PROJECT TITLE: **Intervening to produce and sustain collaborative, mindful learning environments in science classes**

AIMS: This research has an overarching goal of contributing to a science of teaching and learning, with a broad focus on emotions and ways in which they are expressed by teachers and learners engaged in science education. Interventions will be designed to heighten awareness of expressed emotions and emotional styles, and provide teachers and students with control over the connections between expressed emotions and social interactions. We theorize emotions as continuously produced and reproduced as interactions occur in social life. Typically individuals express emotions physiologically in terms of variables such as: pulse rate; oxygenation of the blood; blood pressure; body temperature; breathing characteristics; body movement, posture, and orientation; facial expression; eye gaze and movement; characteristics of the voice; and laughter. We will study expressed emotions as a science curriculum is enacted and develop interventions associated with breathing patterns, mindfulness, emotional styles, and dialogic inquiry to provide teachers and students with opportunities to: heighten awareness and attain control over (a) expressed emotions and (b) conduct in associated social interactions.

The research is framed in terms of the following aims.

> *1*: Study the incidence of, and create an associated grounded theory for, participants' expression of emotions in science classes, participation in dialogic inquiry, extent of mindfulness, and display of emotional styles.
>
> *2:* Create interventions to heighten awareness and provide participants with control of expressed emotions, dialogic inquiry, mindfulness, and emotional styles.
>
> *3:* Produce and validate grounded theory and associated intervention tools and disseminate them to national and international networks of scholars.

BACKGROUND: Based on **almost 40 years of research on teaching and learning science**, especially the last 15 years in urban schools in the United States, we have learned that science teaching and learning are often stressful, unproductive, and replete with distractions (Tobin, Seiler, & Walls, 1999). **Classroom-focused research suggests that certain patterns reoccur over time, reproducing traditional teacher and student roles**. For example our research in Australian schools identified similar patterns of teacher and student practice in the 1980s (Tobin & Gallagher, 1987), 1990s (Tobin & McRobbie, 1996), and 2000s (Ritchie, Tobin, Hudson, Roth, Oakley, & Mergard, 2011). These patterns support a strong consensus on the need for improvements in science education (Tytler, 2007). **However, there is considerable diversity when it comes to recommendations on how to improve science education**. For example, Fensham (2009) has consistently argued for greater relevance of school science to students' lives and interests, conceptualizing science as humanistic activity that "develops students' capacities to function as responsible savvy participants in their everyday lives increasingly affected by science and technology" (Aikenhead, 2005, p. 1). Our stance is that although curriculum changes should be considered continuously, it also is important to emphasize teachers' and students' voices, involving them as researchers of their own practices, and in collaborative strategies that bring students and teachers together in dialogue in which they plan, test, and adapt interventions intended to enhance the quality of learning environments. **The proposed research is designed to identify new theory and practice, building on our research** that uses multi-level, multi-theoretical approaches to understand interrelationships between a prevalence of negative emotions and associated emotional climates, and various forms of dysfunction evident in learning environments that lack fluency and are characterized by cultural breaches, resistance, and lack of focus (Tobin & Ritchie, 2011).

Studies that began in urban science classes in 1998 revealed high levels of turbulence in the sense that widespread asynchrony occurred and classes were often dysfunctional (Tobin, Seiler & Walls, 1999). Efforts to create fluent interactions oriented towards teaching and learning science were frequently thwarted. **We hypothesize that a lack of fluency was associated with high levels of emotional intensity and low levels of mindfulness.** Tobin and Llena (2011) drew attention to the importance of emotions as ever-present constituents of cultural enactment in urban schools, where teachers and students exhibited strong emotions, such as anger and fear, for relatively long periods of time (e.g., 30-40 minutes per hour for several classes a day). We are concerned about the implications of sustained intense emotions for the well-being of teachers and students, especially given well-documented trends associated with teacher turnover (Ingersoll & Perda, 2010) and student absenteeism (Gottfried, 2011). In addition, learning environments can be adversely affected when emotions mediate social interactions in the classroom over extended periods of time.

Ongoing studies of urban science education that originated in Philadelphia, continued in New York City, and have been supported with several grants from the Australian Research Council in Brisbane (in collaboration with Chief Investigator, Stephen Ritchie at Queensland University of Technology) **are a foundation for the proposed research**.

INNOVATION: This research **will produce new theory within a sociocultural framework**, affording fresh insights into science education along a continuum that is multifaceted, extending from the ultra micro- through to the macro-levels. Accordingly, science educators can use the theories produced in this research to raise new questions about expressed emotions, dialogic inquiry, emotional styles, and mindfulness as foci for research, practice, curriculum development, teacher preparation and enhancement, and policy. The theoretical production of this five-year study is potentially transformative across the domain of science education, providing a reflexive framework for teachers and learners to become aware of a vast array of structures that mediate teaching and learning via complex, dynamic, and highly interactive networks.

