Emotional climate of a pre-service science teacher education class in Bhutan

Sonam Rinchen · Stephen M. Ritchie · Alberto Bellocchi

Abstract This study explored pre-service secondary science teachers' perceptions of classroom emotional climate in the context of the Bhutanese macro-social policy of Gross National Happiness. Drawing upon sociological perspectives of human emotions and using Interaction Ritual Theory this study investigated how pre-service science teachers may be supported in their professional development. It was a multi-method study involving video and audio recordings of teaching episodes supported by interviews and the researcher's diary. Students also registered their perceptions of the emotional climate of their classroom at three-minute intervals using audience response technology. In this way, emotional events were identified for video analysis. The findings of this study highlighted that the activities pre-service teachers engaged in matter to them. Positive emotional climate was identified in activities involving students' presentations using video clips and models, coteaching, and interactive whole class discussions. Decreases in emotional climate were identified during formal lectures and when unprepared presenters led presentations. Emotions such as frustration and disappointment characterized classes with negative emotional climate. The enabling conditions to sustain a positive emotional climate are identified. Implications for sustaining macro-social policy about Gross National Happiness are considered in light of the climate that develops in science teacher education classes.

Keywords Emotional climate · Emotion · Preservice teachers · Teacher emotions · Science Education · Sociology of emotion · Gross National Happiness

S. Rinchen ()
College of Education, Royal University of Bhutan, Samtse, Bhutan
e-mail:srinchen.sce@rub.edu.bt

S. M. Ritchie
Murdoch University, Perth, Australia

A. Bellocchi
Queensland University of Technology, Brisbane, QLD, Australia

The role of emotions at individual and collective levels in learning science (Tobin et al. 2013) and learning to be a science teacher (Bellocchi et al. 2014) has become a recent focus in science education research. This is important work because:

> If we want progress in science education, we need to look more carefully at the emotions of science teaching [and learning], both negative and positive emotions, and use this knowledge to improve the working environment of science teachers. (Zembylas 2002 p. 98)

In pre-service science teacher education, one Australian study reported that particular learning experiences in science education courses were related to the in-the-moment emotions expressed by students in the class and particular aspects of the Professor's instruction including the use of science demonstrations and the Professor's practice of articulating her professional reflections on her teaching (Bellocchi et al. 2014). The nation of Bhutan provides a different cultural context for studying the interconnections between emotion and science teacher education because of its unique Gross National Happiness (GNH) policy that seeks to boost the nation's emotional wellbeing and prosperity through numerous strategies including its education system.

Our study approaches the issue of understanding the factors that shape the realization of GNH, at the level of face-to-face classroom interactions, in a pre-service science education class. It achieves this within a sociological theoretical framework that is capable of explaining the flow of emotion across different levels of social structure including the policy, or macro-level, the meso-level (i.e., where the classroom or university is the unit of analysis) and the micro-level of classroom interactions. Bhutan's macro-level policy of GNH offers a unique opportunity to study how policy can inform practice in the micro-level encounters between teachers and students as well as between students and students. Implications are provided for policy-makers and teacher educators who wish to improve emotional experiences and the quality of science teacher education in educational institutions. Before describing the theoretical framework and the study design, we focus on the science education literature that establishes the importance of emotion in learning to teach science.

Emotions in teaching

Teaching is inextricably linked to teachers' personal lives; teachers invest their selves and their sense of identity and self-esteem in their work (Nias 1996). When teachers are asked what they find satisfying about their jobs, they talk about excitement derived from interacting with students and establishing emotional bonds with them, and the curiosity of understanding each student and their background (Kelchtermans 2005). Conversely, many teachers feel uncomfortable dealing with some of the stressful aspects of teaching science (Winograd 2003). For instance, teachers can experience negative emotions such as frustration, anxiety, guilt, anger, fear, and embarrassment as a result of their lack of science content knowledge (Zembylas and Barker 2002). Unsurprisingly, problems occur in Bhutan when primary teachers are allocated to teach secondary sciences (Fahmi 2008). Feelings of concern about science content knowledge also are evident among many secondary teachers in Bhutan who have formal science backgrounds limited to grade 12 (Rinchen, Tshering, Jose, Gyeltshen and Gyeltshen 2011).

Michalinos Zembylas (2002) argued that both positive and negative emotions play an important role in a teacher's construction of his or her science pedagogy, curriculum planning, and relationships with children and colleagues. He emphasized how the emotional aspects of the science-teacher self in becoming or being a science teacher, the acquisition and

use of pedagogical approaches, and the application of professional judgment in practice are inextricably linked. Kenneth Tobin, Stephen Ritchie, Jennifer Oakley, Victoria Mergard and Peter Hudson's (2013) study of a beginning science teacher and her science students from a middle school in Australia showed that the informal interactions that ensued from a role play between the teacher and one of her students were characterized by an interpersonal closeness and high emotional energy. The interactions during the role play were positive because the conversations between teacher and students were dialogic and fluent rather than univocal where the teacher dominated talk. Their interactions were accompanied by the teacher's frequent laughter, clapping of hands, and playful reciprocal mimicking of each other. Furthermore, the study reported that the teacher giggled and used various emotive gestures to contain her laughter when a student presented his science project in a comical way. Her incessant laughter and body action appeared contagious drawing the student presenter and the rest of the class into synchronized laughter. Such collective effervescence generated through role play helped in the smooth transition from collective laughter to a serious discussion of science. As with all effective conceptual learning, learning science requires a nonthreatening environment. Formal interactions that involve dissemination of information instead of open exchange of ideas can produce a dip in emotional climate where verbal interaction follows more of an initiate-respond-evaluate pattern (see Bellocchi et al. 2013). For our purposes, emotional climate (EC) is the collective state of emotional communion between members of a class in which the salience of self for individual members gives way to their collective identity (Kanyangara, Rime, Philippot, and Yzerbyt 2007). Unlike Tobin et al.'s (2013) study, our present study investigated in-the-moment variability in EC from the perspective of pre-service teachers and their tutor during instruction. That is, the pre-service teachers rated the class EC at regular intervals as classroom instruction unfolded.

Emotional climate in pre-service teacher education

As documented in the science education literature (Anderson, Smith and Peasley 2000) pre-service elementary teachers experience negative emotions such as discomfort, anxiety, alienation, fear, and frustration when teaching science. These negative emotions were explained in terms of the pre-service teachers' lack of adequate science content, lack of an emotionally conducive learning environment, pre-service teachers' past negative experiences of school science, and use of disengaging pedagogies.

Michalinos Zembylas and Heidi Barker (2002) argued that changing the valence of pre-service teachers' emotions so that they become more positive would help an elementary teacher develop an emotionally supportive environment to teach science. They set out to transform 60 pre-service elementary teachers' disposition to science by structuring the course around practical, hands-on activities that engaged the students actively in class at a Midwestern Public University in the United States of America (US). These researchers interviewed all participants. They also invited participants to record their reflections of class experiences in a diary. Based on their analysis of these data they concluded that, by the end of the course, the students expressed improved levels of interest in science and science teaching. The researchers further argued that the reflective writing activities in the course motivated students to examine their experiences encountered in schools and evaluate the effects it had on students' feelings towards science. The significance of this approach for teaching pre-service teachers is that establishing close and supportive working relationships between pre-service teachers and their lecturer, and strengthening peer interrelationships, could lead to positive outcomes for new teachers.

Keith Trigwell (2012) and Simone Wittman (2011) suggested that pre-service teachers' disposition towards science and their emotional state are related to classroom

pedagogies and teacher effectiveness in the classroom as measured by the quality of their interactions with students. For instance, a survey of Swedish and German pre-service teachers found there was a relationship between emotions and the prevailing learning methods used in the institutions. More specifically, positive emotions were related to student-centred learning approaches (Wittman 2011). Similarly, university professors reported positive emotions when they adopted student-centred approaches and negative emotions while engaging in transmissive pedagogies (Trigwell 2012). Understanding which of these pedagogies and teacher practices are relevant for the development of positive dispositions to teaching science is vital given that teacher preparation programs provide the initial professional development platform influencing practice.

There have been very few studies conducted on the EC of pre-service science teachers' classes, especially with secondary pre-service science teachers. Alberto Bellocchi, Stephen Ritchie, Kenneth Tobin, Maryam Sandhu and Satwant Sandhu's (2013) study of a pre-service secondary science-teacher education class was the only study to measure pre-service teachers' perceptions of EC during classroom interactions. It investigated the EC using audience response keypads, where classroom participants were invited to enter their perceptions of the EC on a 5-point scale (i.e., 5=very positive, 1=very negative) at three-minute intervals during debates and post-debate discussions. Software installed on a laptop received incoming signals from the keypads as the students clicked their EC ratings. Averaged student ratings of EC were produced by the software and used to construct graphs of EC over time. The average EC represented the emotional state of the group.

