Sustaining Students' Interest and Engagement in Learning School Science During Interactive Lectures

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Abstract
How do teachers elicit and sustain students' interest and engagement in science lessons? This paper answers this question in the context of Bhutan, where students' performance in science is low compared to other subjects, and where falling levels of interest in science are a concern. Like other countries in the Global South, a large proportion of science lessons are delivered through interactive lectures. Data were generated from observation of 78 grade 6, 8 and 10 science lessons at a Bhutanese middle secondary school, complemented by interviews with 4 students in each grade and their teachers. Teachers' questioning techniques were key to interactive lectures that students found interesting and engaging. Using Krapp's Person-Object theory of Interest (POI), questioning practices were analyzed in terms of cognitive challenges, autonomy, cognitive dissonance, and novelty. This paper offers new insights into science pedagogies for contexts where interactive lectures remain common pedagogical practice.

Keywords: Subject interest; engagement; science education; interactive lecture; pedagogical practices

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Introduction

Declining student interest in science as they progress through school is a concern in many countries (Ainley, 2012; Cheung, 2013; Choudhury, 2009; Hidi et al., 2015; Krapp & Prenzel, 2011; OECD, 2008; Potvin & Hasni, 2014; Tsai et al., 2008; Tytler et al., 2008). Reasons for this decline include classroom practices that are fact-oriented, targeting males, primarily for 'smart' students, perceived as irrelevant, and generally of low personal value to students (Lyons, 2006; Osborne et al., 2003). Students' interest and engagement in science lessons are crucial to meaningful learning and securing continuing study beyond compulsory science education. Research has repeatedly found that interest and engagement can be significantly influenced by teachers, their pedagogical strategies, and novel experiences in the classroom (Anderhag et al., 2015; Aschbacher et al., 2010; Reeve & Jang, 2006). Interest and engagement have to do with embedding activities that appeal to students' affective domain (Ateh & Charpentier, 2014).

Prior studies have looked at interest and engagement from a general perspective (Ainley, 2012; Tsai et al., 2008), teachers' perspectives (Anderhag et al., 2015; Xu et al., 2012), and by focusing on students (Swarat, 2009). However, a common limitation in this field is lack of detailed analysis that links classroom practices to students' interest and engagement (Ainley, 2012; Anderhag et al., 2015; Renninger et al., 2019), relying on self-report rather than linking what students and teachers have to say to what can be observed in the classroom (Potvin & Hasni, 2014). This study addresses this gap in the under-researched context of Bhutan, where there are concerns about performance in science and the falling numbers of students electing to study the subject (Ministry of Education, 2014). It combines observation of 78 lessons with interviews, focusing on interactive lectures, a common pedagogical approach in Bhutan and elsewhere, where teachers lead explanations and discussions, interspersed with questions posed to students (MacDonald & Teed, 2020). To that end, we pose the following research question:

RQ1: How do school science teachers sustain students' interest and engagement during interactive lectures?

Bhutan is a small country in the Himalayas, whose modern educational system is relatively young. The schooling system comprises seven years of primary education (pre-primary to grade 6) and six years of secondary education, which includes grades 7-8 (lower secondary), grades 9-10 (middle secondary), and grades 11-12 (higher secondary). The provision and promotion of free education P-12 has been part of a successful effort to make education accessible to all the citizens of Bhutan (Phuntsho, 2013). Science is taught as a single subject from grade 4 to 8, after which biology, chemistry and physics are taught separately, with English language as the medium of instruction (Wangchuk, 2023).

Literature Review

Research on Science Education in Bhutan and the Global South

There is a nascent body of research focused on science education in Bhutan. Some research has focused on students' attitudes towards and perceptions of school science (Das et al., 2017; Zangmo et al., 2016), finding that students' attitude towards science became more positive as they progressed through school grades, interestingly finding no gender differences. However, their participants were already pursuing science courses in grades 11 and 12. Others have investigated what influences choice in science-related careers (Rinchen, 2003), noting a positive influence of elders in the family who had a science background. The Bhutan Education Blueprint also reports the dwindling performance of students in math and science in grade 10 (Ministry of Education, 2014).

