

A Sociocultural Approach to Science Education

Una aproximación sociocultural a la educación científica

Une approche socioculturelle à l'éducation scientifique

Uma aproximação sociocultural à educação científica

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Abstract

I present a sociocultural approach to research and science education that incorporates a recursive relationship between transformation and theory, acknowledges the strengths of subjectivity, and regards difference as a resource for learning. The methodology incorporates hermeneutic-phenomenology, reflexive inquiry, and event-oriented inquiry. Research on emotions contextualizes methodologies for multidisciplinary and multi-level research. Finally, a new journal that was developed as a home for cultural studies of science education is described along with the processes used in manuscript review and publication.

Key words author

Sociocultural Theory, Science Education, Research Methodology, Interventions, Mindfulness, Meditation, Emotions.

Key words plus

Cultural Studies, Science Education, Science, Socio-Cultural, Scientific methodology, Teaching Methods.

Transference to practice

I emphasize the importance of continuously doing research on the enactment of science education, taking steps to ensure that all participants learn and change as a result of being involved in research. Improvements should occur for all individuals involved in research and identified equity problem should be resolved. Cultural Studies of Science Education can disseminate research and provide leadership by publishing studies designed to produce new theory while changing practices for individuals and collectives. Consistent with tenets I outline in this paper, such research would be multi-voiced and incorporate multiple meanings associated with participants from different stakeholder groups.

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Palabras clave autor

Teorías socioculturales, educación científica, metodologías de investigación, intervenciones, conciencia, meditación, emociones.

Palabras clave descriptor

Estudios culturales, ciencia-enseñanza, ciencia-aspectos socioculturales, metodología científica, métodos de enseñanza.

Resumen

Presenta una aproximación sociocultural a la investigación y la educación científica, que incorpora una relación recursiva entre la transformación y la teoría, reconoce la solidez de la subjetividad y considera que las diferencias son un recurso para el aprendizaje. La metodología incluye fenomenología hermenéutica, investigación reflexiva e investigación orientada por eventos. Las investigaciones sobre emociones proveen un contexto para las metodologías multidisciplinares y de múltiples ámbitos. Por último, se describe una nueva revista, desarrollada como plataforma para los estudios culturales de la educación científica y sus procesos para evaluación y publicación de artículos.

Transferencia a la práctica

Enfatiza la importancia de investigar y poner en práctica la educación científica, con la seguridad de que todos los participantes aprendan y cambien, como resultado de su vinculación a la investigación. Todos los individuos involucrados deben beneficiarse de la investigación y, en caso de que se detecte algún problema de inequidad, este debe ser resuelto. La revista *Cultural Studies of Science Education (Estudios culturales de la educación científica)* socializa investigaciones y lidera la publicación de investigaciones diseñadas para producir nuevas teorías y a la vez generar cambios en individuos y grupos. De acuerdo con lo que se esboza en el artículo, estas investigaciones involucrarían múltiples voces y significados para los participantes que forman parte de diferentes grupos.

Mots clés auteur

Théories socioculturelles, éducation scientifique, méthodologies de recherche, interventions, conscience, méditation, émotions.

Mots clés descripteur

Les études culturelles, l'éducation scientifique, la science, la méthodologie socio-culturel, scientifique, les méthodes d'enseignement.

Résumé

Je présente une approche socioculturelle à la recherche et à l'éducation scientifique qu'incorpore un rapport ingénieux entre la transformation et la théorie, cette approche reconnaît la solidité de la subjectivité et considère que les différences sont un moyen pour l'apprentissage. La méthodologie inclut la phénoménologie herméneutique, la recherche réflexive et la recherche orientée par les événements. Les recherches basées sur les émotions donnent un contexte pour les méthodologies multidisciplinaires et de multiples niveaux. Enfin, on décrit une nouvelle revue, développée en tant que plateforme pour les études culturelles de l'éducation scientifique, et ses processus pour l'évaluation et publication d'articles.

Transfert à la pratique

Je me concentre sur l'importance de faire de la recherche et en même temps d'implémenter l'éducation scientifique, en m'assurant que tout le monde participe, apprendre et change, comme résultat de son investissement dans la recherche. Il faut que tous les individus impliqués puissent se bénéficier de la recherche, et dans le cas où qu'il y est un problème d'équité, celui-ci doit être résolu. La revue *Cultural Studies of Science Education (études culturelles d'éducation scientifique)* qui socialise les recherches et fournit la première place dans la publication de recherches qui ont été dessinées pour produire les nouvelles théories et à la fois produire les changements dans les individus et les groupes. En accord avec ce que l'on a dessiné dans l'article, ces recherches impliquent des multiples voix et significations divers pour les participants qui font partie de différents groupes.