This research **uses advanced technologies to study a set of sociocultural constructs that previously have not been investigated collectively.** The study examines emotional expression in ways that include many aspects of the body, obtaining a landscape that is not presently available concerning the ways that teachers and learners express emotions in different science activities. Similarly, research on emotional styles, grounded in Davidson's work in social neuroscience, has not yet been undertaken in science education. The use of heuristics to heighten awareness of specific characteristics about emotional styles expands the possibilities for participants in science education to change their emotional styles if and when they deem it necessary. Science educators involved in teacher education, curriculum development, professional development, research and evaluation, and policy formulation can use the heuristics immediately. The research on dialogic inquiry expands on previous studies involving cogenerative dialogue, incorporating constructs such as radical listening and situating the research and the associated interventions in science classrooms. Finally, the current research on mindfulness in science education is very embryonic, developing a heuristic in a science teacher education context that will serve this study (a) as a starting point for refining the mindfulness in education heuristic and (b) as a model for developing heuristics for dialogic inquiry, expressed emotions, and emotional styles.

This five-year program of research is expected to be generative and can readily be expanded to incorporate new technologies as they become available. As the research is undertaken we anticipate major developments in computer technologies to analyze video and audio files and to measure physiological expression of emotions. An example of a technological advance to be included in the project as soon as feasible is Google Glass (techland.time.com/2012/11/01/best-inventions-of-the-year-2012/slide/google-glass/), which will provide high quality video of what is seen by a participant who wears the unobtrusive recording device. Google Glass will be available commercially in 2014 and will be used to produce audio and video files for meso and micro level analyses.

APPROACH:

Methodology: Multiple methodologies employed in this study include reflexive, interpretive, event-oriented, multi-level, and authentic inquiry.

Reflexive inquiry employs several interventions to study ways in which changing curricula enactments afford higher quality learning of science. Creating awareness about salient characteristics related to the expression of emotions and participation in science can catalyze changes in those characteristics (e.g., mindfulness, dialogic inquiry, and expressed emotions).

Interpretive inquiry (Erickson, 1986) is both emergent and contingent on what is being learned, obtaining answers to two broad questions that frame our research–what is happening, and why is it happening? As we learn from research our progressive subjectivities provide fresh insights as new curiosities arise. Hence, foci for research are contingent on what happens in a field and what we learn from ongoing inquiry. Not only do foci for a study change, but also so too do participants on whom the research focuses (Tobin, 2006). We expect interpretive research to yield a rich set of assertions and associated contradictions that can be explored further using multi-level analyses. Interpretive inquiry will be used to study science achievement by providing thick descriptions of what happens as students enact science in and out of class.

Event-oriented inquiry (Tobin & Ritchie, 2011) will be used throughout the study as a way to move beyond initial landscape studies that address what is happening. Events involve contradictions that arise as culture is enacted. Event selection is analogous to using a zoom lens, and meso-analyses usually involve relatively short events, in the vicinity of 2 to 3 minutes (i.e., focused on one field – meso is intermediate between macro and micro. Having identified an event we employ interpretive research to address what is happening and why it is happening in regards to that event. We then use techniques such as conversation and prosody analysis, facial expression analysis etc to obtain complementary insights into the patterns and contradictions that characterize enactment during the event.

Multi-level inquiry utilizes intensive analyses of relatively large databases (video and audio files) that necessitate extensive and intensive analyses that begin as soon as the data resources are captured and extend for hours, weeks and sometimes years (Tobin & Ritchie, 2011). Typically, we use digital video recorders to capture social practices within classrooms. We analyze all available video files, identifying salient events within them.

Authentic inquiry embraces a goal is for all participants in research to change their ontologies as research is undertaken. There are obvious implications for research design, which should seek to show how participants from each stakeholder group learn from the study and change their ways of participating in science education. A second authenticity criterion is for participants to understand others' perspectives without seeking to change them. Research design affords participants becoming aware of different perspectives between and within salient stakeholder groups (e.g., researchers, teachers, students, school leaders). Two authenticity criteria address individuals and institutions learning (i.e., changing practices) as a result of being involved in research. At an individual level this criterion is viewed through the lenses of equity and social justice. At an institutional level, we study how participation in research benefits each participating school and schools throughout the state and nation. That is, beneficence will be examined in relation to others learning from a study and changing their practices and the structures of the institutions in which they participate.

Development of Heuristics

An important component of the research involves finding answers to questions of the genre "what is happening here". Through the use of interpretive inquiry a variety of data will be used to obtain answers to questions of this sort in relation to mindfulness, emotional styles, expressed emotions, and dialogic inquiry. For each of these social constructs one or more heuristics will be developed for use in the study.

Participants: Initially science teacher education students from QUT will participate in focus groups from which heuristics will be developed using as starting points ongoing research undertaken by the Fellow Laureate (FL) and colleagues. Heuristics will be developed for mindfulness, six emotional styles (i.e., resilience, outlook, social intuition, self-awareness, sensitivity to context, and attention), expressed emotions, and dialogic inquiry (see *Interventions* below). For each heuristic, a focus group leader will manage conversations supported by thinking associated with the personal experiences of participants. Participants will be asked to share the amount and type of talk, listen attentively and respectfully to all speakers, stick with a topic until there are no more contributors on the topic and consensus is reached on it being time to move on, and endeavor to find merits in all contributions as well as seeking alternatives to them. **The goal of the focus group is not to reach consensus concerning characteristics to be included in a heuristic, but to generate characteristics and provide information to illustrate what is meant by examples that emerged during the dialogue**.

