response, participants turned their attention to the presenter. Norbu shared her response representing the group. She said, "*The researcher needs to do more research on the tasting regions of the tongue*". Mrs B acknowledging the response added, the hypothesis could be varied and	Ritual engagement (academic) Pair-work – Trigger of interest Focused attention – indicator of interest/Autonomy (Trigger of interest)/Ritual engagement (academic) Voluntary – Cognitive activation Timed pressure – heightened affect (Trigger of interest) Seeking behaviour/Focused attention as indicator of interest Volunteering (Cog Activation)– indicator of interest

other possibilities are, “*to investigate the taste buds on different individuals or sensitivity of individuals to different taste such as sour and sweet*”. Participants listened attentively to the teacher as she shared the alternative responses. Mrs B continued getting responses from other table groups. The participants focused their attention to other presenters. The completion of the sharing of responses by different groups brought an end to the topic “sense organs”.	Focused attention and seeking behaviour
Mrs B asked students for the next topic, and Norbu joined other students in giving the choral response while, Samten looked in his textbook. Mrs B wrote the topic on the chalkboard and explained saying, “*The next topic is about environment, lifestyle and health, which means, you are going to talk about how environment will affect our health, and how lifestyle will affect our health?*” She then read the objectives from the textbook. Momentarily, both Norbu and Samten looked at the board, then focused on their textbook.	Chalkboard as stimuli for interaction variation to engage students (Trigger).
As usual, Mrs B read from the textbook and explained sentence by sentence, during which the students looked into their textbook to follow teacher’s reading and paid attention to her explanation. Samten complied adopting a fixed posture with folded hands and gaze focused on the book while, Norbu took some time to focus her attention on the textbook.	Authentic engagement (focused attention and concentration)– students are interested in personal matters – Triggers of interest (healthy lifestyle) Effortless attention/Concentration as indicator of interest
As Mrs B elaborated on personal, environmental and hereditary factors that affects one’s health, she linked the lesson to students’ prior learning on balanced diet and types of food. As Mrs B asked about different types of food, Norbu was actively engaged in responding. She smiled and appeared excited. She nodded her head as the teacher repeated some of her responses.	Prior learning– triggers of interest Voluntarily responding – indicator of interest. Excitement as positive emotion – POI
Mrs B continued to read and explain about clean personal habits and need for sufficient bodily rest. Norbu again gave answers like washing ourselves, bathing while Samten focused on looking at his book.	Voluntary participation – indicator of interest
Mrs B covered environmental factors such as pollution, urbanisation and climate change that affect health. As she read and explained, she continued to ask questions such as, “*What pollution does urbanisation cause? What are*	Authentic engagement/sustained interest

some of the examples of unhealthy habits?" Norbu was seen responding to all the questions with other students in the class. She responded to almost all the questions the teacher asked.	Sustained authentic engagement Curiosity Authentic/Ritual engagement Group work
Mrs B continued on how environmental factors affects our health, how we affect the environment, and how it impacts us. Both Samten and Norbu were focused on their textbook	
As Mrs B reached the three types of pollution, she assigned second group work to students, She listed three causes and three preventive measures of pollution on the chalkboard and assigned a topic to all six groups as a part of activity 2.8 from the textbook. The students were given seven minutes to complete the activity. Mrs B stressed that everyone should participate in discussion, list their responses somewhere and later, one of them should present. The participants got causes of land pollution.	Autonomy, independent learning and shared responsibility were observed as indicators of interest (Authentic engagement)
Participants started by reading the textbook individually. Norbu finished first, followed by Samten and they waited for their friend to complete reading. It was Norbu who initiated discussion and one of the members did the notetaking. It was mostly Norbu and Samten contributing the points as the note-taker went on listing.	Ritual compliance – continued to engage in discussion
After few minutes, Mrs B suggested round-table[10] to engage all the students. Participants complied even though, most of their points were already listed. Samten was the first person to write his point. Participants referred their textbook as they added points in the notebook. After one round they discussed on the points listed while other groups started shouting BINGO. The participants were the fourth group to shout BINGO.	Timed pressure cause heightened emotion – trigger of interest Ritual compliance and heightened affect due to time pressure was observed. Authentic engagement for participants observed.
Mrs. B stopped the discussion and asked the group in the left corner of the class to start the presentation. As other groups presented, the participants listened attentively. A girl member presented for the group. Samten was	Focused attention – indicator of interest (ritual compliance) Active participation and positive emotion as indicator of interest

[10] One notebook or paper is passed around for everyone to record their points in the table until all the points get exhausted.

seen writing something in his notebook. Norbu referred her textbook. The presentation was followed by group cheers (Rocket cheers)[11]. Participants were excited as they stood up to do the cheers.	Authentically engaged and focused on learning.
Mrs B continued, "*let's see if you have covered all the points or not. Look into your book*". She began to read and explain again covering air, land and water pollution, and its effect on our health. Both Samten and Norbu became still and looked at the book with folded hands. Samten had his gaze fixed in the book while Norbu was found looking at the teacher and responding to questions whenever opportunity arose.	Social interaction – Trigger of interest Focused attention and cognitive activation – indicator of interest and engagement
On reaching activity 2.8 Mrs B informed the class that they have already covered the first three questions and to respond to the fourth question, she asked each group to come up with one policy to reduce the pollution (3rd group activity). Students were provided with 2 minutes to come up with the policy and shout BINGO if they finish before time. Samten was the first one to speak and gradually Norbu took over as the discussion in the group progressed. All members were equally engaged in discussion eventually. Mrs B stopped the discussion and asked one of the students to present from table number 4. When it came to the participant's turn, Samten shared the response, "*Segregate household waste into degradable and non-degradable*". (Bell rang) Mrs E made all group to share their policy and added on it "impose 200% tax on import of vehicle".	
Lesson Closure:	
She asked if there was science class in the afternoon and when the students said no! Mrs B informed, "*Next topic will be lifestyle and health*". Both Samten and Norbu were seen listening attentively until the teacher stopped and walked to her table.	Authentically engaged until the last moment. Focused attention

As recorded in the vignette, there were three SGDs organised to foster interest and engagement in the lesson. These SGDs provided participants with multiple

[11] Cheers are like accolade for successful completion of an activity or individual presentation.

opportunities to interact with their peers and teachers; relate the lesson to their prior learning or personal experiences; and decide which responses they would share and who would represent the group. While completing each SGD activity, the participants exhibited focused attention, heightened emotion (enjoyment), cognitive activation, and concentration. They were mostly authentically or ritually engaged, thereby exhibiting triggered and sustained interest and engagement in the lesson.

The first SGD activity provided participants as shoulder-partners[12] with the opportunity to generate a possible hypothesis for an experiment on the effect of mango pickle on the taste buds of the tongue. The question was, "*What could be the possible hypothesis of the study?*" Even though the discussion was meant to be between shoulder partners, the participants were engaged in discussing the answer as a whole table group. They were challenged and confused as they could not comprehend the meaning of word "hypothesis". The meaning of "hypothesis" in Dzongkha from the teacher did not particularly help them come to a consensus. The challenge posed by this question led to heightened emotions. Further, the audio recording revealed a misconception about the taste of mango pickle. Norbu was heard saying, "*How can mango pickle be sour and tasteless?*" She repeatedly questioned the other members about the taste of mango, and they had no answer. Time was running out and they did not have a response to their question. The urgency to find the answer to their question increased when other groups shouted "*BINGO*". The discrepancy in terms of inability to comprehend meaning of word "hypothesis", "the sour taste of mango pickle", and the time pressure of "BINGO" kept the students engaged in the activity. Their investment in understanding and answering the question was triggered by the opportunity to collaborate; the cognitive challenge; the time pressure; and their autonomy in deciding their response and who should present it. These triggers ensured that the participants' interest and engagement were sustained in this activity.

The second SGD activity required the participants to discuss the causes of land pollution. Initially, the participants exhibited compliant or ritual engagement while individually reading the content in the textbook. Later, when they autonomously

[12] A form of pair work where the students sitting adjacent to each other are considered as shoulder partner according to Kagan structures

decided who would contribute points and who would take notes, a subtle interest in completing the task was observed. The interest in the activity was heightened when participants were challenged by the teacher to use a round-robin strategy[13], making every individual accountable for contributing points for the group task. Mrs B said: "*Okay one idea, after discussing, you do round table, pass the paper, pass the pen and each one will write one point*." Since some answers were already shared, the participants were challenged cognitively to come up with new ideas. However, there were enough responses generated by the time some groups shouted 'BINGO'. This activity ended with a rocket cheers[14], which appeared to refresh the participants as they sat in their chairs. Here, familiarity of the content and being able to relate to prior knowledge for meaningful learning triggered and sustained the participants' interest and engagement in the activity.

The third SGD activity involved the participants taking on the role of policy makers to minimise pollution. Within 2 minutes the groups were asked to come up with a policy to minimise any type of pollution and to use 'BINGO' to signal the completion of the discussion. The opportunities for diverse responses generated interest and engagement among the participants. The audio recording of the class discussion revealed that the participants discussed minimising the use of minerals and the segregation of household waste into degradable and non-degradable components prior to disposal to minimise land pollutions. Samten was repeatedly heard saying "*segregation of household waste into degradable and non-degradable waste.*" The opportunity for autonomy, social interaction, and relating to prior knowledge were seen as triggers of interest and engagement in this activity.

Three distinct stages were observed in the ways the SGD activities were organised: setting up for the task, monitoring, and follow-up to the SGD. Mrs B said she preferred organising group discussion activities and often used rally coaching followed by numbered heads. Further, she said,

[13] A group brainstorming activity where every individual writes a point on the paper that goes around until all points are exhausted.

[14] Rocket cheers is one kind of accolade for completion of activity or task

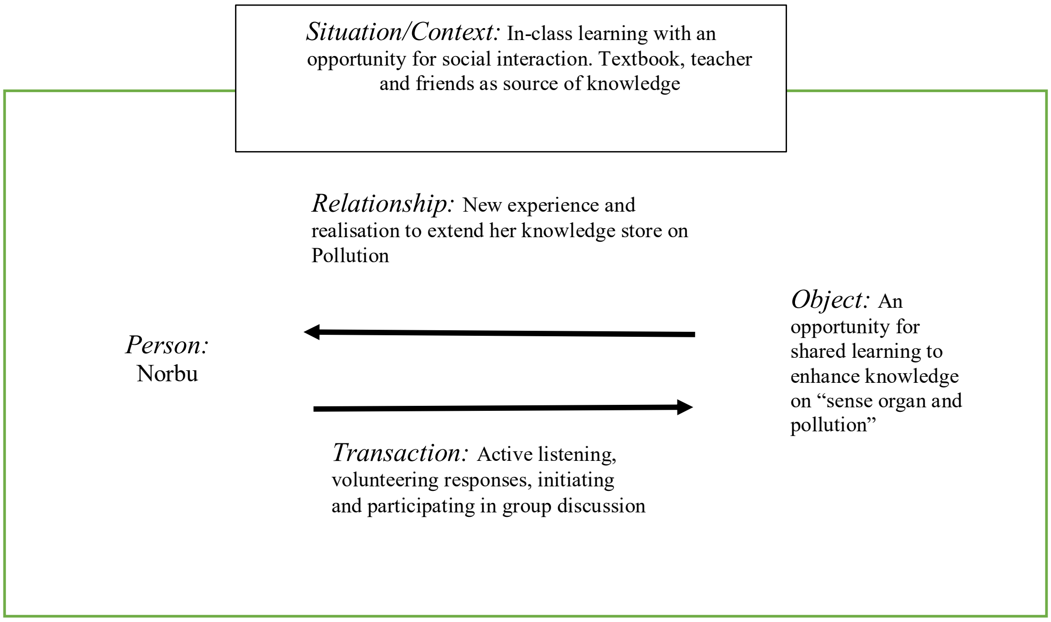
"*When they finish, they will say bingo and there, they have some sense of competition, so when they say bingo first, maybe they feel something great…, And everyone, they will get time to participate, they cannot hide. Because they are numbered 1 to 4 so, they will not know whose number will be called by the teacher so they should be alert and they should be prepared.*"

When analysing the vignette from the perspective of the POI, the setting up of the task, the variations (pacing and interactions), and the support provided by the teacher in terms of scaffolded autonomy were found to assist the development of interest and engagement in the lessons. Confirmation of these findings with reference to other SGD lessons and understanding its impact on the participants' science learning will be further discussed in Section 7.3. Next sub-section discusses Norbu's AoI, as she found the vignette lesson one of the most interesting lessons of that the week.

7.2.2 Analysis and interpretative discussion: Norbu's Action of Interest (AoI)

This sub-section explores Norbu's AoI in order to understand what made this lesson interesting and engaging for her. The analysis is based on the AoI as a current relationship between Norbu and her engagement in learning about pollutions and its alternatives in science lesson. The learning in this context is purposeful and intentional (Krapp, 1993). As mentioned at the beginning of this Chapter, Norbu's AoI is discussed because, she found this lesson the most interesting of all science lessons taught during the week. All five components; person, object, situation, transaction, and the relationship (see Figure 7.1) were considered for detailed characterisation and further explanation on the next page.

Figure 7.1 *Norbu's AoI (A figure adapted from Krapp, 1993)*



Person: Norbu

In addition to the profile information given in Chapter 5 (see Section 5.2.2), Norbu's interest in this particular lesson is described in terms of the situational and personal interest she brought to it (Krapp, 2002). Both types of interest were evident as she interacted in the lesson and then talked about it during the weekly interview.

Three key moments indicate Norbu's situational interest in the lesson. To begin, the first group activity had Norbu unable to comprehend the question and the situation described in it. The audio recordings of the discussion revealed that she asked the teacher for the meaning of the word "hypothesis" and she was loudly trying to figure out, "*How can a sweet mango taste sour when pickled and for some tasteless?*" The cognitive discrepancy or challenge (Renninger & Pozos-Brewer, 2015) stimulated Norbu to become engaged and interested in finding the response until it was the group's turn to share the answer. She volunteered to share her response (see the vignette in Section 7.2.1). After that, in both the second and third SGD activities, Norbu's situational interest was again triggered by the opportunity for social interaction and the ability to relate the lesson content to her previous knowledge or prior learning (Jack & Lin, 2014;

Mitchell, 1993). She could relate the "causes of land pollution to the use of chemical fertilisers", and "policy to minimise pollution to 3Rs (Reduce, Reuse and Recycle)". Most importantly, the zeal and enthusiasm with which she interacted in the group discussion indicated her desire for social interaction (Bergin, 2016).

Two indications confirmed Norbu's emerging personal interest in the SGD activity based on familiarity of content. The first was her quest to learn more about the topic "pollution"; she had continued to look for more information about pollution in the following week. During the second week's interview, she said, "*I think I really liked the topic about pollution so I read more about it sir, in the internet too. It was a very catchy topic, so I did some research on it.*" This was indicative of her emerging personal interest on the topic. According to Renninger and Pozos-Brewer (2015), "the ability to pursue the discipline independently, and the ability to seriously engage the discipline by asking and seeking answers are the characteristics of personal interest" (p. 378). The second indication was her reason for choosing the topic and the deeper understanding of it she exhibited. When asked which topic she preferred and why, she said,

> "*I think pollution because, it tells us how we keep our environment better and cleaner and, it also talks about our health. So I think, more than learning about our sense organ, we need to know about our environment and pollution*".

Furthermore, Norbu could easily relate the function of skin to, "absorption, secretion and sensation", and for pollution, she said, "*I noticed about water pollution when I got intense diarrhoea after accidently drinking water from the river.*" These were indicative of her emerging personal interest on the topic being covered.

Opportunities for social interaction (Bergin, 2016) or involvement (Jack & Lin, 2014; Mitchell, 1993) were found to be the main triggers of both situational and personal interest for Norbu. It was observed that she looked forward to sharing her views and that the opportunities for group activities excited her. The indicators of her situational interest were the zeal and enthusiasm she exhibited to collaborate during the teacher's questioning and at the start of SGD. Norbu was usually the first person to speak up during the group activities. She said, "*It is fun when we are working in the group, we get to share what we know.*" Her consistent vocal responses to the many questions the teacher asked during the elaboration of the lesson content and the enjoyment she derived while getting involved in SGD activities indicates her emerging personal interest in social interaction. Norbu was observed making frequent eye contact with the teacher to gain attention and to share her responses when prompted. Her reaction to the triggers indicates both her situational and personal interest in this particular lesson.

Object: An opportunity for shared learning to enhance knowledge on the topic

The object of interest for Norbu in this lesson was the opportunity to apply her prior knowledge and to further develop her knowledge through social interactions with her peers and the teacher. This was facilitated by the teacher questioning and giving opportunities for the students to interact among themselves within the group. According to Bergin (2016), "peers influence interests by exposing individuals to specific topic or activities and meeting their needs for belongingness" (p. 13). In addition, even when pair work was assigned, Norbu preferred whole group discussion (see the vignette in Section 7.2.1). The group activities saw a strong emphasis placed on the students' cognitive abilities and associated skills (e.g., communication and interpersonal skills). As the individuals in the group interacted, these abilities and skills enhanced their current knowledge on the topic. In all the three SGD activities, Norbu shared her confusions (e.g., "*What does industrial waste mean?*") and her suggestions (e.g., "*The use of chemical fertilisers cause land pollution*"), and often dominated the discussion. The audio recordings revealed that the discussions generated answers for some of her questions and left others unanswered. During her interview, Norbu shared that she had been following up on some of the questions from the lesson by searching the internet. In terms of AoI, huge reliance was placed on the social relationship among students and with the teacher to enhance knowledge.

Situation/Context: SGD activity

Norbu's high interest and engagement in this lesson were triggered and sustained by the opportunity for social interaction to enhance her knowledge of the lesson topic. Three occasions were provided for her to engage in SGD, one of which was self-initiated. All these SGD discussions happened within the table group in the classroom and they were organised to respond to the activity questions in the textbook. However, Mrs B varied the ways in which the participants interacted, the difficulty levels of the questions and the time allocated for the activity. According to POI, the context of an action can be appropriately designed by adding new incentives to the task or object (Krapp, 1993).

The first SGD activity required the participants to discuss the answer to the question that followed the description of an experimental set-up: "What could be the possible hypothesis of the experiment?" Each table group was provided with a different question, and the students were to discuss as shoulder partners for three minutes, after which Mrs B asked the groups to share their answers. While the participants were engaged in the whole group discussion, the teacher stood next to the group, monitoring the progress of the activity. She occasionally moved around the class to clarify the students' doubts. The provision of scaffolded autonomy was evident here. The activity saw groups using "BINGO" to signal the completion of activity, which added time pressure to complete the activity quickly.

The second group activity required the participant's table to discuss and come up with as many reasons as possible for "causes of land pollution". Again, each group was provided with a different question, but this time, they were given 7 minutes to come up with answers using the round-robin technique – a paper is passed around with a pen, where each participant writes a point as it comes to her/him and it goes around until all points are exhausted. Some information was provided in the textbook and the participants were seen reading the content quickly before discussion. Here also, some groups used "BINGO" to signal the completion of activity.

The third group activity gave each table group 2 minutes to come up with a policy to minimise pollution. This time the same question was provided to all the groups and there was no specific order of discussion. Mrs B reminded the groups to use "BINGO" to signal the completion of discussion.

In all the three SGD activities, Norbu was observed to be authentically engaged. The opportunities to interact with her peers and at the same time learn from each other made her focus on the activities and stay interested in them. In times of doubt, she did not hesitate to seek clarification from her teacher and her peers. She participated in each activity with zeal and enthusiasm, contributing her ideas and seeking help to clarify confusions.

The transaction: Participation in discussion

All three SGD activities provided similar opportunities for Norbu to engage with her object of interest, as all of them required abstract cognitive attention to a specific problem (Krapp, 2007). The object engagement that took place in each SGD activity is elaborated below.

During the first SGD activity, cognitive discrepancy triggered interest and engagement for Norbu. As soon as the task was assigned, and despite Mrs B stating the discussion should take place among shoulder partners, Norbu was seen talking across the table. There were two reasons for her confusion: first, she could not comprehend how the mango pickle could taste sour or be tasteless, and second, she could not understand the meaning of word "hypothesis". The following excerpt from the class discussion audio transcripts illustrates her confusion:

Norbu: *Mango is sweet but the pickle is sour. Did anyone taste mango pickle?*

Dechen: *Not me! And, three students found it tasteles*s

Norbu: *What could be the reason for finding tasteless? There's something wrong with their taste buds? Madam, what is the meaning of "hypothesis"?*

Mrs B: *What could be the possible reasons for carrying out the experiment?*

Norbu: *Possible reasons!*

Norbu continued her discussions with Samten until the last minute to find an answer to the activity task assigned to them. Despite being unsure of the response, she volunteered and shared her understanding on behalf of the group. She exhibited both perseverance and help-seeking behaviour as indicators of interest.

The second group activity required the participants to discuss "the causes of land pollution". Here, Norbu was observed trying to relate the information provided in the textbook to her prior knowledge. She could be heard saying, "*Contamination from the agriculture…, does it mean the use of chemical fertilisers?*" Being able to relate the information in the textbook to prior knowledge triggered interest in this situation. The activity also saw Mrs B adding a twist in the format of the discussion by changing it from whole group to round robin to introduce an additional cognitive challenge to find answers individually. This change in the format of discussion and the timed pressure in the form of “BINGO” were seen as means to sustain the students’ interest and engagement in the activity.

The third SGD also involved Norbu and her peers in abstract cognition to come up with “a policy to minimise pollution”. Norbu linked the answer to the 3Rs (Reduce, Reuse and Recycle) concept she had learnt earlier. Furthermore, Mrs B gave the group only two minutes to discuss, which added time pressure to generate a quick response.

The relationship: The outcome

Two distinct relationships were evident in this AoI for Norbu. First, the way she enthusiastically interacted with her peers and involved them in discussion during all the three SGD activities revealed her strong inclination to learn through social interaction. She also joined in the vocal response every time the teacher asked questions or prompted the students to complete sentences. Her preference in learning through verbal exchange is evidenced in the statement, “*Whenever madam tells us to look at the book, I can reach her readings easily sir. So, I just think that I should listen to her than look more on the book.*” Additionally, she often clarified her confusions and suggested responses. It is therefore apparent that Norbu was disposed to learn through social interaction.

Second, Norbu shared her emerging personal interest on the topic “pollution”. With conviction, she said in her interview, “*I think I really liked the topic about pollution so I read more about it in the internet. It was a very catchy topic so I did some research on it*”. She could relate most of the learning on pollution to her prior knowledge or experiences. She felt it was important to learn more about pollution than to know our body parts:

> “*I noticed that when we study about pollution, more than sense organs ... we can know more about our environment and what causes pollution so we can also have more ways to prevent it. We can also keep ourselves healthier than before.*”

She also shared her personal experience of suffering from diarrhoea after drinking contaminated water directly from the river. These comments point towards Norbu’s emerging personal interest in the topic “pollution”.

7.2.3 Mapping SGD with Norbu's AoI

It is evident that Norbu exhibited a prominent interest in social interaction and that social influences played an important role in her learning. The SGD provided her with a platform of autonomy and cognitive challenges that she could use to enhance her knowledge repertoire of the lesson topic being discussed. Further, as may be seen in the lesson topic covered by the vignette and her AoI, Norbu seems to have developed a disposition to understand "pollution" and its impact on the environment. According to Krapp (1993, p. 8),

Every time a person actively interacts with the object of interest, the person-object relation is modified and traces are left on both sides – the object gets modified (in case of art) or the person gains new experience or information, which extends his or her knowledge repository. Norbu's confirmation during her interview of her interest in understanding more about pollution confirms her emerging interest on the topic.

7.3 Variations and scaffolded autonomy were effective in triggering and sustaining students' high interest and engagement in the SGD science lessons

Variations and scaffolded autonomy were found to be crucial in triggering and sustaining the students' high interest and engagement in the SGD lessons. While the variations reduced the students' boredom and focused their attention on the ongoing learning (Darwis et al., 2019), scaffolded autonomy reduced their frustrations (O'Connor et al., 2014) and prepared them to become independent learners (Murray & McPherson, 2006). The lesson observations revealed that whenever these two pedagogic opportunities were provided in SGDs, the students enjoyed the lesson and were attentive and cognitively active. Jitsuen said, "*We had group discussion where we interacted with our friends and everyone enjoyed*". This reference was made to the jig-saw strategy used by grade 10 chemistry teacher where students were provided with the opportunity to interact with peers from other groups instead of their own table group. Here, Mrs D was observed moving from one group to another responding to student queries. Likewise, Phub, talking about the revision lesson on first chapter in grade 6 said, "*The teacher divided us into group and for the whole period, we were asked to* *write down the materials required and procedure for and experiment so that we could do it ourselves*". Here, the students were allowed to choose the format and topic of the discussions, and the kinds of responses to provide. Similarly, another small group discussion lesson about the topic 'solubility' in grade 8, required students to do a graph work under the close supervision and guidance of other group members. To ensure that every member gets chance to plot the graph, students were asked to take turns and accomplish the activity within seven minutes. The participants supported each other and were involved diligently in the task. These SGD activities were used to trigger and sustain the students' high interest and engagement in the science lessons.

However, acknowledging the benefits of the SGD activities, Mr C indicated that engaging students in SGDs was time consuming:

> "*Actually it is good, students get more time and shy students get the opportunity to share their knowledge and talk with friends but, it is very difficult for us to finish the syllabus if we organise is every time.*"

In the following subsections, a brief descriptions of the terms, variation and scaffolded autonomy are presented first. This is followed by a discussion of the prominent triggers of interest and engagement that were observed in the SGD lessons. The findings on how these pedagogic practices (variations and scaffolded autonomy) were enacted in these Bhutanese science classrooms to trigger and sustain students' high interest and engagement are then presented. A brief summary follows.

7.3.1 Variations and scaffolded autonomy

This sub-section describes how the terms variation and scaffolded autonomy are conceptualised in this study.

Variation refers to doing something in a different way or approaching the same thing or purpose or objective through different means to boost teaching and learning. It is also described as the fluctuation that every individual is capable of implementing to avoid repetitive practices (McNamara & Leimar, 2010). In terms of SGD practices in science classrooms, variation is what the teacher does when organising activities to avoid the monotony of repeating them when guiding student interactions by creating or limiting opportunities to participate in them. The teacher controls the content, process and pacing of how SGD activities are carried out during the science lesson to ensure that the students remain interested and engaged. According to POI, variation in SGD activities is the degree of flexibility adopted by the teacher to vary the situation or context for student interactions to achieve the learning outcome of the lesson (Krapp, 2007). In this study the classroom observations revealed that the teachers varied their approaches on how SGD activities were organised to ensure that the students remained interested and engaged in the activity.

Similarly, *scaffolded autonomy* is the temporary supportive structure provided by a teacher to enable students to achieve a task independently. According to Andrzejewski et al. (2019) scaffolded autonomy provides multiple opportunities that students can choose from when demonstrating their mastery of course content. The term combines the concept of scaffolding, which refers to temporary supportive structure or assistance provided by the teacher to accomplish an educational task, and autonomy, which refers to letting students collectively decide on their response, including the format and content of discussion, so long as they come up with the response.