The class average for each interval was graphically represented for each lesson and each graph for each lesson was reviewed to identify those intervals that pointed well above neutral and those intervals that dipped below neutral. Salient video segments were identified for micro-analysis of verbal and non-verbal conduct at these peaks and troughs. Findings from Bellocchi et al.'s (2013) study included: events such as engaging debates and informal talk led to positive EC whereas flat debates and formal talk were associated with low EC. This gave some indication that the quality of teaching and learning episodes could be related to the EC and associated classroom interactions.

In a more recent study, connections between high quality learning experiences and EC and emotions were established in an Australian pre-service science teacher education class (Bellocchi et al. 2014). Pre-service teachers reported positive EC and emotions when the Professor presented science demonstrations and during pre-service teacher role-plays. Both of these teaching strategies were perceived to be high quality learning experiences by pre-service teachers as reported during post lesson review meetings with students, known as cogenerative dialogue or cogen. An interesting outcome of that study was that the professor's self-reflection about her own teaching practice during lessons was also highly valued by students even though these lesson segments were associated with low levels of EC and, on some occasions, even with negative EC. These findings pointed to the highly nuanced relationship that exists between EC, emotions and the perceived quality of learning experiences. Notwithstanding the short-term fluctuations in EC during lessons, the studies reviewed suggest that exploring EC of pre-service science education classes can lead to understanding how micro-interactional processes focused on learning to be science teachers are associated with individual and collective emotions. The studies provide a possible avenue for exploring the connection between Bhutan's GNH policy and classroom EC and emotions at the micro-level.

Sociological perspectives on emotions and social interactions

The sociological theory of emotions developed by Jonathan Turner (2007) is relevant in the context of Bhutan's developmental philosophy of GNH. He explains that emotions are embedded in all levels of social structure (i.e., macro-, meso-, and micro-level). This tri-part classification of social reality is an analytical tool used for understanding the sociocultural context in which emotions are embedded. Based on this scheme, the Bhutanese GNH policy is a macro-level force related to the transmission of culture: more specifically, transmitting collective happiness through institutional domains such as educational systems. An assumption in Turner's theory is that interactions are constrained by meso- and macro-levels of social reality because individuals are always part of a stratified social organization within institutions. For example, students are subordinates of teachers in education structures due to the higher organizational status typically afforded to the teacher. These relationships based on hierarchical status are predicted to constrain any emotions aroused during encounters between teachers and students, and potentially between students and students in the presence of teachers. A close investigation of pre-service teacher education might help to understand how high quality teachers can be developed in Bhutan, who in turn can produce positive emotional climates in school classrooms thereby supporting the realization of the GNH policy.

Emotions as micro-social forces

Despite extensive research interest on emotions, there is no unified definition of the term *emotion* (Turner 2009). Peggy Thoits (1990) developed a conceptualization of emotion that is common within sociological approaches. She identified four elements of emotion including *situational cues* (factors which prompt the arousal of varying intensities and different types of emotions), *emotional labels*—the words used to describe emotions such as happiness and sadness, which can vary across cultures (Smith and Schneider, 2009), *expressive gestures* (including facial expressions and body gestures), and *physiological changes* (e.g., an increased heart beat). The above four elements of emotion are related and mutually influence each other (Turner 2007). For example, any particular emotion (e.g., a teacher getting angry) is influenced by a situation (e.g., a student's misbehaviour) and may be accompanied by expressive gestures (e.g., a scowl on teacher's face with fist thumping a table) and physiological changes (e.g., reddening of the teacher's face).

Emotions can be categorized using four *primary* emotion labels; namely, satisfaction-happiness, aversion-fear, assertion-anger, and disappointment-sadness (Turner 2007). Satisfaction-happiness is classified as a positive emotion whereas the other three are negative. These different kinds of emotions are aroused at different levels of intensity during interactions. There are 17 principles that account for the arousal of discrete emotions based on two key factors: *expectation states* and *sanctions* (Turner 2007). When one's expectations for an encounter are met, then positive emotions are aroused. If expectations are not met this leads to negative emotional experiences. A sanction is a form of appraisal that is exchanged between interaction participants. The arousal of emotions follows the same scheme as with expectation states. That is, when one receives a positive sanction, then positive emotions are aroused. The converse is also true; that is, negative emotions result from negative sanctions.

Interaction rituals as mediators of emotional energy

Another complementary theoretical framework used in this study is Randall Collins' (2004) interaction ritual theory. In interaction ritual theory, interactions are the units of analysis used to understand the production of emotional energy (EE) by individuals within social contexts such as classrooms. Collins (2004) describes successful interaction rituals as those

characterized by bodily co-presence, barriers to outsiders, mutual focus of attention, and shared emotion. When these four basic ingredients are present, groups of people experience a heightened state of communal emotional arousal called *collective effervescence*. This momentary effervescence leads to four outcomes of the interaction ritual including solidarity, emotional energy in the individuals, development of sacred objects and standards of morality (see Figure 1).

**************************INSERT FIGURE 1 HERE *************************

In the interaction ritual model shown in Figure 1, bodily co-presence refers to the close physical proximity of people involved in social encounters; the idea of barriers to outsiders refers to the boundaries that delineate members from non-members, which also safeguard participants from outsiders who could weaken the mutual focus of attention and shared emotion building up within the group; mutual focus of attention means that people attend to the same activity, and have reciprocal awareness of each other's attention; and shared emotion refers to the common mood between interacting participants (Collins 2004). When these participants experience collective effervescence the members begin to overlook their individuality and embrace the group's ideology resulting in positive ritual outcomes. The outcomes include *group solidarity* that refers to harmonized interests, responsibilities among participants in a group for collective action, and status as a group member; *emotional energy* in the individuals refers to a strong steady state that manifests in rhythmically synchronized body movements, eye contact, and in facial expressions and vocalizations between participants; *sacred objects* refer to products that symbolize the efforts of the group that are charged with the group's collective emotional experience; and *morality* relates to a code of conduct sanctioned and adhered to by a group to generate successful interactions.

Enabling conditions for positive emotional climate

Anca Metiu and Nancy Rothbard (2012) identified four enabling conditions that influenced interaction and developed mutual focus of attention among members working in two software development projects in the US. They are *Individual engagement, Compelling direction, Informality of interactions,* and *Frequency of interaction. Individual engagement* refers to individual members deeply engaged with their individual tasks that would apparently lead to group engagement and contribute to numerous subsequent interactions. *Compelling direction* refers to an inspiration that instils in the workers a passion and energy about the tasks and wanting them to contribute to the tasks collectively. The other condition that supported group engagement processes was the informality of interactions. *Informality of interactions* relates to informal conversations where participants can share information openly, clarify doubts, and solve problems amicably. *Frequency of interaction* was both an indicator and a source of high levels of mutual focus of attention. In our study, we were interested in whether these same enabling conditions could be identified in the context of pre-service science teacher education in Bhutan for the generation of positive emotional climate in teacher education classes.

Science education in Bhutan: Situating the study

An account of the origins of science education in Bhutan helps to develop the macro-level and meso-level socio cultural context for the emotions produced in the education system and the impact that has on the realization of policy (see Turner 2007). Science education arrived very late in Bhutan. Teachers and curricula were borrowed from India. Most of these teachers

were inexperienced, and many preferred direct modes of teaching science with heavy reference to textbooks. As a consequence of these practices science education in Bhutan continues to face challenges, which include cultural inappropriateness of curriculum materials, lack of qualified science teachers, resource constraints, science being taught in English (i.e., a foreign language), and the lack of progression in science content across different grades. Ahmed Fahmi (2008) reported the major factor that affected the quality of science programs in schools and beyond was the discontinuity in the pedagogy and science curriculum from primary science to higher secondary science. For instance, in lower grades, activity-based learning is emphasized whereas the predominant mode of instruction becomes direct teaching by grade 9 (Childs, Tenzin, Johnson and Ramachandran 2012). Moreover, as science in pre-primary to grade 3 is taught in Dzongkha (the National language of Bhutan) students find it difficult as they transit to grade 4 and above where science is taught in English. Students even at the tertiary level are not confident communicating in English. Because students feel uncomfortable raising questions or presenting their views openly in class, they often mumble while speaking or seek solace in the group by giving choral answers (Rinchen 2009).