Pedagogical practices across all subjects in Bhutan have been characterised as a mix of student-centered, semi-student-centered, and traditional (teacher-centered) (Sherab & Dorji, 2013). Focusing specifically on science, Childs et al. (2012) found such variation to drop off as students progressed through school grades, with a shift to approaches that were more teacher-centered, with students mostly listening to the teacher, copying notes from the chalkboard, or working from textbooks. The dominance of teacher talks echoes previous research (Dorji, 2005; Royal Education Council, 2009; Sherpa, 2007; Tenzin & Maxwell, 2008), and more specifically a study by Rabgay (2014) who found lecturing to be most common in grade 10 biology classes. Reliance on the state-recommended textbook was also noted by Zangmo et al (2016), who argue that while following a textbook makes life easier for teachers, this comes at the cost of students' developing key scientific ideas. Recent studies have found student teachers find it hard to enact more interactive pedagogies even when they wish to do so (Dolma & Thinley, 2022).

Interactive lectures are a common feature of classrooms in the Global South, shaped by modest resources, large class sizes, and large volumes of curricular content to cover (Choudhury, 2009; Diwakar, 2017; Faikhamta et al., 2018; Laad, 2011; MacDonald & Teed, 2020). Interactive lectures are a particularly interesting context to explore because they appear on the surface to lack the qualities that studies have found commonly promote students' interest and engagement: hands-on learning (Logan & Skamp, 2013; Swarat et al., 2012), group discussions (Shimazoe & Aldrich, 2010), and varied approaches that constitute students as active participants rather than passive recipients of knowledge (Good & Lavigne, 2017). Other features of high-interest lessons such as the introduction of new knowledge (Swarat, 2009) and application to everyday life (Pugh, 2011) are perhaps more obviously available within interactive lectures but are by no means guaranteed. Indeed, evidence suggests that decline in student interest in science in the Global South often stems from what happens (or does not happen) in the classroom, with students being put off by disconnection of science from everyday life, lack of practical experience, and approaches to teaching (Choudhury, 2009; Gorowara & Lynch, 2019; Laad, 2011; Padmanaban, 2008).

Conceptual Framework

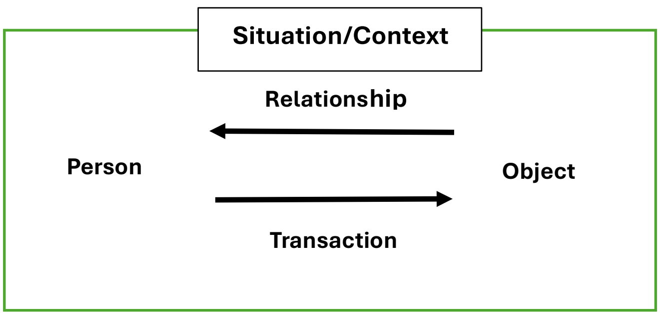
While interest and engagement have been studied separately (Ateh & Charpentier, 2014; Jack & Lin, 2014; OECD, 2008), this study adopts a conceptual framework that links the two: Krapp's Person-Object theory of Interest (POI) (Krapp, 1993; 2002; 2007). POI theory provides a basis to analyze observational data in terms of symbiotic relationships between interest and engagement (Ainley, 2012; Renninger & Bachrach, 2015). This paper does so in a Bhutanese context, where science education research is limited, and studies that combine such theory with detailed data of what happens in classrooms are lacking.

POI describes a person or an individual as the potential source of action and the environment as the object of an action. The object of interest can be a concrete thing, a topic, subject matter, and 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 study conceptualized a symbiotic relationship between interest and engagement: engagement develops students' interest, and once interested, students further engage and re-engage with the object (Krapp, 2007). Conversely, triggering interest can prompt engagement (Renninger & Bachrach, 2015), and repeated engagement can lead to development of interest over time (Christenson et al., 2012; Hidi, 2006).