Procedures used in the development and refinement of the heuristics follows:

1. Identify characteristics for each of the heuristics. Use focus groups of 4 to 6 participants (Session 1).
2. Video record focus groups. Use transcript analysis to identify characteristics.
3. Use identified characteristics to create heuristics that encompass the domain for each of the heuristics.
4. Refine heuristics using focus groups of 4 to 6 participants (Session 2).
5. Enter heuristics into Survey Monkey and administer to a group of science teacher education students at QUT.
6. Analyze data, describe the landscape for the construct in terms of responses to the heuristic and the associated open responses, and revise the characteristics based on the data obtained.
7. Send revised versions of the heuristic to school-based focus groups and make adaptations to suit the context of the school.
8. When heuristics are developed they will be used by participating teachers and students to heighten awareness of: salient characteristics; the extent to which participants enact each characteristic; and whether the characteristics included in a heuristic are relevant to teaching and learning science.
9. Heuristics will be used at regular intervals to obtain descriptive profiles for each class on each of the characteristics contained in a heuristic. Changes over time will be documented for the teacher and students, collectively and individually. All participants will carefully review the extent to which they enact each characteristic in a heuristic and trajectories over time for each characteristic will be analyzed and interpreted by the participants in each class. Becoming aware of patterns and contradictions are essential steps in a reflexive methodology in which heuristics are used as "low-grade" interventions. Using each heuristic in the manner described here provides a context in which individuals can change their conduct to align with the characteristics included in a heuristic if they choose to do so.

Data Collection and Interventions

***Site and Participant Selection*:** Consistent with the principles of emergent design, at least four schools will be selected to participate in the first year of the study (grades 7-9), based on their differences from one another. The first school will be selected in conjunction with Education Queensland and then as each subsequent school is selected, participants from already selected schools will be involved in choosing remaining schools. All schools will be situated in disadvantaged communities even though the goal is to select schools that differ from one another demographically. After the first year additional schools may be selected serially and contingently, depending upon what we have learned so far and what we expect/desire to learn next. A decision to add or delete schools from the study will be collective, involving all stakeholders, including representatives from Education Queensland.

At least one science teacher from each participating school will be involved in the study during the first year. All science teachers within a school will be invited to participate, making it clear that they can join and leave the study at their convenience, for any reason. It will be clear to all of those who are invited to participate that a collaborative research model is intended with teachers and selected students. The multilevel study will commence in the selected schools as soon as it is convenient to do so in the first year of the study.

Consistent with the broad research agenda laid out in this research proposal, collaborative inquiry will be employed in multi-level, multi-theoretic studies of what is happening in participating science classes. The initial focus will be on emotional expression, dialogic inquiry, mindfulness, and emotional styles, social constructs that provide research foci. As the number of sites expands from year 1 through year 5 we expect that each site will commit to undertake research on the enactment of the interventions. We will employ electronic media such as email, Skype and videoconferencing software to ensure that we document what is learned from the additional sites involved in the research and incorporate what we learn from them into ongoing design studies

***Research personnel**:* The FL, postdoctoral researchers, and doctoral students will undertake the coordination of research at each school site. The design principle is that a senior researcher will coordinate research activities, including interventions and on-site research meetings, at assigned schools across the years in which particular schools participate. The FL will coordinate across-school meetings to ensure all research sites inform what we learn from the study. The research coordinator for each school site will establish procedures for analysis, interpretation, and emergent design to reflect what is being learned at each site and what might be learned given what is being learned elsewhere. The research processes are collaborative and research meetings for a particular site will be undertaken at the school building involved in the study.

Design of Interventions: In this study we design interventions to heighten awareness about particular social constructs and expand the tools for controlling and changing social practices if, when, and as a person decides it is necessary. **Broadly speaking, interventions will be designed to address the expression of emotions, mindfulness, and dialogic inquiry.** Emotional expression will be studied in ways that afford the aims of the project and do not disadvantage participants. What will be studied, when, and how will be decided emergently, depending on the goals of all stakeholder groups, who will be involved in creating a flexible design. The initial design, which is a point of departure, will include videotaping all classes using small unobtrusive "flip cams," two positioned to capture the rear and front of the class respectively, and one to zoom in on interesting phenomena. All three recorders will capture audio, which can be separated as necessary, from the video file. Participants also will record their perceptions of EC and complete the heuristics being used in the research at a given time (see Timeline later in this proposal). This data collection plan will be reviewed by a selection of participants, adapted as necessary, and over time will be adjusted to include studies of constructs associated with different modes of emotional expression, emotional styles, and dialogic inquiry.

Emotional expression: The continuous expression of emotions in a social space such as a science classroom saturates structures including spaces, equipment, materials, personnel, and practices. When similar events subsequently arise in a class participants are disposed to reproduce emotions that are similar to those previously expressed—in type and intensity. **We use the construct emotional climate (EC) to refer to participants' experiences of the emotions imbued in social structures** (Durkheim, 1995/1912). In this study, student perceptions of EC will be assessed using Turning Point™ student response keypads (clickers). **At the macro level, class averages of emotional climate will be mapped in a time-series design that will show the impact of the intervention on emotional climate.** We will obtain student perceptions of the emotional climate at five-minute intervals so as to capture moment-to-moment shifts in EC. For each interval, student perceptions of EC will be recorded using a five-point scale of 5, highly positive; 4, positive; 3, neutral; 2, negative; and 1, highly negative. Adopting this procedure allows us to rate EC for the segments that comprise a lesson and collapse these measurements to calculate the average EC for each lesson. Analysis of the segments will help identify salient video-clips for microanalysis.