The Bachelor of Education secondary science program was launched in the Case College of Education (a pseudonym), in which this study took place, in pursuit of developing Bhutan's own human resources in science teaching. Before this, most of the science teachers in the schools were expatriates with a handful of Bhutanese who graduated from abroad. This was also a time when the education system in the country was undergoing transformation. The key to the changes that ensued would be the preparation of our own science teachers in Bhutan. The science course in the Bachelor of Education program was designed to prepare teachers who would be able to teach science disciplines (Physics, Chemistry, & Biology) effectively in secondary schools and integrate the different science disciplines in lower secondary schools. The program aims to help pre-service teachers to understand the use of scientific knowledge, values and skills in their daily lives. This would in turn contribute positively to the scientific development of the nation.

The Ministry of Education (2010) notes anecdotally that a good number of teachers have left teaching for managerial posts or have transferred to other departments. Unfortunately, many of them are science teachers. Rinchen Dorji (2007) reported that 48 teachers from a total of 51 teachers in Bhutan with a teaching experience between 3-35 years expressed frustration, dissatisfaction and low morale and motivation. Factors including lack of training opportunities, unattractive salary packages, and remote postings were cited as reasons for their low morale and frustration. These macro and meso-level factors have clearly influenced the emotions experienced by individuals as predicted by Turner's theory and as reported by Dorji (2007).

Classroom setting and research design for the study

Our study adopted an ethnographic case study design (Simmons 2009) to investigate the EC of a pre-service secondary science teacher course. The research approach was a *case study* because the tutor (Pelmo, a pseudonym) and her students' emotional transactions were the phenomena under examination rather than the college or their classroom in general, and it was *ethnographic* because the students with whom Pelmo interacted and the college form vital components of the culture and context in which the transactions took place (Ritchie et al. 2011).

Case studies are often used in educational settings to study pedagogy and teacher practices (Roth 2007). Case studies generally employ interviews but additional relevant documents, media supplements, and field notes are often used. The advantages of case

studies are their applicability to real-life, contemporary human situations, and their public accessibility through reports. Case study results relate directly to the reader's everyday experience and facilitate an understanding of complex real-life situations (Stake 2005). Conversely the involvement of multiple data sources makes case studies complex.

Pre-service science education class context

The study was situated at the Case College of Education (CCE) at the Royal University of Bhutan (RUB). The participants were 28 Bachelor of Education II (i.e., second year students) secondary science pre-service teachers (majoring in Physics and Maths) taught by Pelmo who is of Bhutanese origin. It was a mixed-gender (10 females and 18 males) class in the age group of 20–23 years. These students had completed one module of Physics Education (Physics Education I) in a previous semester of study.

Pelmo had a master's degree in Physics. She had been teaching Physics in CCE for the last ten years. The first author (i.e., Sonam) and Pelmo had co-taught professional modules to pre-service teachers over several years. For the Physics II module Pelmo was allotted two lecture classes of one-hour duration each and a block period of two hours for practical laboratory activities. Her class activities ranged from lectures, group discussions, and presentations by students. Practical laboratory activities were conducted once a week.

Data sources and data collection

Our study accessed multiple data sources to develop rich understandings about the pre-service teachers' and the tutor's experiences of their classroom over a five-month period. During the research period 16 lessons of one-hour duration were observed and video recorded by Sonam. The data sources included student perceptions of classroom EC (clickers), video recordings, interviews with students, stimulated recall interviews with the tutor, and Sonam's researcher diary. Data interpretation was ongoing which led to the construction of one major claim by the end of the study.

Student perceptions of classroom emotional climate. The primary source of data was pre-service teachers' perceptions of the EC of their science class. Students were asked to record their perceptions of EC for each lesson at three-minute intervals using keypads (clickers) and associated audience response technology (Turning Point^{TM}). Intervals refer to lesson segments of three minutes duration before the students' rating of the class EC. Pre-service teachers were informed that EC represented the emotional state of the group rather than their individual feelings. Ratings of 5 and 4 indicate positive EC whereas ratings of 2 and 1 indicate negative EC (Bellocchi et al. 2013). As perceptions of EC are inputted using clickers, a USB device attached to a laptop computer records the signals and calculates average EC ratings for the class. These average ratings are used subsequently to develop graphs that represent EC for the duration of each lesson.

Sonam indicated the start and end of the three-minute intervals by holding up a white paper or by making a coughing sound. The sound was useful as an indicator when the students were engrossed in discussions. Video recordings of classroom interactions were made using two Sony video cameras. One fixed-position camera focused on students approximately one metre away and a hand-held camera operated by one of the senior students from another Bachelor of Education cohort was used to capture group activity from a different perspective. By using the time-codes in video files and aligning them with the intervals on EC graphs, it was possible to conduct fine-grained micro-analysis of classroom interactions that were associated with troughs and crests in the EC graphs.

Video recording. The cameras captured classroom interactions between students and the tutor. Once salient events were identified from analyses of EC data (i.e., troughs and crests) the video data could be searched for facial expressions, body gestures, and verbal emotive expression. As well, the interactions were transcribed for conversation analysis later. Video became a powerful tool in that it provided a springboard for discussion during interviews, and was a source of reference for changing classroom activities and structures (cf. LaVan 2004). The video recording provided further insight into the verbal and non-verbal interactions between the participants.

Semi structured interviews. The student interviews were used to achieve further insights into the verbal and non-verbal interactions between the participants. Semi-structured interviews were conducted once with all the students. These were typically 25-30 minutes in length and were audio recorded to produce accurate transcriptions. The interview was mainly used to gather students' general perceptions of the class EC but it was also used to supplement the other data sources such as entries in a researcher diary. The topic areas of interview questions were: Pre-service teachers' experiences with the lessons that were positive and negative for the class, views on teaching, and the classroom EC.

Stimulated recall interview. One stimulated recall interview was conducted with the teacher participant (i.e., Pelmo) using video recordings (Gass 2001) and observations from a researcher diary to stimulate recall of events after a lesson (Lyle 2003). Stimulated recall allowed the teacher participant to explain her decision making at certain moments during the lesson (Sime 2006). The use of multimedia sources in recall sessions has the advantage of replaying and reintroducing cues that were present during the task (Slough 2001). It was an effective way for the research team to gain the perspectives of the teacher participant and her interpretation of events (Mackey and Gass 2005). The questions for the stimulated recall interview were also semi-structured in nature. Sample questions included: (i) On certain occasions you used native language (Dzongkha) as a part of your conversation or lecture. Why? (ii) How did you feel when the questions or doubts raised by students in the class remained inconclusive/unanswered?

Researcher diary. The researcher diary provided a chronological account of classroom interactions. The diary proved to be a useful source of information as it contained details of Sonam's experiences and perceptions of what happened in the classroom and how it happened.

Data Analysis

The method for determining student perceptions of the classroom EC was through their responses using clickers. The class average for each interval was graphically represented for each lesson. The average EC ratings for each interval were plotted graphically as shown for Lesson 15 in Figure 2. The shape of the graph was indicative of the variation in EC within a lesson during the study. For instance, intervals 2, 7, 9 and 13 were peaks or crests and intervals 5 and 8 were dips or troughs. The overall mean EC (3.2) for the class from 16 lessons is indicated as a horizontal line for ease of comparison with the results for an individual lesson.

**************************INSERT FIGURE 2 HERE*************************

The peaks and troughs in EC graphs were used to identify relevant video segments for analysis of non-verbal conduct such as facial expressions, proxemics, prosody, and observable physiological changes. These displays of non-verbal conduct helped in the identification of human emotions (Ekman and Friesen 1975). For instance, primary emotions (e.g., surprise, anger, happiness, fear, disgust, and sadness) are identified through facial expressions with movements in eyebrows, eye-lids, cheeks, nose, lips, and chin (Ekman and Friesen 1975). Prosodic features of speech such as pitch, energy intensity in the air, and speech rate are useful indicators of emotional states (Juslin and Scherer, 2008). Emotions with high arousal and activity are characterized by increased pitch, energy intensity, formant, and speech rate while withdrawn emotions are characterized by low pitch, low energy intensity, low formant, and low speech rate (Scherer 1989). For instance, we can expect higher measurement of pitch, energy intensity, formant, and speech rate for joy than sadness. Physiological changes such as hard stare and loudness in speech indicate disgust or anger while reddening of face could mean anger or shyness (Thoits 1990). Interactions between classroom participants in these segments were transcribed and analyzed at the micro level using conventions aligned with conversation analysis (Roth and Hsu 2010) [see Appendix A].