In terms of scaffolded autonomy during the SGD activities in the Bhutanese science classrooms studied, the teachers did not intervene in either the format or the outcome of discussion once the activity was assigned to the groups. So long as the students were productively engaged in the discussion and their responses were related to the objective of the activity, the teachers did not interfere in the discussion unless prompted by the students' questions. This flexibility generated a conducive environment for students to interact and come up with the best possible responses. The teachers did not reprimand students for wrong responses; instead, they supported the students to find the required response through questioning. This facilitated the generation of high and sustained interest and engagement during the SGD activities.

7.3.2 How variations and scaffolded autonomy triggered and sustained the students' interest and engagement in the science lessons

Variation and scaffolded autonomy were the key pedagogic practices for triggering and sustaining high interest and engagement among students during the SGD activities. In all three grades (grades 6, 8 and 10), students were often observed engaging in SGD activities. Karma said, "*Group work happens almost every day.*" The students exhibited enthusiasm for the SGD activities but there were instances where they were confused about the activity task, even though they persevered to clarify the confusion and arrive at a response. The triggers of interest and engagement in SGD activities can be related directly to the three basic need postulates on which POI is based – social relatedness, competence, and autonomy (Krapp, 1993). The video recording revealed that the triggers that prompted the students to be interested and engaged in SGD activities were opportunities for social interactions, the relating of lessons to previous experience or knowledge, autonomy, and cognitive dissonance. Each of these triggers will now be elaborated on.

Opportunities for social interaction: The SGDs provided opportunities for social interaction, with the outspoken students often the first to contribute their ideas. Teachers used numbered heads one to five to engage and encourage those students who often avoided discussion. The students took the opportunity to share what they knew and to assess each other's understanding, thus providing them the access to different ideas and interpretations. They also used activity times to connect with each other. According to Bergin (2016), social interactions expose students to specific topics or activities and meet their needs for belongingness, which can heighten their interest and engagement in the particular topic. As mentioned previously, Jitsuen said, "*Opportunities to engage in discussion among group members made the lesson enjoyable.*" Opportunities for social interaction was thus one of the triggers of interest and engagement during the SGDs (Renninger et al., 2019).

Opportunities to relate to previous experience/knowledge: The SGDs allowed the students to share their previous knowledge or experiences, often in language familiar and comprehensible to everyone in the group. Linking lesson activities to personal past experiences can facilitate triggering and sustaining of interest and engagement among students (Renninger et al., 2019). The students brought their repertoires of knowledge into the classroom and shared them during the SGD activities. For instance, Samten in the third SGD in the vignette above (see Section 7.2.1) used his previous knowledge about segregating waste at the source to minimise land pollution. In the process, the students scaffolded each other's learning and actively engaged in the activity. Further, the science lessons were taught in English but often the discussions used the local language Dzongkha. The students were recorded using Dzongkha and other local dialects during their SGDs, which were later translated while transcribing by the researcher and member checked.

Autonomy: The SGDs provided the students with the freedom to choose the breadth and depth of the topic under discussion. They also had autonomy over the format of the discussion and shared their perspectives in response to the activity task. According to Deci and Ryan (1987), autonomy represents an individual's action that springs from himself or herself where the decisions are his or her own. For example, Mr C stressed, "*I want the students to learn themselves, that was the main objective where students were involved individually first and then in a group/as a team.*" Across all grades, the students were provided with autonomy during the SGD activities. In grade 6, the students were actively engaged with heightened interest during the entire lesson when listing the materials and procedures required for separating salt and sand. In terms of POI, the need for autonomy comprises an individual's strivings to experience themselves as the centre of action (Krapp, 1993). Other ways that teachers can create an autonomy-supportive climate is by trying to understand their students' feelings and thoughts and by sharing concerns for their learning (Tsai et al., 2008). It is apparent that autonomy was one of the triggers of interest and engagement during the SGD lessons that ensured the students were cognitively involved in the activity and enjoyed it.

Cognitive dissonance: The final prominent trigger for interest and engagement during the SGD lessons was cognitive dissonance. Bergin (1999), conceptualised cognitive dissonance as a discrepancy and that people invest themselves in resolving it. According to the basic needs postulates on which POI is based, individuals pursue competence to enhance their capabilities but at times bring misconceptions or misconstrued understanding into their lessons (Krapp, 1993). These misconceptions combined with the need to develop competence can lead to cognitive dissonance, and this characteristic was seen to foster the students' high interest and engagement during the lessons. For instance, in the vignette (see Section 7.2.1) and Norbu's AoI, it was observed that she could not comprehend the meaning of "hypothesis" and misunderstood how mango pickle could be sour. However, she was an active contributor to the SGD.

7.3.3 Patterns in variation and scaffolded autonomy

Before analysing the practices of SGD that promote high and sustained interest and engagement, the concrete features of SGDs will be revisited (see Section 5.4). In all the cases observed, instructions for the SGDs were given by the teachers, who checked the students' understanding of the instructions by asking clarifying questions by or requesting one of the students to repeat the instruction. During the discussions, the teachers moved from group to group, listening to students, asking questions and clarifying doubts. The sequence would conclude with the teacher soliciting answers from each group in the class. However, within these sequence of actions it was observed that there were subtle variations in the ways the activities were conducted.

Patterns in variations: Variations were observed in terms of content, process and pacing. The findings on each of these areas are presented below.

Variations in content: The contents for the SGDs included summarising information after reading the textbook and then explaining to others (e.g., Jigsaw strategy being used in grade 10 chemistry lesson), finding answers to the activity questions (e.g., what is the hypothesis of the experiment?), or digging into their memory (e.g., discuss and write five examples each for foods that taste bitter and those that taste sour). Some contents were more interesting than others for many students (Bergin, 1999) (e.g., write two differences between atoms and molecules), but whenever the contents were relevant to the students' past experiences, they triggered interest (Renninger et al., 2019) (e.g., what is the smallest thing in the world?). It was apparent that the teachers deliberately choose topics for SGD activities that would interest the students.

Variations in process: The SGD itself was one of the pedagogical practices used to vary the process of the students' interactions with the subject matter. Mr E said, "*There are activity after activity so I sometimes, let them do in group and sometimes, I do it through demonstration.*" Another variation observed was in the way the instructions were provided, which included mentioning the purpose of the activity. In addition, the teachers were acquainted with Kagan structures and would regularly use think-pair share, round robin, shoulder partner, face partner, and rally coaching to engage students in the SGDs. Mr C preferred to use inner-outer circle, which he described:

> "*Students are taken outside the classroom and made to stand in two circles, inside and outside. The students face each other and the ones in the inner circle ask question to the one in the outer circle. After sharing the response, the student in the outer circle moves across five students to their right and faces another student in the inner circle, who again will ask question. After repeating the process for few times, the students swap places and take turn to respond.*"

These variations in the processes of interaction among students kept them interested and engaged during the SGD lessons.

Variations in pacing: One of the variations used in organising the SGD activities was the time allocated to the activity. The shortest SGD time allotted was 2 minutes (e.g., discuss one policy to minimise pollution), while a few took the entire lesson duration of 40 minutes (e.g., write down the material required and the procedure to separate sand from salt). The short-duration activities were of high intensity, resulting in a sudden burst of brief and heightened interest and engagement. For the longer activities, the teachers used BINGO to add time pressure to complete an activity as quickly as possible. Students are encouraged to shout "BINGO" to inform the class that they completed the activity. Mrs B said, "*During the group discussion when they finish, they will say bingo and there, they have some sense of competition, so when they say bingo first, maybe they feel something great.*" Pacing the lesson by limiting the time and using BINGO made the SGD activities more interesting and engaging for the students.

Patterns in scaffolded autonomy: Scaffolded autonomy was another key element of SGDs that triggered and sustained students' high interest and engagement in these Bhutanese science lessons. When the students engaged in SGDs, the teachers either stood in front of the class, monitoring it and overseeing that everyone was engaged, moving to the groups when they had questions, or they moved from one group to another listening, intervening and challenging students to think but avoiding judging their responses. However, support was not always provided by the teacher. Hence, the provision of scaffolded autonomy could be looked at from two perspectives: the peer coaching, and the intervention from the teachers during the SGD activities. These perspectives will now be elaborated on to show how high interest and engagement were triggered and sustained.

Peer coaching: was one of the strategies adopted by the teachers to facilitate scaffolded autonomy among the students. It provided an opportunity for collaborative activity (Joyce & Calhoun, 2018) to enhance their learning. “Peer coaching describes a collaborative relationship between an experienced individual and a willing participant” (McQuiston & Hanna, 2015, p. 105). Mr A described peer coaching in science classrooms:

> “*As students engage I think they learn from each other talking to each other, asking questions not necessarily to the teacher, so trying to find out the answer among themselves you know, so if I see that sort of behavioural indicator so I would assume that you know they are interested in science.*”

During the fieldwork, I observed that the grouping of students on each table was done carefully to include mixed abilities so as to encourage learning from each other. Mr A confirmed this:

> “*This is done consciously so that they learn from each other, by supporting each other you know and, through that sort of arrangement I think, there is more collaboration, more exchange of ideas, peer learning that also builds relationships among the students.*”

Mrs B from grade 8 said,

> “*I mostly use that rally coach. Rally coach is guiding one another, either face partner or shoulder partner. When one solves the problem, the other one guides and takes turn.*”

The students also found peer coaching befitting: “*It is enjoyable to work in groups, we get to share what we know and we can give chances to others too.*” The video recordings revealed that students in grade 6 discussed in groups when instructed. For example, Semyang said, “*I did not know the answers to the question. After discussing with the group, I came up the answers.*” However, in grade 10, whenever the teacher asked questions, the students preferred to cross check among themselves before sharing their responses. Jitsuen said, “*First I think the answers and I ask my friends whether it is right or not…, group work provided opportunities for interaction and everyone enjoys.*”

And Kezang, also from grade 10 said, "*I want my other friends to participate as well. I mean, I tell the answer and hope that they hears it and might participate.*" This is not exactly scaffolding, but he was still trying to help his friends. These statements indicate that peer coaching was commonly used as scaffolded autonomy to generate of interest and engagement in learning in these Bhutanese science classrooms.

Teacher's support: During the field work, I observed two forms of teacher's support for scaffolded autonomy during the SGDs. The first was action-oriented support, where teachers moved around the classroom from one group to another clarifying students doubts, listening to them talk, and encouraging them to dig deeper for possible answers. They visited particular groups multiple times, spending considerable time ensuring the groups were on task and helping them explore answers at deeper levels, which in turn kept the students interested and engaged in the assigned SGD task. At other times, the teachers simply moved around the class, monitoring and responding to students' queries when approached. The teachers' proximity kept the students engaged on the task. Semyang said, "*Our science sir uses different means of questioning to make us understand better.*" And Binod commented, "*Teachers are using strategies including sharing of personal experiences and questioning to make us remember better.*" From the reactions of the students, it was apparent that the personal attention to each group seemed to trigger increased interest and engagement.

The second form of teacher's support was connected to their personal beliefs about teaching and how they implemented these in their lessons. For example, Mrs D said, "*One way to encourage students is to let them find answers themselves.*" This was echoed by Mrs B: "*I thought it will be better if we let them do it in group by themselves, it will help them understand.*" In terms of interest and engagement, Mr A observed, "*In general, the lessons where students work in groups to find solutions, they enjoyed the most.*" These statements indicate that these teachers believed in scaffolded autonomy, the evidence being the students' enjoyment during the lessons. Engaging students in SGDs promoted deep reflection, which increased their competency to deal more effectively with their doubts and concerns. By believing in the value of scaffolded autonomy in their science classrooms, the teachers were able to trigger and sustain their students' interest and engagement.

In summary, varying the contents of the SGDs challenged individual students to engage in different levels of problem solving; varying the processes provided opportunities for students to interact with different individuals and materials in the classroom; and varying the pacing resulted in students exhibiting heightened positive emotions or enjoyment. Activities with shorter duration produced intense interactions, whereas longer ones required perseverance. With regard to scaffolded autonomy, both the students' peers and their science teachers were crucial in helping individual students find answers to their queries. The seating arrangements of each group ensured that high and average performing students could support each other. The proximity of the teachers and their availability for clarification at any time during the SGDs also supported the students' interest and engagement.

Table 7.1 provide examples of the components emerging from the SGDs, as recorded in the video transcripts. It was observed that these components supported the students' interest and engagement in the activity.

Table 7.1 *Components emerging from SGD lessons in Bhutanese science classrooms*

Components	Key elements	Example(s) from video transcripts
Variations in organising SGDs	Variation in content	E.g. 1 (Focusing on previous knowledge) Discuss the answers to the following two questions 1. What is the smallest thing in this world? 2. Where it is found? E.g. 2 (Focusing on reading from the textbook) Read the content from the textbook assigned to your group and come up with two important points to share with the whole class E.g. 3 (Activity questions or end of chapter questions) Discuss the answer to the assigned question to your group
	Variation in process	Shoulder/Face partner discussion as a part of think-pair-share activity or rally coaching, Round Robin, Brainstorming, Inner-Outer circle, Jigsaw strategy, Table Group Discussion followed by numbered head
	Variation in pacing	Activity timing ranging from 2 minutes to the whole lesson timing followed by BINGO E.g. 1 In your table group, discuss one policy to reduce pollution within two minutes. E.g. 2 Read the passage individually, discuss in your group and come up with one most important term and write it on the chalkboard. After that, using all the terms written on the chalkboard, each group can come up with a creative activity (song, role play, poem or any other means of presentation) to share your understanding about those words (This activity took the whole 40 minutes)
Scaffolded autonomy	Peer support	Use of rally coaching (Find one difficult questions in this chapter and discuss the answer by sharing with your group members) SGD activities itself provides opportunities for peer support
	Teacher support	Fading to support autonomy Proximity to boost confidence and ensure availability

7.4 Chapter conclusion

By looking closely into a vignette and an AoI of student Norbu, this study found that the teachers' variations in organising SGDs and their provision of scaffolded autonomy were key pedagogic practices that triggered and sustained students' high interest and engagement in these Bhutanese science classrooms. The main triggers of interest generated during the SGDs were opportunities for the students to socially interact and share personal/previous experiences; autonomy; and cognitive dissonance. These triggers contributed to the students' attentiveness, concentration, enjoyment and learning.

Chapter 8 will look at hands-on learning lessons – another key feature that triggered and sustained students' interest and engagement in these Bhutanese science classrooms.

Chapter 8: Understanding Hands-On Learning in Science Lessons Through the Person-Object Theory of Interest

8.1 Introduction

Hands-on learning (HoL) was the third prominent signature pedagogical practice deployed in Bhutanese science lessons observed in this study. Through HoL, the participating teachers assigned responsibilities to students to take charge of their science learning in a collaborative environment. There were two distinct ways in which the distribution of responsibilities took place among the members in the group as they carried out the HoL activities. Similar to Chapters 6 and 7, this Chapter scrutinises the different ways that the participating teachers used HoL to foster student interest and engagement in learning science. Using a vignette lesson and drawing on the Action of Interest (AoI) of one participant through the person-object theory of interest (Krapp, 1993), this Chapter presents the emerging patterns on the enactment of HoL activities in these Bhutanese science lessons, thus answering the question "How are HoL activities enacted in the context of Bhutanese science lessons in ways that trigger and sustain students' interest and engagement?" The intention is to promote a richer understanding of HoL lessons in the dynamics of interest and engagement in real-life science lessons in Bhutan.

Section 8.2 introduces a lesson in grade 6 science to show how HoL activities are enacted in Bhutanese science lessons. This particular lesson is relevant for discussion because it shares the lesson narrative with commentary using the lens of person-object theory of interest. This section also includes Semyang's AoI to understand the development of her interest and engagement during the HoL activity or as the lesson unfolded. These findings were used to generate preliminary emerging patterns in Semyang's teacher's practice that triggered high and sustained interest and engagement among the participating students. Using the initial emerging patterns, section 8.3 looks across the 12 HoL lessons to establish the key practices and sources of interest and engagement for participants. This leads to a new understanding of how HoL activities are enacted in ways that help to produce higher and sustained interest in Bhutanese science classrooms, as interpreted through POI. Finally, section 8.4 concludes the Chapter and paves the way to the conclusion of this thesis.

In continuation of the information provided in section 5.4.3, there are four contextual facts to be considered in understanding HoL activities in Bhutanese science classrooms. First, according to Kilbrink et al. (2014), HoL is based on constructionist view of learning, in which students actively construct learning from experience. It includes all those learning activities that involved or allowed the use of touching with the hands and are characterised by active personal involvement (Flick, 1993). Second, all the HoL activities observed were carried out in groups ranging from four to 10 members due to limited resources. All participating teachers and students agreed that HoL activities were "always in groups" and the teachers affirmed that, "the equipment are not sufficient". Representing all teachers, Mr E said, "*Individually, materials will not be enough so group work, in groups, they will carry out.*" Third, the HoL activities were held either in classrooms or in the science laboratories. The field notes recorded teachers walking into the classroom for the experiment with materials from the laboratory. And finally, the format adopted to carry out the HoL activities was either individualised, where each member had a different role, or shared, where each member did the same task.

The quantitative aspect of the HoL data reveals that 14 of the 78 lessons observed were delivered using HoL activities, and it could be because of this rarity that none of them was categorised under the low-interest category (see Section 5.4). Among these 14 HoL lessons, 12 were categorised as high and sustained interest and engagement lessons, and two were categorised as less than high but briefly sustained interest and engagement lessons. The data analysis for this Chapter focuses on the 12 lessons that triggered high and sustained interest and engagement among participants.

The data analysis involved video recordings, field notes, class discussion audio recordings, interview transcripts and curriculum documents to tease out common themes across the teachers' practices. It also explored patterns of interactions among key participants in order to make meaning of their experiences of interest and engagement in learning science. The establishment of themes is based on the three key steps of the iterative framework: (1) What are the data telling me? (2) What is it that I want to know? and (3) What is the dialectical relationship between what the data are telling me and what I want to know? (Srivastava & Hopwood, 2009).

8.2 Understanding the enactment of HoL in a grade 6 science lesson

This vignette is about a science lesson in grade 6. The lesson was on separating immiscible liquids by decantation using a glass rod. There were 26 students in the class, divided into 7 table groups. In this lesson, Mr A taught the first of the two methods of separating immiscible liquids. It was a second-period lesson taught for 50 minutes in the classroom.

The following conditions were considered for selecting this particular lesson. First, the lesson was one among those that were categorised as triggering high and sustained interest and engagement among participants. Second, grade 6 had the highest frequency of lessons being delivered using HoL activities. For every 10 lessons, three were delivered using HoL activities, making this pedagogical practice a more prominent approach to teaching and learning in grade 6 (see Table 5.4). Most importantly, students Semyang and Phub found this lesson the most interesting of all the science lessons taught during the week, hence making it possible to analyse more closely the features that triggered and sustained their interest and engagement in learning science. Semyang was chosen because she carried out the main task of separating the liquids. Hence, the analysis of this lesson was considered to be the best choice to understand the enactment of HoL lessons through the person-object theory of interest.

8.2.1 Vignette: Separating immiscible liquids

Narrative	Commentary
Lesson Introduction:	
The lesson began with a brief meditation followed by Mr A, asking students what the next topic was. A chorus response said, "*Separating immiscible liquids*" (Semyang	Settling the mind – A strategy to engage students in the lesson
was one among them). Acknowledging the response, Mr A then, recapitulated the	Linking lesson to prior learning – transitioning
previous lesson by asking questions. Semyang volunteered and responded to the question of the two processes of separating soluble solids.	Authentic engagement/Cognitive activation as an indicator of interest

Narrative	Commentary
Getting back to the lesson topic, Mr A made the students copy the topic on their notebook as he wrote on the chalkboard. This was followed by outlining the lesson and the objectives. Semyang was found excited and nodding her head as Mr A mentioned the word "experiment" and she checked her textbook	The excitement and focused attention as the indicator of interest
Lesson Development:	
Pointing at the word "immiscible" on the chalkboard, Mr A asked if someone could explain the term "immiscible" with some examples. Semyang raised her hands again, but the teacher looked for someone else to respond.	Stimulus variation – engaging students in the lesson
To carry out the experiment, Mr A introduced the liquids by holding them up for everyone to see. He then asked students to look into page 46 and 47 to check the procedure for	Another stimulus variation to engage and interest students in the lesson
separation. (At this moment the students were excited, they were found talking among themselves about the separation and hardly paid attention to the teacher). He told the students to follow the picture to carry out the experiment.	Concentration and excitement as indicators of interest
He informed the students of the material they will get and asked the table group to appoint the group captain to collect the materials. Semyang was unanimously voted as the group captain (see Figure 5.1) for the participant's table. Mr A then called the group captains turn-wise to get the material from him.	Autonomy as a trigger of interest
Semyang got the beakers and a glass rod for the group. As the teacher measured and poured water and oil for each group, participants are seen observing the teacher pouring the liquid	Focused attention, concentration, higher cognitive functioning
and discussing which liquid will stay below and why the water will not evaporate because of the oil.	Seeking behaviour to indicate interest
After the liquids were poured for the group, they were found discussing more scientific questions such as, "*What will happen if honey is poured in? If a stone is put? What is the process called?*"	Cognitive activation as an indicator of interest
Semyang picked up the glass rod and looked around to check how other groups were using it, she was seen asking her friends, but they were not sure. This made Semyang look closely into her textbook. Phub	Decision making – autonomy

Narrative	Commentary
and other members continue to discuss how the liquids will be separated.	
At this moment, Semyang took the mixture and tried to pour out the oil directly into another beaker. Phub was heard saying, "*No! Use the glass rod.*" Mr A passing by noticed	Phub monitoring and heightened affect as a trigger of interest
that and immediately intervened by asking, "*Is that the way?*" He made Semyang refer the picture and corrected the way to pour the oil. With the procedure corrected, the focus then	Heightened affect as a trigger of interest and perseverance as the indicator
was on separating the oil from the water completely. All members closed-in to watch Semyang pour oil using the glass rod. Sonam was seen holding the glass rod as Semyang poured the oil under the supervision of Phub and Namgyel. The intense look on members face indicated their high cognitive and emotional involvement. Semyang stopped	Focused attention as an indicator of interest
several times to check if the progress is going smoothly. The members observed both the containers whenever Semyang stopped. The ongoing conversation also indicated that all	Heightened affect was caused by time pressure and the goal for precise separation.
members were equally engaged and concerned about the separation. Sonam was seen helping hold the glass rod as she poured the oil out under focused	Assisting in the conduct Perseverance as the indicator of interest
supervision of the group members. The intense look on members face indicated their high cognitive and emotional involvement. They caution and at the same time encourage Semyang to push on for greater accuracy. She	Focused attention
was highly focused and concentrated on pouring all the oil out. A group shouted, "*BINGO*" (signal for completion of activity) adding time pressure to the remaining groups to complete the	Time pressure adding to heightened affect
separation. Semyang returns to pouring again occasionally holding up the beaker for the group to check for remaining oil. As she poured again, others cautioned her to be careful and ensure that water does not flow out. Nearing completion of the separation, Semyang revealed, "*I am stressed*". She poured out the final last bit and confirmed the	Precision and heightened affect
completion. Meanwhile, Mr A encouraged the groups to do the best possible and checked if students were nearing completion of the activity.	Enjoyment as the trigger of interest

Narrative	Commentary
As Mr A walked past the group, Phub confirmed that the group completed the separation and Namgyel affirmed it. Mr A walked around and checked the beaker containing oil (some water had gone in) acknowledging that it was almost perfect. Semyang looked satisfied and relieved. Stopping the activity, he enquired if all group could separate the mixture.	Heightened emotion (a sign of relief) as an indicator of interest The cognitive challenge as a trigger of interest
As a follow-up to the activity, Mr A asked the two questions given in the textbook, "*What kind of mixture is it? And, What is this process called?*" He further asked for the definition of "decantation" and explained the process of separation using another example. Semyang gave focused attention while Phub yawned as the teacher continued to explain. At this point, Mr A introduced the next lesson on "Decantation using separating funnel". To bring an end to the activity, he asked students to copy the diagram, write the procedure, and answers to the questions in their notebook. The students were reminded to show their complete work to the teacher before the end of the session. The assignment of the task made the participants active again. They were seen immediately getting down to writing while Semyang raised her hand to clarify the doubt. Semyang was the first person to finish among the participants. She stood up and went to show the work. Mr A informed the class to stay in their seat and raise their hands; he would come to the individuals. Semyang returned to her seat with a raised hand. As Mr A completed checking Semyang's work, other members also completed and showed it one after another. Mr A provided feedback individually.	On task engagement Seeking behaviour – an indicator of interest
With the task complete, participants were engaged in some other discussion for some time. Mr A stopped correction to end the lesson.	
Lesson Closure: Mr A informed the class that he will stay back and correct the work for those who have not shown it yet. He asked, "*What did we learn today? What method we used?*" Talked briefly about the next lesson on decantation using	Focused effortless attention – Indicator of interest

Narrative	Commentary
separating funnel and apprised the class that the next drawing competition will be on that diagram. Phub appeared worried about the competition whereas, Semyang was distracted by her scout scarf and badge.	Concentration – active listening as an indicator of interest
Mr A asked the group captains to return the material before leaving for the session break. He sat on his chair to continue checking the students work. Semyang put the materials in the tray for the group.	Compliant engagement to fulfil the role of group captain

This lesson saw Mr A providing opportunities for students to engage in HoL activities by taking the material from the chemistry laboratory into the classroom. The reason he gave for conducting the activity in the classroom was: "*If I have to take them to the lab, five minutes on the way to the lab and another five minutes on their way back to the class so, it will be difficult to cover the syllabus*". Besides, the group size reduced to table members (usually four) when the HoL activities were conducted in the classroom; otherwise, in the laboratory, there was always a minimum of six members. Even so, the teachers organised most of the HoL activities in the laboratories.

Explicit instructions were often provided prior to commencing the HoL activities and followed by a checking of the students' understanding of the instruction. In the vignette lesson, the instructions for the practical work comprised informing students of the two liquids they would be separating followed by introducing each material provided. Mr A asked the students to appoint the group captain from within the table group and instructed them to follow the procedural steps and the diagram given in the textbook. He repeatedly reminded students to follow the procedure.

Even though Mr A did not explicitly mention who would do what within the group as they proceeded with the activity, it was understood that the group captain would perform the separation while others would be responsible for assisting with the completion of the activity. Mr A said,

> "*I leave it up to the captains to organise the activity themselves. The captain ensures that the experiment is conducted properly from the start to the end. That*

expectation has been made very clear, and that is also consciously done because I want them to sort out their differences and then, improve teamwork."

Semyang volunteered to be the captain by raising her hand, while the others accepted being led by her. In the process of carrying out the separation of the fluids, Phub ensured that Semyang followed the correct procedure by reminding her to use the glass rod. Sonam assisted by holding the glass rod and Namgyel provided different scenarios and asked questions to keep the group members cognitively engaged in the separation.