In addition we will ask participants to "complete a heuristic at the end of each science lesson for any emotion that was strong enough for you to notice." Participants are asked to *underline one or more (or none)* of 15 emotions they experienced during a lesson (happiness/joy; sadness/disappointment; anger/irritation**;** anxiety; disgust; pride; wonder; enthusiasm; frustration; embarrassment; fear; helplessness; shame; tense; and other). For each emotion they experienced participants select the intensity from numerals in a second column (ranging from 0 to 10 anchored with the phrases not really noticeable to as intense as I have ever felt). Participants are also asked to use a scale from 0 to 10 to indicate their level of interest during the science lesson and have space to comment on either the emotions experienced, intensity, and level of interest.

Researchers will identify emotions through interpretive analyses of video and audio files. We employ frameworks of Davidson with Begley (2012), Ekman (2003), Turner (2007), and Collins (2004) to identify and analyze emotions, using video files that afford repeated replay and manipulation of speed in research that integrates what we learn from analyses of prosody (the quality of the voice – including inflections, loudness, pauses between

utterances, pace of speech) and the content of verbal interaction, body movements and orientation, gestures, facial expressions, and eye movements and gaze. Collins employed microanalysis to examine interactions in terms of proximity, focus, synchrony and entrainment (also elements of mindfulness) in relation to the development of what he referred to as shared mood and collective effervescence. Collins employed the idea of positively and negatively valenced emotional energy as important "in-the-moment" constructs to consider. Turner's research on facial expression posits four primary emotions (i.e., happiness, fear, sadness, anger) and a plethora of secondary and tertiary emotions in terms of elaborations/combinations of primary emotions. We use Ekman's framework (Ekman, 2003) and online resources to train researchers to analyze facial expression of emotions (https://face.paulekman.com/face/default.aspx). The framework is especially valuable when we analyze video frames (stills). ThirdSight software will be used in electronic analyses of facial emotions (ThirdSight, 2012). The software provides in-the-moment measures of happiness, sadness, fear, anger, surprise, and disgust as well as neutral. The analysis involves movement of facial muscles and data are obtained for each video frame (i.e., 30 frames per second). The limitation of using the software is that dependable measures can only be obtained from a full face.

Proxemics is central to our studies of participants' enactments in social fields and ways in which they act using their bodies in relation to space and time. Movement, posture, gesture, orientations of parts of the body such as the shoulders, head, eyes, and limbs are foci for research. **We use a theory of interaction ritual chains** (Collins, 2004) **to study how emotions arise from interactions among participants**, allowing us to see how constructs such as mutual focus, proximity to others, synchrony, and entrainment are associated with the emergence of a shared mood, collective effervescence of emotional excesses, and identity inscriptions such as solidarity and alienation (Tobin & Llena, 2011). **Most of our research on proxemics has employed digital files (still "off print" images, video files, and audio files and a methodology of event oriented social inquiry** (Tobin & Ritchie, 2011).

We will involve participants in the analysis and interpretation of data to obtain their self-reports and learn from them – even though we do not privilege self-report data. **Involvement of participants in analysis and interpretation allows them to understand what we are learning from a study and fosters reflexivity and positive change in their practices**. Their participation strengthens research by making it more polysemic – presenting opportunities for us to learn from multiple meaning-making frameworks. For example, in a small group conversation involving a teacher and several students (Tobin, Ritchie, Hudson, Oakley, & Mergard, 2013), participants were shown offprints from a video file. Without having to listen to the audio track, participants quickly recognized facial expression, orientation of the head to the rest of the body, and upper body posture, associating these characteristics with the teacher being "crabby." Body stance/orientation was associated with emotions such as frustration. For example, as the most energetic sound was uttered during an interaction ritual described as nagging, the offprints captured at precisely this moment revealed that the teacher adopted a similar body orientation each time she produced a nagging utterance. Her head was angled in much the same way each time she enacted a nagging routine. Similarly her shoulders and hips were aligned in particular ways that repeated across nagging interactions and her arm was placed in a similar position, allowing her to lean back on the right-hand as she raised her voice. Once we had this information we could anticipate nagging interactions before they happened. Importantly for the purposes of this study, once the teacher was aware of relationships between body orientation/stance and emotions she could ameliorate her verbal practices as soon as she felt her body tense up and move in particular ways. That is, she designed her own intervention based on an awareness of her own body movements. We have not identified similar body/head orientations for other emotions, however preliminary analyses of happiness suggest that similar gestures and body movements are associated with making jokes and laughing. **We anticipate that studying proxemics expression of emotions will allow us to see how the body orientates and moves in time and space in ways that reflect in the moment emotions** (Harrigan, Rosenthal, & Scherer, 2008). Accordingly, **as we learn from our analyses, we intend to use what we've learned to study proxemics of emotion and connect what we learn to the teaching and learning of science.** As results emerge we will share them with participants, thereby allowing results to be used reflexively, allowing participants to become aware of relationships between proxemics and emotions.