Prosodic analysis in teacher education research was first used in the ethnographic study of science intern teachers in the United States (Roth and Tobin 2010) to study prosody during teacher-student interactions. The speech parameters used in our study include, energy intensity, pitch, formant, and speech rate using PRAAT software. PRAAT (www.praat.org) is freely available software used by linguists around the world that exists for Macintosh, Windows, Linus, and SG platforms. It handles a number of different sound file formats, which is saved directly from the video recorder (Tobin and Roth 2006). Prosody analysis allowed researchers to review salient parts of speech (e.g., loud voice) and individual utterances that supported other data about students' and their tutor's emotional arousal. Variations in pitch of speech can determine how a listener perceives what is said (Roth and Tobin 2010) and can indicate the valence of emotional arousal (Scherer 1989).

In our study, prosodic characteristics of utterances of interest were measured for pitch or vocal frequency (F_o) in hertz [Hz], energy intensity in decibels (dB), and speech rate (syllables/s) – the main reliable variables used in studies of the vocal expression of emotion such as happiness, anger, fear, and sadness (Scherer 1989, 2003). These characteristics are embedded in relevant speech turns within the transcripts of selected episodes. Emotions with high arousal and activity are characterized by increased pitch, range, and variability, as well as intensity, whereas the converse is true of submissive and withdrawn emotions (Scherer 1989).

Absolute values for the prosodic parameters for specific emotions do not exist; however, comparing values of a specific utterance with other utterances, considered more neutral, can be used to identify emotions (Ritchie et al. 2013). For instance, the speech of a yelling speaker is expected to show increase value in pitch, increase in energy intensity, and an increased value of F_1 (i.e., the first formant frequency) but a decrease in F_1 bandwidth when compared with neutral speech. From these kinds of analyses, we were able to reconstruct significant features of classroom events that corresponded with the EC ratings on the graph. Relevant sections of the video were transcribed to present exemplary extracts that corresponded with various EC ratings from the graphs and for the purpose of conversation analysis.

Facial expressions of students and their tutor were analyzed qualitatively using the categories of neutral, satisfaction-happiness, assertion-anger, aversion-fear, disappointment-sadness, and disgust (Turner 2007). These categories of emotion are used in eMotion (facial emotion software; Sebe, Lew, Sun, Cohen, Gevers and Huang 2007). The software provided sophisticated analyses of frontal images of faces from video files to obtain measures of the

emotions of the participant for each frame in a video clip where possible. This technique does not work for side images whose angle of tilt of the head exceeds 15 degrees, in which cases we referred to Ekman's Facial Action Coding System (Ekman and Friesen 1975) for manual assessment of the emotions. Facial expressions as the sole data analysis technique for identification of discrete emotions have been criticized because some expressions may be culturally dependent. For this reason, other methods were used in conjunction with facial analysis.

Conversation analysis is an approach to the study of social interaction embracing both verbal and non-verbal conduct. Wolff-Michael Roth (2006) posits that social life is shaped and reproduced through interactions with others. Conversation analysis of selected interactions within the classroom was undertaken in our study. Detailed transcripts of conversations from the selected video segments that were identified initially from EC data were made. The notation conventions from conversation analysis (Roth and Hsu 2010) were used to mark up the transcripts so that readers could appreciate the manner in which the words were uttered (Grbich 2007). The transcripts provided data about how the conversations occurred, the relationships between students and their teacher, and how they produced their own actions and dealt with the actions of others (Grbich 2007).

Interview recordings were transcribed as the study progressed. After completing the transcription, the first author reviewed it with the audio recorder and diary notes to ensure that nothing was missed out and that the non-verbal cues like facial expressions and body gestures were taken into consideration. The transcripts were made available to the tutor and students for member checking and clarification. Later, the transcripts were searched for themes and contradictions that were relevant to the research.

Activities that impact on emotional climate

Analyses of multiple data sources presented in this section support the general claim that the emotional climate of the class depended on the type of learning activity in which classroom participants engaged. This claim is elaborated further through a series of assertions and contradictions that establish that positive EC was associated with the use of video clips, models and class discussions; but EC decreased and became negative at times when unprepared presenters took lessons and during formal lectures.

Assertion 1: Positive EC was associated with the use of video, models and class discussion

A general pattern in the data across the study period indicated that positive EC was associated with particular types of classroom learning activities in which the students participated. Activity types associated with positive EC were related to classroom presentations by pre-service teachers that included video-assisted presentations and model-assisted presentations whereas classroom discussion led by the tutor was another form of learning experience associated with positive EC. Where relevant, contradictions to these patterns are identified.

Assertion 1a: Video assisted student presentations. In the context of this study *video assisted activities* refer to classroom presentations led by students using short video clips to supplement their explanation of a science concept. Here, individual or pairs of students were required to lead a session on selected science topics from high school Physics. For example, students presented topics including forces and energy concepts. Such exercises aimed to provide students with first-hand experiences of leading a class prior to their high-school based field experience and to familiarize them with the school science syllabus (SCE 2009). When student presentations were scheduled the class typically started with the presenter

showing a concept map of the key science topic using digital technology (i.e., PowerPoint™). Video clips were embedded in their presentations to highlight the concept being taught. Following the presentation, students discussed the concept for ten minutes in their groups, with close monitoring of conversations by the tutor and the presenter. After the small group discussion, the tutor and presenter facilitated whole-class discussions to check for student understanding and appreciate the applicability of this strategy in high school classrooms.

During the study period there were only five lessons that included video-assisted activities. Figure 3 presents the EC for these five lessons; that is, lessons 12, 13, 15, 20 and 22 out of a total of 16 lessons observed during the study period. The overall mean EC for the 16 lessons (3.2) is shown as a horizontal black line for ease of comparison with individual lessons. The number of the interval at its base annotates the bar for each interval. For instance, number 1 on the bar in lesson 13 indicates interval 1 and number 2 in lesson 12 represents interval 2 and so on (Figure 3). Each lesson consisted of a different number of EC intervals. As explained before, the interval refers to lesson segments of three minutes duration before the students' rating of class EC with the clickers. The reason for having different numbers of intervals per lesson was that some lessons finished in less time than others thereby allowing for fewer intervals of EC to be recorded.

**************************INSERT FIGURE 3 HERE************************

More specifically, lesson 12 had 16 intervals, lesson 13 had 15 intervals, lesson 15 had 13, lesson 20 had 19 and lesson 22 had 17 intervals. Mean EC values for each three-minute interval was represented graphically to capture variation in EC for each interval for every lesson. Figure 3 presents one interval for each of lessons 12 and 13, four intervals for lesson 15, three intervals for lesson 20, and two intervals for lesson 22 that had video presentations. The average EC of the 5 lessons assisted with video clips was positive (3.6). In-fact it was the highest average EC recorded across intervals associated with the different types of activities identified.

Video analysis of lesson segments associated with video-assisted activities reveals that the introduction of video clips was, in the main, well received by both the students and tutor. In lesson 15, for example, during interval 1 the class was noisy with students moving around as they were getting ready for the class. This occurred before the video clip was presented. The EC at that time was recorded at 3.2. As the video commenced the students went silent and there was a decrease in energy intensity from 0.33 μWatts/m^2 (80 dB) at interval 1 to 0.32 μWatts/m^2 (78 dB) at interval 2. The clip consisted of an animated explanation of *torque* and its application in our everyday life with English subtitles. The 2 min 10s video clip on torque (Lesson 15, Interval 2) presented by Singey (all names are pseudonyms) generated mutual focus between students and the tutor. For instance, the moment the video clip was projected on the screen most of the students and Pelmo aligned their bodies and gaze towards the screen. The students were leaning forward with their gaze focussed on the screen. The averaged EC rating for the interval was 4–the highest across all lessons recorded in the study. Similarly, mutual focus was produced when students were viewing a video clip on the concept of *Force* (lesson 13) with cartoon animation. Video analysis of some students and the tutor during this interval (i.e., L13, Figure 3) shows the students and tutor looking at the screen. Their eye gaze and bodies are oriented toward the screen suggesting that they were engaged in this activity.

In Figure 4a, the video animation has entrained Sangay (S6) and Sogyal (S2) into laughter as evident from their bodies aligned towards each other and their hand covering their mouth to conceal their laughter. This occurred at the same time that the video animation

showed a duck kicking a football to demonstrate that force can change the direction of an object. Before the captured clip in Figure 4a, Sogyal (S2) was laughing out hysterically with his body moving back and forth. Other students (S15, S5, S21, S4, S16, and S7) were also seen laughing with their gaze fixed on the screen and their bodies aligned to it (Figure 4b). A higher positive EC of 3.9 was recorded at this interval when compared to the preceding interval. Student 20 was seen smiling at the outset of the video clip. Such synchrony in gaze (i.e., students turning their attention towards the screen simultaneously), body gestures and collective laughter reinforces the assertion that animated video clips produced mutual focus and synchronized gaze, conditions necessary for generating positive communal effervescence (Collins 2004).