In terms of monitoring and support during the HoL activity, Mr A went around the class ensuring that the students carried out the task as shown in the picture. He noticed Semyang pouring the oil out directly and corrected this immediately, asking, "*Is that the way?*" Pointing at the image in the textbook, he corrected her use of the glass rod. He returned to the group to check the progress and assess how successful they were in the separation. Mr A focused on positive reinforcement to keep the students engaged and interested in the activity. The students shouted "*BINGO*" to indicate the completion of the activity.

The HoL activities were always followed up with the consolidation of learning through either a whole-class discussion or an individual task. In the above vignette, the HoL activity was followed by both a whole-class discussion and an individual task. Mr A started by asking students, "*What do you call this process of separation?*" This was followed by "*Can somebody define decantation?*" Then, ensuring students understood the definition, he asked the students to write about the procedure, draw the diagram and answer the two questions in the textbook and then show these to him. The completion of writing brought an end to the lesson, but before closing the lesson Mr A asked questions to check if the objectives of the lesson were achieved.

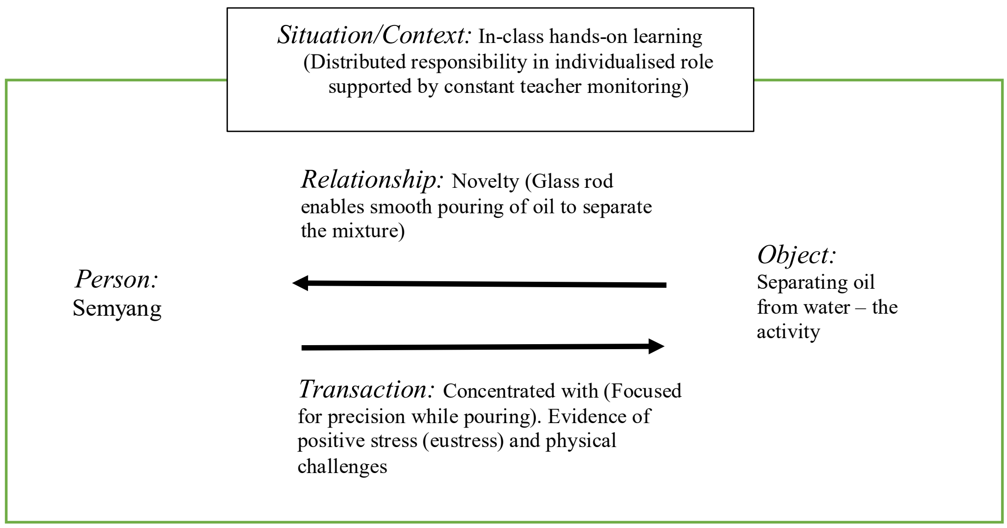
In summary, the teacher provided opportunities for students to interact with scientific equipment from the laboratory; there was novelty in using the glass rod to pour out the liquid. During her interview, Semyang said, "*If we are separating a mixture, we need a glass rod because, the glass rod makes it more comfortable like, oil goes very slowly and carefully in the beaker*". Mr A provided autonomy within the group by letting them choose the captain and distribute responsibilities among themselves. The act of pouring was physically challenging and emotionally stressful, yet with the support and encouragement from the teacher and from among themselves, the group successfully accomplished the task and derived satisfaction and enjoyment from its completion. According to Holstermann et al. (2010, p. 745), "Interest will be strengthened when a person experiences a learning activity as enjoyable, pleasant, stimulating and important" (p.745).

Even though Semyang did the separation, the group functioned as a team, with each participant autonomously taking up a specific role. The distributed responsibilities each participant adopted seemed to trigger and sustain high interest and engagement among participants. The next section will address the research question by analysing Semyang's AoI from the perspective of the person-object theory of interest.

8.2.2 Analysis and interpretative discussion: Semyang's Action of Interest (AoI)

Figure 8.1 provides the diagrammatic representation of Semyang's AoI as a current relationship between her and the activity of separating the oil from water using a glass rod as a part of the HoL task. The relationship brings out those features of the activity that generated high and sustained interest and engagement for Semyang. Teasing out the features may bring us a step closer to establishing a new understanding of the relationship between HoL activities and students in fostering high and sustained interest and engagement in learning science in Bhutanese classrooms.

Figure 8.1 *Semyang's AoI (A figure adapted from Krapp, 1993)*



Person: Semyang

In a continuation to the profile information (see Section 5.2.2 Grade 6: Semyang), Semyang's AoI is characterised by the behaviour she exhibited during in this particular HoL activity (situational interest), and the preferences and experiences (personal interest) that she brought into it (Krapp, 1993). Each of these factors is discussed next.

The following incidents indicate Semyang's situational interest in the HoL activity. First, the opportunity to interact with the equipment triggered her interest. She volunteered to be the "group captain" by raising her hand. Next, she seemed unsure about the use of glass rod and could not make out what to do from the picture in the textbook; she was seen holding it and looking around to check how others were using it. As she tried to pour the oil directly, the teacher corrected her. The uncertainty or discrepancy on the use of glass rod created enough situational interest to keep her going. Again, the realisation of how to use the glass rod to facilitate pouring was a novelty (Renninger et al., 2019). She said, "*Glass rod made the oil go carefully*". Furthermore, the HoL activity provided autonomy and presented the challenge of its own (Krapp, 2005). Semyang said,

> "*Because, in that experiment, we got to do it by ourselves and we only had a picture to follow it in the textbook. We read all the procedures in the textbook, and we had to do it ourselves.*"

Finally, the social interaction and the support from the group members and the teacher helped her to accomplish the task despite experiencing heightened affect and physical challenge. At one point during the pouring she confessed, "*I am stressed.*"

Semyang's personal interest in HoL activities was apparent in her readiness to lead the group and perform the task in the capacity of group captain. She consistently volunteered to lead the group and she had an understanding that "*Those works should be done by the captain*", which matched her preferred learning style: "*By doing it practically*". Therefore, leading the group provided her the opportunity to engage physically with the teaching and learning materials. In addition, the perseverance Semyang exhibited towards the stressful final moments of separation of oil and water was indicative of her preference to learn by doing.

Object: The activity (separating oil and water)

Semyang's object of interest in the vignette lesson was the HoL activity itself – the pouring of oil to separate it from water. The activity started with confusion over the use of glass rod, but once corrected, Semyang persevered until the last drop of the oil was poured out. She invested her complete attention and concentration to this physically demanding and emotionally stressful task. The observation record indicates that she stopped many times during the pouring to lift the beaker to eye level to check the progress and to ensure that water was not poured out. Other participants also moved closer to assess the situation and the following conversation was recorded:

Semyang:	*Is it almost done?*
Phub:	(Checking) *Little bit oil…, bubbles. I see those bubbles.*
Sonam:	*They did not say to mix.*
Namgyel:	*Be careful.*

In this activity, Semyang persevered through the tedious, drop-by-drop, mentally draining act of pouring out the oil. As mentioned earlier, towards completion, she said, "*I am stressed*". However, once completed, there was approval from other participants and she was complimented on her achievement. Phub was heard saying "*Pure water! Can we drink it?*" while pointing at the beaker containing water, thus indicating how efficiently Semyang had done the separation. It was observed that the group found the task stimulating, pleasant, and enjoyable, leading to a positive experience on the novel use of the glass rod. Therefore, the object of interest in the HoL activity that was responsible for triggering and sustaining high interest and engagement was the act of pouring itself.

Situation/context: HoL in the classroom

The opportunity for Semyang to carry out the separation of oil and water was a matter of choice for her, yet it was set up by her teacher, Mr A. Semyang could do the activity because she volunteered for it and was supported by her peers (the other participating students). The activity aligned with her preferred way of learning, and she knew that she would get to do the activity if she was accepted as the group captain. At the same time, the activity was made possible by Mr A, who wanted his students to get first-hand experience by actually separating the immiscible liquids; he had walked into the classroom with the material from the laboratory.

It was rather unusual doing the separation in the classroom, but this familiar environment not only allowed Semyang to focus on her group's HoL activity without distraction, it also provided additional time to interact with the materials (the time otherwise taken to walk to and from the laboratory). The other benefit was the group size being limited to four table members (most laboratory work would have six or more students in a group). This also facilitated Semyang's working within her comfort zone.

Besides Semyang, the participants were presented with the opportunity to decide their roles in the activity. Each group member took up a distinctive role to support Semyang in completing the separation successfully. Phub constantly monitored whether Semyang was carrying out the activity according to the procedure, Namgyel kept the participants engaged by asking many questions, and Sonam assisted Semyang by holding the glass rod to help her focus on pouring. Mr A moved from one group to another, monitoring and assessing each one's progress and intervening wherever required. Among the students themselves there was also time-bound pressure generated to increase the pace of pouring the liquid when one of the group shouted "BINGO". However, it was the distributed responsibility, the social influence, the shared emotion, and the conversations within the group that aided the successful outcome of the activity task. The timely scaffolding from Mr A also played a vital role in helping Semyang to complete the activity.

The transaction: The pouring of oil

The transaction to accomplish the separation of oil and water required many steps. To begin, as group captain, Semyang collected the materials from the teacher. Next, under the supervision of Phub, Semyang had to leave the mixture of oil and water on the table for one minute to settle. After that, as she began to pour the oil directly from one beaker to another, Phub could be heard saying, "*Use the glass rod*". At that moment, the teacher walking by also saw Semyang pouring the oil directly and corrected her by showing how to use the glass rod. Then, with the procedure corrected, Semyang was seen using the glass rod to ease the flow of oil. The mouth of the beaker was rested on the glass rod as she poured, which helped her control the rate of pouring the oil. Every time she poured out some oil, she was found checking the leftover oil in the beaker containing the mixture. She asked, "*Is it almost done?*" soliciting emotional support from her peers. As she neared completion, Sonam could be seen holding the glass rod (see Figure 8.2). Semyang poured some oil and checked again, "*Let's see, a bit!*" answering herself. Finally, with another drop poured out, she exclaimed, "*Done!*", and proudly showed the beaker containing water only saying, "*Here see, pure water*".

Figure 8.2 *Semyang pour oil as Sonam holds the glass rod*

The transaction saw Semyang persevere with the physically challenging and emotionally stressful task of pouring out the oil in very small amounts and making sure that the water was not poured out along with the oil. She ensured that the separation was as precise as possible. However, once completed, she was relieved and appeared to have enjoyed the stressful moment of pouring. She showed the water in the beaker proudly to indicate her achievement to the participants. The perseverance and the concentration she demonstrated in the HoL activity were clear indicators of her interest and engagement.

Relationship – the outcome

This subsection explores how invested Semyang was as she interacted in the activity – was it relatively persisting and might it be generalised across different situations in the sense of habitual or dispositional personality features? The HoL activity that she carried out for the vignette lesson was yet another opportunity for her to physically engage with the materials as the group captain. During the interview, she said, "*I had to do it because I was the group captain. Others were supposed to help the captain.*" The consistency she maintained in leading the group activities and interact with the materials are evidence that her relationship with the hands-on activity was stable. According to Holstermann et al. (2010), hands-on activities can positively influence students' interest in activities.

In this activity, Semyang persevered through the stressful high-stakes moment of pouring every drop of oil from the mixture through to the point where she spoke. She repeatedly mentioned during the interview that the use of the glass rod for separation was memorable learning for her: "*If we are separating a mixture, we need a glass rod because, the glass rod makes it more comfortable like, oil goes very slowly and carefully in the beaker.*" The way she connected to the hands-on activities and how she was attracted to it suggests that her preference for hands-on learning was steady.

8.2.3 Mapping HoL with Semyang's AoI

Semyang's interest in the HoL activity was triggered by the opportunity to engage physically with the materials. Her understanding that as captain she would do the physical activities seems to have prompted her to volunteer during the HoL activities. This matches her preferred learning style, although other participants also liked learning by doing. She also encountered novelty, this being the first time she had ever used the glass rod to separate or pour liquids. As mentioned earlier, she repeatedly spoke about how the glass rod facilitated the smooth flow of oil and eased the separation process. According to Holstermann et al. (2010) interest will be strengthened when a person experiences a learning activity as enjoyable, pleasant, stimulating and important. Other key triggers that fostered interest and engagement in the HoL activities for Semyang were autonomy and heightened affect. Her volunteering to lead the group and her separating the liquids at her own pace provided autonomy. While the physically challenging and emotionally stressful task led to heightened affect, her perseverance allowed her to derive satisfaction and enjoyment on completing the separation of oil and water.

8.3 Distributed responsibility as means to trigger and sustain students' interest and engagement in Bhutanese science lessons

Distributed responsibility was the key strategy for triggering and sustaining students' interest and engagement during the HoL lessons observed in this study. The science teachers had organised almost all the HoL activities in groups due to inadequate teaching and learning materials or equipment. As Mrs D said, "*We always let them do in groups because of insufficient chemicals and apparatus. Moreover, I am not confident to let every student handle chemicals.*" The students engaging in the HoL activity either carried out an individualised specific task (e.g., performer, idea generator, note taker or assistant) or took turns to carry out the same task (e.g., taking turns to mix a spatula full of sugar in lemonade) in order to accomplish the learning goal of the HoL activity. The responsibility that each member of the group took depended on the nature of the HoL activity assigned to them. These responsibilities were understood as distributed responsibilities. The two forms of distributed responsibilities observed during HoL activities were (1) distributed responsibility in an individualised role, and (2) distributed responsibility in a shared role. These forms of distributed responsibility were consistently found to be key in triggering and sustaining interest and engagement in the HoL lessons.

The following subsections begin with a description of the distributed responsibility arrived at during this study and how it was relevant to the students' interest and engagement. This will be followed by an account of how two types of distributed responsibility were enacted in the Bhutanese science lessons to trigger interest and engagement. Finally, the Chapter summary will highlight the commonalities and differences between the two types of distributed responsibility to show their relevance to triggering and sustaining high interest and engagement during HoL activities.

8.3.1 What is distributed responsibility?

In this study, the term distributed responsibility was chosen after careful consideration of the meanings of three similar terms: collective cognitive responsibility (Scardamalia, 2002), collective responsibility (Smiley, 2017), and shared responsibility (Conzemius & O'Neill, 2001). Distributed responsibility refers to the responsibilities undertaken by the students during the group practical work in the science classroom. A collaborative action towards a shared goal that provides a right condition for students' contribution. The teachers set up the practical work to encourage students to accept responsibility for their learning with the belief that "learning is something that learners do, not something done to them" (Royal Education Council, 2012b). Additionally, the literature suggests that sustained creative work can be supported through distributed, flexible, adaptive social structures (Engestrom, 2008) rather than being concentrated in the leader (Zhang et al., 2009). Instead of being confined to an observational role, the students take responsibility for manipulating equipment, taking and recording measurements, constructing explanations based on scientific knowledge, and communicating their ideas. In this study, since the HoL activities were always organised in groups, the ways in which responsibility was distributed to and taken up by students had some features that were distinctive and reflective of the Bhutanese classroom context. Responsibility had two key forms – an individual role and a shared role – each of which was differently associated with interest and engagement.

8.3.2 How is distributed responsibility relevant to interest and engagement in learning science?

Distributed responsibilities were the only means to keep the students engaged and interested in the HoL activities. All participants preferred learning by physically interacting with hands-on materials. However, not everyone in the group had the opportunity to interact with the materials in the same way. While cooperating to complete the assigned task, the participants engaged with it in a way that fostered an interest in the activity. In relating distributed responsibility to interest and engagement in HoL activities, the four main sources of interest – autonomy (Blumenfeld et al. (2005), novelty and involvement (Palmer, 2009), and meaningfulness (Mitchell, 1993; Novak, 2010) – were prominent. Each of these sources of interest will now be elaborated on to show how it was responsible for triggering and sustaining high interest and engagement during the HoL activities.

Autonomy: Distributed responsibility provided autonomy to students in three ways that keep them interested and engaged during the HoL activities in science lessons. The first was the autonomy to decide who would do what (e.g., performer, idea generator, monitor, assistant or note-taker), based on individual strengths and preferences. Being able to contribute based on individual strength/potential was seen as a means to stay interested and engaged in the HoL activities. The second was the autonomy to decide how they would proceed with the activity. At times, this opened up multiple pathways to complete the task and created possibilities for diverse responses. According to Blumenfeld et al. (2005), autonomy in HoL activities promotes students' interest. The third was the autonomy to stop the activity.

Novelty: Novelty refers to an insight perceived as new, different or unusual in a student's everyday life (Swarat, 2009). Distributed responsibility provided many opportunities for the participants to experience novelty in various capacities and stages as they engaged in HoL activities. While interacting with the material during experiments, they encountered novelty in terms of entirely new learning or in new applications of their learning. Conflicting ideas triggered interest in terms of novelty. In HoL activities such as experiments, novelty can be the most crucial source of situational interest (Palmer, 2009). The novelty propelled by the feeling of enjoyment triggered high and sustained interest and engagement in all the HoL lessons observed.

Involvement: Involvement refers to the degree to which students feel they are active participants in the learning process (Mitchell, 1993). Distributed responsibility in HoL activities provides opportunities for students to interact with and manipulate scientific equipment as active participants when learning the new material. Palmer (2009), suggest there can be a strong possibility of significant cognition during HoL activities when the experiments do not involve mindless drill or practice. When students experience the process of learning as absorbing, then that process is perceived as empowering to students and will therefore tend to hold their interest. According to Mrs B,

> "*The practical went well because students could see with their own eyes, the transferring of copper ion on the nail… getting deposited on the nail.*"

Furthermore, the students' involvement induced social interaction, communication and collaboration as they engaged in accomplishing the assigned task (Palmer, 2009). Distributed responsibility made these individuals accountable for the success of the learning activity. As they communicated among themselves, the need to feel connected and accepted elicited excitement that triggered and sustained their interest and engagement. Each participant contributed to the achievement of successful learning through the HoL activities.

Meaningfulness: Meaningfulness refers to students' perceptions of the topic under study as meaningful to them in their lives. Students maintain their interest when they perceive the content as personally meaningful and empowering (Mitchell, 1993). Distributed responsibility allowed the learning to be meaningful to participants. They could contribute to the group's success by bringing to the activity each individual's strengths and ideas. Distributed responsibility provided opportunities for them to share their views and understandings. Meaningful learning results when the learner chooses to relate new information to ideas they already know; its quality depends on the conceptual richness of the new material to be learned and the quantity and quality of the organisation of the relevant knowledge held by the learner (Novak, 2010). Distributed responsibility provided opportunities for the participants to engage in meaningful learning, which acted as one of the primary sources of interest.

8.3.3 Distributed responsibility in Bhutanese science lessons

This section explores the enactment of distributed responsibility that triggered and sustained high interest and engagement among participants during HoL activities in the Bhutanese science lessons. The distributed responsibility can be better understood by looking closely at the commonalities and differences between the individualised and shared responsibilities. The contextual information (see Section 8.1), and the main sources of interest generation (see Section 8.3.2) are referred to in order to understand how students' interest and engagement in the HoL lessons were triggered and sustained.

Distributed responsibility in the individualised role

Distributed responsibility in the individualised role – where each participant in the group takes up a specific role – can bring out the common features of the HoL lessons. This subsection explores how the teacher set up and facilitated distributed responsibility in individualised roles in ways that triggered and sustained interest and engagement.

In this class arrangement, the participants took up a specific role: a group captain or a performer, who would typically carry out the physically embodied task; a recorder or a checker, who would record data and keep notes or make sure that the performer strictly followed the procedural steps in carrying out the task; an idea generator or a strategist, who would facilitate the sharing of ideas and contribute to the discussion or activity; or a helper, who assisted in the experiments. As membership of the group increased, some participants would become the presenter or the observer. Most HoL lessons in the laboratory had six members. The next excerpt and the explanation following it highlight the enactment of HoL lessons in distributed responsibility in the individualised role.

Namgyel:	*Just tell me, Phub, what is sedimentation and decantation?*
Phub:	*Sedimentation is the settlement of the mixture and decantation is pouring it.*
Semyang:	*Can I pour it now? Can I pour it?*
Sonam:	*Are we supposed to pour it out?*
Phub:	*Oh! Does that mean water will stay here and oil will come here*?
Semyang:	*Can I pour it?*
Phub:	*Wait…, did it go one minute? Who has the watch? No no…, glass rod, glass rod.*

For the practical work referred to in this excerpt, the individualised role of each participant was clear. Semyang, who had volunteered to be the captain, was supported by Namgyel and Phub (See Figure 5.1). The other participants were immersed in the roles they were comfortable with. Often, as Semyang performed the activity task, Namgyel would be the idea generator, Phub would check if Semyang was adhering to the procedure and take notes, and Sonam would help her carry out the activity task. In this excerpt, Semyang asks permission to pour the oil, Namgyel asks questions to keep the group engaged, and Phub cautions Semyang about timing and using the glass rod for pouring. Sonam also questions if it is OK to pour the oil from the mixture.

In grade 6, Mr A had established an understanding that "*they (students) take turns to be captains, and I leave it up to the captains to organise the activity themselves*". It was observed that when the captains changed, the roles altered, providing opportunities for participants to take up varied responsibilities. However, in grade 10, Mrs D had an additional reason for organising HoL activities through individualised responsibilities. S mentioned earlier, she said, "*Moreover, I am not very confident to let all students handle the chemicals and equipment, some students are very naughty*", and at times she asked a few students to demonstrate the experiment.

As the participants complied with their responsibilities, all four sources of interest and engagement mentioned earlier were triggered. Autonomy was observed in the ways the participants took up their individualised responsibilities and judged when to stop. They were involved throughout the activity observing, commenting and sharing the heightened affect that Semyang went through. The learning was meaningful as they "got to do it by ourselves" and they appeared satisfied with the outcome of the separation. Finally, the participants experienced novelty in the use of a glass rod. They found that the glass rod could ease the process of separation by supporting the beaker and controlling the pace of pouring the liquid. Semyang said, "*The glass rod makes it more comfortable, oil goes very slowly and carefully in the beaker.*" The participants exhibited their interest and engagement through focused attention and concentration, heightened emotion, and increased enjoyment as they persevered through the process of separation. Distributed responsibility in individualised role thus triggered and sustained high interest and engagement among the participants throughout the HoL activity.

To set up the abovementioned HoL activity, the teachers said to their classes:

> Mr A: *Today, we will separate two immiscible liquids by following exactly how it is done in the diagram. You should be able to identify and define the process. You will do this in groups, and your group captain will collect the materials. I want you all to appoint the captain on your own (Teacher distributes the material through the captain). Now, follow the diagram, and try and separate.*

> Mrs B: *One member from each group will do this. After I put on the Bunsen burner, you will come here and ignite your magnesium ribbon. Once ignited, you will quickly take it back to your group to observe. Once burnt, place the residue on the watch glass and observe it again.*

The teachers' instructions shown here clearly informed the students that it would be a group activity and an individual "group captain" or "one member" would be responsible for the conduct of the task and communicate the individualised roles that members were to adopt. They would not specify the distributed responsibility of the individualised roles per se. However, as the students settled into the task, they took up their responsibilities and contributed to the successful completion of the activity. Besides, the nature of the task appeared to prescribe the responsibilities the individuals should take.

In addition, Mr A had informed grade 6: "*Group captain will coordinate the activity, okay and you will take the lead, and you will be doing most of the things, but rest should also provide necessary support.*" The students seemed to have concluded that the captain would always do the physically embodied tasks. During her interview, Semyang said, "*I did it! Cos, I was the captain, so like sir said, those work should be done by the captain, and the other members should help the captain.*" The alternative explanation could be made from the nature of the task assigned where an individual was required to carry out the entire task. Completion of the task by the group required one individual to perform, with the remaining members taking up the roles they were comfortable with. Like Semyang, as observed in the vignette lesson, who often volunteered to perform the physically embodied activities, Norbu and Yiga, both in grade 8 and 10 respectively, were found to be more interested in interacting with the materials.

As the students engaged in the task, the teachers monitored the activity, constantly both guiding and challenging students to get the best result. They frequently moved around the classroom or the laboratory to ensure that the practical work or experiments were successfully carried out using the scientific processes and procedures and that everyone was involved. Sometimes they spent more time with one group than others. In the vignette lesson, Mr A was heard saying, "*Were you able to separate the oil and water completely?*" The class observation records reveal that during one of the experiments, he visited the participants' group as many as 13 times to facilitate smooth transaction during the activity.

In summary, it was ascertained from repeated watching of the video recordings and listening to the audio recordings of students discussing similar HoL activities that they practised distributed responsibility in an individualised role in situations where the fair testing of the practical task required an individual to manipulate the material. Often girls were more forthcoming than boys. Distributed responsibility was either set up by the teacher by assigning a group captain or holding somebody responsible and other times, it was left for the group to decide based on the nature of the task and previous experience. In all the HoL activities that required a member to perform a task, participants readily emerged to take up each responsibility. As confirmed by the participants, they took the hint from the instructions provided and the nature of the task to settle into the roles they were comfortable with. Observation data reveal that throughout the HoL activity participants exhibited high and sustained interest and they engaged consistently with their various roles.

Distributed responsibility in a shared role

Distributed responsibility in a shared role provided opportunities for each member of the group to carry out one part of the activity successfully to accomplish the group task (e.g., making one strip of local indicator or mixing one spatula of sugar in lemonade). They were able to experience interest and engagement through embodied interaction and the materiality of science because each participant could do a task similar to those done by other members in the group. In carrying out the task under the supervision and guidance of their friends, they were able to experience the autonomy, novelty, involvement and meaningfulness of the learning task. Hence distributed responsibility in a shared role fostered and sustained high interest and engagement among the participants when learning science through HoL activities.

Figure 8.3 in the next page shows the participants engaged in dissolving a spatula of sugar in lemonade. They took turns to measure a spatula of sugar, put it in the beaker containing lemonade and stir it until the sugar dissolved. They look focused and the enjoyment indicates their interest and engagement in the shared responsibility.

Figure 8.3 *Participants take turn to dissolve sugar in lemonade*

During the interview, Samten said they were surprised when 30 mL of lemonade could dissolve 13 spatulas of sugar. It was evident that they supported each other, with Samten also saying:

"When I measured the amount of lemonade, my peers were guiding whether it was accurate or not and also helped me count the number of spatulas of sugar we added."

Mrs B gave the following instruction to set up the HoL task and engage participants in the shared responsibilities:

> "*To learn more about solubility, we are going to do activity 6.1: How much solute can we dissolve?..., First put one spatula of sugar, stir it and if it dissolves, again add and again if it dissolves, keep on adding till you reach a point where no more sugar can dissolve…, you may do it turn-wise.*"

The mention of 'turn-wise' was enough to set up the participants shared responsibility. They autonomously agreed on who would start first, and as one member engaged in stirring, another guided and made sure that the sugar completely dissolved. Every member in the group had an opportunity to dissolve the sugar at least once. In this way, all were involved in meaningful learning by triggering the novelty of the amount of sugar in the lemonade. As Samten said, "*We were like, how could the lemonade dissolve this much sugar, if a person drinks, he could get diabetes.*" Excitement and enjoyment were evident as participants interacted with the apparatus.