Action of Interest (AOI) conceptualizes the relationship between a person and an object in a concrete situation. An AOI is the special case of an interest-oriented pedagogic practice deployed by the teacher to engage students with the lesson content (Krapp, 1993; 2002; 2007). An AOI establishes an immediate relationship between the student and the lesson outcome in the classroom context - where the teacher orchestrates the happenings in the classroom. An AOI has several related features, shown in Figure 1.

Figure 1

Action of Interest as a Current Relationship Between a Person and an Object



Note. Adapted from "The construct of interest: Characteristics of individual interests and interest--related actions from the perspective of a person--object—theory," by Krapp, 1993, *Studies in Educational Psychology, 1*. 1-20

As the *person* learns and develops, they are characterized by a distinctive structure of capacities, knowledge, attitude and goals (Krapp, 1993; 2002). The *object* can be knowledge about something, a concrete artefact, or symbolically represented fact (conveyed through conversation). The significance of the object varies from person to person and may be momentary or lasting. *Transaction* (also referred to as object engagement) denotes a person's interaction with the object relevant to their experience and behaviors (Krapp, 1993; 2002; 2007). The *transaction* includes hands-on engagement with the object and abstract cognitive working. At the same time, the *relationship* between the object and the person depends on the intensity and quality of its subjective significance. These become habitual willingness to engage (general interests) or dispositions that can generate situation-specific interest or more sustained individual preferences. Finally, *situation/context* refers to the circumstances created for an individual to interact with the object of interest. Teachers design the context of action, potentially creating new situation-specific interest (Krapp, 1993). Through the lens of POI, and specifically AOI, three research sub-questions were addressed:

1. What patterns of high and sustained interest and engagement are evident in relation to the observed science lessons?
2. How can instances of high, sustained interest and engagement in interactive lessons be understood in terms of students' action of interest?
3. What pedagogical practices triggered and sustained students' interest and engagement in science lessons using interactive lectures?

Research Design

This study used an ethnographic case study approach, defined as a prolonged observation in a natural setting within a bounded system (Angers & Machtmes, 2005). It was ethnographic in the sense of concerning the culture and context of particular interactions, and a case study in the bounded focus on teaching and learning of science within one school. Studying interest and engagement through POI means grounding data in specific classroom experiences. To that end, a combination of classroom observation and interviews with teachers and students about sampled lessons was appropriate. Prioritising richness of data over generalization, the study focused on science lessons in one school (pseudonym Vajra Middle Secondary School). Richness came from collecting data over different grades (6, 8 and 10), multiple lessons (78 in total, covering 16 science topics), and the experiences of four students in each grade (12 in total) and their science teachers (5 in total). The aim was to capture granular aspects of classroom practices as they relate to students' interest and engagement.

Typical of lesson structures in Bhutan (Paro College of Education, 2020), all 78 observed lessons had four distinct phases: pre-teaching (recording attendance followed by brief meditation practice); introduction (checking students' prior knowledge); lesson development (the main part of the lesson where new content was taught); and conclusion (summarising, pointing to the next lesson). Each lesson was categorised according to approaches documented by others in Bhutan and elsewhere (REC, 2021):

- Interactive lecture: teacher-led pedagogy where teacher talk is broken intentionally at least once so that students contribute and participate in some way (MacDonald & Teed, 2020);
- Small group discussions: face-to-face discussions on a specific topic with more than two students per group for at least two minutes (Bennett et al., 2010);
- Practical lessons (referred to as hands-on learning by participants): students handle scientific equipment or manipulate materials with the intention of embodied participation to construct meaning from hands-on experiences (Holstermann et al., 2010).