**************************INSERT FIGURE 4 HERE *************************

During interviews students also used various expressions to communicate their experiences with the video-assisted activities. Student 10 claimed that he sensed student excitement during his video-assisted presentation. He said:

> When I was leading a session on "Newton's Laws of Motion" I sensed that my friends were very excited and curious as I could spot smiles on their faces. The session became very interesting and informative as the video clip conveyed all about the laws of Newton. Because of that they could successfully carry on the class discussion by recollecting what they have already learnt about Newton's Law theoretically. (Personal Interview)

The tutor was also appreciative of how video-assisted activities helped students to supplement their presentation. She was fascinated by the way Singey (S3) used video clips to explain "how gears work" in lesson 15 (interval 13). She elaborated:

> That was the best part of the lesson. If it was me, I could have simply lectured or explained verbally the Physics concept. I enjoyed the lesson and the concepts became clearer though. I have learnt these things during my school days. (Personal Interview)

The tutor and two students; namely, Chenzom and Choeden, gave a round of applause to Singey (presenter) immediately after he projected a clip showing how gears work. This was clear evidence of spontaneous positive emotions shared among students.

Unlike interval 2 of lesson 15 where the EC was 4, the EC in the next interval (Interval 3) dropped to 3.5, possibly due to the prolonged display of a video clip. A decrease in EC associated with extended display of videos was also observed in lessons 20 and 22. For example, the EC dropped from 3.7 in interval 4 in lesson 20 to 3.4 in interval 5 and further down to 3 in interval 6 when the clip showed for more than 7 minutes. The researcher diary observations report that whenever video clips were shown, students' attention was drawn immediately to the screen and they had smiles on their faces. The attention to the task when the students experienced positive emotions during the video-assisted activities may have helped them comprehend the concepts and sustain their interest in the topic, at least as far as the students' self reports during interviews are concerned. The combination of these data sources present an interesting outcome related to video-assisted presentations. Although the videos generated short-term spikes in positive EC, this was not sustained for prolonged periods. Nevertheless, the self-reports and researcher diary suggest that student appraisal of these learning activities remained positive well after the EC effect had subsided. This

indicates that short bursts of positive EC are sufficient to establish longer-term positive perceptions of learning episodes.

Assertion 1b: Student presentations were assisted by models. Experiences that led to positive EC occurred not only with video clips as described above, but also with classroom activities where student presentations were assisted by models. Here *models* refer to scientific artefacts used by students to assist their presentation. For instance, the top part of a beer bottle can be used as a funnel and the bottom portion as a beaker when halved. Similarly a fused electric bulb can be used as a round bottom flask (SCE 2009). As part of their training program, the students are required to acquire skills for designing and improvising scientific models using locally available resources. This is done to prepare teachers in the event that they are placed in remote schools without access to a science laboratory during their school-based field experiences.

Student groups came up with four models, three of which were observed in lesson 16. Singey (S3) was the first to present on behalf of his group and his model was called *Factory*. Sogyal (S2) presented the next model, followed by Sithup (S11) who used a model of gears. The average EC during those activities involving models was positive (3.5). In particular, higher positive EC was reported in interval 5 (Singey's presentation) and interval 1 (Sogyal's presentation). When Singey commenced his presentation, the EC was 3.8 at interval 5 and gradually declined to 3.4 as he prolonged his presentation in interval 6. Similarly for Sogyal, the EC dropped in the next interval. Though the EC dropped in intervals immediately following the presentations of the model, possibly due to a prolonged presentation, the EC of the class remained (positive) above average.

The presentations associated with models were well received by the students as the average EC during model presentations was positive. Video analysis shows that Singey was quite expressive through his gestures and body movements during his presentation. Furthermore, the tutor and other students reciprocated with a gaze fixed on him and smiling in response to his humorous remarks representing synchrony and mutual focus among the students.

The students and their tutor oriented their bodies and heads toward Singey (presenter) while smiling. Singey was explaining the functions of his model *Factory* based on the lay principle "hot air rises and cold air sinks" using vertical hand gestures to emphasize his points. Furthermore, the conversation generated during Singey's presentation produced a positive EC of 3.8, the highest EC for that lesson. The interactions are represented in Extract 1.

Extract 1: Lesson 16, Interval 5

Turn	**Speaker**	**Transcript**
01	Singey	((smiling at the class holding his model)). This is a factory. Do you believe it?
02	Student 4	|YES|
03	Singey	|Druk| factory ((smiles))
04	Students	((Broke into laughter and giggles))
05	Student 7	(3s) once |more|
06	Student 24	|once more|
07	Singey	this is () Druk factory to produce candle an:d incense sticks ((smiles))
08	Student 8	Druk factory
09	Singey	Factory
10	Students &	((laughter))

tutor

Extract 1 provides a prelude to the typical structure of interactions that were observed throughout this study during student presentations. Singey's first statement in turn 01 contains a positive emotional expression in the form of a "smile" as he introduced his model *Factory* by holding it up and asking a rhetorical question to the class. Student 4 confirms it by uttering a loud YES in turn 02. By adding the word *Druk* to the factory, meaning *Bhutan Factory*, in turn 03 while smiling, humour appears to have been generated as evidenced by students breaking into laughter and giggles in turn 04. Overlapping speech in turns 02-03 and in 05 and 06 happens so fast that there is no pause between the utterances providing evidence of synchrony. The (3s) pause by Student 7 in turn 05 communicates his apology for not getting the name of the model right as Singey added a word *Druk* to the initial factory name. Singey stressed Druk factory as the name of his model and further adds humour by saying it can produce candles and incense sticks. As he uttered the word *Druk Factory* in turn 07, his mouth was open with teeth exposed and corners of lips drawn back and up. Creases running down from his nose to the outer edge beyond the corners of lips corresponded with Paul Ekman and Wallace Friesen's (1975) facial characteristics for happiness.

The prosody analysis of the emphasized words *Druk Factory* in turn 07 confirms that Singey was happy as there was an increase in pitch (F_o: 200Hz v 183Hz) and speech rate (speech rate: 4.10 syllables/s VS 4.05 syllables/s) when compared with the similar utterance considered neutral in turn 03. The chain of interactions in turns 01–09 support the classification of this event as a positive interactional structure because one person's statement was directly followed by another with minimal pauses indicating fluency in the interaction. Furthermore, the laughter generated in turn 10 in the class was indicative of positive emotional energy that eased the transition to the next presentation by Sogyal. Most (70%) students expressed in the interviews that their presentations using models were well received by the tutor and friends. For instance, Student 27 expressed "I enjoyed and felt quite motivated looking at different models and listening to their presentation." Comments like this reinforce the association established between positive EC, positive emotions and the value of using models during learning experiences.

Contradiction: When low EC was generated during student presentations. Not all student-led presentations produced a highly positive emotional climate. As discussed earlier in the description of context for the study, the students were required to do a presentation on the given science topics and initiate class discussions. Though students in general appreciated a shift from the tutor-dominated classes to student-led sessions, they were displeased with sessions led by unprepared presenters. The average EC of the two lessons (lesson 17, EC=3.0; lesson 18, EC=3.1) when this occurred was below the average EC of all lessons (3.2). Furthermore, the rating of 3.0 for lesson 17 was one of the lowest ratings recorded during the entire study period. An example of an unprepared student-led presentation occurred in lesson 17 where the presenter (i.e., Samphel) admitted to not having done enough homework to lead the session on *Thermal Expansion.* His apologetic statement was:

> Good afternoon. Ah…today we are (2s) going to start a new chapter… Thermal Expansion chapter nine. Ah…me ... myself and Mr Surjay will be presenting. To be frank…to be frank... ah… I don't think both of us ...any one of us are really prepared because we just knew that we had presentation today morning itself. So, I don't think that we are very prepared, we will try our level best to answer your questions and I hope madam will also be there ah…to (.) accompany us.

The stilted nature of his utterance with multiple instances where he uses the filler sound “ah” and the short multiple pauses denoted as “(2s)” and “…” are indicative of the stalling tactics used by people experiencing shame (Retzinger 1991). His repeated statement “to be frank” followed later by “really prepared” is indicative of feelings of inadequacy (Retzinger 1991). Further evidence of his feelings of shame are represented by Samphel’s body language (body tilted toward his left), eyes pointing down to the left and tensed facial expression that matched his apology to suggest he was disheartened and sorry for not having come prepared. The prosody analysis of speech “ah...I don’t think” when compared with a similar neutral utterance “so...I don’t think” from the same lesson confirmed that he was disheartened and felt sorry for not having prepared his presentation. The analysis shows a decrease in pitch, energy intensity, and speech rate (F_o: from 182Hz to 156Hz; energy in air: from 81dB to77dB; speech rate: from 6.2 syllables/s to 3.8 syllables/s) consistent with the emotion of sadness.