Similarly, in Mr A's grade 6, students engaged in shared responsibility when they tested the acidity or alkalinity of solutions using the litmus paper. Mr A demonstrated the experiment and gave the following instructions:

> "*You will take your watch glass and with the help to dropper - take in some amount of vinegar and put some three to four drops of it in the watch glass. Using the forceps, take a leaf of red litmus paper first and drop it into the vinegar. Make sure that you do not dip or touch the vinegar with your forceps. Observe the colour change and write your observation in the table. Do the same with blue litmus paper and record. Once recorded, throw the vinegar in the washbasin and rinse the watch glass for the next solution. You can take turns and record your observations in the table.*"

Mr A explicitly made it clear to students that they should take turns in conducting the HoL activity and he went around the groups reminding them to do so. In this lesson participants also took turns to test the acidity or alkalinity of different solutions. When one member was physically involved in using the dropper, forceps and litmus paper, others were guiding and monitoring the activity. There was autonomy in this decision making and in the way each individual wanted to test the solution. The participants found it meaningful and engaging as they could relate the learning to foods that they eat. As Phub said, "*It is important to know which foods are acidic and which ones were alkaline.*" Finally, there was a novelty in the use of litmus paper and the procedures involved in testing the substances.

Both of these practical classes were conducted in the chemistry laboratory, with six students in each group. In these situations, the possibility of repeating an activity many times allowed participants to engage in distributed responsibility in a shared role. In the first activity, participants dissolved 12 spatulas of sugar in 30 ml of lemonade. In the second, participants tested the acidity and alkalinity of five different solutions using the litmus paper. In both classes, each participant had an opportunity to complete a part of the task, thus sharing responsibility as equal partners.

The teachers focused on monitoring, encouraging participation and ensuring the activities were completed within the allocated time. Both Mrs B and her students were satisfied with the outcome of their experiment with the lemonade. Mrs B said,

> "*They took turns and ensured that the experiment was conducted properly from the start till the end. That expectation was made clear, and that was consciously done, because besides learning the content, maybe, sort out their differences and then, improve teamwork.*"

And Samten said,

> "*We were divided into four groups so, each group was given a different amount of lemonade to test the solubility. We were also given sugar so, we enjoyed stirring it, dissolving it and there were many…, I could see the excitement in the eyes of students…, they were enjoying very much and seeing that I also enjoyed very much.*"

However, Mr A had to intervene during one HoL activity:

> "*I came across one group where one wanted to do the whole thing, and I told them, this is a group work, you will have to sort out your differences. And then, they moved on and completed the experiment. But, I think, making the group members experiment in turn, would provide equal opportunities to all.*"

It is apparent that these teachers endeavoured to provide opportunities for all their students to get the first-hand experience of the experiments for meaningful learning, which is one of the sources of interest and engagement in learning science.

In summary, the observation data reveal that the teachers encouraged and the students practised distributed responsibility in their shared roles when the HoL activities allowed for repeated performance of the same task. As one of the members performed the activity, the remaining members monitored and guided the performer and recorded the observations. The students' facial expressions showed their heightened interest and engagement when it was their turn to perform the activity. Even though participants were engaged throughout the HoL activity, they experienced peak interest and engagement while performing the task. Distributed responsibility in shared roles allowed all participants to engage in a similar task, thereby fostering similar levels of interest and engagement among them. However, based on prior experience, the effect of HoL activity on interest and engagement being the same for individualised and shared role is inconclusive.

8.4 Chapter conclusion

This Chapter highlights how HoL activities are enacted in Bhutanese science classrooms. It specifically focuses on one of the ten lessons using HoL that triggered and sustained high interest and engagement among participants. By exploring each participant's AoI, the Chapter also highlights how their interest and engagement were triggered and sustained throughout the lesson as they interacted with scientific equipment. The analysis of the lessons that triggered the students' high and sustained interest and engagement reveals that as they engaged in HoL activities the prominent sources of interest (autonomy, involvement, meaningfulness, and novelty) were evident. These sources of interest were exhibited in the ways students organised the activities, their physical, mental and emotional engagement in the activity, and the enjoyment they derived on its completion.

Furthermore, this analysis also reveals that as they engaged in HoL activities, the teachers and students practised two sorts of distributed responsibility: individualised responsibility and shared responsibilities. In the individualised version, while not everybody was physically involved throughout the task, they all engaged in roles that contributed something vital and necessary to its accomplishment and experienced high and sustained interest and engagement throughout the group HoL activities. In the shared version, their interest and engagement were heightened when they actually manipulating the experimental items and bodily interacted with the materiality of science.

Chapter 9 will conclude this thesis revisiting the answers to the research questions, outlining the contributions to knowledge, and reflecting on implications.

Chapter 9: Findings, Limitations and Conclusion

9.1 Introduction

This Chapter presents the key findings and arguments of this thesis. My study contributes significantly to research into students' interest and engagement in science, while simultaneously adding to the scholarship of science education in Bhutan. It focuses on classroom practices that facilitated and sustained interest during lessons. The study used the conceptual framework of the 'Action of Interest' under the person-object theory of interest (POI) to understand the transactions that established specific person-object relationships in the science lessons. When applied to classroom learning and development, the POI posits that students' interest is always directed at certain contents or objects whether they are concrete or an abstract cognitive schema (Krapp, 2007). While the study found three distinctive signature pedagogies in science lessons across three grades, these were not in themselves key to triggering and sustaining students' interest and engagement. Instead, it was the practices within each of these signature pedagogies: questioning (in interactive lectures); variations and scaffolded autonomy (in small group discussions); and distributed responsibilities (in hands-on learning). These research findings also support and potentially explain some of the characteristics of interest established in previous research.

The study was conducted in an urban Bhutanese middle secondary school that has classes from pre-primary to grade 10. Three classes, one each in grades 6, 8 and 10, were observed to generate the data. The study recruited 12 students (two boys and two girls from each grade 6, 8 and 10) and five teachers (one from each of grades 6 and 8, and three subject teachers (one each of Biology, Chemistry and Physics from grade 10). The analysis focused on two students from each grade, but reference was made to the larger sample when emerging patterns in the data were identified. The pseudonymised participants were: Semyang, Phub and Mr A (grade 6); Norbu, Samten and Mrs B (grade 8); and Yiga, Kezang, Mr C (Biology), Mrs D (Chemistry) and Mr E (Physics) (grade 10).

The observational data were generated in two phases of two weeks in each grade, that is, four weeks per grade. In total, 86 lessons were observed, producing 82 field notes, 83 video recording, 79 group discussion audio recording and 78 sets of still photographs. The video lessons were further reduced to 78 for analytical purposes. Additionally, data were generated from 58 interviews. The student participants were interviewed four times for roughly 15 minutes per week based on the lesson observed, generating 48 interview transcripts for analysis. The teacher participants were interviewed twice for about 60 minutes each, at the beginning and the end of the fieldwork. All interviews and the selected videos, along with the group discussion audios, were transcribed verbatim.

The remainder of this Chapter consists of six sections. Section 9.2 addresses the overarching research question by bringing together the responses to the research sub-questions. Section 9.3 presents the key contribution of this study. A reflection on GNH practices in light of my findings is presented in section 9.4. Section 9.5 critically reflects on the study and considers its limitations. Section 9.6 explores the implications of the study for practice and for future research. Finally, section 9.7 provides the concluding remarks on pedagogical practices that trigger and sustain students' interest and engagement in Bhutanese science lessons.

9.2 Research questions and answers

This section presents the summary of findings in terms of answers to the research questions. This is the first time in the thesis that all the research questions have been addressed together. Chapter 5 responded to the first two research sub-questions, and Chapters 6, 7, and 8 to the third. Drawing on these responses, this section now returns to research questions to share the substantive contribution of this study.

The overarching research question was:

> *What pedagogical practices trigger and sustain students' interest and engagement in Bhutanese science lessons?*

The detailed responses to the overarching research question are spread over Chapters 5 to 8. This study found that the various lesson-wide approaches to teaching and learning of science in these Bhutanese classrooms could be categorised under three broad signature pedagogies: interactive lecture (IL); small group discussions (SGD); and hands-on learning (HoL). These signature pedagogies in themselves did not trigger interest and engagement in science; however, embedded within them were key pedagogic practices that did. In IL, the key pedagogical practice was questioning; in SGD, it was variations and scaffolded autonomy; and in HoL, it was distributed responsibilities.

The observational data and interview transcripts revealed that questioning stimulated cognitive challenge, autonomy, novelty, and often cognitive dissonance (in students' responses), with cognitive challenge the main trigger of high and sustained interest and engagement. The grade 6 students promptly raised their hands to participate, whereas the grade 10 students preferred to mouth or whisper answers among themselves to verify it. Focused attention, greater concentration, willingness to learn, and enjoyment were the prominent indicators of interest and engagement.

Variations and scaffolded autonomy were the main features of SGD that stimulated and sustained students' interest and engagement in science lessons. The variations were observed in terms of pacing, format and frequency of SGD activities. The pacing of SGD varied according to time allocation and the use of timed pressure. The format variations covered the types and order of interaction in the group (e.g., round-robin, rally-coaching, jigsaw, and brainstorming). Besides, more than one SGD was conducted within a lesson. The scaffolded autonomy featured the support structure provided during the SGDs that made the students actively engage during the activity. Focused attention, greater concentration, enjoyment, and willingness to learn were the indicators of interest and engagement. The main triggers of interest were opportunities for social interaction, cognitive challenge, autonomy, and novelty. Of these, opportunities for social interaction triggered high interest and engagement in SGD activities.

During HoL, the groups of students were either assigned or opted for one of the two forms of distributed responsibility to keep themselves interested and engaged in their activities. In the individualised role, each group member carried out a different HoL task (performer, idea generator, note-taker/recorder or assistant) to accomplish the common goal of completing the activity. In the shared role, members took turns to carry out the same task (e.g., collecting one set of data), thus experiencing heightened interest and engagement when they got to do their part. The students in both forms of hands-on learning experienced novelty, autonomy, involvement and meaningfulness of the practical work.

The details of how interest and engagement were triggered and sustained are presented in the following sections in response to the research sub-questions.

9.2.1 Research sub-question 1.

> *What are the main pedagogical practices enacted in Bhutanese science lessons across grades 6, 8, and 10?*

It was necessary to respond to this sub-question before addressing the other research sub-questions and hence the overarching question. A detailed response is presented in Chapter 5. Using the combination of an iterative framework and thematic analysis (using NVIVO 12), the varied approaches to teaching and learning of science observed during the fieldwork were broadly categorised as the three signature pedagogies mentioned earlier: IL, SGD, and HoL. This study focused not on why the teachers used these signature pedagogies but on how the students' interest and engagement could be triggered and sustained in science lessons. Research sub-question 3 addressed this.

The classification of the signature pedagogies was characterised by the approaches adopted in delivering the main lesson content. All lessons were divided into three parts: introduction, lesson development, and closure. Brief descriptions of each signature pedagogy and its observed prevalence during the fieldwork are presented next.

The pedagogical practices enacted in the Bhutanese science lessons

a) Interactive lecture: IL includes those lessons that involved a significant component of teacher-led pedagogy yet engaged the students as active participants in various ways. Here, the teacher interrupted the lesson at least once to have students participate in an activity (Macdonald & Teed, 2020). The lessons in this category comprised those where the teacher demonstrated using concrete materials (laboratory equipment or working models), explained using teaching-learning materials (charts, audio-visuals, chalkboard or textbook), and generated whole class discussion (e.g., questioning), individual problem solving (e.g., reading text individually, or solving numerical) and pair work (e.g., shoulder partner or face partner discussion). Thus, the ILs were not totally teacher-centric but had several student-centred approaches to teaching-learning.

Despite associations between the varied practices of IL and the traditional notion of students as passive recipient of knowledge (Dorji, 2005), this study found that it was indeed possible to trigger and sustain students' interest and engagement across the science lessons. Furthermore, the widespread use of IL in this study corresponds with that of others who associate it with the means teachers use to cope with heavy curriculum load and limited time (Childs et al., 2012).

b) Small group discussions: SGDs are lessons that involve students in the face-to-face discussion on a specific topic in groups of more than two students per group for at least two minutes (Bennett et al., 2010). SGDs can be used in order to ascertain the prior knowledge of the students, link their learning to everyday life based on the material presented by the teacher, or check their understanding of the assigned reading materials. In this study, the SGDs the teacher led had the introduction, set-up, and plenary discussion, but the discussing among the students was the key feature of the lessons. This required students to exchange ideas and consider others' perspectives, thereby building their intra-personal and interpersonal skills to foster values of interdependence and happy coexistence (Department of Curriculum Research and Development, 2012).

Most of the SGDs occurred as students sat in groups of four at each table in all the classrooms. The teachers varied the interactions among the members by following the Kagan structures such as brainstorming, round-robins and rally coaching. When the teacher assigned pair work, the students, based on the proximity of seating arrangement and the difficulty level of the task, took the opportunity to discuss as a whole table group. The use of cooperative learning (Jigsaw strategy) was observed in one of the lessons.

c) Hands-on learning: All those lessons in which the students handled the scientific equipment or manipulated the materials while attempting to learn the lesson contents were classified as HoL. These lessons required students to participate significantly in the learning process by using prior knowledge and constructing the meanings of the new experiences (Holstermann et al., 2010). In most cases, these lessons took place in the laboratories (Chemistry and Biology), and in a few instances, whenever it was not messy or risky, the materials were taken to the normal classroom for students to carry out the practical work. Due to limited amount of materials and equipment, the HoL lessons were mostly carried out as group activities, and in some cases, individuals were appointed by the teacher to conduct the entire practical work for the group – a kind of peer demonstration.

The classroom HoL lessons were done in table groups when there was sufficient equipment for more than seven groups of students. Those conducted in the laboratory had fewer equipment sets, and more than six students in each group. Most practicals in the laboratory had a minimum group size of six. Bringing the scientific equipment in the classroom or visiting the laboratory for HoL excited the students, triggering interest and engagement in the lessons.

The prevalence of pedagogical practices across grades 6, 8 and 10

Table 5.2 summarises the prevalence of various pedagogical practices across the 86 lessons (20 – grade 6; 30 – grade 8; and 36 – grade 10). Eight lessons in grade 8 were clubbed as four block periods. Four lessons in grade 6 were revision lessons, and therefore not included in the analysis. Hence, the prevalence of the varied teaching-learning approaches is based on 78 lessons.

Of the 78 lessons observed, 16 lessons were from grade 6; 26 from grade 8; and 36 from grade 10. Forty-five lessons were offered using IL, 29 using SGD, and 14 using the HoL. The table shows the prevalence of IL followed by SGD and finally, HoL. It is likely that the higher number of IL lessons was because of the variety of lessons included in that category. The findings concur with conclusions drawn in previous studies of most lessons being teacher-led. The frequency of IL and HoL was more prominent in grade 6, whereas grades 8 and 10 had the highest numbers of IL lessons. Proportionately, HoL was more prominent in grade 6 (Tenzin & Maxwell, 2008), SGD in grade 8, and IL in grade 10 (Childs et al., 2012). Grade 6 had six lessons of 40 minutes per week, the curriculum document suggesting teaching-learning approaches be mostly hands-on. Similarly, grade 8 had seven periods, the curriculum document suggesting some activities. Grade 10 was allotted three periods, with more curriculum content to be covered. Therefore, it was observed that as the grades progressed, shifts occurred from HoL to SGD, and finally to IL.

In summary, the teaching-learning approaches used in these Bhutanese science lessons can be categorised into three broad signature pedagogies: IL, SGD, and HoL. The higher prevalence of IL lessons may be due to the larger number of teaching-learning approaches under that category. The next section addresses research sub-question 2 by examining the patterns in terms of how high and sustained interest and engagement were related to the three pedagogical practices.

9.2.2 Research sub-question 2

> *What are the patterns in terms of how high and sustained interest and engagement relate to these signature pedagogies?*

The second research sub-question explored whether there were clear patterns in the relationship between these signature pedagogies at the lesson level and in lessons where higher interest and engagement were observed. Table 5.4 maps the intensity of interest and engagement with the duration of activity (e.g., teacher demonstration, group discussion or the practical session). This table was generated by following three rigorous procedures: first, the key indicators of interest and engagement relevant to the Bhutanese context were identified by using videos, observation notes and interview transcripts. Second, using observations and interviews and drawing on prior research, the lessons were categorised into high and low interest and engagement lessons. Finally, the timing of activities was noted to segregate the lessons into sustained and brief interest and engagement.

Of the 78 lessons observed, 65% had high rates of interest and engagement among the participants. However, in 12% of lessons this interest and engagement was brief. This meant 50% of the 78 lessons had high and sustained interest and engagement. Similarly, 35% of 78 lessons were identified as having low interest and engagement; in 25% (3%+22%) of lessons this was brief and in 10% (4%+6%), it was sustained.

The key findings were:

1. High and sustained interest and engagement were evident in all three kinds of lessons. Within each signature pedagogy, over 70%, 50% and 40% of HoL, SGD and IL lessons respectively were found to have characteristic features that triggered and sustained high interest and engagement among participants. The features of the lesson will be discussed as a response to the subsequent research questions.
2. High but only brief interest and engagement was evident in all the three kinds of lesson, indicating that the broader pedagogical practice in itself is not the key to sustaining interest. The high but briefly interesting and engaging lessons were the ones where a quick activity was slotted in the process of teaching and learning (e.g., individual problem-solving in IL lessons, a quick group discussion to generate a policy, or a short observation to verify the input from the teacher). These activities lasted for a few minutes, requiring students to draw quick inferences.
3. Lower interest and engagement were evident in SGD and IL lessons. No HoL lessons were found in the lower interest and engagement category. Given the limitations of the sample (see Section 9.5), this is not interpreted as indicating that HoL lessons are in themselves and by default a means to trigger high interest and engagement. These broader patterns show that both triggering and sustaining high interest and engagement were not features of all the observed HoL lessons. Therefore, as with the other signature pedagogies, HoL was subjected to a more detailed analysis. This finding indicates that there were additional specific pedagogical practices within HoL lessons that triggered and sustained students' interest and engagement.

9.2.3 Research sub-question 3

> *How is each of these signature pedagogies enacted in Bhutanese science lessons in ways that trigger and sustain students' high interest and engagement?*

The answers to research sub-question 2 were presented in Chapters 6, 7 and 8. Taking each practice as the unit of analysis, each of these Chapters looked in greater detail into IL, SGD and HoL lessons. The AoI was used to establish relationship between key participants and the object of interest in order to bring out the pedagogical practices within the signature pedagogies that triggered and sustained students' high interest and engagement in the lessons. The following sub-sections summarise the findings of these Chapters.

Questioning as key to interactive lectures

Questioning was key in triggering and sustaining students' high interest and engagement during science IL lessons. The analysis focused on teacher questioning, as only a few instances were observed where the students asked the questions to the teacher. Often teachers were found using more questions during the IL lessons. They asked questions to link the lessons, ascertain the students' previous knowledge of the lesson content to be delivered, and diagnose and assess their learning. Most questions were in the lower-order thinking category, but there were also questions that challenged the students' thinking. The questions matched the requirement of lessons stages: questions during a lesson introduction focused on finding prior knowledge of the students; lesson development questions diagnosed students' learning to ensure learning; and lesson closure questions assessed if the learning objectives of the lesson had been achieved or not. Teachers' classroom questioning kept the students on their toes and facilitated triggering and sustaining of students' interest and engagement in the lesson.

The questioning technique adopted by the teacher participants appeared to follow a clear pattern. First, as mentioned above, the questions were attuned to the lesson phases (lesson introduction, development, and closure). Second, the questions were planned by writing them on the lesson note or using the textbook's questions, and in the process of asking these questions, teachers often provided hints for the upcoming questions. Third, the act of asking the question comprised directing the question to the whole class (rather than to an individual), rephrasing the question (if required), pausing (to provide thinking time), identifying the respondent, redirecting, and finally, acknowledging and providing reinforcement to the response. This practice ensured that students sustained their high interest and engagement in the lesson.

Interpreted through POI, questioning was critical to IL lessons in terms of triggering and sustaining students' high interest and engagement, as they aroused cognitive challenge (Good & Brophy, 2008), cognitive dissonance (Bergin, 2016), autonomy

(Reeve & Jang, 2006) and novelty(Förster et al., 2010). These triggers were indicated by focused attention on the teacher, higher concentration, excitement, and enjoyment when able to participate and relate learning, and the look of surprise when unfamiliar responses were shared. Among the four indicators of interest and engagement, cognitive challenge was more prominent in IL lessons. The questions caught the students' immediate attention, and their behavioural indicators signalled the presence of cognitive activation. These findings indicate that maintaining the cognitive challenge posed by questions should relate to students' prior knowledge and extend their learning.

In summary, questioning practices facilitated the triggering and sustaining of students' high interest and engagement in IL lessons. Questioning practices were found to trigger and sustain students' interest and engagement during the IL lessons. A mixture of both low- and high-order thinking questions was evident in the lessons, with some inclination towards low order, and an emerging pattern was observed in the teachers' questioning practices and the opportunities they provided for students to ask questions. Questioning triggered cognitive challenge, cognitive dissonance, autonomy, and novelty, and among these the most prominent and immediate indicator was cognitive challenge.

Variations and scaffolded autonomy as key to small group discussions

Variations and scaffolded autonomy were found to be the main pedagogic practices in triggering and sustaining students' high interest and engagement among the students in the SGDs. All SGDs followed three stages: the set-up, the discussion, and the follow-up. During the set-up, the teacher provided explicit instruction, culminating in checking if the instruction was understood. In the discussion phase, students engaged in the task while the teacher monitored and provided the necessary support. In the follow-up phase, the whole class came together to generate a common understanding of the content being discussed. The variations covered organisational aspects of SGD such as pacing, structure and content. Scaffolded autonomy focused on the support structure, which was not only confined to support from the teacher but also among the group members themselves.

Again, as interpreted through POI, variations were key to triggering and sustaining students' interest and engagement. In terms of pacing, there were variations in the duration and the number of SGD activities. As many as three short-duration SGDs were observed per lesson, and there were instances where a single SGD activity consumed the whole session. While shorter SGDs created spurts of high interest and engagement and helped sustain them throughout the lesson, the longer SGDs sustained high interest and engagement throughout the lesson. Regarding the structure of the SGDs, students' interest and engagement were triggered and sustained by varying the way they interacted with each other. Structures such as round-robin, rally coaching, brainstorming, table groupings and jigsaw were deployed to change the ways students interacted and supported each other's learning. Finally, the content was varied by providing opportunities to explore different sources, including the students' prior knowledge. Questions from the textbook, a short passage, or information on butcher's paper were provided. At times, different groups were provided with different topics and, at other times, the same topic. Timed pressure (Bingo) was used to get a quick turnaround of the activities. Especially when the SGDs became an informal 'race', students were required to complete the activity and shout "Bingo!" These variations triggered and sustained high interest and engagement among the students.

Scaffolded autonomy was another pedagogic practice that triggered and sustained students' high interest and engagement during the SGD lessons. The two words, scaffolding and autonomy, indicate the provision of guidance by the teacher (e.g., relating science content to everyday life) and letting students continue to explore further on their own. The guidance and trust associated with these two concepts were vital to triggering and sustaining students' high interest and engagement. Students were encouraged to come up with appropriate responses independently, with the teacher always around to diagnose and clarify misconceptions. However, the support also came from knowledgeable others within the group. Teachers were seen either moving from one table group to another, listening or clarifying doubts, or standing in front of the class monitoring and overseeing students engaged in the SGDs. The balance of scaffolding combined with autonomy was found to trigger and sustain high interest and engagement among the students during the SGDs.

The various scaffolded autonomy practices not only provided social interaction opportunities, they also offered cognitive challenges, autonomy and novelty for learning. Of these, opportunities for social interaction were found to be the key trigger. The student participants were keen on interacting among themselves, and through scaffolding this social interaction helped them generate shared meanings of the SGD content of discussion (Pressick-Kilborn, 2015).

Distributed responsibility as key to hands-on learning

The findings indicate that the key to students' high and sustained interest and engagement during HoL lessons was distributed responsibilities. Due to limited resources, almost all the HoL lessons were organised in groups and conducted in either the laboratories or the classroom. In the classroom, groups were limited to table members, but in laboratories the group size increased due to the fewer tables. Once the activity task was assigned, the responsibilities were distributed in one of the two ways: individualised and shared. Each had distinctive connections with interest and engagement.

In the individualised role, each group member was involved meaningfully in achieving the common goal while independently enhancing their learning. Throughout the activity, each participant engaged in a role they were comfortable with and that would maintain their interest to achieve a successful outcome. For example, while one performed the experiment, another recorded the procedurals steps and the data, the third engaged the group by bringing in diverse thinking, the fourth assisted in performing the task.

In shared responsibility, all group members did a similar task to complete the assigned activity successfully. Students waited for their turn to complete a part of the activity task. Everyone was able to manipulate the equipment and experience the materiality of science only when their turn came. In this way, individual students experienced heightened interest and engagement when they got to carry out the embodied activity.

From the perspectives of POI, the key triggers of interest and engagement for distributed responsibilities were autonomy, novelty (Nieswandt & Horowitz, 2015), involvement (Palmer, 2009), and meaningfulness (Mitchell, 1993; Novak, 2010). The new learning (novelty) in terms of lesson content, the use of scientific equipment, or the equipment itself contributed significantly to triggering and sustaining the students' high interest and engagement in learning science in this Bhutanese classroom. During the post-lesson interview, student participants often shared their new learning with enthusiasm.

In summary, novelty was found to be the main trigger of high and sustained students' interest and engagement in science lessons, with cognitive challenge the key in questioning for ILs and social interaction playing a major role in SGDs. And while novelty cuts across the three signature pedagogical practices, it stood out more prominently for HoL lessons in terms of the materiality of scientific equipment and the learning that took place. Autonomy and meaningfulness (in terms of relating to prior knowledge or experience) seem to be present in all the pedagogies.

9.3 Contributions to knowledge

This section highlights three novel contributions of my study. The first concerns a new empirical insight into pedagogical practices and significant advancement in understanding interest and engagement in Bhutanese science lessons. The second puts the Global South in the limelight in the field of interest and engagement, which is usually dominated by the affluent north. Its third contribution is to the literature on interest and engagement in science more generally.

9.3.1 Pedagogical practices and interest and engagement in Bhutanese science classrooms.

My study is one of the few to look at Bhutanese science classroom practices in detail across grades 6, 8 and 10. Most recent Bhutanese science education studies have tended to study particular grades (Nidup & Choden, 2017; Rabgay, 2014, 2018; Wangdi et al., 2020; Wangdi et al., 2018). Looking into these three grades extends the findings of previous studies on classroom practices that looked into Bhutanese science lessons more widely (Childs et al., 2012; Royal Education Council, 2008; Sherab & Dorji, 2013; Tenzin & Maxwell, 2008). My study has brought out more detailed practices under each pedagogy in grades 6, 8 and 10 simultaneously to see how students' interest and engagement can be triggered and sustained during science lessons..