Palavras-chave autor

Teorias socioculturais, educação científica, metodologias da pesquisa, intervenções, consciência, meditação, emoções.

Palavras-chave descritor

Os estudos culturais, educação científica, a ciência, a metodologia sócio-cultural, científico, métodos de ensino.

Resumo

Apresento uma aproximação sociocultural à pesquisa e à educação científicas que incorpora uma relação recursiva entre a transformação e a teoria, que reconhece a solidez da subjetividade e que considera as diferenças como um recurso à aprendizagem. A metodologia inclui a fenomenologia hermenéutica, a pesquisa reflexiva e a pesquisa orientada por eventos. Pesquisas sobre emoções proveem um contexto para as metodologias multidisciplinares e de múltiplos níveis. Finalmente, descreve-se uma nova revista, desenvolvida como plataforma para os estudos culturais da educação científica e seus processos para avaliação e publicação de artigos.

Transferência à prática

Faço ênfase na importância de pesquisar e ao mesmo tempo pôr em prática a educação científica, assegurando-se de que todos os que participem aprendam e mudem, como resultado de seu envolvimento na pesquisa. Todos os indivíduos envolvidos devem beneficiar-se da pesquisa, e caso se detecte algum problema de equidade, este deve ser resolvido. A revista *Cultural Studies of Science Education (Estudos Culturais da Educação Científica)* socializa pesquisas e oferece liderança ao publicar investigações que foram desenhadas para produzir novas teorías e ao mesmo tempo para produzir mudanças em indivíduos e grupos. De acordo com o que está esboçado no artigo, estas pesquisas envolveriam múltiplas vozes e diferentes significados para os participantes de diversos grupos.

Introduction

Sociocultural theories are increasingly used as frameworks for research in the social sciences. However, appropriate uses that fully embrace the potential for transforming education through research necessitate continuous and wide-ranging reflexivity—especially interrogating purposes of research and what is taken for granted. Informed by Guba and Lincoln's authenticity criteria (Guba & Lincoln, 1989) we incorporate a standpoint that research should benefit participating individuals and institutions (Tobin, 2006). This explicit axiological stance is in part due to the questionable morality of researchers exploiting others for personal and collective gains in lieu of seeking to improve practice through the conduct of research (Tobin, 1998). The stance addresses a traditional dichotomy that tends to assign more weight to producing theory than to improving practice (Arendt, 1958). We prefer to maintain balance by producing theory while affording transformations of individuals and institutions. Instead of arguing that we can use what we learn from research to benefit others like those involved in the research, we insist that participants and their associated institutions can benefit directly from involvement in research. Unfortunately, many colleagues regard this idea as alien because they make sense of research in terms of it being objective and testing a-priori hypotheses. An example is the dismissive position taken by the chair of a university ethics review committee who rejected the idea that all participants and institutions in a study could benefit from being involved in research, insisting that changing what happens during a study based on what is learned from the study would invalidate the research. He argued, benefits from a study are for a population and are disseminated after a study is concluded to others like those involved in the research. In contrast, through sociocultural lenses we view research and social life as interacting, maintaining a continuous flow of culture between the fields of research and practice. We do not believe it is ethical to withhold benefits that might improve the quality of teaching and learning. When and as necessary we heighten awareness of what we are learning and suggest possible ways to improve what is happening. We regard our research as potentially catalytic for the institutions we study and tactical for individuals, especially those who are unaware of their disadvantage and are not well placed to improve their opportunities to learn. Although we are resolved to disseminate what we learn to improve science education to the largest possible group of stakeholders we feel a strong responsibility to benefit participants and institutions through our ongoing research.