The contradictions to the general pattern established between positive EC and student-led presentations indicate that the absence of resources such as video clips and models as well as a general inability to represent the requisite science concepts is associated with lower levels of emotional climate when compared to lessons where these elements are present.

Assertion 1c: Interactive whole-class discussions produce positive EC. Interactive whole class discussions refer to student-led activities where pre-service teachers could simulate the role of a teacher in discussions about teaching Physics in schools. Such activities helped the tutor to engage students, especially the shy ones. The mean EC for the ten lessons involving interactive discussions was positive with a value of 3.4. The highest EC value was recorded at 3.7 in lessons 9 (Interval 6), 13 (Interval 4) and 20 (Interval 15). The lowest EC value of 3.1 was recorded in interval 12, lesson 20.

Extract 2 illustrates how a group of students generated positive EE through interactions with Singey (presenter), the tutor, and other students in Lesson 15, Interval 11. The tutor was sitting with the class as Singey started the session by presenting a concept map followed by a group discussion. The verbal exchanges focused on the topic of centre of gravity. The discussion drew on anecdotes from everyday examples. The whole class broke into laughter on occasions, elevating energy levels. The EC became more positive as the discussion progressed as evident from the small rise in EC from 3.2 in interval 8 to 3.6 in interval 11. The interactions started with Sangda asking a question of the presenter (Singey) in turn 01. His question generated excitement in students as laughter erupted from the whole class in turn 02. His question also invited lots of responses from fellow students in turn 03 but unfortunately the cameras did not record clearly comments that could be attributed to individuals present.

Extract 2: Interactive whole class discussion - Lesson 15, Interval 11

Turn	**Speaker**	**Transcript**
01	Sangda	In stability the lower part of the body should be made heavy but in case of human, it is said ourhead is heavier than the body. So we should be upside down. Why is it not happening?
02	Students	((class broke into laughter. Various views were expressed by Samphel, Serpo, Sergyal and Shacha)) but ()
03	Tutor	ah... just listen here... Which of the two will have more surface area? Human head or our juta ((or slipper)) when it is in contact with the ground.
04	Students	Juta madam ((unison))

05	Tutor	Yeah
06	Tutor	Juta will be more because the base is more. (4s) somebody said earlier the centre of gravity is within our body. Do you know where it is?
07	Sangda	((Pointing toward their face and running down the body.))
08	Tutor	Show me ((turning toward the left)) where it is? Where is our centre of gravity? ((Fingers clasped together)).
09	Samdrup	here madam ((pointing toward his stomach))
10	Students	((All class broke into laughter))
11	Tutor	I KNOW YOU ARE SHOWING SOMEWHERE IN THE ABDOMEN, but we don't know where it is ((smiling)).

The tutor intervened in turn 04 introducing everyday examples that could be used by students to help with conceptual development. Students' answers to the tutor's question in turn 05 and their repeat of the local dialect for shoes (i.e., "juta") in turn 05 while smiling suggests synchrony and mutual focus.

Samdrup (S4) entrained the students and tutor into laughter in turn 11 when he explained that the location of the centre of gravity in the human body is near the abdomen (turn 10). Students and the tutor were laughing as Samdrup gestured his hand toward his abdomen to show the location of the centre of gravity in the human body. The majority of students (80%) interviewed reported that they felt positive when the session was interactive. Mutual focus and a shared mood during interactions where students could openly express their views were observed. Student 9's comment during an interview supported this observation:

> Ah…for me ah…I felt very positive during a session on *Force*. In that lesson somebody asked a question about "push and pull" [forces], which drew the whole class into discussion and debate. When there is debate and discussion among friends, even though I don't have knowledge, I gain lots of knowledge from my friends because different people have different perceptions so they elaborate on that particular topic. So, that's why I can say, I feel positive when the class is very interactive or when debate is going on in the class. (Personal Interview)

Assertion 2: Formal lectures produced low or negative emotional climate

Although we did not set out to study the impact of lectures on EC, it is important to identify those activities that did not generate positive EC. In the case of the use of lectures, there was an observable trend of lower EC ratings that sometimes reached negative values (i.e., below 3.0). There were nine lessons dominated by lectures, most of which had EC values below the mean of 3.2. The maximum EC value was 3.4 observed in lesson 16 (Interval 8) and lesson 20 (Interval 16), and a negative EC of 2.7 was recorded in lesson 22 for two intervals.

Video analysis shows that lecture sessions in general lacked positive EE. These sessions were typically characterized by univocal speech, interrupted only occasionally from brief student responses such "Yes" or "No." Most of the students were seen dozing during lecture sessions as captured in Figure 5. In Figure 5a Student 14 and Student 28 are caught in slumber, and Student 3 is seen yawning. These observations are consistent with the low EC ratings reported during the lesson.

**************************INSERT FIGURE 5 HERE ****************************

Students typically remained silent throughout the lectures. Figure 5b shows S12 and S13 resting their cheeks on their hands. The tired body language of students, absence of humour, and their serious looks reinforce the assertion that lecture-dominated classes were associated with negative or low EC.

Students in the interviews also expressed that they disliked lectures because they were monotonous and less interactive. They used various expressions to describe lecture-dominated classes, such as; it puts them to sleep, they feel drowsy, they concentrate less, they become angry, bored, negative, and there is no space for discussion. A representative comment was:

> I feel sleepy in a lecture-dominated class because there was no humour, no discussion, only madam was speaking and we were simply listening. Listening for hours, I lose my concentration and I am not able to understand anything. I found those classes a bit dull, nobody was interested, their face shows that they were tired and their mind was somewhere else. A lesson where the tutor simply lectures with no input from the students becomes monotonous and put students to sleep. (Personal Interview, Student 7)

The low EC, and sometimes negative EC, produced during lectures is unsurprising given that a study of pre-service teachers in an Australian context reported similar results (Bellocchi et al. 2013). In that study, the authors investigated student debate presentations and found that when the Professor (i.e., Bellocchi) initiated discussions through long monologues or when one student responded to discussion questions with long monologues, the EC values decreased. Presently, our results suggest that lectures, or long monologues, have the same anesthetizing effect on students irrespective of cultural differences. Outcomes from this study led to an important insight about the way in which education can serve to meet Bhutan's political desire to improve science teaching while at the same time fostering gross happiness in the nation.

Emotional climate of a science education class: Summary

We began this study with the goal of exploring the micro-interactional processes associated with EC in a Bhutanese science teacher education class. Our study was conceived to explore the realization of the GNH macro-social policy by investigating the micro-situational production of positive emotional climate embedded in a meso-social structure (i.e., an educational institution). As Turner (2007) theorizes, macro-social phenomena impose constraints and affordances on meso-level and micro-level phenomena. Educational institutions in Bhutan are seen to be one of the pillars that support the GNH policy potentially generating a bottom-up effect where micro-social and meso-social forces support or hinder the actualization of the macro-social policy. Theoretically, this is achieved if the culture of the meso-level social structures support the ideology imposed at the macro-level. This study made headway into understanding how micro-social forces during classroom interactions embedded in an educational institution can sustain or inhibit GNH during face-to-face encounters. Previous research in science education has focused on micro-level forces of interactions and emotions and their relationships to classroom level emotional climate (see Bellocchi et al. 2014). This previous work took place in Australia where educational policy is focused on the quality of science teachers and university teaching and learning. Whereas that study offered insights into the connections between micro-situational experiences of students and the quality of learning experiences, our present work extends those understandings by illustrating the interactional factors that sustain high quality learning experiences and macro-

social policy about happiness. We conclude from our analyses that educational institutions can foster national ideals such as collective positive emotions if particular types of learning environments are generated through the application of specific kinds of interactional sequences and certain forms of instruction that deviate from lecture-modes of presentation to produce a classroom culture that challenges the normatizing forces of dominant social culture. In Bhutanese culture, it is common for students to be submissive to teachers as a form of respect and acknowledgement of the teacher's higher social status. When students in our study broke this cultural code by no longer giving choral answers and by leading the classroom learning sequences, they produced structures that promoted positive emotional climate. We now detail those structures.