Previous studies have characterised the teaching and learning of science in terms of rather broad approaches by labelling it as either teacher instruction or teacher-led learning (Royal Education Council, 2008; Sherab & Dorji, 2013). A few studies have made passing reference to cooperative learning strategies (Rabgay, 2018) and HoL (Childs et al., 2012; Nidup & Choden, 2017). My study has revealed that all three approaches were practised by the participating science teachers, and it has looked at each of them closely, giving them equal weight in the analysis for the first time. It adds more detail to SGDs and HoL in Bhutanese science classrooms to balance the three pedagogical practices.

My study is the first to add another layer of detail to the three pedagogical approaches commonly observed in Bhutanese science classrooms. The detailed descriptions of each practice bring out the minute details of the lessons. For instance, I found that when previous researchers talked about lecture methods or teacher-led lessons (Childs et al., 2012; Dukpa et al., 2019) in Bhutanese science classrooms, they meant ILs. Despite lectures being an old-fashioned approach to teaching and learning, this study has brought out the varied features of ILs that accommodate students' contributions to their own learning. Likewise, the SGDs incorporated different strategies to challenge students and HoL was facilitated in classrooms and laboratories by providing students with opportunities to take up varied roles. Hence, my study extends previous findings by showing these various pedagogical practices in greater detail and how they enrich Bhutanese science lessons.

My research is also the first of its kind to deploy detailed and extensive observations (using field and video recordings) with immediate follow-up interviews to understand the observed pedagogic practices more holistically. Armed with the theoretical understanding of Krapp's person-object theory of interest (Krapp, 1993), this study identified the indicators of interest and related them to the triggers to specify which aspects of the pedagogic practices triggered and sustained students' high interest and engagement in science lessons. In this way, my study adds to quantitative studies of perceptions (Rinchen, 2001; Sherpa, 2007) and attitudes (Rabgay, 2018; Zangmo et al., 2016) in regard to particular pedagogical practices or science in general. Finally, this study is timely as it will contribute significantly to the promotion of STEM education Bhutan, as outlined in The Educational Reform [Royal Edict] (December 17, 2020).

In summary, my study has looked closely into the three pedagogical practices and contributed by adding another layer of specific detail of what can happen in Bhutanese science lessons when these practices are enacted. This is a crucial contribution to understanding interest and engagement in classroom-based pedagogical practices in the Bhutanese context.

9.3.2 Science classroom practices in the Global South

Studies have documented the decline in students' interest in science in India (Garg & Gupta, 2003; Padmanaban, 2008), Bangladesh (Ashraf, 2008; Choudhury, 2009), Nepal (Acharya et al., 2019; Diwakar, 2017), and Thailand (Faikhamta et al., 2018; Klainin, 2012). However, there is limited literature from the Global South perspective when it comes to the triggering and sustaining of students' interest and engagement in science. Hence, this study can be a starting point for future similar studies in the Global South.

Most of the relevant studies undertaken in the Global South acknowledge the importance of science and technology for overall development of the country concerned. The issues and challenges commonly facing these countries are inadequate resources, large class sizes, and the competencies of the science teachers (Choudhury, 2009; Laad, 2011; Padmanaban, 2008). These issues contribute to the decline in students' interest in science. Some of the studies from the Global South have suggested that inquiry-based or hands-on learning would promote students learning by ensuring real-life applicability (Gorowara & Lynch, 2019). My study indicates that in classrooms inhibited by scarce resources and large class sizes, it is not the signature pedagogies that trigger and sustain students' interest and engagement; rather, it is the layer below, which comprises questioning in IL lessons; variations and scaffolded autonomy in SGD lessons; and distributed responsibilities in HoL lessons.

Furthermore, many of the studies in the Global South have quantitatively examined the perceptions and attitudes of students and teachers. My research has looked at how to maintain students' interest and engagement in science from the perspective of classroom practices.

9.3.3 Contribution to the literature on interest and engagement in general

My research adds Bhutan to the growing list of countries where the study on students' interest and engagement in science have been carried out. It provides insights into science lessons in the Global South when there are limited resources in terms of materiality, human and technological support. Most other studies pertaining to the interest and engagement have been carried out in developed western countries like Australia (Ainley, 2012; Lyons & Quinn, 2010; Tytler et al., 2008a), Germany (Krapp & Prenzel, 2011), Sweden (Anderhag et al., 2016), UK (Archer et al., 2013) and USA (Swarat, 2009; Vartuli, 2016).

The use of the person-object theory of interest was crucial in this research. It helped reveal that questioning was valuable in generating interest and engagement in IL lessons in Bhutanese science classroom; this corroborates other findings that questions can be stepping stones for continued interaction and deeper learning (Chin, 2007; Rabgay, 2014). Likewise, variations and scaffolded autonomy were found to be crucial for SGD (Pol et al., 2019) and distributed responsibilities played a critical role in triggering and sustaining students' interest and engagement in HoL lessons. The significant contribution that my study makes to the existing literature is in terms of scaffolded autonomy and distributed responsibilities. It also adds new nuance to questioning practices.

9.4 Gross National Happiness and science

GNH is a crucial feature of the Bhutanese education system. Article 9 of The Constitution of Bhutan states: "The State shall strive to promote those conditions that will enable the pursuit of Gross National Happiness" (Royal Government of Bhutan, 2008, p. 18). The science curriculum framework (SCF) was developed to infuse the principles of GNH and instil in students the essence of living in harmony with the environment, upholding the traditions and cultural heritage of Bhutan, and engendering more fully the values of humanity and capability (Ministry of Education, 2014; Royal Education Council, 2012b). Thus, the SCF provides suggestions to incorporate the four pillars and nine domains of GNH through the delivery of science content and the use of various pedagogies. The four pillars of GNH are

1. sustainable and equitable socio-economic development,
2. conservation of the environment,
3. preservation and promotion of culture, and
4. good governance. (Ministry of Education, 2010; Ura, 2009)

The nine domains of GNH are

1. good governance,
2. psychological well-being,
3. community vitality,
4. education,
5. health,
6. cultural diversity and resilience,
7. ecological diversity and preservation,
8. time use, and
9. living standards. (Ura et al., 2012)

As I began this study, I anticipated that GNH might be a more explicit feature of the science lessons; perhaps students and teachers would talk about it during the lesson. However, when I asked my participants about GNH during the interviews, they hesitated when responding. On probing further, they appeared uncomfortable, and their answers were thinner, which suggested that it was not possible to analytically link GNH to interest and engagement in school science. Childs et al. (2012), also found that their respondents talked very little about GNH in terms of the science curriculum and that GNH was not a significant part of teachers' lesson planning. I decided to focus on where the evidence was richer, namely the pedagogical practices that trigger and sustain students' high interest and engagement in science lessons. Hence, GNH is not featured in the details of my responses to the research questions.

In fact, there were many situations created during science lessons that could easily have been related to one of the domains of GNH. For instance, during the group work, the values associated with domains of good governance, psychological well-being, community vitality and time use could have been highlighted. Good governance in assigning tasks, fixing accountability, and respecting individuals and their views could be associated with community vitality and psychological wellbeing, while completing a task on time could be related to time use (Ministry of Education, 2010; Ura, 2009). Similarly, the delivery of science could be related to education (learning something new), health (related to their body), ecological diversity (environment and living in harmony with nature) and living standards (Childs et al., 2012); and questioning practice could be related to community vitality, cultural diversity and resilience in terms of taking turns in responding and respecting the view of others. Future researchers might want to investigate possible linkages between GNH and the fostering of interest and engagement in Bhutanese science lessons.

9.5 Limitations of the study and critical reflections

In this section I identify and reflect on three limitations of the study. First, it is based on a sample from one school, namely a section from each of grades 6, 8 and 10 and their science teachers, and interviews with 12 student participants. Furthermore, the findings are based on data from six students (two each from three grades). A larger sample that includes students and schools from different regions may have yielded more varied data. The limitations of the current study provided an opportunity to explore more deeply and across the variety of lessons within the school. The time that would have been used in commuting from one school to another was utilised instead inside the classroom in the sample school.

Second, the sampling favoured high achievers, and this could be the reason for the participating students having high levels of interest and engagement in the science lessons. In other words, the practices identified might not work similarly with different categories of students. Further, as mentioned earlier, the student participants were reduced to two per grade for analysis. Focusing on these students helped identify the indicators and triggers more clearly in the analysis.

Finally, the design of the study does not enable analytical separation of grades and teachers. At this point, it is difficult to point out if something was the feature of a grade 6 lesson, for example, or of a particular participant in that grade. Nor does the study allow longitudinal claims. However, doing the cross-sectional study in both depth and breadth helped me bring out the features of pedagogical practices more distinctly across grades.

9.6 Implications and future research directions

In this section, I share the implications and possible future directions for other researchers keen to study interest and engagement in contexts similar to Bhutan's.

9.6.1 Implications

a) For relevant stakeholders

This section draws on the theories and conceptual framework outlined in Chapters 2 and 3 to discuss what the contributions of this study might mean for various stakeholders involved in developing scientific literacy. The findings presented are based on ideas and opinions expressed by six student participants and five teacher participants in addition to my own observations. Given the small sample, empirical generalisation is not intended.

b) Implications for science teachers and science teacher educators

This study offers suggestions for teachers and teacher educators. While teachers may focus on the suggestions directly in terms of their classroom practices, teacher educators may consider building these skills among future teachers.

First, when teachers are planning and delivering IL lessons, it would be worthwhile to consider questioning practices. In the Bhutanese science lessons studied in this research, the repertoire of questions or the ways the questioning techniques were used strongly influenced the triggering and sustaining of students' high interest and engagement. Questioning sets up cognitive challenges by igniting the prior knowledge or personal experiences of the students. Being able to relate classroom learning to everyday life or prior experiences makes learning enjoyable for students (Chin, 2006), thereby triggering and sustaining their interest and engagement in science.

Similarly, if the teacher is using SGD, they should try to vary the ways the activities are carried out and to avoid monotony. Variations in tempo, pacing, groupings, and formats were found to foster the triggering of students' high interest and engagement in science lessons. It is also worth considering the incorporation of scaffolded autonomy in SGD lessons. The presence of knowledgeable others who are not necessarily teachers can assist students to engage in learning (Taber, 2018). Variation and scaffolded autonomy both provide opportunities for students to engage in social interactions and thus have breaks from teacher instruction.

Likewise, if the teacher is organising HoL lessons, they might want to consider how they want their students to learn new things while learning the topic. Both individualised and shared responsibilities can trigger novelty, but neither practice is superior to the other. In the HoL lessons observed in this study, novelty was the main trigger of interest to foster lifelong interest and engagement in learning science.

c) Implications for curriculum developers

In curriculum development, it is recommended that not only content but also lesson approaches be specified and professional development in pedagogic practices to science teachers be provided. This study found that it is important to have a balance between IL, SGD and HoL lessons by giving teachers discretion and capacity to implement the three pedagogic practices associated with them: questioning; variations and scaffolded autonomy; and distributed responsibilities. Furthermore, REC could consider professional development in these pedagogic practices to enable teachers to trigger interest and engagement among students in science lessons.

9.6.2 Future research directions

This section recommends future research directions based on the current study. Firstly, since the students recruited for this study were mostly high achievers in science, it is recommended that similar studies be undertaken with participants having a range of achievement levels.

Second, the school where this study was conducted, Vajra MSS, is a middle secondary school with students from grades pre-primary to 10. It is a day school located in an urban area. It is recommended that similar studies be conducted in remote or other difficult areas of Bhutan.

Third, this study combined the varied approaches to teaching and learning into three signature pedagogies, namely, IL, SGD and HoL. These signature pedagogies are broad and encompass multiple practices (e.g., IL comprises of teacher explanation, teacher demonstration, individual problem solving, pair work, and whole-class discussion). Each of these practices could be studied separately.

Fourth, this study looked at grades 6, 8 and 10 only. Future studies could look into each of grades 4, 5, 7 and 9, either individually or collectively.

Finally, as pointed out earlier, GNH is crucial for the Bhutanese education system, but this study could not establish sound evidence to link GNH to pedagogical practices that trigger and sustain students' interest and engagement in science. It would be befitting the science fraternity in Bhutan if a more extensive study were done in this particular field.

9.7 Final concluding remarks

The purpose of this study was to investigate the pedagogical practices that triggered and sustained students' interest and engagement in Bhutanese science lessons in grades 6, 8 and 10 using the person-object theory of interest. The main findings indicate the keys to triggering and sustaining these students' high interest and engagement do not lie in the signature pedagogies but in the next layer of classroom practices, namely, questioning for interactive lectures, variations, and scaffolded autonomy for small group discussions.

Based on the prior research literature, my study also found that these pedagogic practices were responsible for a particular set of triggers of interest and engagement. During IL lessons, while the practice of questioning generated cognitive challenge, cognitive dissonance, autonomy and novelty, the key was cognitive challenge. Likewise, in SGD lessons, variations and scaffolded autonomy created opportunities for social interactions, cognitive challenge, autonomy, and novelty, but the key was opportunities for social interaction. Finally, for HoL lessons, distributed responsibilities triggered novelty, meaningfulness, involvement, and autonomy, but the key was novelty.

This study makes a crucial contribution in the field of students' interest and engagement in science by extending the understanding of the roles of pedagogical practices in triggering and sustaining students' high interest and engagement.

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APPENDIX A: Interview protocol

Teacher Interview Protocol

Researcher: Thank you again for agreeing to participate in this interview. I would just like to confirm your permission to audiotape this interview. (Interviewee responds.) Again, all information obtained during this interview will remain confidential and your chosen pseudonym will be used to protect your identity. The interview should take approximately 30 minutes. Do you have any questions about the study or interview procedures? (Pause. Answer any interviewee questions before proceeding.)

Grand Tour Question
As a part of my PhD studies, I am carrying out this study to identify pedagogical practices that sustain students' interest and engagement in school across primary-middle school interface. In this regard, could you please share your experiences of teaching science to children at various grades?

Sub-questions (Round 1)
1. Tell me about a recent lesson that you think went really well. What was so good about it? What were you doing? What were students doing?
2. If I walk into a typical science lesson you were teaching, what would I see you doing? What would your students be doing?
3. What have been some of the highlights of your experience teaching science so far?
4. What do you find works well to stimulate students' interest and engagement in science?
5. Think about a recent lesson when you thought the students were interested and engaged. How could you tell?
6. Please tell me about a science lesson you taught where GNH were incorporated.
7. Is there anything that you want to tell me about your science teaching? What do you think about current status of teaching and learning science in Bhutan?

Sub-questions (Round 2; about one or more specific lessons)
1. What were you thinking about when you planned this lesson? What was the objective behind the lesson?
2. Did the lesson go according to what you had planned? What changed? Were the students able to achieve what you wanted them to learn?
3. What moments or activities struck you as ones that particular interested and engaged students?
4. Can you tell me a bit more about this (selecting an aspect of students' work from the lesson, eg a worksheet, or snapshot of group activity)
   a. What was your thinking when you planned this?
   b. What happened at the time?
   c. What do you think about it now, in hindsight?
5. How was GNH incorporated in that particular lesson?
6. Of the recent lessons, which lesson students liked most? Why? How do you know?
7. Do you have any additional comments to our discussion? Is there anything you would like to add about the lesson, or that you think is important to understanding student interest in learning science?

Researcher: Thank you again for agreeing to be a part of my study. I greatly appreciate the time you have given up in order to answer my questions. I will be in contact with you to share the transcript of the interview and confirm the accuracy of your responses. If you think of anything else you would like to add or have any further questions, please feel free to email me at BijoyKumar.Rai@student.uts.edu.au or call me at +61 . Again, thank you for sharing your views and insight.

Student Interview Protocol

Researcher (1st meeting after the consent): Hi, Thank you for agreeing to see me and share your experiences in learning science. Just like you, I am also a student (an old one!) at a university in Australia. I am doing a study on students' interest and engagement in science in schools. As and when required, I will catch up with you and ask some questions but, it is totally okay, if you don't want to tell the answers. The questions will be general and not to test your science knowledge… I will use voice recorder to record the answer because, as I said, I am old and forget quickly. Your name will *NOT* be mentioned in my report instead, I will use a different name, what would you like to be called? If you do not want me asking you questions, just let me know okay. Do you have any questions?

Grand Tour Question
As a part of my study, I am trying to understand what kind of teaching and learning will help students stay interested and engaged in science when they are in school. In this regard, could you please share your experiences of how you have been learning science so far?

Sub-questions
1. What was the best thing about your last science lesson? Why?
2. What did you learn? How did you learn? Is what you learnt, important?
3. Tell me more about this (show picture or point to something written in their notebook)? What were you doing? How did you do it? What, if anything, interested you about it?
4. What was the most important thing you learned in this lesson, and why do you think it was important?
5. Was there any aspect of the lesson that related in some way to GNH? What connections do you see?
6. Is there anything else you want to tell me about today's lesson or what you think about science?

(Note: Some questions will depend on class observation and follow-up interview will depend on it)

How do you react when you really like something? (In what ways does listening/note taking help you in learning science?) What qualities in the teacher makes you learn science best? Which science subject do you like best and why? (Grade 10)

Again, thank you very much!

How did you manage to score the mark that you got? What did you do to score that mark?

Researcher: Thank you again for agreeing to be a part of my study and the time you have given up in order to answer my questions. I will show you what I have written to check if it is what you meant. If there is anything that you want to tell me, email me at BijoyKumar.Rai@student.uts.edu.au or call me at +61 [redacted] (Bhutan mobile number).

APPENDIX B: Observation record template

Pedagogical practices to sustain students' interest and engagement in science across late primary-middle school interface

Observation Template

Date: Grade/Section: Start time/Duration:

Topic:

Time	Teacher activity/Pedagogy / Resources used	Triggers of interest and engagement evident	Students' activity (ies)	Nature of the activity (Ind/Pair/ Small Gr/ Whole Class	Indicators of interest and engagement observed	Types of indicators (Behavioural/ Cognitive /Affective/ Emotional)	Observer's comment and follow-up

Observer:

APPENDIX C: Trajectory of research questions

The trajectory of research questions

Main Research Question	Sub-Questions	Interview Questions T1	Interview Question T2	Interview Question Std	Observation Notes
What pedagogical practices trigger and sustain students' interest and engagement in Bhutanese science lessons?	1. What are the main pedagogical practices enacted in Bhutanese science lessons across grades 6, 8 and 10?	1. Tell me about a recent lesson that you think went really well. What was so good about it? What were you doing? What were students doing? 3. What have been some of the highlights of your experience teaching science so far? 6. Please tell me about a science lesson you taught where GNH was incorporated	4. Can you tell me a bit more about this (showing something). What was your thinking when you planned this? What happened at the time? What do you think about it now, in hindsight? 5. How was GNH incorporated in that particular lesson?	2. What did you learn? How did you learn? Is what you learnt, important? 3. Tell me more about this (showing something). What were you doing? How did you do it? What, if anything, interested you about it? 7. What qualities in the teacher makes you learn science best? 5. Was there any aspect of the lesson that related in some way to GNH? What connections do you see?	Content, Teacher and Student activities, Pedagogy deployed & Teaching learning materials used
	2. What are the patterns in terms of how high and sustained interest and engagement relate to these practices?	4. What do you find works well to stimulate students' interest and engagement in science? 5. Think about a recent lesson when you thought the students were interested and engaged. How could you tell?	3. What moments or activities struck you as ones that particularly interested and engaged students? 6. Of the recent lessons, which lesson students liked most? Why? How do you know?	6. How do you react when you really like something? (Which science subject do you like best and why?)	Student activity, Triggers and indicators of students' interest and engagement & Nature of activity
	3. How is each of these practices enacted in Bhutanese science lessons in ways that trigger and sustain students' high interest and engagement?	2. If I walk into a typical science lesson you were teaching, what would I see you doing? What would your students be doing?	1. What were you thinking about when you planned this lesson? What was the objective behind the lesson? 2. Did the lesson go according to what you had planned? What changed? Were the students able to achieve what you wanted them to learn?	1. What was the best thing about your last science lesson? Why? 4. What was the most important thing you learned in this lesson? Why do you think it was important?	Content, Teacher and student activity, and nature of activity

APPENDIX D: Research permission from MoE, Bhutan

དཔལ་ལྡན་འབྲུག་གཞུང་། ཤེས་རིག་ལྷན་ཁག།
Royal Government of Bhutan
Ministry of Education
Department of School Education
School Planning and Coordination Division

--Rethinking Education--

MoE/DSE/SPCD/SLCU(2.1)2018/ 1260 25th June, 2018

The Principals
Khangkhu MSS, Bitekha MSS- Paro
Changangkha MSS- Thimphu Thromde
Chapcha MSS- Chukha

Subject: An approval to conduct data collection for a research study

Sirs/Madams,

Mr. Bijoy Kumar Rai, a faculty of Paro College of Education is undergoing postgraduate studies at University of Technology Sydney, Australia in Science Education.
As a part of PhD studies, he is taking research to look at "*sustaining students' interest and engagement in science across grades up to middle secondary schools in Bhutan.*

In this regard, as Mr. Bijoy has chosen your school as one of the locations to carry out the research the Department of School Education is pleased to accord an approval for carrying out the research study in your school based on his application dated 19/06/2018.

Therefore, you are requested to kindly facilitate him to carry out the research study from 25th February, 2019 to 30th June, 2019 without disturbing the normal school routine.

The application of Mr. Bijoy Kumar Rai is attached for your reference please.

Thanking you,

Sincerely yours,

Production Note:
Signature removed prior to publication.

(Karma Tshering)
Director General

CC:
1. Chief DEO/TEO, Paro, Chukha and Thimphu Thromde for kind information.
2. The Chief Program Officer, SPCD for kind information
3. Mr. Bijoy Kumar for information and follow up.

Post Box No. 112, Kawajangsa, Thimphu, Bhutan, Tel: : +975 2 321710/326307/322252/328608/332362, www.education.gov.bt

APPENDIX E: Participant invitation letter

UTS UNIVERSITY OF TECHNOLOGY SYDNEY

INVITATION LETTER (TEACHER)

Pedagogical practice to sustain students' interest and engagement in science across the primary-middle school interface

Dear ……………………………

My name is Bijoy Kumar Rai and I am a student at the University of Technology, Sydney.

I am conducting research into what teachers can do to sustain students' interest and engagement in science from primary to middle school in Bhutan and would welcome your assistance. The research will involve observation and video recording of your time tabled science lessons for 4 weeks (2 periods of 2 weeks, with a 4 weeks break in between), and two interviews (up to 1 hour each) that will be audio recorded. I have asked you to participate because you teach science in either grade 6 or grade 8 or grade 10 at the school identified for this study.

This research is for my studies in University of Technology Sydney (UTS) to pursue Doctor of Philosophy in Science Education.

If you are interested in participating, I would be glad if you would contact me in person, via email at bijoykumar.rai@student.uts.edu.au or via phone +975 ------ or my supervisors Dr. Kimberley Pressick-Kilborn (Email: kimberley.pressick-kilborn@uts.edu.au, Phone no.: +61 2 9514 5330) and Dr. Nick Hopwood (Email: nick.hopwood@uts.edu.au, Phone no.: +61 2 9514 465 before February 22, 2019.

You are under no obligation to participate in this research.

Yours sincerely,

Bijoy Kumar Rai
PhD Student (SoE)
Faculty of Arts and Social Science
University of Technology Sydney (UTS)
235 Jones St. Ultimo NSW 2007
Mobile No.
Bijoykumar.rai@student.uts.edu.au

NOTE:
This study has been approved by the University of Technology, Sydney Human Research Ethics Committee. If you have any complaints or reservations about any aspect of your participation in this research which you cannot resolve with the researcher, you may contact the Ethics Committee through the Research Ethics Officer (ph: +61 2 9514 2478 Research.Ethics@uts.edu.au), and the UTS HREC reference number. Any complaint you make will be treated in confidence and investigated fully and you will be informed of the outcome.

UTS UNIVERSITY OF TECHNOLOGY SYDNEY

INVITATION LETTER (PARENT)

Pedagogical practice to sustain students' interest and engagement in science across the primary-middle school interface

Dear ……………………………

My name is Bijoy Kumar Rai and I am a student at the University of Technology, Sydney.

I am conducting research into what teachers can do to sustain students' interest and engagement in science from primary to middle school in Bhutan and would welcome your assistance. The research will involve observation and video recording of your child's time tabled science lessons for 4 weeks (2 periods of 2 weeks, with a 4 weeks break in between), and 4 interviews (15-20 minutes and one per week) that will be audio recorded. I have asked your child to participate because s/he is interested in science.

This research is for my studies in University of Technology Sydney (UTS) to pursue Doctor of Philosophy in Science Education.

If you are interested to let your child participate, I would be glad if you would contact me in person, via email at bijoykumar.rai@student.uts.edu.au or via phone +975 ------- or my supervisors Dr. Kimberley Pressick-Kilborn (Email: kimberley.pressick-kilborn@uts.edu.au, Phone no.: +61 2 9514 5330) and Dr. Nick Hopwood (Email: nick.hopwood@uts.edu.au, Phone no.: +61 2 9514 465 before February 22, 2019.

You are under no obligation to let your child participate in this research.

Yours sincerely,

Bijoy Kumar Rai
PhD Student (SoE)
Faculty of Arts and Social Science
University of Technology Sydney (UTS)
235 Jones St. Ultimo NSW 2007
Mobile No. [redacted]
Bijoykumar.rai@student.uts.edu.au

NOTE:
This study has been approved by the University of Technology, Sydney Human Research Ethics Committee. If you have any complaints or reservations about any aspect of your participation in this research which you cannot resolve with the researcher, you may contact the Ethics Committee through the Research Ethics Officer (ph: +61 2 9514 2478 Research.Ethics@uts.edu.au), and the UTS HREC reference number. Any complaint you make will be treated in confidence and investigated fully and you will be informed of the outcome.

INVITATION LETTER (STUDENT)

Pedagogical practice to sustain students' interest and engagement in science across the primary-middle school interface

Dear ……………………………

My name is Bijoy Kumar Rai and I am a student at the University of Technology, Sydney.

I am conducting research into what teachers can do to sustain students' interest and engagement in science from primary to middle school in Bhutan and would welcome your assistance. The research will involve observation and video recording of your time tabled science lessons for 4 weeks (2 periods of 2 weeks, with a 4 weeks break in between), and 4 interviews (15-20 minutes and one per week) that will be audio recorded. I have asked you to participate because you are interested in science.

This research is for my studies in University of Technology Sydney (UTS) to pursue Doctor of Philosophy in Science Education.

If you are interested in participating, I would be glad if you would contact me in person, via email at bijoykumar.rai@student.uts.edu.au or via phone +975 ------ or my supervisors Dr. Kimberley Pressick-Kilborn (Email: kimberley.pressick-kilborn@uts.edu.au, Phone no.: +61 2 9514 5330) and Dr. Nick Hopwood (Email: nick.hopwood@uts.edu.au, Phone no.: +61 2 9514 465 before February 22, 2019.

You are under no obligation to participate in this research.