Participants

The number of middle school students electing to study science in Grade 11 informed the purposive sampling (Patton, 2001) of a school to act as the case study: Vajra Middle Secondary School. The principal granted permission to approach science teachers from grades 6, 8 and 10. Spanning these grades was important due to declining interest in science noted over this period (Archer et al., 2013; Potvin & Hasni, 2014). Five teachers were recruited, one teaching grade 6 (Mr. A), one for grade 8 (Mrs. B), and three covering biology, chemistry, and physics separately for the same class in grade 10 (Mr. C, Mrs. D, Mr. E). Four students from each class were recruited through an invitation letter sent to students, with an opt-out letter sent to parents. The first two male and first two female students in each class to opt in were chosen as participants.

Data Generation and Analysis

Fieldwork was conducted over 13 weeks, during which time all science lessons for each class were observed (n=78) except for revision lessons and class tests. For every lesson (45-50 minutes) observed handwritten notes were taken, alongside video and audio recordings for each of these lessons. Based on the key lesson of the week, each student was interviewed four times (15-20 minutes x 4) over four weeks spent in each grade, focusing on specific activities from the observed classes, asking them to nominate times they were particularly engaged and interested in (48 student interviews in total). Each teacher was interviewed twice (about 60 minutes x 2), focusing first on their background and approach to teaching in general, and later lessons that had been raised by students as interesting and engaging (10 teacher interviews in total).

Referring to the memos in the fieldnotes and interview transcripts as the primary source, data analysis was conducted in three phases, combining thematic analysis (Braun & Clarke, 2006) with the theoretical considerations of POI (Krapp, 2007). Grounded and theoretical aspects were explored in iterative relationships following Srivastava and Hopwood's (2009) framework where emergent insights progressively inform theoretically informed interpretations. The first phase involved analyzing the 78 lessons for evidence of focal students' interest and engagement based on observation memos recorded in fieldnotes, answering sub-question 1. This was based on criteria relating to: focused attention, elevated concentration, enjoyment, and cognitive activation (Krapp 2007; Krapp et al., 1992; Renninger et al., 2019). Interest and engagement were regarded as being sustained rather than brief if they were evidence for more than 10 minutes (Ainley, 2012; Reinninger et al., 2019). The next phase answered sub-question 2 through a granular analysis of lessons where students' engagement and interest were both high and sustained. This took each student's perspective, combining observation and interview data to explore person, object, transaction, relationship and situation/context in specific activities (Figure 1). The final phase looked across all the granular analyses and shifted the focus back to what teachers were doing - their pedagogical practices - answering sub-question 3.

Findings

Of the 78 lessons, 45 were interactive lectures, consistent with prior findings regarding the dominance of teacher-led practices in Bhutanese science classrooms (Childs et al., 2012). Interactive lectures involved teachers reading from textbooks, writing on the chalkboard or flipcharts, demonstrating experiments, or showing videos. Teacher interviews showed interactive lectures was not their preferred practice, because they regarded them as less interesting and engaging for students than group discussions or practical. However, they felt there was little choice due to the need to cover curriculum content and the lack of equipment, as illustrated by Mr. E's comment:

"There are many topics where we need to lecture or download the information to the children".

Sub-Question 1: What patterns of high and sustained interest and engagement are evident in relation to the observed science lessons?

Thirty-nine (50%) lessons met criteria for high and sustained interest and engagement, using the criteria explained above. While high and sustained applied to 71% of the practical lessons, and 53% of small group discussion lessons, only 42% of interactive lectures triggered and sustained high levels of interest and engagement, as shown in Table 1. This points to the importance of understanding more about those interactive lectures that *did* trigger and sustain high levels of interest and engagement, given that these more teacher-centered approaches are more common, and that teachers believe that it can be harder to engage students and make learning science interesting in this format.

Table 1

Interest and Engagement Across Observed Interactive Lectures (n=45)

Intensity / Duration	Low Interest and Engagement	High Interest and Engagement
Brief	17 (38%)	4 (1%)
Sustained	5 (1%)	19 (42%)
Total	22 (49%)	23 (51%)

Sub-question 2: How can instances of high, sustained interest and engagement in interactive lessons be understood in terms of students' AOI?