Pre-service teachers' ratings of EC using clickers helped identify salient events/activities associated with positive and negative emotional arousal by the tutor and students. Student-led presentations that used video clips and models were characterized typically by highly positive EC ratings. Video animations in particular generated laughter and fun among students and the tutor, thus creating a positive learning environment. The practice of students leading a session gave them firsthand experience of teaching. It also provided a forum for other students to participate in classroom discussion as they felt comfortable interacting during the sessions led by their peers. In contrast, univocal interactions, lack of eye contact, lack of humour, and low levels of EE characterized the formal lectures and presentations by unprepared presenters. This supports earlier research that found that these types of interactions led to decreases in EC in a pre-service science education class in Australia (Bellocchi et al. 2013). At the micro-social level of face-to-face interaction, classroom activities employed by teacher educators are vital in the development of positive EC and high quality learning experiences. The activities associated with positive EC identified in this study produced social structures in the classroom that consisted of the expression of positive emotions by individual students, the class and the tutor. Reproducing these activities in other teacher education courses would be one way for Bhutanese educators to actualize macro-level policy to advance national happiness.

We observed positive emotional climate when presenters used task-related artefacts such as video clips and models. The use of artefacts was critical in interactions that generated and maintained shared visual attention on an object and positive emotional energy for individuals. For instance, the video animation and model presentations made science concepts explicit even if the presentations were brief. Not all classroom activities produced positive EC. Formal lectures resulted in a decrease in EC and, in two intervals of the same lesson, negatively valenced EC. During lecture sessions, students showed low EE where they simply responded to the tutor's questions. This is consistent with Bellocchi et al.'s (2013) findings that during formal discussions on the educational implications of the topic discussed in class debates, there were fewer cases of laughter and mutual focus on the task, resulting in low positive EC.

A way forward – Enabling conditions for positive EC and GNH

The analysis of classroom events in our study recognized several enabling conditions for the successful interactions among class members. These were: individual engagement, frequency of interaction and informality of interaction, and presence of resources. How each of these enabling conditions contributed to successful interactions that led to positive classroom EC is discussed in turn below.

Individual engagement was vital in enabling group interactions because only pre-service teachers who were deeply involved in their individual tasks could contribute to the various subsequent interactions (cf. Metiu and Rothbard 2012). Another condition that

enabled students' engagement in our study was the *frequency of interactions* between peers. As the frequency of interactions among students increased, it appeared that there was greater mutual focus of attention and shared emotions. For instance, the class EC was positive during activities (e.g., interactive class, and student led class) in which students interacted frequently. Conversely, activities such as formal lectures in which the EC was lower than other activities were characterized by infrequent interactions between peers. The third enabling condition that increased mutual focus and shared emotion among students in our study was *access to resources*. The results of the study indicate that the presence of relevant resources is vital for the production and sustenance of mutually focused interactions because resources help participants to engage and to share a common mood. For example, when video clips or models were displayed, students leaned forward with their gaze fixed on the screen, attended to the explanation of a scientific concept, and laughed at video animations. An interesting observation was that the videos were more refined resources than the home-made models because the models tended to be self-made resources from simple materials. This suggests that it is not the aesthetic quality of the resources that are necessary for the production of high positive EC. By providing a focus for visual attention, the models and videos allowed students to become entrained in one another's moods to generate a collective positive climate. As predicted by interaction ritual theory, these emotions and general climate become attached to a symbol (i.e., the videos and models) that focuses the group's attention. Each time the symbols were reinstated, they invoked the same emotions and EC that was developed during their first encounter.

Contributions and implications of the study

Our study makes three important advances in science teacher education. Firstly, the study articulates a new enabling condition for producing positive EC that extends the conditions originally proposed by Metiu and Rothbard (2012). The new enabling condition was the need for individuals to gain access to relevant resources to transform classroom practices. Secondly, this study confirms the relevance of the principles of emotional arousal in that it documented similar findings to those of previous studies on emotions conducted in Western contexts (e.g., Bellocchi et al. 2014). The third contribution was that two of Turner's (2007) 17 principles were reinforced in this different cultural context; more specifically, principle 1 (e.g., the tutor and other students applauded Singey [positive sanction] for clarifying a scientific concept using video clips) and principle 3 (e.g., the tutor became irritated [experienced negative emotion] when students failed to understand the article "Team testing.").

The involvement of the tutor (i.e., Pelmo) in our research led to transformations in her pedagogy and her interactions with students that improved the EC of the classroom. Pelmo felt empowered by the research process and the shared understandings that supported her own goals of teaching. It was the first time she had participated in classroom research so she became aware of what was involved in an ethnographic case study and the process of conducting interviews. Pelmo claimed that she will now use these techniques in her own research about her teaching.

The cohort of pre-service teachers who participated in the study was the first group of teachers in Bhutan to engage in a teaching-related research project. They are aware of the role of emotions in teaching and learning of science and the importance of focusing on creating engaging activities that evoke suitable emotional responses from students. In the five-month research period, most students metamorphosed from shy and introverted students to confident and interactive students. The students have become resourceful and critical in

their thoughts, and they began to take greater responsibility for their own learning during the research. Students who seldom raised questions in class had started to question the tutor.

Our study investigated the events that produced positive and, on two occasions in the same lesson, negative EC valences. Future studies should continue to study the EC of science classes and its impact on teaching and learning of science with a special emphasis on the EC of Physics content modules. The tutor has the flexibility to use various strategies and incorporate activities while teaching Physics Education modules and these modules have no written exam unlike content modules. Therefore, research should be carried out in Physics content modules to determine the extent to which the levels of interaction and EC are similar to our study. The students who participated in our research were the first group of Bhutanese future teachers to become aware of the importance of emotion in science education. These students are conscious of the classroom practices and pedagogies that impact the EC of the class. Research could be conducted by following these teacher graduates into their beginning years of teaching to investigate their classroom practices and to gauge whether they are able to create positive EC in the school settings as suggested by Bellocchi et al. (2013).

The quality of science education is central in building human capital, especially in the case of Bhutan where science and technology is still at the rudimentary stage. There is a need to challenge the way science is currently taught in the schools and colleges of Bhutan. Instead of following the existing curriculum and textbooks, a new approach that values students' views and draws on wisdom of generating successful interactions between the teacher and students should be put in place. Bhutan's macro-social policy of GNH can only be realized if it reflects happiness that exists between face–to–face interactions among the teachers and students during micro-social processes in classrooms. Reproduction of the structures associated with positive EC in this study might help the development of macro-social structures (cf. Collins, 2004) such as GNH.

Acknowledgement

This study was made possible by the agreement between Queensland University of Technology and the Ministry of Education, Bhutan. The Australian Research Council (DP120100369) helped resource the study.

References

Anderson, L., Smith, D., & Peasley, K. (2000). Integrating learner and learning concerns: Prospective elementary science teachers' paths and progress. *Teaching and Teacher Education, 16,* 547–574. doi:10.1016/S0742-051X(00)00017-2

Bellocchi, A., Ritchie, S. M., Tobin, K., Sandhu, M., & Sandhu, S. (2013). Exploring emotional climate in pre-service science teacher education. *Cultural Studies of Science Education, 8,* 529-552. doi: 10.1007/s11422-013-9526-3

Bellocchi, A., Ritchie, S. M., Tobin, K., King, D., Sandhu, M., & Henderson, S. (2014). Emotional climate and high quality learning experiences in science teacher education. *Journal of Research in Science Teaching,* Advanced online publication. doi: 10.1002/tea.21170

Childs, A., Tenzin, W., Johnson, D., & Ramachandran, K. (2012). Science education in Bhutan: Issues and challenges. *International Journal of Science Education, 34*, 375–400. doi:10.1080/09500693.2011.626461

Collins, R. (2004). *Interaction ritual chains*. Princeton, NJ: Princeton University Press.

Dorji, R. (2007, October). *Teacher morale and motivation*. Paper presented at the first Royal University of Bhutan research conference, Royal Institute of Health and Sciences, Thimphu, Bhutan.

Ekman, P., & Friesen, W. V. (1975). *Unmasking the face. A guide to recognizing emotions from facial clues*. Englewood Cliffs, New Jersey: Prentice-Hall.

Fahmi, A. (2008). Science education in Bhutan. *United Nations – Newsletter, Bhutan, 1* (1), 1–6.

Gass, S. M. (2001). Innovations in second language research methods. *Annual Review of Applied Linguistics, 21*, 221–232. doi:10.1017/S0267190501 000137

Grbich, C. (2007). *Qualitative data analysis: An introduction*. London: Sage Publications.

Juslin, P. N., & Scherer, K. R. (2008). Vocal expression of affect. In J. A. Harrigan, R. Rosenthal, & K. S. Scherer (Eds.), The new handbook of methods in nonverbal behavior research (pp. 65-136). New York: Oxford University Press.