Yours sincerely,

Bijoy Kumar Rai
PhD Student (SoE)
Faculty of Arts and Social Science
University of Technology Sydney (UTS)
235 Jones St. Ultimo NSW 2007
Mobile No. (
Bijoykumar.rai@student.uts.edu.au

NOTE:
This study has been approved by the University of Technology, Sydney Human Research Ethics Committee. If you have any complaints or reservations about any aspect of your participation in this research which you cannot resolve with the researcher, you may contact the Ethics Committee through the Research Ethics Officer (ph: +61 2 9514 2478 Research.Ethics@uts.edu.au), and the UTS HREC reference number. Any complaint you make will be treated in confidence and investigated fully and you will be informed of the outcome.

APPENDIX F: Participant information sheet and informed consent form

UTS UNIVERSITY OF TECHNOLOGY SYDNEY

PARTICIPANT INFORMATION SHEET (PARENT and STUDENT)

Pedagogical practice to sustain students' interest and engagement in science across the primary-middle school interface

WHO IS DOING THE RESEARCH?

My name is Bijoy Kumar Rai and I am a student at UTS. My supervisors are Dr. Kimberley Pressick-Kilborn (Email: kimberley.pressick-kilborn@uts.edu.au, Phone no.: +61 2 9514 5330) and Dr. Nick Hopwood (Email: nick.hopwood@uts.edu.au, Phone no.: +61 2 9514 4658).

WHAT IS THIS RESEARCH ABOUT?

This research is to find out about what teachers can do to sustain students' interest and engagement in science from primary to middle school in Bhutan.

FUNDING

Funding for this project has been received from UTS as a HDR scholarship under UTS International Research Scholarship (UTS IRS) and UTS President's Scholarship (UTSP).

WHY HAVE I BEEN ASKED?

You have been invited to participate in this study because you are a parent to the student in grade 6, 8 or 10. A small number of students have been asked to participate in the study because they seem interested in science lessons.

IF I SAY YES, WHAT WILL IT INVOLVE?

If you decide to let your child participate, I will invite you to allow me to

- ✓ *observe their participation in science lessons over 4 weeks (2 weeks, then a break, then 2 more weeks)*
- ✓ *conduct short interviews with your child about a science lesson they have just had, around 15-20 minutes once per week; the interview would be audio recorded*
- ✓ *video record the science lessons focusing on what the teacher does, and your child's participation in group work*

ARE THERE ANY RISKS/INCONVENIENCE?

Yes, there are some risks/inconvenience. They are, your child might feel uncomfortable when the lessons are observed, and in interviews. Steps will be taken to minimise this and if your child feels uncomfortable she/he can change their mind at any time. There could be some inconvenience related to the time spent with me for interviews. This will be reduced by giving your child a say in when the interviews take place, and keeping the time taken to a minimum.

DO I HAVE TO SAY YES?

Participation in this study is voluntary. It is completely up to you whether or not you decide to take part.

WHAT WILL HAPPEN IF I SAY NO?

If you decide not to let your child participate, it will not affect your child's/your relationship with the Teacher or the Principal of the school. Teaching and learning, the study pattern or grades of your child will not be affected in any way. If you wish to withdraw them from the study once it has started, you can do so at any time without having to give a reason, by contacting the Principal, Mr. Gomchen Tenzin in person or via phone +975 or via email at khangkhumss@education.gov.bt or Bijoy Kumar Rai in person or via phone +975 or email at bijoykumar.rai@student.uts.edu.au.

If you decide to leave the research project, we will not collect additional personal information from you, although personal information already collected will be retained to ensure that the results of the research project can be measured properly and to comply with law. You should be aware that data collected up to the time you withdraw will form part of the research project results.

CONFIDENTIALITY

By signing the consent form, you consent to the research team collecting and using personal information about your child for the research project. All information will be treated confidential. All data will be stored/archived in a locked filing cabinet at the researcher's office and electronic files password protected with access to researcher and his supervisors only. The participants will be provided an opportunity to review their interview transcripts prior to publication. Your child's information will only be used for the purpose of this research project and it will only be disclosed with your permission, except as required by law.

We plan to publish the results as thesis at UTS, articles in journal papers and as conference proceedings. In any publication, information will be provided in such a way that your child cannot be identified.

WHAT IF I HAVE CONCERNS OR A COMPLAINT?

If you have concerns about the research that you think I or my supervisor can help you with, please feel free to contact us on BijoyKumar.Rai@student.uts.edu.au (Phone no. +975) or my supervisors Dr. Kimberley Pressick-Kilborn at Kimberley.Pressick-Kilborn@uts.edu.au (Phone no. +61 2 9514 5330) or Dr. Nick Hopwood at Nick.Hopwood@uts.edu.au (Phone no. +61 2 9514 4658).

You will be given a copy of this form to keep.

NOTE:
This study has been approved by the University of Technology Sydney Human Research Ethics Committee [UTS HREC]. If you have any concerns or complaints about any aspect of the conduct of this research, please contact the Ethics Secretariat on ph.: +61 2 9514 9772 or email: Research.Ethics@uts.edu.au, and quote the UTS HREC reference number ETH18-2605. Any matter raised will be treated confidentially, investigated and you will be informed of the outcome.

PARTICIPANT INFORMATION SHEET (TEACHERS)

Pedagogical practice to sustain students' interest and engagement in science across the primary-middle school interface

WHO IS DOING THE RESEARCH?

My name is Bijoy Kumar Rai and I am a student at UTS. My supervisors are Dr. Kimberley Pressick-Kilborn (Email: kimberley.pressick-kilborn@uts.edu.au, Phone no.: +61 2 9514 5330) and Dr. Nick Hopwood (Email: nick.hopwood@uts.edu.au, Phone no.: +61 2 9514 4658).

WHAT IS THIS RESEARCH ABOUT?

This research is to find out about what teachers can do to sustain students' interest and engagement in science from primary to middle school in Bhutan.

FUNDING

Funding for this project has been received from UTS as a HDR scholarship under UTS International Research Scholarship (UTS IRS) and UTS President's Scholarship (UTSP).

WHY HAVE I BEEN ASKED?

You have been invited to participate in this study because you are a science teacher teaching in grade 6, 8 or 10 in the school participating in this study.

IF I SAY YES, WHAT WILL IT INVOLVE?

If you decide to participate, I will invite you to allow me to,

- ✓ *observe your teaching of science lessons for 4 weeks (2 weeks, then a break, then 2 more weeks)*
- ✓ *video record your science lessons over this period, focusing on your pedagogical practices, and a select group of students*
- ✓ *invite you to participate twice in a semi-structured interview that will be audio recorded and last maximum one hour each.*

ARE THERE ANY RISKS/INCONVENIENCE?

Yes, there are some risks/inconvenience. They are, you might feel uncomfortable when the lessons are observed, and in interviews. There could be some inconvenience related to the time spent with me for interviews.

DO I HAVE TO SAY YES?

Participation in this study is voluntary. It is completely up to you whether or not you decide to take part.

WHAT WILL HAPPEN IF I SAY NO?

If you decide not to participate, it will not affect your relationship with the Principal of the school or your employment in any way. Teaching and learning, your teaching pattern or your employment will not be affected in any way. If you wish to withdraw from the study once it has started, you can do so at any time without having to give a reason, by contacting the Principal, Mr. Gomchen Tenzin in person or via phone +975 [redacted] or via email at khangkhumss@education.gov.bt Bijoy Kumar Rai in person or via phone +975 [redacted] or email at bijoykumar.rai@student.uts.edu.au.

If you decide to leave the research project, we will not collect additional personal information from you, although personal information already collected will be retained to ensure that the results of the research project can be measured properly and to comply with law. You should be aware that data collected up to the time you withdraw will form part of the research project results.

CONFIDENTIALITY

By signing the consent form, you consent to the research team collecting and using personal information about you for the research project. All information will be treated confidential. All data will be stored/archived in a locked filing cabinet at the researcher's office and electronic files password protected with access to researcher and his supervisors only. The participants will be provided an opportunity to review their interview transcripts prior to publication. Your information will only be used for the purpose of this research project and it will only be disclosed with your permission, except as required by law.

We plan to publish the results as thesis at UTS, articles in journal papers and as conference proceedings. In any publication, information will be provided in such a way that you cannot be identified.

WHAT IF I HAVE CONCERNS OR A COMPLAINT?

If you have concerns about the research that you think I or my supervisor can help you with, please feel free to contact us on BijoyKumar.Rai@student.uts.edu.au (Phone no. +975) or my supervisors Dr. Kimberley Pressick-Kilborn at Kimberley.Pressick-Kilborn@uts.edu.au (Phone no. +61 2 9514 5330) or Dr. Nick Hopwood at Nick.Hopwood@uts.edu.au (Phone no. +61 2 9514 4658).

You will be given a copy of this form to keep.

NOTE:
This study has been approved by the University of Technology Sydney Human Research Ethics Committee [UTS HREC]. If you have any concerns or complaints about any aspect of the conduct of this research, please contact the Ethics Secretariat on ph.: +61 2 9514 9772 or email: Research.Ethics@uts.edu.au], and quote the UTS HREC reference number ETH18-2605. Any matter raised will be treated confidentially, investigated and you will be informed of the outcome.

UNIVERSITY OF TECHNOLOGY SYDNEY

CONSENT FORM – TEACHER

Pedagogical practice to sustain students' interest and engagement in science across the primary-middle school interface

I ________________________________ agree to participate in the research project "*Pedagogical practice to sustain students' interest and engagement in science across primary-middle school interface*" approved via UTS HREC approval reference number being conducted by Bijoy Kumar Rai (Email: BijoyKumar.Rai@student.uts.edu.au and mobile no.: +975 [redacted]). I understand that his study is a part of UTS HDR scholarship.

I have read the Participant Invitation Sheet or someone has read it to me in a language that I understand.

I understand the purposes, procedures and risks of the research as described in the Participant Information Sheet.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described and understand that I am free to withdraw at any time without affecting my relationship with the school, researchers or the University of Technology Sydney.

I understand that I will be given a signed copy of this document to keep.

I agree to:
- ☐ Have researcher in the class
- ☐ Being observed and video recorded
- ☐ Participate in two interviews which will be audio recorded.

I agree that the research data gathered from this project may be published in a form that:

- ☐ Does not identify me in any way

I am aware that I can contact Bijoy Kumar Rai if I have any concerns about the research, and I know whom to contact if I want to withdraw.

________________________________ ____/____/____
Name and Signature [participant] Date

________________________________ ____/____/____
Name and Signature [researcher] Date

UTS UNIVERSITY OF TECHNOLOGY SYDNEY

CONSENT FORM – PARENT and STUDENT

Pedagogical practice to sustain students' interest and engagement in science across the primary-middle school interface

I ____________________________________ agree to let my child participate/participate in the research project "*Pedagogical practice to sustain students' interest and engagement in science across primary-middle school interface*" approved via UTS HREC approval reference number being conducted by Bijoy Kumar Rai (Email: BijoyKumar.Rai@student.uts.edu.au and mobile no.: +975 [redacted]). I understand that his study is a part of UTS HDR scholarship.

I have read the Participant Invitation Sheet or someone has read it to me in a language that I understand.

I understand the purposes, procedures and risks of the research as described in the Participant Information Sheet.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described and understand that I am free to withdraw at any time without affecting my relationship with the school, researchers or the University of Technology Sydney.

I understand that I will be given a signed copy of this document to keep.

I agree to have my child/to be:

☐ Audio recorded
☐ Video recorded
☐ Being observed.

I agree that the research data gathered from this project may be published in a form that:

☐ Does not identify my child/me in any way

I am aware that I can contact Bijoy Kumar Rai if I have any concerns about the research, and I know whom to contact if I want to withdraw.

____ ____/____/____
Name and Signature [parent] Date

____ ____/____/____
Name and Signature [student] Date

____ ____/____/____
Name and Signature [researcher] Date

APPENDIX G: UTS ethics approval letter

UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Human Research Ethics Committee
Ethics Secretariat
C/O Research and Innovation Office
15 Broadway, Ultimo NSW 2007

T: +61 2 9514 9681
Research.Ethics@uts.edu.au

PO Box 123
Broadway
NSW 2007 Australia
www.uts.edu.au

UTS CRICOS PROVIDER CODE 00099F

19th December 2018

Associate Professor Nick Hopwood
Faculty of Arts and Social Sciences
UNIVERSITY OF TECHNOLOGY SYDNEY

Dear Nick,

UTS HREC ETH18-2605– Associate Professor Nick Hopwood, Dr Kimberley Pressick-Kilbourne, A/Prof Anne Prescott (for Mr Bijoy Kumar Rai Rai, PhD student) – "Pedagogical practice to sustain students' interest and engagement in science across the primary-middle school interface"

Thank you for your response to the Committee's comments for your project titled, "Pedagogical practice to sustain students' interest and engagement in science across the primary-middle school interface". The Committee agreed that this application now meets the requirements of the National Statement on Ethical Conduct in Human Research (2007) and has been approved on that basis. You are therefore authorised to commence activities as outlined in your application.

You are reminded that this letter constitutes ethics approval only. This research project must also be undertaken in accordance with all UTS policies and guidelines including the Research Management Policy (http://www.gsu.uts.edu.au/policies/research-management-policy.html).

Your approval number is UTS HREC REF NO. ETH18-2605.

Approval will be for a period of five (5) years from the date of this correspondence subject to the submission of annual progress reports.

The following standard conditions apply to your approval:

- Your approval number must be included in all participant material and advertisements. Any advertisements on Staff Connect without an approval number will be removed.

- The Principal Investigator will immediately report anything that might warrant review of ethical approval of the project to the Ethics Secretariat (Research.Ethics@uts.edu.au).

- The Principal Investigator will notify the UTS HREC of any event that requires a modification to the protocol or other project documents, and submit any required amendments prior to implementation. Instructions can be found at https://staff.uts.edu.au/topichub/Pages/Researching/Research%20Ethics%20and%20Integrity/Human%20research%20ethics/Post-approval/post-approval.aspx#tab2.

- The Principal Investigator will promptly report adverse events to the Ethics Secretariat (Research.Ethics@uts.edu.au). An adverse event is any event (anticipated or otherwise) that has a negative impact on participants, researchers or the reputation of the University. Adverse events can also include privacy breaches, loss of data and damage to property.

- The Principal Investigator will report to the UTS HREC annually and notify the HREC when the project is completed at all sites. The Principal Investigator will notify the UTS HREC of any plan to extend the duration of the project past the approval period listed above through the progress report.

- The Principal Investigator will obtain any additional approvals or authorisations as required (e.g. from other ethics committees, collaborating institutions, supporting organisations).

- The Principal Investigator will notify the UTS HREC of his or her inability to continue as Principal Investigator including the name of and contact information for a replacement.

I also refer you to the AVCC guidelines relating to the storage of data, which require that data be kept for a minimum of 5 years after publication of research. However, in NSW, longer retention requirements are required for research on human subjects with potential long-term effects, research with long-term environmental effects, or research considered of national or international significance, importance, or controversy. If the data from this research project falls into one of these categories, contact University Records for advice on long-term retention.

You should consider this your official letter of approval. If you require a hardcopy please contact Research.Ethics@uts.edu.au.

If you have any queries about your ethics approval, or require any amendments to your research in the future, please do not hesitate to contact Research.Ethics@uts.edu.au.

Yours sincerely

Production Note:
Signature removed prior to publication.

Associate Professor Beata Bajorek
Chairperson
UTS Human Research Ethics Committee

APPENDIX H: Opt-out letter

UTS UNIVERSITY OF TECHNOLOGY SYDNEY

OPT OUT LETTER

Pedagogical practice to sustain students' interest and engagement in science across the primary-middle school interface

Dear Parent,

A research study is being conducted in Khangkhu Middle Secondary School. The researcher is Bijoy Kumar Rai, a Bhutanese former teacher who is now studying at UTS in Australia. He wants to understand how teachers can keep students interested and engaged in science. He is focusing on grades 6, 8 and 10. You are receiving this letter because your child is in a class that has been provisionally selected for the study.

The study will focus on only four students in each class. However, Bijoy intends to be present in science lessons over for four weeks (two weeks, then a break, then two more weeks). He will not collect any data about your child, unless you hear separately that your child has been asked to participate (in which case your written consent will be asked).

Bijoy will make notes on what the teacher does, and video record the teacher and selected students. Your child, the class or science teacher will not be identified in any publications such as books or articles, that will be written about the project. Video recordings will not be shown to anyone outside of the project.

If you have any concerns or do not wish your child to be in the class, please contact Principal of the school, Mr. Gomchen Tenzin (email: khangkhumss@education.gov.bt, mobile no.: +975 [redacted]). Alternative arrangements will be made that will ensure your child does not miss any science lessons.

APPENDIX I: Science lessons time table changes

Science lessons time table (March 4, 2019)

Grade 6 Science (Mr E)

Period	1	2	3	4	5	6	7
Days	9:00-9:55	9:55-10:45	11:00-11:50	11:50-12:40	13:20-14:05	14:05-14:50	14:50-15:35
Mon		Sci					
Tue					Sci		
Wed				Sci			
Thu					Sci		
Fri							Sci

Grade 8 Science (Mrs D)

Period	1	2	3	4	5	6	7
Days	9:00-9:55	9:55-10:45	11:00-11:50	11:50-12:40	13:20-14:05	14:05-14:50	14:50-15:35
Mon		Sci					
Tue		Sci					Sci
Wed			Sci		Sci		
Thu		Sci					
Fri		Sci					Sci

Grade 10 Phy (Mr A), Che (Mrs B) & Bio (Mr C)

Period	1	2	3	4	5	6	7
Days	9:00-9:55	9:55-10:45	11:00-11:50	11:50-12:40	13:20-14:05	14:05-14:50	14:50-15:35
Mon	Phy						
Tue			Bio				Che
Wed	Phy			Che		Bio	
Thu							
Fri	Phy	Che			Bio		

Science lessons time table (May 1, 2019)

Grade 6 Science (Mr E)

Period	1	2	3	4	5	6	7	8
Days	9:00-9:45	9:45-10:25	10:40-11:20	11:20-12:00	12:00-12:40	13:20-14:00	14:00-14:40	14:40-15:20
Mon				Sci				
Tue			Sci		Sci			
Wed			Sci					
Thu						Sci		
Fri		Sci						

Grade 8 Science (Mrs D)

Period	1	2	3	4	5	6	7	8
Days	9:00-9:45	9:45-10:25	10:40-11:20	11:20-12:00	12:00-12:40	13:20-14:00	14:00-14:40	14:40-15:20
Mon				Sci	Sci			
Tue			Sci					
Wed					Sci			
Thu				Sci			Sci	
Fri								Sci

Grade 10 Phy (Mr A), Che (Mrs B) & Bio (Mr C)

Period	1	2	3	4	5	6	7	8
Days	9:00-9:45	9:45-10:25	10:40-11:20	11:20-12:00	12:00-12:40	13:20-14:00	14:00-14:40	14:40-15:20
Mon	Phy				Che			
Tue		Bio		Che				
Wed	Phy					Bio		
Thu	Phy							
Fri				Che	Bio			