This section explores an interactive lecture where students' interest and engagement were high and sustained. It takes the perspective of one grade 10 student, Kezang (Pseudonym), exploring his AOI.

When asked to choose a particularly interesting lesson, Kezang chose a physics lesson taught by Mr. E on electricity and magnetism:

Last year, we also learnt about electricity and magnetism but, I wasn't fully attentive last year. It was 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 so it has been more of a success.

In this lesson, Mr. E asked 17 questions, which was notable given interactive lecture lessons with lower interest and engagement typically involved far fewer questions (5 to 10). Table 2 presents a vignette covering the key phases of the lesson, highlighting evidence of Kezang's interest and engagement in the right-hand column.

Table 2

Vignette of a Physics Lesson Kezang Found Highly Interesting and Engaging

Classroom activity	Indicators of Interest and Engagement
In the introduction Mr. E said: "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?" In interview, Kezang said he felt tense when no students offered an answer; he nudged his peer into answering. For the next question, Kezang smiled and discussed the answer with his peer, and the teacher asked him to answer, which he did (correctly). For the remainder of the introduction, Kezang had his hand on his head, appearing focused on the teacher.	Heightened emotion Enjoyment Persistence and concentration
The lesson development focused on terms such as insulator and conductor. Throughout, Mr. E asked for examples, definitions, properties, units, and explanations from students. Mr. E discussed the flow of water and drew a diagram on the board showing electron flow from negative to positive. Kezang smiled as he discussed responses to these questions with his peers, and at one point stroking his chin when asked what is the SI unit of charge?	Cognitive activation and focused attention
At one point Mr. E held up a AAA battery and asked students which was the positive and negative end, receiving answers in chorus. Later, Kezang was again observed whispering excitedly to his peer when Mr. E asked how to define a volt.	Enjoyment and cognitive activation
In the lesson closure, Mr. E asked Jitsuen (another participating student) a sequence of questions to summarise what she learned. As she spoke, Kezang looked at Jitsuen, nodding in confirmation.	Focused attention and cognitive activation

We now explore Kezang's AOI in this lesson, linking to features in Figure 1 (Krapp, 1993, 2002). From interviews it was clear Kezang (the *person*) had enduring personal interest in science, and in this lesson situational interest was triggered, key to which were the chance to clarify prior confusion (Bergin, 1999), and the cognitive challenge presented by questions that required him to think, rather than just remember (Renninger et al., 2019). He explained how he felt about resolving his prior uncertainty:

Eventually, there was this part where I could get to learn this, I could understand it... that actually helped and I enjoyed.

Kezang's explanation is evidence of his cognitive processing, a form of authentic engagement (with focus and positive emotions) that sustains students' interest (Mitchell, 1993). When Mr. E was talking, or other students answering, Kezang had focused attention (Krapp et al., 1992), as confirmed in his comment regarding his physical posture as noted in Table 2:

When I am trying to process, 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].

The object of his interest (Figure 1) was to overcome his prior confusion on how current flows. This centered on the direction of flow of current:

Back then, I had a bit of confusion on how charge 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.

Considering the situation or context as an enabling environment, Mr. E's pedagogy provided multiple opportunities for Kezang to help him overcome his confusion (Table 2). These included an analogy based on the flow of water, a diagram on the chalkboard, and pointing to positive and negative ends on a physical battery with which students are able to connect readily based on prior experience. Mr. E's many questions, of varied forms, amplified these opportunities.

Transaction refers to engagement with the object (Krapp, 2002, 2007), which for Kezang was primarily abstract cognitive working. His efforts in thinking reflected an intention to resolve confusion about flow of charge. When asked in interview what was going on in his mind when he put his hands-on his chin or forehead (Table 2), he said,

I was trying to process actually, 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.