Kanyangara, P., Rime, B., Philippot, P., & Yzerbyt, V. (2007). Collective rituals, emotional climate and intergroup perception: Participation in "Gacaca" tribunals and assimilation of the Rwandan genocide. *Journal of Social Issues, 63*, 387-403. doi:10.1111/j.1540-4560.2007.00515.x

Kelchtermans, G. (2005). Teachers' emotions in educational reforms: Self-understanding, vulnerable commitment and micro political literacy. *Teaching and Teacher Education, 21*, 995–1006. doi:10.1016/j.tate.2005.06.009

LaVan, S. K. (2004). *Cogenerative fluency in urban science classrooms*. Unpublished doctoral dissertation, University of Pennsylvania, Philadelphia, PA.

Lyle, J. (2003). Stimulated recall: A report on its use in naturalistic research. *British Educational Research Journal, 29*, 861–878. doi: 10.1080/014119203200013 7349

Mackey, A., & Gass, S. M. (2005). *Second language research: Methodology and design*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Metiu, A., & Rothbard, N. P. (2012). Task bubbles, artefacts, shared emotion, and mutual focus of attention: A comparative study of the micro processes of group engagement. *Organization Science, 24*, 455–475. doi: 0.1287/orsc.1120.0738

Nias, J. (1996). Thinking about feeling: The emotions in teaching. *Cambridge Journal of Education, 26,* 293–306.

Retzinger, S. M. (1991).*Violent emotions: Shame and rage in marital quarrels.* London: Sage.

Rinchen, S., Tshering, K. Jose, K. C., Gyeltshen, T., & Gyeltshen, K. (2011). Student-teacher's perceptions of the B. Ed programmes offered at the Samtse College of Education and its impact on the teaching-learning in the schools in Bhutan. *Academic Journal of College of Education, 5,* 35–42.

Rinchen, S. (2009, June). *Developing reflective thinking: Encouraging pre-service teachers to be responsible for their own learning.* Paper presented at 'Teacher education crossing borders: Cultures, contexts, communities and curriculum' the Annual Conference of the Australian Teacher Education Association (ATEA), Albury.

Ritchie, S. M., Tobin, K., Hudson, P., Roth, W.-M., & Mergard, V. (2011). Reproducing successful rituals in bad times: Exploring emotional interactions of a new science teacher. *Science Education, 95*, 745–765. doi:10.1002/sce.20440

Ritchie, S.M., Tobin, K. G., Sandhu, M., Sandhu, S., Henderson, S., & Roth, W.-M., (2013). Emotional arousal of beginning physics teachers during extended experimental investigations.
Journal of Research in Science Teaching, 50, 137-161. doi: 10.1002/tea.21060

Roth, W.-M. (2006). Conversation analysis: Deconstructing social relations in the making. In K. Tobin, & J. Kincheloe (Eds.), *Doing educational research* (pp. 15-57). Rotterdam, The Netherlands: Sense Publishers.

Roth, W.-M. (2007). *Doing teacher research: A handbook for perplexed practitioners.* Rotterdam, The Netherlands: Sense Publishers.

Roth, W.-M., & Hsu, P. L. (2010). *Analyzing communication*. Rotterdam: Sense Publishers.

Roth, W.-M., & Tobin, K. (2010). Solidarity and conflict: Aligned and misaligned prosody as a transactional resource in intra and intercultural communication involving power differences. *Cultural Studies of Science Education, 5, 807-817*.doi: 10.1007/s11422-009-9203-8

Samtse College of Education. (2009). *The handbook for B. Ed secondary programme*. Samtse, Bhutan: Royal University of Bhutan.

Scherer, K. R. (1989). Vocal correlates of emotional arousal and affective disturbance. In H. L. Wagner, & A. S. R. Manstead (Eds.), *Handbook of psychophysiology: Emotion and social behaviour* (pp. 165–197). London: Wiley.

Scherer, K. R. (2003). Vocal communication of emotion: A review of research paradigms. *Speech Communication, 40*, 227–256. doi: 10.1016/s0167-6393(02)00084-5

Sebe, N., Lew, M. S., Sun,Y., Cohen, I., Gevers, T., & Huang, T. S. (2007). *Authentic facial expression analysis*. *Image Vision Computing, 25*, 1856–1863. doi:10.1016/j.imavis.2005.12.021

Sime, D. (2006). What do learners make of teachers' gestures in the language classroom? *International Review of Applied Linguistics in Language Teaching, 44*, 211–230. doi:10.1515/IRAL.2006.009

Simmons, H. (2009). *Case study research in practice.*Thousand Oaks, CA: Sage.

Slough, L. (2001, April). *Using stimulated recall in classroom observation and professional development.* Paper presented at the American Educational Research Association, Seattle, Washington.

Smith, H., & Schneider, A. (2009). Critiquing models of emotions. *Sociological Methods and Research, 37*, 560-589. doi: 10.1177/0049124109335790

Stake, R. E. (2005). Qualitative case studies. In N. K. Denzin, & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (3rd ed., pp. 443–466). London: Sage Publications.

Thoits, P. A. (1990). Emotional deviance: Research agendas. In T. D. Kemper (Ed.), *Research agendas in the sociology of emotions* (pp. 180-203). Albany: State University of New York Press.

Tobin, K., & Roth, W.-M. (2006). *Teaching to learn: A view from the field*. Rotterdam, The Netherlands: Sense.

Tobin, K., Ritchie, S. M., Oakley, J., Mergard, V., & Hudson, P. B. (2013). Relationship between emotional climate and the fluency of classroom interactions. *Learning Environments Research, 6*, 71–89. doi:10.1007/s10984-013-9125-y

Trigwell, K. (2012). Relations between teachers' emotions in teaching and their approaches to teaching in higher education. *Instructional Science, 40*, 607–621. doi: 10.1007/s11251-011-9192-3

Turner, J. H. (2007). *Human emotions: A sociological theory*. New York: Routledge.

Turner, J. H. (2009). The sociology of emotions: Basic theoretical arguments. *Emotion Review*, 1, 340–354. doi: 10.1177/1754073909338305

Winograd, K. (2003). The functions of teacher emotions: The good, the bad, and the ugly. *Teachers College Record, 105*, 1641–1673. doi: 10.1108/002204109109 98924

Wittman, S. (2011). Learning strategies and learning-related emotions among teacher trainees. *Teaching and Teacher Education, 27*, 524–532. doi:10.1016/j. tate.2010.10.006

Zembylas, M. (2002). Constructing genealogies of teachers' emotions in science teaching. *Journal of Research in Science Teaching, 39*, 79–103. doi: 10.1002/tea.10010

Zembylas, M., & Barker, H. B. (2002). Pre-service teacher attitudes and emotions: Individual spaces, community conversations and transformations. *Research in Science Education, 32*, 329–351.doi:10.1023/A:1020862000107

Author Biographies

Sonam Rinchen is a lecturer in the Department of Science, Samtse College of Education, Royal University of Bhutan. He recently completed his PhD in Education from Queensland University of Technology, Brisbane under the supervision of Professor Dr. Stephen Ritchie and Dr. Alberto Bellocchi. His research interests include teacher education and women studies. He is also interested in the study of emotions and emotional climate of science classrooms both at the school and university level.

Stephen M. Ritchie is Dean of the Faculty of Education, Murdoch University, Australia. Steve's research has focused mostly on classroom issues that relate to teaching and learning science. He currently conducts research on the emotional engagement of students in science classes as they become more scientifically literate. He is also interested in the emotional experiences of beginning science teachers and the quality of pre-service science teacher education.

Alberto Bellocchi is a researcher and lecturer at the Queensland University of Technology, Brisbane, Australia. His research program in science education focuses on sociology of emotions and emotional climate in teaching and learning within university pre-service education classes, and high school classrooms. His other research interests include analogies in science, context-based teaching and learning, and the use of games for learning science.

APPENDIX A

Transcript Coding Conventions Adapted from Roth and Hsu (2010)

Symbol	Meaning	Examples
#	Bounds utterance said quickly	# we learnt about research #
__	Underline for emphasis; the extent of underlining within individual words locates emphasis and also indicates how heavy it is.	Ethnography
:	Stretched-out sound/ elongation; the more colons, the more elongation.	Fie:ld
‖	Bounds overlapping talk	Stood up (3s) researchers have to stay in the field for a |longer period of time| |they go native|
()	Inaudible	Ethnography ()
(.)	Untimed brief pause a micropause, hearable but too short to measure.	Stood up (.) researchers have to stay in the field
(s)	Timed paused in seconds	Remember what we learnt in the last (3s) class?
((laughing))	Additional comments or observations from the transcribe	Yes we learnt about Ethnography ((laughing))
CAPITALS	Mark speech that is louder than surrounding speech. This is beyond the increase in volume that comes as a by product of emphasis.	ETHNOGRAPHY