It is often the case that studies of teaching and learning highlight problems of practice and necessity for changes to occur. In such cases problems identified usually are not resolved in the study. For example, studies that began in urban science classes in 1998 revealed high levels of turbulence in the sense that many things seemed to be happening at the same time (Tobin, Seiler & Walls, 1999). Furthermore, there were high levels of asynchrony, giving the impression that classes were frequently dysfunctional. Efforts to create fluent interactions oriented towards teaching and learning science were frequently thwarted. Our impression is that a lack of fluency is often associated with high levels of emotional intensity and low levels of mindfulness. Similarly, 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 wondered about

Article description | Descripción del artículo | Description de l'article | Artigo descrição

This reflexive article provides a sociocultural framework developed for scholarship in science education. Examples from ongoing research in the United States of America and Australia are provided to illustrate the affordances of the theoretical framework. Also, I examine the ways in which research is used to improve practice through the design and research of interventions based on what is learned from the research program. Finally, I describe the development of a journal, *Cultural Studies of Science Education*, which publishes research that adopts sociocultural theory and associated methodologies in science education.

the implications of sustained intense emotions for the well-being of teachers and students, especially given the well-documented trends associated with teacher turnover (Ingersoll & Perda, 2010) and student absenteeism (Tobin et al., 1999). One of the teachers who engaged longitudinally in our research in urban science classes had a history of heart problems and it was evident that high levels of anger frequently characterized his classes (Tobin & Llena, in press). The teacher maintained he was “acting”; that the anger was not real. We were not convinced this was the case and felt certain that even if the initial goal was to act, the teacher’s physiological processes reflected intense anger. Furthermore, the teacher’s anger spread like wildfire, as if all students in the class were infected with an emotional contagion (Goleman, 2006). Accordingly, we immediately expanded our research goals to include studies of the relationships between physiological variables and in-the-moment emotions.

Consistent with our goal to transform practice through research, we sought to design interventions to afford teachers and students improving the quality of teaching and learning. In this paper I discuss ways in which what we learn from research in an ongoing way is used to design high- and low-grade interventions for the purpose of improving teaching and learning. High-grade interventions are changes in the ways the intended curriculum is planned and enacted. Low-grade interventions involve using research data to heighten awareness about what we are learning, thereby allowing participants to decide whether changes are desirable. We have learned from enacting low-grade interventions that creating awareness can structure changes even if there are not conscious efforts to enact changes. Three examples of interventions addressed in the paper are using: breathing meditation to ameliorate emotions; cogenerative dialogue to allow teachers and students to produce adaptive culture, cater for diversity, and enact equitable practices; and, a heuristic to increase the incidence of mindfulness.

Overview

The remainder of this paper consists of three main sections that lay out the sociocultural perspectives we employ in our research, the use of interventions of transform practice of science education, and the structure and rationale for *Cultural Studies of Science Education*, a journal that embodies these frameworks and affords research undertaken from a sociocultural perspective.

Theoretical and empirical foundations

Our stance on research methodology regards subjectivity as strength. In accepting that the presence of a researcher implies subjective experiences we acknowledge the importance of documenting our a-priori subjectivities and ways in which they change as research progresses. Accordingly, documenting changing subjectivities progressively for all stakeholders, including researchers, is a goal of research and a feature of research design. Furthermore, we do not embrace a necessity to produce only convergence in terms of what researchers and other participants learn from research. The theoretical umbrella for our studies regards convergence and divergence as dialectical, an example of culture manifesting as both coherence and contradictions (Sewell, 2005). We endeavor to identify patterns of sameness and ever-present differences, contradictions from which we can inevitably learn even more than is accomplished by pushing for

consensus. Accordingly, within our research squad we embrace diversity, encourage alternative standpoints, and solicit different perspectives. Rather than pressing for consensus our stance is to understand others' perspectives as fully as possible, acknowledge their potential, and endeavor to learn from them.

Our basic approach is grounded in Bourdieu's reflexive sociology (Bourdieu & Wacquant, 1992). Within this framework the construct of field is a convenient starting point in a bricolage of theories that includes cultural sociology. A field is a social space in which culture is enacted, structured with resources that can be appropriated as individuals pursue their goals. Structures are sites for social resonance (a central construct I address later), affording the creation of practices and schemas without an actor having full control over cultural production, reproduction and transformation. Enacted culture becomes a resource for subsequent actions of all participants, agency and passivity are enacted continuously, and we regard them as dialectically related. Since dialectically related constructs co-occur, each presupposing the existence of others, we do not seek causal, bivariate relationships, preferring instead to investigate relationships that are recursive and complex (Tobin, 2010a). This approach provides a novel theoretical window into science education, which has been dominated by conceptual change theory.