For Kezang, this transaction was fuelled by the challenge that came in Mr. E's questions. He said he was excited because Mr. E "brings in some tricky questions and entice[s] students with that". Kezang saw tricky questions as engaging, not threatening. Interest and engagement were sustained for Kezang as he and his peers mouthed and whispered answers to each other. They were able to interact about the content, even when the more overt talk was between the teacher and another student.

Completing the analysis of Kezang's AOI, the relationship (Figure 1) was a matter of gaining new information to extend his knowledge (Krapp, 2007). The repeated engagement with the object through different means, such as verbal explanation, chalkboard and battery helped stabilize the person-object relationship (Krapp, 1993). He said by the end of the lesson he was convinced about the convention of the flow of current.

Sub-question 3: What pedagogical practices triggered and sustained students' interest and engagement in science lessons using interactive lectures?

This section builds on findings from the broader analysis of overall lessons (sub-question 1) and granular analyses of AOI for all students in lessons in which interest and engagement were high and sustained (sub-question 2, illustrated above in relation to one lesson for Kezang).

Analyses focused on all twelve students' AOI in multiple interactive lectures confirmed the importance of teachers' questioning. Not only were teacher questions more numerous in the most interesting and engaging lessons, but they were different in nature compared to those in lessons that were less interesting and engaging. In the latter, questions focused on recall or required students to repeat what was written on the chalkboard, those found in other Bhutanese science classrooms. In the former, there was a mix of lower- and higher-order questions.

All participating teachers used questions to capture attention and facilitate students' engagement with scientific content. By varying the level of the questions and the frequency of opportunities to interact, teachers "enticed" (as mentioned by Kezang) students into learning science. Questions triggered cognitive challenges, provided autonomy, caused cognitive dissonance, and generated novelty through his interactions with his students and among the students themselves. Each of these will now be considered in turn.

Questions asked during the lessons that triggered and sustained high interest and engagement posed *cognitive challenge*. Questions can 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, as when Kezang commented that Mr. E introduced "tricky questions" that kept them engaged in the lesson.

Teachers' questioning drew out students' knowledge while promoting internal dialogue and leading to independent thinking - *autonomy*. They 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 promoting students' interest and engagement. Students whose teachers ask questions that afford students autonomy-oriented learning show higher intrinsic motivation, positive emotion, and more active involvement.

Cognitive dissonances were created when students shared their misconceptions or unexpected responses to the teacher's questions. For instance, when Mr. E asked for an example of an insulator, one student answered 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 humor and focused the students' attention on the lesson.

Questions also generated *novelty* and possibilities for applying newly acquired knowledge into novel situations, which triggered and sustained students' interest and engagement in the lesson. 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. During her fourth interview, Semyang 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 (Table 2).

Discussion

The focus on interactive lectures reflects a widely used pedagogical approach in Bhutan and other Global South contexts. It is relevant to Bhutanese classrooms because recent research has suggested aural learning to be preferred by many students in Bhutan (Timisina et al., 2021), although we note this may reflect familiarity and comfort with lessons dominated by teacher talk, and comparative rarity of other approaches.

Questioning was a key practice in interactive lecture lessons in the studied Bhutanese science classrooms that elicited and sustained students' high interest and engagement. The questioning was more frequent in interactive lecture lessons than in hands-on or small group discussion lessons. Furthermore, the interactive lectures associated with higher and sustained interest and engagement involved more and different kinds of teacher questions than those with lower or briefer interest and engagement where answers to the questions were written on chalkboard (Child et al., 2012). Teachers asked diverse lower- and higher-order questions to link lessons, ascertain the students' previous knowledge of the lesson content to be delivered, and diagnose and assess their learning to capture students' interest and engagement with scientific content (Dos et al., 2016; Morris & Chi, 2020). A recent study in Bhutan focused on teachers' verbal feedback relating to students' spoken language accuracy (Wangchuk, 2023). Our study shares a focus on how teacher talk can engage students and support their learning, but is different through its focus on science lessons and questioning rather than corrective feedback.