Recently we studied participants' breathing patterns (abdominal and thoracic) in science classes. Philippot, Chapelle and Blairy (2002) connected the production of emotions to breathing patterns that were similar across individuals and clearly differentiated for different emotions. The use of characteristic breathing patterns associated with an emotion led to the production of that emotion. For example, happiness/joy was produced when participants used slow, deep, regular breathing through the nose. Similarly, anger was produced with fast, deep, irregular nasal breathing, and sadness occurred when participants used nasal breathing with average amplitude and frequency. Accordingly, emotions and physiological variables can be manipulated reflexively and **in this study breathing will be used as an intervention to mediate production of emotions in terms of type and intensity**.

Prosody **concerns the quality of the voice, including aspects such as frequency, intonation, intensity and energy spectra of the sound wave**. Prosodic analysis has proved to be an ideal method of inquiry in multi-level analysis (Roth & Tobin, 2010). **When an event is identified the prosody of the interactions is described qualitatively using video and audio tracks.** Care is taken to make note of prominent features of the distributions of the power of

the waves in the air, intensity of utterances, fundamental frequency, intonation, overlapping speech, simultaneous speech, and interruptions. Conversation analysis is often augmented by prosody analysis when microanalyses are undertaken. **A transcript is produced for conversation analysis and to locate utterances for prosodic analysis**, adapting conventions of Have (2007), including inserting measures of relevant time intervals, fundamental frequencies, and intensities of utterances. The transcript routinely includes measurements of characteristics such as intonation, frequency contours of syllables and words, variations in loudness/intensity, cadence, gestures, body movements and orientations, facial expressions, and eye gaze (Roth & Tobin, 2010). **Conversation and prosody analyses mainly involve coordination of frame-by-frame analysis of the video file to capture such important factors as gestures, eye gaze, and head orientation with computer-aided analyses of the acoustic waves from the video soundtrack**. We use PRAAT software (http://www.fon.hum.uva.nl/praat/) to measure time intervals between utterances in seconds (s), fundamental frequencies of acoustic waves in Hertz (Hz) and acoustic intensity (i.e., the amount of energy of a sound wave in the air standardized for time and area) of utterances (Roth & Tobin, 2010). When it is relevant to do so, we analyze higher frequency spectra for utterances, inspect formants, and obtain and analyze a spectral slice for singularities of interest (e.g., when emotions peak) (Tobin & Ritchie, 2011). For example, in a recent study of teaching science we identified an event based on the teacher having a high pulse rate (i.e., high pulse rate defined the event). When we looked at the energy of the sound wave during this time we noticed a number of spikes in the curve with high-energy peaks occurring at intervals of five seconds. Each of these peaks was associated with a vowel that appeared to contribute a shrill sound to the phoneme. In this example, more energy was associated with higher formants (i.e., F_1, F_2, & F_3) than the fundamental (i.e F_0). This characteristic gave each energy peak a shrill sound that may have been annoying to participants. Interestingly, the periodic distribution and short time interval between high-energy peaks may have produced a cascade – i.e., before an in-the-moment emotion such as annoyance could die to zero it was reinforced as another shrill utterance occurred, thereby increasing the intensity of the negative emotion.

Physiological expression of emotions. **We use finger pulse oximetry to obtain measures of pulse rate, percentage of oxygen in the blood, and strength of the heartbeat**. Preliminary results indicate that teachers often have a high heartbeat rate and oxygen levels of the blood fluctuate from a saturation level of 100% to low levels beneath the percentage considered safe for jet pilots to fly a plane (i.e., <92%). We obtain three measures per second for pulse rate and oxygenation and examine patterns and contradictions in relation to coordinated analyses of other databases. **Such analyses provide a micro view of ways in which teaching, learning, and expression of emotions are related to wellness**. The results provide baseline data to create awareness about physiological variables that usually are not considered in research and programs for practicing and prospective teachers. Early indications are that awareness of unexpected results lead to high levels of resolve to change pulse rate and oxygenation levels to levels particular individuals find acceptable.

Mindfulness and emotional styles. Brown, Ryan, and Creswell (2007, p. 212) describe mindfulness as "receptive attention to and awareness of present events and experience," involving nonjudgmental attention to present-moment experiences (e.g., sensations, cognitions, and emotions and sights, sounds and smells in the environment). According to Brown, Ryan, and Creswell, **being mindful involves orienting attention toward registering facts observed, shutting down habitual processing, and making efforts to be present in the moment.** As well as being less emotional, mindful individuals have greater: control over their thought processes; awareness of experience while being immersed in it; objectivity; tendency to defer judgment; likelihood to act as ecological stewards; levels of cooperation with others; and social attunement. Baer and Sauer (2009) regard mindfulness as a type of attention or awareness that includes qualities such as openness, acceptance, non-judging, non-reactivity, curiosity, and compassion. A concern expressed by Brown and Ryan (2003) is that attachment to emotions can reduce focus, productivity, and physical well-being.