A massive amount of research embraces agency, in particular a discourse of argument, without explicitly taking account of passivity, which coexists as a dialectical partner with agency (Roth, 2007). Passivity concerns receptivity to learn, being open to learning by being in a field with others and coparticipating with them (Schön, 1985).

Learning from others about teaching and learning

As director of teacher education at the University of Pennsylvania I was concerned that prospective teachers struggled with only limited success to be effective teachers in urban schools. In 1997 we developed a plan for prospective teachers to meet with two or three students from an urban high school class they were teaching. The students were selected to be as different from one another as possible, and their main role was to respond to the question: "How can you better teach students like me?" Because we had simultaneously adopted a coteaching model for learning to teach, the group that met to discuss answers to these questions consisted of coteachers and selected students. When it was possible to do so university supervisors and the resident teacher from the school, who is a "mentor" for particular coteachers, began to participate in these conversations. We established a rule for participation in the activity, that only stakeholders who had been coparticipants in a particular class could be involved. We soon learned that many of the ideas suggested by students were of little value, and yet the conversations themselves seemed to build strong social bonds that transferred into the classroom in the sense that the students involved in small group discussions were cooperative with the coteachers and often assisted them to be effective. This observation carried the potential to use discussions like these to produce desirable forms of culture with the goal of transferring new culture to the classroom. Accordingly, the purposes of the activity were expanded around the construct of dialogue. Rather than privileging student voice we pursued a goal of equality for all voices and use of radical listening (described in the next section). Initially, we regarded the principal goal as negotiating and arriving at consensus about ways in which to improve the quality of learning and teaching. We opted for cogenerative dialogue (hereafter, cogen) as an apt

name for the activity, thereby embracing theoretical frameworks that became increasingly salient.

As we had more experience with this activity we noticed that an important outcome was that participants learned to work collaboratively to achieve shared goals. Furthermore, they learned to speak, listen, and participate in different ways. We observed that what they learned in cogen also was enacted in the classroom. When we realized the importance of this observation we adjusted our goals to give higher priority to the authenticity criteria we used in our research. We considered one of the most important outcomes to be learning new forms of culture that could potentially be enacted, as appropriate, in other fields of the lifeworld. Because of our standpoint that individuals and institutions should benefit from their participation in research we expanded the goal of teaching others about one another's standpoints to include understanding and learning from others' standpoints. Respecting rights of others to be different was central to this process. Also important was cogeneration of understanding and respect of others, solidarity, and identity inscriptions associated with belonging to this group and collaborating with its members to arrive at agreed to goals.

We value cosmopolitanism in the sense that all participants in a study are entitled to be in the world uniquely, to act in accordance with their personal frameworks, with the proviso that they respect others' uniqueness, rights to participate, and freedom to be different. The purpose of cogen is not to identify social truths and reach consensus on them, but to build understandings about others' responses to questions such as: "what is happening?" and, "why is it happening?" The primary goal of cogen is hermeneutic, making sense of others' stances and the potential they have for improving individual and collective attainment. Convincing others about particular perspectives is not a goal. Instead, participants are encouraged to listen, learn, and in so doing, change ontologies (not to colonize others' understandings hegemonically). As a result of participating in cogen individuals build an understanding of one another's standpoints as they are represented in their answers to what is happening and why it is happening. Accordingly, participants can come to understand one another's perspectives and values; that is, epistemologies, ontologies, and axiologies.

Cogen is a social activity in which successive actions are in synchrony across space and time. Although dialogue often focuses on audible speech we have in mind a broader view of dialogue that also includes self talk (Vygotsky, 1962). Consistent with the idea that speaking includes inner and outer talk; cogen embraces equality of speaking. We reject the behaviorist view that the only tool that counts is what another can observe (Kincheloe & Tobin, 2009). Instead we acknowledge the importance of inner speech and its hermeneutic roles. All participants can speak and be heard and have opportunities to learn from one another. In cogen participants act synchronously across time in terms of their own and others' actions (i. e., actions are in synchrony with self and other). Within a social group involved in cogen, when all actions occurring at a single moment in time are considered, synchrony would be observed among participants. When all moments in time that comprise an event are considered, entrainment, which consists of pervasive synchrony is a possibility. The route from synchrony to entrainment involves social resonance in which the emergence of particular structures affords passive processes that create culture without the actor intending this to happen. The process involved is not entirely agentic and actors may not be aware that new culture has been enacted. That is, enactments occur without the actors' intentions (i. e., agency) as structures

emerge and a “sense of the game” kicks in, affording patterns of enactment that bear a family resemblance to those enacted historically when structures like these were previously encountered. For example, somebody successfully solving a difficult problem at the front of the class might catalyze clapping and cheers from all or the majority of the class (Olitsky, 2007). Structures associated with the moment of success might constitute a field that affords entrained conduct, in this case clapping and cheering. Similarly, someone laughing during an awkward silence might catalyze entrained laughter.