APPENDIX J: Data generation plan and file naming protocol

Week	Day/Date	Grade	Session/ Period	Duration	Video (VR)	Video transcription or summary (VT)	Video remarks/ Memo (VM)	Observation Notes (ON)	Observation notes photo (ONP)	Observation Note Memo (ONM)	Observation Photograph (OP)	Observation Photograph Memo OMP (if any)	Student Self Video (SSV)	Student Self Video Memo (SSVM)	Interview Audio (IA)	Interview transcription or summary (IT)	Interview Transcripts Memo (ITM)
3 (DCW1)	Monday 04/03/19 Tuesday 05/03/19 Wednesday 06/03/19 Thursday 07/03/19 Friday 08/03/19	006	1 to 5	45 to 55 minutes	VR006.1.190304.P1.MTS VR006.2.190304.P1.MTS VR006.3.190304.P1.MTS VR006.4.190304.P1.MTS VR006.5.190304.P1.MTS	VT006.1.190304.P1.docx VT006.2.190304.P1.docx VT006.3.190304.P1.docx VT006.4.190304.P1.docx VT006.5.190304.P1.docx	VM006.1.190304.P1docx VM006.2.190304.P1docx VM006.3.190304.P1docx VM006.4.190304.P1docx VM006.5.190304.P1docx	ON006.1.190304 ON006.2.190304 ON006.3.190304 ON006.4.190304 ON006.5.190304	ONP006.1.190304.12345.jpg ONP006.2.190304.12345.jpg ONP006.3.190304.12345.jpg ONP006.4.190304.12345.jpg ONP006.5.190304.12345.jpg	ONM006.1.190304.docx ONM006.2.190304.docx ONM006.3.190304.docx ONM006.4.190304.docx ONM006.5.190304.docx	OP006.1.190304.12345.jpg OP006.2.190304.12345.jpg OP006.3.190304.12345.jpg OP006.4.190304.12345.jpg OP006.5.190304.12345.jpg	OPM006.1.190304.docx OPM006.2.190304.docx OPM006.3.190304.docx OPM006.4.190304.docx OPM006.5.190304.docx	SSV006.1.190304.12345.MTS SSV006.2.190304.12345.MTS SSV006.3.190304.12345.MTS SSV006.4.190304.12345.MTS SSV006.5.190304.12345.MTS	SSVM006.1.190304.docx SSVM006.2.190304.docx SSVM006.3.190304.docx SSVM006.4.190304.docx SSVM006.5.190304.docx	IA006.1.190304.SA1.mp3 IA006.2.190304.SB1.mp3 IA006.3.190304.SC1.mp3 IA006.4.190304.SD1.mp3 IAT.1.190304.TA1.mp3 IAT.2.190304.TB1.mp3 IAT.3.190304.TC1.mp3 IAT.4.190304.TD1.mp3 IAT.5.190304.TE1.mp3	IT006.1.190304.SA1.docx IT006.2.190304.SB1.docx IT006.3.190304.SC1.docx IT006.4.190304.SD1.docx ITT.1.190304.TA1.docx ITT.2.190304.TB1.docx ITT.3.190304.TC1.docx ITT.4.190304.TD1.docx ITT.5.190304.TE1.docx	ITM006.1.190304.SA1.docx ITM006.2.190304.SB1.docx ITM006.3.190304.SC1.docx ITM006.4.190304.SD1.docx ITTM.1.190304.TA1.docx ITTM.2.190304.TB1.docx ITTM.3.190304.TC1.docx ITTM.4.190304.TD1.docx ITTM.5.190304.TE1.docx
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5 (DCW3)	Monday 18/03/19 Tuesday 19/03/19 Wednesday 20/03/19 Thursday 21/03/19 Friday 22/03/19	008	1 to 8	45 to 55 minutes	VR008.1.190318.P1.MTS VR008.2.190318.P1.MTS VR008.3.190318.P1.MTS VR008.4.190318.P1.MTS VR008.5.190318.P1.MTS VR008.6.190318.P1.MTS VR008.7.190318.P1.MTS VR008.8.190318.P1.MTS	VT008.1.190318.P1.docx VT008.2.190318.P1.docx VT008.3.190318.P1.docx VT008.4.190318.P1.docx VT008.5.190318.P1.docx VT008.6.190318.P1.docx VT008.7.190318.P1.docx VT008.8.190318.P1.docx	VRM008.1.190318.P1docx VRM008.2.190318.P1docx VRM008.3.190318.P1docx VRM008.4.190318.P1docx VRM008.5.190318.P1docx VRM008.6.190318.P1docx VRM008.7.190318.P1docx VRM008.8.190318.P1docx	ON008.1.190318 ON008.2.190318 ON008.3.190318 ON008.4.190318 ON008.5.190318 ON008.6.190318 ON008.7.190318 ON008.8.190318	ONP008.1.190318.12345.jpg ONP008.2.190318.12345.jpg ONP008.3.190318.12345.jpg ONP008.4.190318.12345.jpg ONP008.5.190318.12345.jpg ONP008.6.190318.12345.jpg ONP008.7.190318.12345.jpg ONP008.8.190318.12345.jpg	ONM008.1.190318.docx ONM008.2.190318.docx ONM008.3.190318.docx ONM008.4.190318.docx ONM008.5.190318.docx ONM008.6.190318.docx ONM008.7.190318.docx ONM008.8.190318.docx	OP008.1.190318.12345.jpg OP008.2.190318.12345.jpg OP008.3.190318.12345.jpg OP008.4.190318.12345.jpg OP008.5.190318.12345.jpg OP008.6.190318.12345.jpg OP008.7.190318.12345.jpg OP008.8.190318.12345.jpg	OPM008.1.190318.docx OPM008.2.190318.docx OPM008.3.190318.docx OPM008.4.190318.docx OPM008.5.190318.docx OPM008.6.190318.docx OPM008.7.190318.docx OPM008.8.190318.docx	SSV008.1.190318.12345.MTS SSV008.2.190318.12345.MTS SSV008.3.190318.12345.MTS SSV008.4.190318.12345.MTS SSV008.5.190318.12345.MTS SSV008.6.190318.12345.MTS SSV008.7.190318.12345.MTS SSV008.8.190318.12345.MTS	SSVM008.1.190318.docx SSVM008.2.190318.docx SSVM008.3.190318.docx SSVM008.4.190318.docx SSVM008.5.190318.docx SSVM008.6.190318.docx SSVM008.7.190318.docx SSVM008.8.190318.docx	IA008.1.190318.SA1.mp3 IA008.2.190318.SB1.mp3 IA008.3.190318.SC1.mp3 IA008.4.190318.SD1.mp3	IT008.1.190318.SA1.docx IT008.2.190318.SB1.docx IT008.3.190318.SC1.docx IT008.4.190318.SD1.docx	ITM008.1.190318.SA1.docx ITM008.2.190318.SB1.docx ITM008.3.190318.SC1.docx ITM008.4.190318.SD1.docx
6 (DCW4)	Monday 25/03/19 Tuesday 26/03/19 Wednesday 27/03/19 Thursday 28/03/19 Friday 29/03/19	008	1 to 8	45 to 55 minutes	VR008.9.190318.P1.MTS VR008.10.190318.P1.MTS VR008.11.190318.P1.MTS VR008.12.190318.P1.MTS VR008.13.190318.P1.MTS VR008.14.190318.P1.MTS VR008.15.190318.P1.MTS VR008.16.190318.P1.MTS	VT008.9.190318.P1.docx VT008.10.190318.P1.docx VT008.11.190318.P1.docx VT008.12.190318.P1.docx VT008.13.190318.P1.docx VT008.14.190318.P1.docx VT008.15.190318.P1.docx VT008.16.190318.P1.docx	VRM008.9.190318.P1docx VRM008.10.190318.P1docx VRM008.11.190318.P1docx VRM008.12.190318.P1docx VRM008.13.190318.P1docx VRM008.14.190318.P1docx VRM008.15.190318.P1docx VRM008.16.190318.P1docx	ON008.9.190318 ON008.10.190319 ON008.11.190318 ON008.12.190318 ON008.13.190318 ON008.14.190318 ON008.15.190318 ON008.16.190318	ONP008.9.190318.12345.jpg ONP008.10.190318.12345.jpg ONP008.11.190318.12345.jpg ONP008.12.190318.12345.jpg ONP008.13.190318.12345.jpg ONP008.14.190318.12345.jpg ONP008.15.190318.12345.jpg ONP008.16.190318.12345.jpg	ONM008.9.190318.docx ONM008.10.190318.docx ONM008.11.190318.docx ONM008.12.190318.docx ONM008.13.190318.docx ONM008.14.190318.docx ONM008.15.190318.docx ONM008.16.190318.docx	OP008.9.190318.12345.jpg OP008.10.190318.12345.jpg OP008.11.190318.12345.jpg OP008.12.190318.12345.jpg OP008.13.190318.12345.jpg OP008.14.190318.12345.jpg OP008.15.190318.12345.jpg OP008.16.190318.12345.jpg	OPM008.9.190318.docx OPM008.10.190318.docx OPM008.11.190318.docx OPM008.12.190318.docx OPM008.13.190318.docx OPM008.14.190318.docx OPM008.15.190318.docx OPM008.16.190318.docx	SSV008.9.190318.12345.MTS SSV008.10.190318.12345.MTS SSV008.11.190318.12345.MTS SSV008.12.190318.12345.MTS SSV008.13.190318.12345.MTS SSV008.14.190318.12345.MTS SSV008.15.190318.12345.MTS SSV008.16.190318.12345.MTS	SSVM008.9.190318.docx SSVM008.10.190318.docx SSVM008.11.190318.docx SSVM008.12.190318.docx SSVM008.13.190318.docx SSVM008.14.190318.docx SSVM008.15.190318.docx SSVM008.16.190318.docx	IA008.5.190318.SA2.mp3 IA008.6.190318.SB2.mp3 IA008.7.190318.SC2.mp3 IA008.8.190318.SD2.mp3	IT008.5.190318.SA2.docx IT008.6.190318.SB2.docx IT008.7.190318.SC2.docx IT008.8.190318.SD2.docx	ITM008.5.190318.SA2.docx ITM008.6.190318.SB2.docx ITM008.7.190318.SC2.docx ITM008.8.190318.SD2.docx
7 (DCW5)	Monday 1/04/19 Tuesday 2/04/19 Wednesday 3/04/19 Thursday 4/04/19 Friday 5/04/19	010	1 to 3 (BCP)	45 to 55 minutes	VR010.1B.190401.P1.MTS VR010.1C.190401.P1.MTS VR010.1P.190401.P1.MTS VR010.2B.190401.P1.MTS VR010.2C.190401.P1.MTS VR010.2P.190401.P1.MTS VR010.3B.190401.P1.MTS VR010.3C.190401.P1.MTS VR010.3P.190401.P1.MTS	VT010.1B.190401.P1.docx VT010.1C.190401.P1.docx VT010.1P.190401.P1.docx VT010.2B.190401.P1.docx VT010.2C.190401.P1.docx VT010.2P.190401.P1.docx VT010.3B.190401.P1.docx VT010.3C.190401.P1.docx VT010.3P.190401.P1.docx	VRM010.1B.190401.P1docx VRM010.1C.190401.P1docx VRM010.1P.190401.P1docx VRM010.2B.190401.P1docx VRM010.2C.190401.P1docx VRM010.2P.190401.P1docx VRM010.3B.190401.P1docx VRM010.3C.190401.P1docx VRM010.3P.190401.P1docx	ON010.1B.190401 ON010.1C.190401 ON010.1P.190401 ON010.2B.190401 ON010.2C.190401 ON010.2P.190401 ON010.3B.190401 ON010.3C.190401 ON010.3P.190401	ONP010.1B.190401.12345.jpg ONP010.1C.190401.12345.jpg ONP010.1P.190401.12345.jpg ONP010.2B.190401.12345.jpg ONP010.2C.190401.12345.jpg ONP010.2P.190401.12345.jpg ONP010.3B.190401.12345.jpg ONP010.3C.190401.12345.jpg ONP010.3P.190401.12345.jpg	ONM010.1B.190304.docx ONM010.1C.190304.docx ONM010.1P.190304.docx ONM010.2B.190304.docx ONM010.2C.190304.docx ONM010.2P.190304.docx ONM010.3B.190304.docx ONM010.3C.190304.docx ONM010.3P.190304.docx	OP010.1B.190401.12345.jpg OP010.1C.190401.12345.jpg OP010.1P.190401.12345.jpg OP010.2B.190401.12345.jpg OP010.2C.190401.12345.jpg OP010.2P.190401.12345.jpg OP010.3B.190401.12345.jpg OP010.3C.190401.12345.jpg OP010.3P.190401.12345.jpg	OPM010.1B.190401.docx OPM010.1C.190401.docx OPM010.1P.190401.docx OPM010.2B.190401.docx OPM010.2C.190401.docx OPM010.2P.190401.docx OPM010.3B.190401.docx OPM010.3C.190401.docx OPM010.3P.190401.docx	SSV010.1B.190401.12345.MTS SSV010.1C.190401.12345.MTS SSV010.1P.190401.12345.MTS SSV010.2B.190401.12345.MTS SSV010.2C.190401.12345.MTS SSV010.2P.190401.12345.MTS SSV010.3B.190401.12345.MTS SSV010.3C.190401.12345.MTS SSV010.3P.190401.12345.MTS	SSVM010.1B.190401.docx SSVM010.1C.190401.docx SSVM010.1P.190401.docx SSVM010.2B.190401.docx SSVM010.2C.190401.docx SSVM010.2P.190401.docx SSVM010.3B.190401.docx SSVM010.3C.190401.docx SSVM010.3P.190401.docx	IA010.1.190401.SAB1.mp3 IA010.2.190401.SBC1.mp3 IA010.3.190401.SCP1.mp3 IA010.4.190401.SDB1.mp3	IT010.1.190401.SAB1.docx IT010.2.190401.SBC1.docx IT010.3.190401.SCP1.docx IT010.4.190401.SDB1.docx	ITM010.1.190401.SAB1.docx ITM010.2.190401.SBC1.docx ITM010.3.190401.SCP1.docx TM010.4.190401.SDB1.docx
8 (DCW6)	Monday 8/04/19 Tuesday 9/04/19 Wednesday 10/04/19 Thursday 11/04/19 Friday 12/04/19	010	1 to 3 (BCP)	45 to 55 minutes	VR010.4B.190408.P1.MTS VR010.4C.190408.P1.MTS VR010.4P.190408.P1.MTS VR010.5B.190408.P1.MTS VR010.5C.190408.P1.MTS VR010.5P.190408.P1.MTS VR010.6B.190408.P1.MTS VR010.6C.190408.P1.MTS VR010.6P.190408.P1.MTS	VT010.4B.190408.P1.docx VT010.4C.190408.P1.docx VT010.4P.190408.P1.docx VT010.5B.190408.P1.docx VT010.5C.190408.P1.docx VT010.5P.190408.P1.docx VT010.6B.190408.P1.docx VT010.6C.190408.P1.docx VT010.6P.190408.P1.docx	VRM010.4B.190408.P1docx VRM010.4C.190408.P1docx VRM010.4P.190408.P1docx VRM010.5B.190408.P1docx VRM010.5C.190408.P1docx VRM010.5P.190408.P1docx VRM010.6B.190408.P1docx VRM010.6C.190408.P1docx VRM010.6P.190408.P1docx	ON010.4B.190408 ON010.4C.190408 ON010.4P.190408 ON010.5B.190408 ON010.5C.190408 ON010.5P.190408 ON010.6B.190408 ON010.6C.190408 ON010.6P.190408	ONP010.4B.190408.12345.jpg ONP010.4C.190408.12345.jpg ONP010.4P.190408.12345.jpg ONP010.5B.190408.12345.jpg ONP010.5C.190408.12345.jpg ONP010.5P.190408.12345.jpg ONP010.6B.190408.12345.jpg ONP010.6C.190408.12345.jpg ONP010.6P.190408.12345.jpg	ONM010.4B.190308.docx ONM010.4C.190308.docx ONM010.4P.190308.docx ONM010.5B.190308.docx ONM010.5C.190308.docx ONM010.5P.190308.docx ONM010.6B.190308.docx ONM010.6C.190308.docx ONM010.6P.190308.docx	OP010.4B.190408.12345.jpg OP010.4C.190408.12345.jpg OP010.4P.190408.12345.jpg OP010.5B.190408.12345.jpg OP010.5C.190408.12345.jpg OP010.5P.190408.12345.jpg OP010.6B.190408.12345.jpg OP010.6C.190408.12345.jpg OP010.6P.190408.12345.jpg	OPM010.4B.190408.docx OPM010.4C.190408.docx OPM010.4P.190408.docx OPM010.5B.190408.docx OPM010.5C.190408.docx OPM010.5P.190408.docx OPM010.6B.190408.docx OPM010.6C.190408.docx OPM010.6P.190408.docx	SSV010.4B.190408.12345.MTS SSV010.4C.190408.12345.MTS SSV010.4P.190408.12345.MTS SSV010.5B.190408.12345.MTS SSV010.5C.190408.12345.MTS SSV010.5P.190408.12345.MTS SSV010.6B.190408.12345.MTS SSV010.6C.190408.12345.MTS SSV010.6P.190408.12345.MTS	SSVM010.4B.190408.docx SSVM010.4C.190408.docx SSVM010.4P.190408.docx SSVM010.5B.190408.docx SSVM010.5C.190408.docx SSVM010.5P.190408.docx SSVM010.6B.190408.docx SSVM010.6C.190408.docx SSVM010.6P.190408.docx	IA010.5.190408.SAC2.mp3 IA010.6.190408.SBP2.mp3 IA010.7.190408.SCB2.mp3 IA010.8.190408.SDC2.mp4	IT010.5.190408.SAC2.docx IT010.6.190408.SBP2.docx IT010.7.190408.SCB2.docx IT010.8.190408.SDC2.docx	ITM010.5.190408.SAC2.docx ITM010.6.190408.SBP2.docx ITM010.7.190408.SCB2.docx ITM010.8.190408.SDC2.docx

9 (DCW7)	Monday 15/04/19 Tuesday 16/04/19 Wednesday 17/04/19 Thursday 18/04/19 Friday 19/04/19	006	1 to 5	45 to 55 minutes	VR006.11.190304.P1.MTS VR006.12.190304.P1.MTS VR006.13.190304.P1.MTS VR006.14.190304.P1.MTS VR006.15.190304.P1.MTS	VT006.11.190304.P1.docx VT006.12.190304.P1.docx VT006.13.190304.P1.docx VT006.14.190304.P1.docx VT006.15.190304.P1.docx	VM006.11.190304.P1docx VM006.12.190304.P1docx VM006.13.190304.P1docx VM006.14.190304.P1docx VM006.15.190304.P1docx	ON006.11.190304 ON006.12.190304 ON006.13.190304 ON006.14.190304 ON006.15.190304	ONP006.11.190304.12345.jpg ONP006.12.190304.12345.jpg ONP006.13.190304.12345.jpg ONP006.14.190304.12345.jpg ONP006.15.190304.12345.jpg	ONM006.11.190304.docx ONM006.12.190304.docx ONM006.13.190304.docx ONM006.14.190304.docx ONM006.15.190304.docx	OP006.11.190304.12345.jpg OP006.12.190304.12345.jpg OP006.13.190304.12345.jpg OP006.14.190304.12345.jpg OP006.15.190304.12345.jpg	OPM006.11.190304.docx OPM006.12.190304.docx OPM006.13.190304.docx OPM006.14.190304.docx OPM006.15.190304.docx	SSV006.11.190304.12345.MTS SSV006.12.190304.12345.MTS SSV006.13.190304.12345.MTS SSV006.14.190304.12345.MTS SSV006.15.190304.12345.MTS	SSVM006.11.190304.docx SSVM006.12.190304.docx SSVM006.13.190304.docx SSVM006.14.190304.docx SSVM006.15.190304.docx	IA006.9.190415.SA3.mp3 IA006.10.190415.SB3.mp3 IA006.11.190415.SC3.mp3 IA006.12.190415.SD3.mp3	IT006.9.190415.SA3.docx IT006.10.190415.SB3.docx IT006.11.190415.SC3.docx IT006.12.190415.SD3.docx	ITM006.9.190304.SA3.docx ITM006.10.190415.SB3.docx ITM006.11.190415.SC3.docx ITM006.12.190415.SD3.docx
10 (DCW8)	Monday 22/04/19 Tuesday 23/04/19 Wednesday 24/04/19 Thursday 25/04/19 Friday 26/04/19	006	1 to 5	45 to 55 minutes	VR006.16.190304.P1.MTS VR006.17.190304.P1.MTS VR006.18.190304.P1.MTS VR006.19.190415.P1.MTS VR006.20.190415.P1.MTS	VT006.16.190304.P1.docx VT006.17.190304.P1.docx VT006.18.190304.P1.docx VT006.19.190415.P1.docx VT006.20.190415.P1.docx	VM006.16.190304.P1docx VM006.17.190304.P1docx VM006.18.190304.P1docx VM006.19.190415.P1docx VM006.20.190415.P1docx	ON006.16.190304 ON006.17.190304 ON006.18.190304 ON006.19.190415 ON006.20.190415	ONP006.16.190304.12345.jpg ONP006.17.190304.12345.jpg ONP006.18.190304.12345.jpg ONP006.19.190415.12345.jpg ONP006.20.190415.12345.jpg	ONM006.16.190304.docx ONM006.17.190304.docx ONM006.18.190304.docx ONM006.19.190415.docx ONM006.20.190415.docx	OP006.16.190304.12345.jpg OP006.17.190304.12345.jpg OP006.18.190304.12345.jpg OP006.19.190415.12345.jpg OP006.20.190415.12345.jpg	OPM006.16.190304.docx OPM006.17.190304.docx OPM006.18.190304.docx OPM006.19.190415.docx OPM006.20.190415.docx	SSV006.16.190304.12345.MTS SSV006.17.190304.12345.MTS SSV006.18.190304.12345.MTS SSV006.19.190415.12345.MTS SSV006.20.190415.12345.MTS	SSVM006.16.190304.docx SSVM006.17.190304.docx SSVM006.18.190304.docx SSVM006.19.190415.docx SSVM006.20.190415.docx	IA006.13.190422.SA4.mp3 IA006.14.190422.SB4.mp3 IA006.15.190422.SC4.mp3 IA006.16.190422.SD4.mp3	IT006.13.190422.SA4.docx IT006.14.190422.SB4.docx IT006.15.190422.SC4.docx IT006.16.190422.SD4.docx	ITM006.13.190422.SA4.docx ITM006.14.190422.SB4.docx ITM006.15.190422.SC4.docx ITM006.16.190422.SD4.docx
11 (DCW9)	Monday 29/04/19 Tuesday 30/04/19 Wednesday 1/05/19 Thursday 2/05/19 Friday 3/05/19	008	1 to 8	45 to 55 minutes	VR008.17.190429.P1.MTS VR008.18.190429.P1.MTS VR008.19.190429.P1.MTS VR008.20.190429.P1.MTS VR008.21.190429.P1.MTS VR008.22.190429.P1.MTS VR008.23.190429.P1.MTS VR008.24.190429.P1.MTS	VT008.17.190429.P1.docx VT008.18.190429.P1.docx VT008.19.190429.P1.docx VT008.20.190429.P1.docx VT008.21.190429.P1.docx VT008.22.190429.P1.docx VT008.23.190429.P1.docx VT008.24.190429.P1.docx	VRM008.17.190429.P1docx VRM008.18.190429.P1docx VRM008.19.190429.P1docx VRM008.20.190429.P1docx VRM008.21.190429.P1docx VRM008.22.190429.P1docx VRM008.23.190429.P1docx VRM008.24.190429.P1docx	ON008.17.190429 ON008.18.190429 ON008.19.190429 ON008.20.190429 ON008.21.190429 ON008.22.190429 ON008.23.190429 ON008.24.190429	ONP008.17.190429.12345.jpg ONP008.18.190429.12345.jpg ONP008.19.190429.12345.jpg ONP008.20.190429.12345.jpg ONP008.21.190429.12345.jpg ONP008.22.190429.12345.jpg ONP008.23.190429.12345.jpg ONP008.24.190429.12345.jpg	ONM008.17.190429.docx ONM008.18.190429.docx ONM00819.190429.docx ONM008.20.190429.docx ONM008.21.190429.docx ONM008.22.190429.docx ONM008.23.190429.docx ONM008.24.190429.docx	OP008.17.190429.12345.jpg OP008.18.190429.12345.jpg OP008.19.190429.12345.jpg OP008.20.190429.12345.jpg OP008.21.190429.12345.jpg OP008.22.190429.12345.jpg OP00823.190429.12345.jpg OP008.24.190429.12345.jpg	OPM008.17.190429.docx OPM008.18.190429.docx OPM008.19.190429.docx OPM008.20.190429.docx OPM008.21.190429.docx OPM008.22.190429.docx OPM008.23.190429.docx OPM008.24.190429.docx	SSV008.17.190429.12345.MTS SSV008.18.190429.12345.MTS SSV008.19.190429.12345.MTS SSV008.20.190429.12345.MTS SSV008.21.190429.12345.MTS SSV008.22.190429.12345.MTS SSV008.23.190429.12345.MTS SSV008.24.190429.12345.MTS	SSVM008.17.190429.docx SSVM008.18.190429.docx SSVM008.19.190429.docx SSVM008.20.190429.docx SSVM008.21.190429.docx SSVM008.22.190429.docx SSVM008.23.190429.docx SSVM008.24.190429.docx	IA008.9.190429.SA3.mp3 IA008.10.190429.SB3.mp3 IA008.11.190429.SC3.mp3 IA008.12.190429.SD3.mp3	IT008.9.190429.SA3.docx IT008.10.190429.SB3.docx IT008.11.190429.SC3.docx IT008.12.190429.SD3.docx	ITM008.9.190429.SA3.docx ITM008.10.190429.SB3.docx ITM008.11.190429.SC3.docx ITM008.12.190429.SD3.docx
12 (DCW10)	Monday 6/05/19 Tuesday 7/05/19 Wednesday 8/05/19 Thursday 9/05/19 Friday 10/05/19	008	1 to 8	45 to 55 minutes	VR008.25.190506.P1.MTS VR008.26.190506.P1.MTS VR008.27.190506.P1.MTS VR008.28.190506.P1.MTS VR008.29.190506.P1.MTS VR008.30.190506.P1.MTS VR008.31.190506.P1.MTS VR008.32.190506.P1.MTS	VT008.25.190506.P1.docx VT008.26.190506.P1.docx VT008.27.190506.P1.docx VT008.28.190506.P1.docx VT008.29.190506.P1.docx VT008.30.190506.P1.docx VT008.31.190506.P1.docx VT008.32.190506.P1.docx	VRM008.25.190506.P1docx VRM008.26.190506.P1docx VRM008.27.190506.P1docx VRM008.28.190506.P1docx VRM008.29.190506.P1docx VRM008.30.190506.P1docx VRM008.31.190506.P1docx VRM008.32.190506.P1docx	ON008.25.190506 ON008.26.190506 ON008.27.190506 ON008.28.190506 ON008.29.190506 ON008.30.190506 ON008.31.190506 ON008.32.190506	ONP008.25.190506.12345.jpg ONP008.26.190506.12345.jpg ONP008.27.190506.12345.jpg ONP008.28.190506.12345.jpg ONP008.29.190506.12345.jpg ONP008.30.190506.12345.jpg ONP008.31.190506.12345.jpg ONP008.32.190506.12345.jpg	ONM008.25.190506.docx ONM008.26.190506.docx ONM008.27.190506.docx ONM008.28.190506.docx ONM008.29.190506.docx ONM008.30.190506.docx ONM008.31.190506.docx ONM008.32.190506.docx	OP008.25.190506.12345.jpg OP008.26.190506.12345.jpg OP008.27.190506.12345.jpg OP008.28.190506.12345.jpg OP008.29.190506.12345.jpg OP008.30.190506.12345.jpg OP008.31.190506.12345.jpg OP008.32.190506.12345.jpg	OPM008.25.190506.docx OPM008.26.190506.docx OPM008.27.190506.docx OPM008.28.190506.docx OPM008.29.190506.docx OPM008.30.190506.docx OPM008.31.190506.docx OPM008.32.190506.docx	SSV008.25.190506.12345.MTS SSV008.26.190506.12345.MTS SSV008.27.190506.12345.MTS SSV008.28.190506.12345.MTS SSV008.29.190506.12345.MTS SSV008.30.190506.12345.MTS SSV008.31.190506.12345.MTS SSV008.32.190506.12345.MTS	SSVM008.25.190506.docx SSVM008.26.190506.docx SSVM008.27.190506.docx SSVM008.28.190506.docx SSVM008.29.190506.docx SSVM008.30.190506.docx SSVM008.31.190506.docx SSVM008.32.190506.docx	IA008.13.190506.SA4.mp3 IA008.14.190506.SB4.mp3 IA008.15.190506.SC4.mp3 IA008.16.190506.SD4.mp3	IT008.13.190506.SA4.docx IT008.14.190506.SB4.docx IT008.15.190506.SC4.docx IT008.16.190506.SD4.docx	ITM008.13.190506.SA4.docx ITM008.14.190506.SB4.docx ITM008.15.190506.SC4.docx ITM008.16.190506.SD4.docx
13 (DCW11)	Monday 13/05/19 Tuesday 14/05/19 Wednesday 15/05/19 Thursday 16/05/19 Friday 17/05/19	010	1 to 3 (BCP)	45 to 55 minutes	VR010.7B.190513.P1.MTS VR010.7C.190513.P1.MTS VR010.7P.190513.P1.MTS VR010.8B.190513.P1.MTS VR010.8C.190513.P1.MTS VR010.8P.190513.P1.MTS VR010.9B.190513.P1.MTS VR010.9C.190513.P1.MTS VR010.9P.190513.P1.MTS	VT010.7B.190513.P1.docx VT010.7C.190513.P1.docx VT010.7P.190513.P1.docx VT010.8B.190513.P1.docx VT010.8C.190513.P1.docx VT010.8P.190513.P1.docx VT010.9B.190513.P1.docx VT010.9C.190513.P1.docx VT010.9P.190513.P1.docx	VRM010.7B.190513.P1docx VRM010.7C.190513.P1docx VRM010.7P.190513.P1docx VRM010.8B.190513.P1docx VRM010.8C.190513.P1docx VRM010.8P.190513.P1docx VRM010.9B.190513.P1docx VRM010.9C.190513.P1docx VRM010.9P.190513.P1docx	ON010.7B.190513 ON010.7C.190513 ON010.7P.190513 ON010.8B.190513 ON010.8C.190513 ON010.8P.190513 ON010.9B.190513 ON010.9C.190513 ON010.9P.190513	ONP010.7B.190513.12345.jpg ONP010.7C.190513.12345.jpg ONP010.7P.190513.12345.jpg ONP010.8B.190513.12345.jpg ONP010.8C.190513.12345.jpg ONP010.8P.190513.12345.jpg ONP010.9B.190513.12345.jpg ONP010.9C.190513.12345.jpg ONP010.9P.190513.12345.jpg	ONM010.7B.190513.docx ONM010.7C.190513.docx ONM010.7P.190513.docx ONM010.8B.190513.docx ONM010.8C.190513.docx ONM010.8P.190513.docx ONM010.9B.190513.docx ONM010.9C.190513.docx ONM010.9P.190513.docx	OP010.7B.190513.12345.jpg OP010.7C.190513.12345.jpg OP010.7P.190513.12345.jpg OP010.8B.190513.12345.jpg OP010.8C.190513.12345.jpg OP010.8P.190513.12345.jpg OP010.9B.190513.12345.jpg OP010.9C.190513.12345.jpg OP010.9P.190513.12345.jpg	OPM010.7B.190513.docx OPM010.7C.190513.docx OPM010.7P.190513.docx OPM010.8B.190513.docx OPM010.8C.190513.docx OPM010.8P.190513.docx OPM010.9B.190513.docx OPM010.9C.190513.docx OPM010.9P.190513.docx	SSV010.7B.190513.12345.MTS SSV010.7C.190513.12345.MTS SSV010.7P.190513.12345.MTS SSV010.8B.190513.12345.MTS SSV010.8C.190513.12345.MTS SSV010.8P.190513.12345.MTS SSV010.9B.190513.12345.MTS SSV010.9C.190513.12345.MTS SSV010.9P.190513.12345.MTS	SSVM010.7B.190513.docx SSVM010.7C.190513.docx SSVM010.7P.190513.docx SSVM010.8B.190513.docx SSVM010.8C.190513.docx SSVM010.8P.190513.docx SSVM010.9B.190513.docx SSVM010.9C.190513.docx SSVM010.9P.190513.docx	IA010.9.190513.SAP3.mp3 IA010.10.190513.SBB3.mp3 IA010.11.190513.SCC3.mp3 IA010.12.190513.SDP3.mp3	IT010.1.190401.SAB1.docx IT010.2.190401.SBC1.docx IT010.3.190401.SCP1.docx IT010.4.190401.SDB1.docx	ITM010.1.190401.SAB1.docx ITM010.2.190401.SBC1.docx ITM010.3.190401.SCP1.docx TM010.4.190401.SDB1.docx
14 (DCW12)	Monday 20/05/19 Tuesday 21/05/19 Wednesday 22/05/19 Thursday 23/05/19 Friday 24/05/19	010	1 to 3 (BCP)	45 to 55 minutes	VR010.10B.190520.P1.MTS VR010.10C.190520.P1.MTS VR010.10P.190520.P1.MTS VR010.11B.190520.P1.MTS VR010.11C.190520.P1.MTS VR010.11P.190520.P1.MTS VR010.12B.190520.P1.MTS VR010.12C.190520.P1.MTS VR010.12P.190520.P1.MTS	VT010.10B.190520.P1.docx VT010.10C.190520.P1.docx VT010.10P.190520.P1.docx VT010.11B.190520.P1.docx VT010.11C.190520.P1.docx VT010.11P.190520.P1.docx VT010.12B.190520.P1.docx VT010.12C.190520.P1.docx VT010.12P.190520.P1.docx	VRM010.10B.190520.P1docx VRM010.10C.190520.P1docx VRM010.10P.190520.P1docx VRM010.11B.190520.P1docx VRM010.11C.190520.P1docx VRM010.11P.190520.P1docx VRM010.12B.190520.P1docx VRM010.12C.190520.P1docx VRM010.12P.190520.P1docx	ON010.10B.190520 ON010.10C.190520 ON010.10P.190520 ON010.11B.190520 ON010.11C.190520 ON010.11P.190520 ON010.12B.190520 ON010.12C.190520 ON010.12P.190520	ONP010.10B.190520.12345.jpg ONP010.10C.190520.12345.jpg ONP010.10P.190520.12345.jpg ONP010.11B.190520.12345.jpg ONP010.11C.190520.12345.jpg ONP010.11P.190520.12345.jpg ONP010.12B.190520.12345.jpg ONP010.12C.190520.12345.jpg ONP010.12P.190520.12345.jpg	ONM010.10B.190520.docx ONM010.10C.190520.docx ONM010.10P.190520.docx ONM010.11B.190520.docx ONM010.11C.190520.docx ONM010.11P.190520.docx ONM010.12B.190520.docx ONM010.12C.190520.docx ONM010.12P.190520.docx	OP010.10B.190520.12345.jpg OP010.10C.190520.12345.jpg OP010.10P.190520.12345.jpg OP010.11B.190520.12345.jpg OP010.11C.190520.12345.jpg OP010.11P.190520.12345.jpg OP010.12B.190520.12345.jpg OP010.12C.190520.12345.jpg OP010.12P.190520.12345.jpg	OPM010.10B.190520.docx OPM010.10C.190520.docx OPM010.10P.190520.docx OPM010.11B.190520.docx OPM010.11C.190520.docx OPM010.11P.190520.docx OPM010.12B.190520.docx OPM010.12C.190520.docx OPM010.12P.190520.docx	SSV010.10B.190520.12345.MTS SSV010.10C.190520.12345.MTS SSV010.10P.190520.12345.MTS SSV010.11B.190520.12345.MTS SSV010.11C.190520.12345.MTS SSV010.11P.190520.12345.MTS SSV010.12B.190520.12345.MTS SSV010.12C.190520.12345.MTS SSV010.12P.190520.12345.MTS	SSVM010.10B.190520.docx SSVM010.10C.190520.docx SSVM010.10P.190520.docx SSVM010.11B.190520.docx SSVM010.11C.190520.docx SSVM010.11P.190520.docx SSVM010.12B.190520.docx SSVM010.12C.190520.docx SSVM010.12P.190520.docx	IA010.13.190520.SA4.mp3 IA010.14.190520.SB4.mp3 IA010.15.190520.SC4.mp3 IA010.16.190520.SD4.mp4 IAT.6.190520.TA2.mp3 IAT.7.190520.TB2.mp3 IAT.8.190520.TC2.mp3 IAT.9.190520.TD2.mp3 IAT.10.190520.TE2.mp3	IT010.13.190520.SA4.docx IT010.14.190520.SB4.docx IT010.15.190520.SC4.docx IT010.16.190520.SD4.docx ITT.6.190520.TA2.docx ITT.7.190520.TB2.docx ITT.8.190520.TC2.docx ITT.9.190520.TD2.docx ITT.10.190520.TE2.docx	ITM010.13.190520.SA4.docx ITM010.14.190520.SB4.docx ITM010.15.190520.SC4.docx ITM010.16.190520.SD4.docx ITTM.6.190520.TA2.docx ITTM.7.190520.TB2.docx ITTM.8.190520.TC2.docx ITTM.9.190520.TD2.docx ITTM.10.190520.TE2.docx
15 (DCW13)	Monday 27/05/19 Tuesday 28/05/19 Wednesday 29/05/19 Thursday 30/05/19 Friday 31/05/19	006 008 010	1 to 9/8/3	45 to 55 minutes	Any shortage of data to be compensated in this week											