Research suggests that an increase in mindfulness will enhance wellness. For example, Davidson et al. (2003, p. 564) report that mindfulness, involving meditation, produces demonstrable effects on brain and immune function. Davidson identified six emotional styles corresponding with specific locations in the brain (Davidson with Begley, 2012). *Resilience* varies from individuals who are slow to recover from adversity through to those who recover quickly when adverse circumstances arise. *Outlook* is an emotional style that pertains to how long a person can sustain positive emotion. *Social intuition* relates to the extent to which a person is adept at picking up social signals from others around him/her. *Self-awareness* concerns how well an individual perceives bodily feelings that reflect emotions (e.g., facial expressions, body temperature, pulse rate). *Sensitivity to context* has to do with an individual being able to regulate emotional conduct to take account of context. Finally, *Attention* concerns the sharpness and clarity of a person's focus. Individuals have a tendency to exhibit characteristic positions along continua associated with these emotional styles—positions that are not set in stone! **Depending on context and life experiences the primary patterns for any of the six emotional styles can vary due to neuroplasticity of the brain**. This is a promising scenario as far as education is concerned because individuals might want to change their tendencies as far as some or all of the emotional styles are concerned – if, when, and as necessary. The research by Davidson and

colleagues provides micro-level data, associated theories, and empirical validation for the plasticity/adaptability of the brain, raising promising scenarios for education to design and enact curricula that afford the development of tools related to changing emotional styles. Consistent with Tobin's extensive involvement in multilevel research (Tobin & Ritchie, 2011), **this proposal seeks funding to develop interventions that can be used in classrooms and other social institutions to change individuals' emotional styles if, when, and as they choose to do so.**

Our first step in planning a low-grade intervention is to create a heuristic for the activity to be enacted, including salient characteristics for a particular construct and a 5-point rating scale so that respondents can assess the frequency of occurrence of each characteristic. We have found that a good place to start is to create a **survey**. We explicate characteristics of a construct (e.g., mindfulness), as short statements about the construct. The short statements serve the purpose of bringing particular characteristics to the awareness of those who use the heuristic. The inclusion of a **Likert scale** affords participants connecting each characteristic to their perceptions of its frequency of occurrence in a specific field. We try not to be repetitive, but instead include characteristics to stimulate reflexivity (Bourdieu, 1992). As particular uses of a heuristic change in their contextual details we expect the characteristics included in the heuristic to be adapted to better-fit contextual details. We use the metaphor of "shape shifter" to convey the idea that a heuristic can change its characteristics for contexts of interest. Table 1 includes 29 characteristics that comprise the *Mindfulness in Education* heuristic to be used as a starting point in the development of an intervention to increase mindfulness in science education classes**.**

Table 1: *Characteristics of mindfulness in education*

1. I am curious about my feelings as they rise and fall.
2. I can tell when something is bothering other students.
3. I recognize others' emotions by looking at their faces.
4. I find words to describe the feelings I experience.
5. The way in which I express my emotions depends on what is happening.
6. I am aware of my emotions as they are reflected in my face.
7. I identify distracting thoughts but let them go (without them influencing future action).
8. The way in which I express my emotions depends on who is present.
9. My emotions are evident from the way I position and move my body.
10. I am not hard on myself when I am unsuccessful.
11. I can focus my attention on learning.
12. The way I position and move my body changes my emotions.
13. I recover quickly when I am unsuccessful.
14. I feel compassion for myself when I am unsuccessful.
15. I can tell others' emotions from the way they position and move their bodies.
16. I pay attention to my moment-to-moment sensory experiences.
17. I feel compassion for others when they are unsuccessful.
18. I am aware of emotional climate and my role in it.
19. I am aware of the relationship between my emotions and breathing pattern.
20. When I produce strong emotions I easily let them go.
21. Seeking attention from others is not important to me.
22. I am aware of changes in my emotions and pulse rate.
23. I gauge my emotions from changes in my body temperature.
24. I use breathing to manage my pulse rate.
25. I maintain a positive outlook.
26. I am aware of others' emotions from characteristics of their voices.
27. I use breathing to manage my emotions.
28. I can tell when something is bothering the teacher.
29. I am aware of my emotions being expressed in my voice.

In this study the mindfulness in education heuristic will be revised, used, and continuously reviewed with an expectation that changes can be made to cater for additional contexts that arise in the research. The elaboration of the mindfulness heuristic will be an initial task for participants that will subsequently identify characteristics to be included in a heuristic for each emotional style, emotional expression and dialogic inquiry.

Dialogic inquiry. Inquiry has been central to policies for reforming science education since the launch of Sputnik-inspired curriculum revolutions of the 1960s. A close associate for the emphasis on inquiry has been a process approach to science and the emergence of science process skills, often referred to as inquiry skills. An example is exemplified in the 5 Es learning cycle model (engagement, exploration, explanation, collaboration, evaluation; Bybee et al., 1989). Unfortunately there is often a tendency to regard scientific inquiry dichotomously; that is, either it is there or it is not. Quality of enactment may not be an issue in many studies in science education. In contrast, our

research in science education shows that patterns of verbal interaction exhibit disruption, multiple simultaneous speakers, and scant evidence of sustained dialogue and radical listening. It seems obvious that quality criteria are important considerations when scientific inquiry is considered as part of an enacted curriculum. **We regarded it as a priority to identify characteristics of high quality inquiry and incorporate these into a low-grade intervention.**

Roth (2007) offered a critique of the emphasis of personal agency in extant models of science inquiry. His stance focused on a necessity to take account of passivity as an ever-present dialectical partner to agency. Our research project accepts this position and also emphasizes the salience of "others" as an often-missing component of agency. Not only is it essential to acknowledge the importance of receptivity to learning (Juffé, 2003) from others but also to be aware of characteristics of the unfolding verbal interaction. Power relationships are involved when verbal interaction is enacted in a field and it is important in our work to elevate concerns about power and the goal of achieving symmetry in the weights associated with different voices. Consistent with this concern is our preference to incorporate radical listening and characteristics associated with cogen into a heuristic for science inquiry, which we refer to as dialogic inquiry (DI).