Radical listening

Joe Kincheloe introduced me to radical listening, as part of a hermeneutic framework for research in education (Tobin, 2010b). In an endeavor to present the essence of radical listening and explicate its features I address several constituents, which can be considered as dialectically related. I emphasize that radical listening is a holistic construct that does not consist of temporally ordered parts. In terms of axiology, priority is given to focusing self-talk on learning from others and listening attentively to others’ verbal interaction while being receptive to learning from them. The process is dialectical and personal frameworks are used to make sense others’ oral contributions. Making sense of what others are saying and exploring the potential of their ideas is important in a process that consciously avoids attempts to refute others’ ideas. At least initially radical listening is agentic for most participants in a field, being grounded in an axiology that assigns priority to making sense of others’ oral contributions and the systems of logic that support them. The idea of “setting aside” personal frameworks is a metaphor for assigning them lower status as efforts are made to learn from others. What needs to be set aside is skepticism and radical doubt. Developing a solid understanding and considering the potential of those ideas is a goal, as is juxtaposing new understandings with prior understandings to develop an awareness of the added value of what is being learned. Care can be taken to avoid creating dichotomies such as self and other or better and worse. Difference is a resource for learning and adding hybrid vigor to systems of knowledge.

In radical listening there is a time to exercise radical doubt about others’ perspectives. Claims that a particular proposition is viable should be juxtaposed with likelihood that the opposite of those claims also is viable (Bourdieu & Wacquant, 1992). In our research this idea is consistent with Sewell’s theory of culture in which patterns having thin coherence are accompanied by contradictions (Sewell, 2005). Accordingly, any claims arising from our research are nuanced with contradictions—support for the idea that cultural

enactment is a site for struggle. Bringing polar opposites into dialectical relationships raises the possibility of creating hybrid vigor in a knowledge system and establishing nuance that accompanies claims about social truth. Importantly, any claim to truth always is associated with contradictions. The claims, which may be regarded as statements about coherence, always must be interpreted in the context of contradictions to those patterns of coherence that support the claims.

Learning from difference

Consistent with our explicit valuing of difference, we embrace theoretical bricolage, employing frameworks considered salient by researchers. The bricolage is fluid, theories being introduced and applied contingently, when and as necessary. We regard theories metaphorically as lights, illuminating experience in particular ways, while at the same time obscuring (Tobin, 2008). Acknowledging that theories illuminate and obscure provides impetus for the hermeneutic-phenomenological research in which we engage (Erickson, 1986), an approach that is both emergent and contingent on what is being learned. Emergence reflects continuous feedback loops that educate stakeholders about answers we obtain to two broad questions that frame our research—what is happening, and why is it happening? As we learn from a study our progressive subjectivities provide fresh insights as new objects for our curiosity arise. Hence, foci for research are contingent on what happens in a field and what we learn from what happens. Not only do foci for a study change, but so too do participants on whom the research focuses—that is, research foci depend on what happens and who is involved (Tobin, 2006).

Research is a way of being in social life, a form of social inquiry in which practices and associated schemas are produced continuously and change dynamically. A dialectical relationship between practices and schemas, as with all dialectical relationships, implies that the entities involved are constituents of the whole, presuppose one another, and incorporate contradictions. From this theoretical standpoint, research will always produce theory and transformed practices at individual and collective levels. Furthermore, all claims about research, represented as patterns having thin coherence, are characterized by contradictions. In representing what has been learned from research it is important to accept a crisis of representation; that cultural production is transcendent, beyond the grasp of what can be represented with language. Furthermore, because different participants have different ontologies, the research methods we employ are polyphonic, ensuring that diverse ontologies are represented in the research dialogue and contribute to nuanced outcomes that embrace theories and practices forged

within a context that values difference and its manifestation in polysemia. That is, outcomes of research will not converge toward one truth but will open up to support ongoing dialogue.