The questioning practices used by the teachers in the most interesting and engaging lessons involved some common features. First, questions were attuned to the lesson phases (lesson introduction, development, and closure). 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. Second, many questions were planned by teachers in advance, meaning they could provide hints for upcoming questions, creating heightened emotion through the expectation of a pending question. Third, questions were asked to the whole class (rather than individuals) and often rephrased before teachers paused to provide thinking time. Only then were respondents identified and redirected if needed before teachers acknowledged and reinforced the response.

Understood through POI, such questioning triggered and sustained students' high interest and engagement, because they aroused cognitive challenge (Good & Brophy, 2008), cognitive dissonance (Bergin, 2016), autonomy (Reeve & Jang, 2006) and novelty (Förster et al., 2010). According to Good and Brophy (2008), questions can 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). Teachers' questioning drew out students' knowledge while promoting internal dialogue and leading to independent thinking - *autonomy*. They 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 (Reeve & Jang, 2006). Such autonomy can enhance students' interest and engagement (Krapp, 2002). When teachers ask questions that promote autonomy, students tend to show higher intrinsic motivation, experience more positive emotions, and participate more actively in learning (Tsai et al., 2008). According to Bergin (1999), "people often manifest interest in resolving the discrepancy" (p. 93). *Cognitive dissonances* were created when students shared their misconceptions or unexpected responses to the teacher's questions. Questions also generated *novelty* and possibilities for applying newly acquired knowledge into novel situations, which triggered and sustained students' interest and engagement in the lesson. Novelty refers to something unfamiliar or not yet experienced (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 on students when unfamiliar responses were shared. Among the four indicators of interest and engagement, the cognitive challenge was more prominent in interactive lecture lessons. Questions caught students' attention, and their behavioral indicators signalled the presence of cognitive activation.

Limitations

There are limitations relating to the sampling in this study, both the focus on one school, and the self-selection of participating students. The insights revealed here pertain to students who likely already had relatively developed personal interest in science, in a school setting where science was an evidently popular subject. While this means the findings do not generalize to other settings or students, the key finding around the importance of questioning in interactive lectures holds: this is a valuable focus for teachers wishing to trigger and sustain students' interest and engagement during interactive lecture lessons.

Conclusion

Like teachers in other studies, teachers in this study use interactive lessons as a mechanism to cope with heavy curriculum load, limited time and modest resources (Childs et al., 2012; Sherab & Dorji, 2013; Tenzin & Maxwell, 2008). A key finding was that students' interest and engagement could indeed be triggered and sustained in interactive lecture science lessons, despite associations between this approach and the traditional notion of students being passive recipients of knowledge (Ainley, 2012; Ateh & Charpentier, 2014).

Questioning was key to triggering and sustaining students' interest and engagement in interactive lecture lessons, through cognitive activation, cognitive dissonance, autonomy and novelty. Teachers used questions to link lessons to prior knowledge, diagnose learning, and assess students' learning from the lesson. Planning questions in advance, so they could create heightened emotion, teachers used a range of lower-order questions to boost confidence and encourage participation and higher-order thinking questions challenged students' thinking.

This study contributes to knowledge in several ways. It is the first in a Bhutanese context to look in such detail at students' interest and engagement in science, grounded in observed classroom practices. It also breaks new ground by focusing specifically on interactive lectures - a common practice in many countries in the Global South (Choudhury, 2009; Diwakar, 2017, Faikhamta et al., 2018; Laad, 2011), but rarely explored in-depth, and not previously by using POI theory in a science subject context. Interactive lectures are deemed a necessity by many teachers, and this study shows that this need not come at the expense of student interest and engagement. Not only does this study shed new light on the under-researched area of science education in Bhutan, but it reveals findings that are relevant to teachers in other countries and of other subjects where lessons based on interactive lectures are common.

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