DI focuses on the quality of the interactions among participants in a class. As we mentioned previously, the construct does not privilege forms of conduct that are observable but instead takes account of all forms of conduct. The key to DI is maintaining focus with the goal of making sense of experiences. It is important to be cognizant of the dialectical relationship between individual and collective. The characteristics of DI can be constructed from the perspective of an individual but always should include symmetrical perspectives involving others in the field. Each individual does not act only for him/herself but also acts for others in a class. Accordingly, individuals should be on the lookout to act and at the same time encourage others to participate. Actions have the dual purpose of promoting personal learning while affording others' learning. **A reflexive approach to DI incorporates awareness of the possibilities for action for the self and others and acknowledges a responsibility to be involved for the purpose of promoting personal learning and affording others' learning**. From the perspective of radical listening it is important to focus on the others' actions, making sure to learn from them and explore their potential. In so doing it is important to develop a sense of the added value of others' perspectives, examining the potential of what they can afford before subjecting them to radical doubt. The essence of radical doubt is not to adopt a deficit perspective to others' enactments but instead to search for contradictions to claims. Given the dialectical relationship between patterns of coherence and contradictions it is important to search for and learn from both. The approach values difference as a learning resource while adhering to the value of identifying contradictions and learning from them. Hence, DI embraces a hermeneutic approach to learning and a reflexive stance grounded in the idea that culture is a site for struggle and always will involve the production of patterns that have thin coherence along with ever-present contradictions. **Accordingly, learning through DI involves complexity – identify consensus among the participants while seeking to find exceptions to the consensus**. This may be considered as a search for parsimony while acknowledging the value of complexity.

Respect is central to DI. It is important to stress that respect includes both the self and others. Individuals should have the courage to participate when they have something to contribute, having confidence that others will value their participation as a resource. Respecting the self includes assuming that others will respect an individual's contributions. Similarly and symmetrically it is important to show respect for others' participation and regard what others do as resources that can enhance individual and collective learning. When DI occurs culture will be enacted fluently as successive participants build on what is happening while contributing in ways that allow others to participate fluently. We theorize fluency as acting in ways that are appropriate, anticipatory, and timely. Fluency is often accompanied by a shared mood that can be an important component of the development of solidarity that assumes effective collaboration among participants. When individuals act fluently the individual components of action are synchronous and when the actions of individuals are examined collectively entrainment occurs. That is to say when cultural fluency occurs over time and space the unfolding structures produce practices within and across individuals that afford resonance, evidence being observed in the production of positive emotions that are examples of collective effervescence – such as smiling, laughter, and applause.

To the extent possible individuals should be aware of, focus on, and learn from what is happening, as it unfolds, without judging whether practices/contributions are good or bad. Mindful individuals neither judge their own practices nor judge others' practices. Instead all forms of participation are interpreted with the goal of learning from them. Once learning has occurred and the potential of the new ideas has been explored all knowledge claims are subject to radical doubt, which involves the exercise of skepticism about all claims, acknowledging that all cultural enactment is associated with contradictions. That is, knowledge claims emanating from a cultural field are always nuanced.

In Year 3 of the study we will address the dissemination of what we have enacted with additional teachers and classes within the participating schools. That is, Aim 3 will be addressed as Aims 1-2 are pursued with the remaining original teachers. *In years 4 and 5* we will expand the number of participating schools and focus on applying what we have learned in science teacher education courses at QUT and other universities throughout Australia.

Timeline:

2014: Term 1 (10 weeks)	**2017: Term 1 (10 weeks)**
Undertake research in high school grades on: • Mindfulness heuristic • Emotional expression heuristic • Emotional climate • Breathing meditation • Pulse rate, strength and oxygenation	Undertake research in high school grades on: • Self-awareness, sensitivity to context, and attention • Emotional climate • Breathing meditation • Pulse rate, strength and oxygenation
2014: Terms 2 & 3 (20 weeks)	**2017: Terms 2 & 3 (20 weeks)**
Analysis, interpretation and dissemination of high school data	Analysis, interpretation and dissemination of high school data
2014: Term 4 (10 weeks)	**2017: Term 4 (10 weeks)**
Review, revise and evaluate heuristics for dialogic inquiry, emotional expression, and mindfulness. QUT teacher education students will be involved	Review, revise and evaluate all heuristics using QUT teacher education students
Develop, test and adapt heuristics for resilience, outlook, and social intuition in science teacher education classes	Undertake research in QUT teacher education classes using heuristics, breathing meditation, emotional climate, and physiological variables
Undertake research in QUT teacher education classes using all heuristics, breathing meditation, emotional climate, and physiological variables	**2018: Terms 1 & 2 (20 weeks)**
	Analysis, interpretation and dissemination of science teacher education data
2015: Terms 1 & 2 (20 weeks)	**2018: Term 3 (10 weeks)**
Analysis, interpretation and dissemination of science teacher education data	
2015: Term 3 (10 weeks)	Infuse what has been learned into science teacher education courses at QUT
Undertake research in high school grades on: • Resilience, outlook, and social intuition • Emotional climate • Breathing meditation • Pulse rate, strength and oxygenation	Develop and enact professional development programs for Queensland science teachers, school leaders, and policy makers based on what was learned in the research.
2015: Term 4 and 2016: Term 1 (20 weeks)	**2018: Term 4 (10 weeks)**
Analysis, interpretation and dissemination of high school data	Nationwide dissemination of teacher education and professional development programs and materials throughout Australia
2016: Term 2 (10 weeks)	International dissemination and translation of research products into languages other than English.
Review, revise and evaluate heuristics using QUT teacher education students	Nationwide dissemination of teacher education and professional development programs and materials throughout Australia
Develop, test and adapt heuristics for self-awareness, sensitivity to context, and attention in science teacher education classes	International dissemination and translation of research products into languages other than English.
Undertake research in QUT teacher education classes using heuristics, breathing meditation, emotional climate, and physiological variables	
2016: Terms 3 & 4 (20 weeks)	
Analysis, interpretation and dissemination of science teacher education data	