APPENDIX K: Lesson mapping

Span/Intensity	Lower I&E (Bored/Complacent)	Higher I&E (Active and Enjoying)	Lower I&E: HoL	Lower I&E: SGD	Lower I&E: IL	Higher I&E: HoL	Higher I&E: SGD	Higher I&E: IL
Brief moments of I&E	G6: L10, L11, L16, L20 G8: L6, L10, L14, L15, L16, L21, L28 G10: BL4, BL10, CL3, PL5, PL6, PL8, PL10, PM12	G6: L4 G8: L1, L7, G10: BL9, CL5, CL6, CL7, CL8, CL9, CL10, PL3, PL7,		G8L15-Grafting G8L16-Adap&Sur	*G6L10-H&Swater* G6L11-SolinLiq, G6L16-SepMiLiq, G6L20-RelM&Wt G8L6-Fo&PerHab G8L10-AbsRoots *G8L14-RepPlants* G8L21-SolSalt G8L28-CalMoMas G10BL4-BloodP G10BL10-Reflex G10CL3-M2MRel G10PL5-KE&PE G10PL6-LawCoE G10PL8-SusEngy G10PL10-GeoEgy G10PL12-emf TV	G6L4-NatAcid G8L8-RootSys G10CL10-Electro	G10BL9-NervSys G10PL7-SourceEn	G8L1-SOEyeTon G10CL5-GaYLLaw G10CL6-M2NoRel G10PL3-Power
More sustained I&E	G6: L12, L15, G8: L8, L22, L26 G10: PL2, PL4,	G6: L1, L2, L3, L6, L7, L8, L9, L13, L14 G8: L2, L3, L4&5, L9, L11&12, L13, L17&18, L19, L20, L23, L25&25, L27, L29, L30 G10: BL1, BL2, BL3, BL5, BL6, BL7, BL8, BL11, BL12, CL1, CL2, CL4, CL11, CL12, PL1, PL9, PL11,		G6L12-SepSol^2 G8L7-NatSelec	G6L15-DecSepF G8L26-CheReact G10PL2-Ene&Wo G10PL4-PoMach	**G6L14-SepO&W**, G6L6-LitmInd, G6L8-OwnInd, G6L9-TestOInd, G6L13-SepSol^2, G8L11&12-Osmo G8L20-Solubility G8L23-SoluSugar G8L29-VerMasCh **G8L30-CheReact** **G10CL9-RedCuO**	*G6L1-Ele&Co(B)* G6L2-Ele&Sym, G6L3-Ac&Alk, G8L2-SONosSki **G8L3-EnvLi&Hth** **G8L4&5-Lif&Hth** G8L13-InorFarm G8L17&18-BalEq G8L24&25-SoCur G10BL7-Respira **G10BL12-RegSug** **G10CL7-Metalgy** **G10CL8-Metalgy**	***G6L7-UnivInd(P)*** **G8L9-AbRoots** G8L19-BalEq G8L22-FacAffSolu G8L27-CheReact G10BL1-CirSys G10BL2-Plasma G10BL3-Urine G10BL5-BloodGr G10BL6-Kidney G10BL8-Respira G10BL11-NervPW G10CL1-EmpFor G10CL2-MolFor G10CL4-M2VRel G10CL11-Disso G10CL12-Dischg G10PL1-HyJack G10PL9-BioWndE **G10PL11-EleCir**

APPENDIX L: A sample of video lesson transcript

Grade 6: Separation of two immiscible liquids (Lesson 14)

Students wished us when we walked into the class and as I set the camcorder for recording, the teacher walked to teacher's table with tray containing equipment and his books and placed it there… he picked the class logbook and readied to mark the attendance… signed on the logbook, set the timer on his mobile phone

Alright, get ready for the class. Take out your textbook, notebook and pencil or whatever you write with (Tr. moves along the front of the class to make sure that students are getting ready for the lesson). Alright! Let's have our meditation first… shall we, on the count of 3… one, two, three (Tr. stand straight with his eyes closed, hands folded above waist and in front of the participant's table… opens his eyes to check in between and lets the meditation go for about 50 seconds). Claps his hand to stop meditation… alright! Good morning… (good morning sir). So, today we will look at the next topic…what is the next topic?

Std.: In chorus… separating immiscible liquids

Tr.: Separating immiscible liquids… (moves towards the left side of the class). But before we go there, as usual, let's find out what we did and what we learnt in our last (class) class… Can somebody tell me what we did in the last class? (tr. raises his hand calling for volunteers) yesterday, what we did in the lab? (Somebody from the back of the class volunteered and the teacher picked him)

Std.: Separating soluble solids… mixture

Tr.: Alright, the topic was separating soluble (solids) solids from their mixtures right… and I gave you a challenge right! To separate salt from sand… so, in that experiment, you used two processes to separate sand and salt, what are the two processes? (Picking Semyang to respond)

Semyang: Filtration and evaporation

Tr.: Take your seat! So, what kind of solids are separated by filtration? (Moving towards the right side of the classroom)

Std.: Salt and sand…

Tr.: What was separated by filtration? What separated when you used the filter paper?

Another student: Sand and salt (both were separated, when you used the filter paper)… umm, sand!

Tr.: So, sand… is it soluble or insoluble (insoluble)… alright, insoluble solids are separated by filtration. And, what kind of solids are separated by evaporation? (Walking towards the front centre of the classroom). What kind of solids are separated by evaporation? (making eye contact with Namgyel and expecting him to respond but, when he did not volunteer, tr. diverted his attention to other students at the back of the class)... through evaporation

Std.: Soluble solids

Tr.: Soluble solids are separated through evaporation… alright, in the last class we learnt that insoluble solids can be separated through filtration and then soluble solids through evaporation (Looks at the participants to confirm and nods his head). Is that okay? Alright, today we will look at separation of immiscible liquids (looks at the book and reads and after that, moves to the board to write the topic). Can you take out your notebook and write (Tr. uses block writing). So, the topic is separating immiscible liquids (moves to the back of the classroom on my left announcing the topic)… Done! (Yes sir) so all eyes on me hmmm, so you all will carry out one experiment okay (simple experiment) one simple experiment… a very simple experiment (indicating with hand movements) and you will be separating two immiscible liquids (Namgyel nods his head while looking at teacher attentively) and at the end, you should be able to identify that process, what process was used to separate these two immiscible liquids (catches eyes briefly with Namgyel who continuously looks at him) and then, you should also be able to define that process. But, before we do that, let's find out whether you remember this term (pointing at the board) immiscible. Can somebody tell me what are some immiscible liquids?

Std.: When two liquids can't mix (mix with each other completely, they are known as immiscible liquids… teacher jumps in)

Tr.: Alright, liquids which do not mix with each other completely are known as (chorus response from students) immiscible liquids… good! Take your seat. Can somebody give me two examples… right, here… calling out the student's name

Std.: water and oil (tr. repeats… water and oil), kerosene and oil (kerosene and oil)

Tr.: Do you all agree with him? Alright, good! Take your seat. So today, we will be using two immiscible liquids (tr. walks towards the table where he had put the materials previously to pick the material. Holds the bottles containing oil and water to students who confirms the content in the bottles… oil and water) oil and water okay and then, you will basically follow the procedures given in the experiment on page number 46 (takes a closer look in the Phub's textbook and continues to provide instruction) and then 47 as well, the top part. So, you follow the procedure and you use the steps by looking at the picture given there (how to do… some students are confused)… can you see one picture given there? (yes sir) alright, do exactly like that and then, I want you to separate water and oil (completely) completely okay… and then you should be able to identify that step and you should be able to define that step. Is it okay? So, you will do this work in groups… (students are already busy talking to themselves and hardly listen to the teacher… teacher walks to his table to get the remaining material and places them on the participant's table). Alright, here… so, each group… listen up… each group will get (holding two beakers high for students to complete the statement – two beakers) two beakers and I will be giving you oil 20 mL and water also (20 ml) 20 mL okay. So, your group captain will come here and collect (as student's get ready to collect the material they do not give attention to the teacher) 20… listen up, listen up (tr. aware that the class is not listening)… so, I will give you 20 mL water and then 20 mL of (oil) oil and then you will mix it up and then you will look at the picture and then, do exactly like that picture and then try and separate and then, show it to me… you will get in addition to water, oil and beakers (holding up the glass rod), you will also get one (glass rod) glass rod… you will be using this glass rod and then separating two liquids (tr nods his head to get assurance from students). So, I want you all to appoint a captain each on your own (tr. looks around to see if all groups have appointed their captain or not). There (pointing at the first group on far left hand side of the classroom) appointed? Alright, come over here (hands over two beakers and a glass rod to one boy… rest of the group captains also starts to move towards the teacher)… wait, wait, wait (asking others to stop moving towards him), yeah! That group (pointing at the second group… a girl come up to collect the material)… that group (indicating the next group… a boy comes up to collect the material)… this group (another boy collects the material) Yeah, this group (places the material on the table… Semyang reaches forward to hold the material while rest just looks at the material). Yeah, that group (hands over the material to a boy in the 6th group and reaches out to the last group to hand over the material – a girl). Alright, so you will get (20 mL) 20 mL so, I will get that (holding the water in wash bottle and a measuring cylinder and pouring water in it). Yeah! That group (after measuring 20 mL…pointing to the first group) come and collect your water (the group captain collects), that group (indicating the next and measuring water in measuring cylinder again… first group captain check if there is 20 mL of water in his beaker or not)… the teacher pours and provides 20 mL of water to all groups (some students say that they did not get 20 mL as the beaker also has the level…) Next, what will you get? (OIL… chorus answer… teacher measures oil in the same measuring cylinder and tries to be accurate with his measurement… pouring back and forth)… Now follow the procedure and try and separate, next group… (Repeats the same procedure to distribute oil to second group and then decides to go around the tables to distribute the oil)…what is the procedure to stir? Follow the procedure… the procedure is not saying you all to mix it… but, it's okay… it is okay, it does not matter.

Phub: 'if we put honey, honey will be at the bottom'… goes one to explain while others listen. Namgyel explains after reading from the book, Semyang reads the instruction in the book. She removes the glass rod from the beaker and places it upside down and yet again changes the position while other look at her. Sonam tries to help but, Semyang looks confused and tries to check around what others are doing… she still has the glass rod in her hand when the teacher walks to the table. He points at the beaker containing water and oil to check if the liquids has settled or not (everyone checks) and moves the remaining material to the teacher's table. Participant discuss with Phub leading while Semyang touches the glass rod again. Participants continue to discuss about the experiment… Semyang picks up the beaker in preparation to pour it in the other beaker… she pours from the side of the beaker (not using the glass rod) carefully… Namgyel says to use the glass rod and the teacher walks in questioning, 'is that the way?' Points in the picture to indicate the use of glass rod and accordingly, Semyang changes the position to pour out oil into the other beaker. All are focused and watching as, Semyang carefully pours out the oil (drop by drop as per Phub)… one can check the facial expression of their engagement. Tr. moves away and Semyang tries to bring the glass rod closer to the beaker by holding it to pour out more oil and at this moment, Sonam offers help to hold the glass rod… Namgyel instructs while Phub watches… (Namgyel: All the oil are in the upper part. Phub: It is 30 mL). Semyang and Sonam checks the level of oil in the second beaker. Phub notices some bubbles (water has gone in)… as they check, another group shouts “BINGO” to indicate that they have completed the experiment. (Namgyel: I know which one is water now… they seem to discuss in English language only). Sonam stirs the oil in the second beaker while Semyang checks for traces of oil in the first beaker and tries to pour that out too with Phub and Sonam helping. (Namgyel is now reading his textbook). Semyang tries to pour out all the oil from the water in the beaker. As Semyang holds up the first beaker, everyone checks to make sure that there is no more oil in the beaker… she pours again, trying her best to separate all the oil from water… (check the engagement… this kind of activities can lead to students interest in science… one can see authentic engagement as students are working on their own and they seem to strategize and make sure that they separate the oil completely from water). Namgyel points out that some water has gone in the oil

Tr.: If you can separate completely, it is good… is there complete separation? (NO)

The group continues to make sure that all oil and water are separated… Phub has the focused look on his face… Sonam inclines her body as she watches Semyang pour more oil out of the beaker one. Checks if there is leftover oil and points at the beaker… As teacher walks past the group, Phub confirms to teacher that their group also completed the experiment (Done!)… Namgyel affirms (Done!) and Phub says, they got pure water… can we drink it (water). Semyang tries to mix the little water that has gone into the oil by stirring with glass rod. The participants continue to discuss… Sonam said something to Namgyel (I went to take the picture of the separated liquids and they look at what I am doing…found some water in the oil beaker). They check for water in the beaker containing oil… Tr. comes along and checks for mixtures in each beaker by lifting it above the eye level…

Tr.: Allright, class, class… yes, yes! So, could you separate the water from the oil? (Yes! But not…) Mostly, right! (Yes! Pure dhi ma then la… did not get the pure one). Alright, there are two questions… one, what is this process called? (Waits…) So, what do you call this process of separation? (indicating with his hands… hand picking… decantation). Yes! (pointing at the student who mentioned it… Decantation) So, this process is known as (Decantation) decantation (tr. goes to the table to pick the chalk and write the topic on the chalkboard). Good! (Waiving hand to indicate the student to sit). Alright, can somebody define what is decantation method? I think you use decantation method (yes, in class five) in separating oil and water so, how to define decantation.... (Tr. picks a student to respond but says the name wrongly… students correct the teacher… to pour the mixture carefully with the help of glass rod). Do you agree with him? He is saying, ‘pouring the mixture with the help of a glass rod and separating two immiscible liquids’. Do you agree with him? Does anybody have a different definition? His ideas… your answer is quite correct but, would you like to add something… naming another student.

Std.: Decantation is a process to obtain pure liquid from a mixture

Tr.: To obtain pure liquid from a mixture… alright, take your seat. So, I think, they used the word ‘pouring’ right! So, basically decantation means separating immiscible liquids by pouring it carefully (thinking…) in a container… okay. It is known as decantation (Waiving hand at the student asking him/her to sit and moving towards the chalkboard to write). It can be defined as separation of an immiscible liquid by pouring it into a container. And this decantation can be done in a different way okay… today, we used a glass rod… we poured the oil on the glass rod and we separated the oil from the water but, basically what we are doing… we are ‘pouring’ right… pouring the oil into a new clean (container) beaker or into a container so, that process is known as decantation (decantation). Therefore, decantation is used for separating what… what kind of liquids? (immiscible liquids… chorus response) Immiscible liquids… Let’s take one more example… let’s say I put some oil and I put some stones in it and then I shake it (indicating with the movement of his hands) and I pour the oil in a container… that is also decantation. So, decantation is basically pouring… (indicating with his hands and moving towards the right side of the classroom) an immiscible liquid into a container (tries to make eye contact to the participants – Sonam and Semyang). We can do decantation with the help of a glass rod and then, we can also do decantation by using some special apparatus (looking at the textbook in front of Phub) known as separating funnel so, that we will do in the next (class) class okay… So, have you understood? (YES SIR!) So, what is the method used for separating immiscible liquids (pointing at the board)? (DECANTATION!) decantation and it is basically defined as (reading from the board) separation of immiscible liquid by pouring into a (container) container. Alright, in the next class, we will again separate oil and water through decantation but, we will be using another method, another apparatus okay… that apparatus is known as separating (funnel) funnel but the process is exactly the same… still decantation… we will be pouring and immiscible liquid into a new container. Alright so with this we come to the end of today’s lesson so, for rest of the period what you will do is (question and answer)… you will write this topic, you will read and write the procedure and then, you answer that question “what is this process called” okay and then, you can write the definition and then, maybe, you can also draw a simple diagram (holds up the textbook to show the diagram) this diagram but then, you don’t have to draw this coloured one, just a simple one, show the beaker, show the glass rod (and show the pouring) and show the oil and (water) water. Can you do that? (YES SIR!) So, in your diagram there should be two beakers (showing on the picture in the textbook), one glass rod, and then in the top, beaker… you should reflect what? Oil and water…alright, complete this work and show it to me before the end of the period…alright, start!

Participants: Phub starts writing immediately, Namgyel hold the half part of his notebook as he writes on the other part, Semyang opens her pencil bag to take out pen and Sonam has started writing already… Initially, all began by doing individual work however, gradually Semyang asked something to Sonam who was doubtful and finally decided to raise her hand… tr. did not see her as he moved to the back of classroom… Semyang continued to keep her hand raised even though, there was discussion happening on the table. Finally, teacher came and cleared her doubt and, gave some responses… all started to write again and were engrossed. Phub copied the definition from the board…. Semyang quite often talks to Sonam… Namgyel let go of holding the notebook… as they draw diagram, they use the eraser to rectify the mistake… Namgyel and Phub has the geometry box while Sonam and Semyang carries a pencil bag…They giggle, exchange quick glances or words as they work on the task (tr. continues to go around the class in the entire process… giving answers to individual or to the whole class or at times questioning the whole class and getting the response)

Phub and Namgyel checks each other's work… Semyang finished and takes her book to show it to tr. but, the tr. sends the stds back to their seat asking them to raise their hand and stay there… Tr. checks Semyang's notebook and tells her to use the ruler while drawing otherwise, what is the point in bringing it to the class… Sonam has also finished her work so the tr. checks her work next (writes some comments and tells them to revise) Sonam and Semyang talks to each other… Phub has finished too… Tr. checks his work (what is wrong with the beaker? Corrects the error by showing the real beaker in front of them and gives feedback on the writing. Do you have ruler? Why do you bring it to school if you don't want to use it… picking up the set square… draw it straight… the diagram is not good enough). Namgyel passes the ruler… Tr. checks Namgyel's work next and corrects some error there as well indicating to label the different materials…it is the mixture of immiscible liquids focusing on the use of language. Tr. ultimately lands up writing for Namgyel. Tr. talks to the whole group on the use of correct language). Namgyel is happy with his diagram… Sonam fiddles with the glass rod talking to Semyang… Namgyel and Phub checks their notebook… After the teacher left the table they start talking to each other (not revising as instructed) on making comparison… Semyang intervenes but gradually, boys talk to each other and girls do the same…

Tr.: Alright, stop writing and listen to me… I will stay here and do the correction okay…so, what did we learn today? We learnt about separating immiscible liquids (separating immiscible liquids – chorus response from students) through what method? (Decantation – chorus) and decantation can be done in many different ways so, today we use a glass rod for doing decantation… tomorrow, we will do decantation in another way for that we will go to the (lab) lab (filtration – another boy) and that diagram will be given as drawing (competition) second drawing competition of the year (this one)… I am just informing you in… no, no that separating funnel, that will be done tomorrow after the experiment… I am just informing you in advance. Alright, you can go for your break (wish you all the best of luck) and rest, if you want to show your work, bring it here… moves towards his table… Captains put the materials back…

Participants get ready to move to their other seating places while Semyang collects the material to return. Tr. puts the tray on the participant's table to collect the material…

APPENDIX M: A sample extract from student discussion audio transcript

(Note: This extract is for the same lesson as given in APPENDIX L)

Namgyel: No! it just says, allow it to stay for one minute
Tr: Follow the procedure, the procedure is not saying you all to mix it. But, it is okay, it is okay, it does not matter (As he goes around pouring oil into the beaker for remaining groups)
Namgyel: Ah the water is lower while the oil is upper
Semyang: What do we need to do?
Sonam: Allow it to stand…
Phub: If we put honey, honey will be at the bottom. Water will be in the middle and this will… (explaining to the group)
Semyang: Be on the top
Phub: What will happen if you put stone in a honey?
Namgyel: Stone… stone will sink while the honey will be there
Sonam: What will we observe?
Semyang: We observe that oil will float on the water because of less density. What kind of mixture is this? Immiscible liquids
Namgyel: Immiscible
Semyang: Now observe the picture… we need to keep the glass rod here. Is this like this?
Namgyel: I don't know, others are keeping it here. This one is I think for the second one
Sonam: Like this (speaking in Dzongkha)
Semyang: The lower one has to be…
Tr: So, basically ladies are allowed…
Phub: Settle it… so, sedimentation and decantation, both
Semyang: Ah here, it is 40 ml
Namgyel: Not 20! Is it 40…
Phub: Sedimentation and decantation using the glass rod method. We use the glass rod to…
Namgyel: Just tell me Phub, what is sedimentation and decantation?
Phub: Sedimentation is settlement of the mixture and decantation is pouring it
Semyang: Can I pour it now? Can I pour it
Sonam: Are we supposed to pour it out (speaking in Dzongkha)
Phub: Oh! Does that mean water will stay here and oil will come here
Semyang: Can I pour it? (Speaking in Dzongkha) As in the picture…
Phub: Wait… did it go one minute? Who has the watch? No no… glass rod, glass rod (indicating Semyang to use glass rod to pour out the oil but, she does not listen and continues to pour directly from one beaker into another). From the glass rod (Phub knows how to do it but, others don't listen to him)
Namgyel: Oh, I know because we will separate the oil. Oil will go first and last the water.
Phub: And, we won't pour that water.
Semyang pours out oil directly without using the glass rod…

Tr: Is that the way? Where is it being poured?(showing the picture on the book)
Semyang: Oh! On that side? (Nervous giggle)
Phub: I saw it… It is going drop by drop
Sonam: ooooh
Namgyel: Because it will slide like that and go down
Tr: And it should not go out
Phub: It is going out a bit
Namgyel: No Phub
Sonam: No
Namgyel: I think Phub because all the oil will go
… all the oil are upper part and there is only little oil and then finished.
Phub: Is it 30 ml? 30 ml, now 20 ml and it will be 10 ml
Namgyel: I think it should be 20, about to reach… Phub, we can also separate the oil by… what do you say (speaking in Dzongkha)? Filter paper. Don't you remember? Last time the madam tried… the oil
Sonam: Who madam?
Phub: We only have a science teacher
Sonam: XXX
Namgyel: Madam YYY
Phub: YYY last year… But!
Namgyel: Similar like that I can remember that
Phub: But you told last time and not last year
Namgyel: Yes! Do you remember that she came here last time… with all of the other teachers. And, that's the time when we meet our sir
Semyang: Is it almost done
Phub: (Checking) Little bit oil… bubbles. I see those bubbles
Sonam: They did not say to mix
Namgyel: Be careful
A group: BINGO
Namgyel: Be careful
Sonam: No!
Namgyel: Not a single water should come out. Oh! I know which one is water now
Phub: This one
Namgyel: Yep
Sonam: The smaller beaker… there is little left
Phub: There is little left
Semyang: Ah cha cha. I feel stressed
Phub: There is a bit
Namgyel: Separating funnel… here. I told you that funnel can also work
Phub: That's the main key to our experiment (Talking about accuracy) little bit little bit… There is little bit
Namgyel: You can't tell right now…
Semyang: Let's see… a bit
Namgyel: Fully it might not (speaking in Dzongkha). Right now, the water did not go
Phub: No!
Namgyel: I know that
Phub: There is little bit of oil Namgyel
Namgyel: Because, if there is little bit of water, it should go down
Phub: None of the water went down

Namgyel: So!
Phub: One last…
Namgyel: Sir is doing like that… (Checking on the teacher). This string (rod) was another way to separate that oil
Semyang: Done
Phub: Done!
Semyang: Yeah, done… see!
Phub: (to teacher) Done!
Tr: Done!
Sonam: 123 Bingo (Instigating her friends)
Phub: Pure water! Can we drink it tey…
Namgyel: No Phub
Phub: We might get dehydrated
Namgyel: Drink it!
Phub: Drink it
Namgyel: Ya! But there is little bit of oil. There can be the taste of oil no! chances for the water. It might not get mixed but Phub, little bit dirty
Semyang: Here see, pure water
Namgyel: Yes but Phub thinks that some oil might go into the water…
Another group: BINGO!
Namgyel: We got water
Phub: Here water, here oil
Namgyel: No! I mean in the other beaker where we were separating the oil, we did not get the water
Me: Some bubbles
Phub: Yes no, yes no, yes no… I don't know
Namgyel: Yes! There might be
Phub: Yes, no… yes, no
Namgyel: Because there might be little bit left…
Me: Water…
Phub: Let's see the lower meniscus…
Namgyel: Lots of water
Phub: WHAT!
Me: Water bubbles are there…
Tr: Done!
Phub: Pure water
Tr; All right, mostly water
Phub: (As teacher picks up the beaker containing oil) Little bit water
Tr: Yeah! Little bit water is there…
Namgyel: It has more oil… this one has more oil
Tr: All right, class class (gaining attention)