SIGNIFICANCE AND NATIONAL BENEFIT: Neither teaching nor learning can be regarded as separate from the other. It is not just teachers who need to know about the culture of students, but also students need to know the culture of the teacher. If success is to occur in social life the participants must use adaptive forms of culture (interstitial or hybridized; Bhabha, 2006; Hall, 1990). **We will enact dialogues consistently, thereby providing a third space for teachers and students to experience and adapt to the other so that they can show respect for**

one another, produce hybrid forms of culture that work in the moment, and produce solidarity. Culture produced in these dialogues can be enacted in classrooms **to produce and sustain viable learning environments**. Such activities are safe spaces in which interstitial culture is produced to improve learning.

The enhancement of dialogic inquiry has the potential to dramatically transform traditional approaches to teaching and learning. Since dialogic inquiry emphasizes the dialectic of individual and collective, the intervention in science classes will allow science to be taught and learned as interstitial culture in ways in which all participants' voices will be involved in dialogue, in a context of focused/mindful interactions that do not produce enduring emotions that shape identities in ways that are not helpful. The use of the dialogic inquiry heuristic, as it is planned here as an intervention, is consistent with Tytler's exhortation, for: "re-imagining of science education that involves a re-thinking of the nature of science knowledge dealt with in schools, moving away from authoritarian knowledge structures to more flexible, and more challenging, conceptions of classroom activity and more varied ways of thinking about knowledge and learning." (Tytler, 2007, p. 67)

This project contributes to the **National Research Priority** *Promoting and Maintaining Good Health – Strengthening Australia's social and economic fabric.* Given the complexity of social life, being mindful and healthy appeal as life skills for all citizens. From walking in the streets to driving in traffic it is important to know how to control your own body and mind and maintain emotional states that are healthy and do not produce debilitating stress, anger, sorrow etc. Similarly, in learning contexts, it is important to identify positive emotional climates and know how to mediate social artifacts (i.e., events) that are charged with negative emotions. **We anticipate that successful attainment of Aim 3 might transfer to social fields in the lifeworlds of citizens—being aware of emotional climates in other fields and knowing how to ameliorate the buildup of negative (dysfunctional) emotional climates**.

Interventions designed on the basis of ongoing research, adapted locally for different structures represents an approach to professional development and teacher education that begins with professional assumptions about prospective and practicing teachers—that they can adapt interventions to meet the needs of their local communities and students, they can do research to see what works and what needs to change, and they can call on the talents of their students to join them as coresearchers, curriculum developers and evaluators.

COMMUNICATION OF RESULTS: Educative authenticity assumes that all participants have a right to learn from the research and change the way they think about their lives in relation to science. Accordingly, on each occasion that we meet within the participating schools, we will look for opportunities to **educate stakeholders** (including those not involved in the study) about the study and what we are learning. We will document stakeholders' progressive subjectivities over the five years of the research. **Monthly seminars will focus on dissemination of the research throughout the group of all participants**, who will be encouraged to *pass on* to others what they learn from the research.

We regard it as a priority to **disseminate to colleagues** with the purpose of receiving critique, subjecting what we have learned to alternative standpoints—including theories and methodologies. We will use live streaming software to disseminate meetings to scholars with whom we collaborate in numerous countries and we will use QuickTime Pro to create Podcast style movies to increase access to what we have learned through You Tube and a website where Podcasts will be available for download.

Researchers will co-author manuscripts for presentation at national and international conferences. These manuscripts will be refined and submitted to both professional and high impact research journals (such as the *Journal of Research in Science Teaching, Science Education, Research in Science Education*). Outcomes from the study will form the basis of a book with an international publisher such as Springer.

Important **dissemination products** are interventions we design and implement in the study. These will be made **available to other researchers, teacher educators, and schools throughout Australia and the international community**. Each intervention will be based on rich theory and the results of our ongoing research. Each year we will undertake **regional workshops** in other states of Australia as a primary dissemination mechanism that involves peer researchers, teacher educators, teachers and school leaders.

D3. References

(Include a list of references. Write a maximum of five A4 pages.)

Attached PDF

D3: References

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