We believe in clearly communicating the purposes of our research to all participants, updating them on what we learn and changes we are considering to goals and design. We solicit their input on such matters and take account of what they suggest because we do not regard participants as subjects; that is, as identical objects to be studied and manipulated. Instead, we recognize each person's individuality and associated rights to hear and be heard. We acknowledge that participants in social life have different experiences and construe social truths in ways that reflect their positioning in social space and social categories with which they are associated (e. g., gender, ethnicity). That is, our research not only accepts polysemia, but also is designed to make it visible by ensuring that data resources are multi-voiced.

An important social criterion is how difference is considered within a collective. We regard difference as a resource for learning and design research to allow participants to become aware of one another's standpoints and learn from them. The purposes for our research include affording all participants, including researchers, opportunities to change their ontologies. What this means, in effect, is to change participants' stories. We employ hermeneutic lenses to consider ways in which ontology can change continuously, employing reflexive social inquiry whereby what happens and associated reasons for what happens become objects for reflection, creating contexts in which continuous, dynamic change is possible for all participants (Alvesson & Skoldberg, 2001). That is, the research design facilitates individual and collective inspection of answers to broad framing questions or to areas of curiosity. Stakeholders interact over answers to such questions and the extent to which individual and collective interests are met. Individuals can commit to changes that reflect their individuality as long as they do not act in ways to harm others and their actions are in synchrony with collective goals and others' practices. Difference is valued in terms of roles/divisions of labor and personal frameworks. We do not use a simple causal model for change, but instead embrace dialectical relationships among constructs including: changing ontology; understanding others' ontologies; and affording institutional and individual improvement.

Emotions

Emotions have a long history in educational research. For example, leading scholars such as Dewey (1894, 1895), Darwin (1872), and James (1884) studied emotions in the late 19th century. We view the

production and representation of emotions as central to learning in the sense that emotions are continuously produced and mediate all other production/enactment. From this standpoint our ongoing research includes theories of emotion from psychology, sociology, and social neuroscience. In the following subsections we address the expression of emotions in various ways that have been salient to our research.

Proxemic expression of emotions

Proxemics is central to our studies of participants' enactments in social fields and the 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 can arise from interactions among participants. The use of interaction ritual theory has allowed 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 & Llana, 2010). Most of our research on proxemics has employed digital files (images, video, and audio) together with a methodology we refer to as event oriented social inquiry (Tobin & Ritchie, 2012).

Recently we have included analyses of breathing patterns (abdominal and thoracic) used by participants in science classes. This has been a salient addition to our work because of the connection of breathing patterns to emotions. Although most changes in emotion occur passively, emotions and physiological variables can be manipulated. 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.

Prosodic expression of emotions

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. For example, in a recent study of teaching science we identified an event based on the teacher having a high pulse rate. 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. When we examined these peaks each was associated with a vowel that appeared to contribute a shrill sound to the phoneme. Here I use an analogy from high school physics; the frequencies that occur in a stretched string, such as is found in a guitar. If the string is plucked at the center the emitted sound consists mainly of the fundamental frequency, with lesser amounts of energy being distributed across discrete harmonics. In prosodic analysis of the human voice the fundamental and the harmonics are referred to as formants and are labeled F_0 , F_1 , F_2 , etc. In the analysis of the energy spikes 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 that contributed to high levels of annoyance. That is, before an in-the-moment emotion such as annoyance could die to zero it was rebuilt with another shrill utterance, thereby increasing to a higher level. Since shrill utterances occurred at intervals of a half second the result may have been an upward cascade of the intensity of annoyance. In this example, an initial shrill utterance and its regular reproduction every fraction of a second might act as a resonant structure for the production of high intensity annoyance. If the period of shrill sounds is sufficiently small the build up of annoyance might be considerable.

Facial expression of emotions

We employ Turner's framework consisting of combinations of primary and compound emotions (e. g., primary, secondary, tertiary etc.) in many studies of urban science classrooms (Turner, 2002). Primary emotions are happiness, sadness, fear, and anger. This theoretical framework, which is grounded in evolutionary theory and lends itself to microanalysis, is a staple in our multi-level, multi-theoretical approach that includes analyses of conversation, prosody, proxemics, and facial expression (Tobin & Ritchie, 2012). In addition, we use Ekman's widely used framework to analyze facial expression of emotion (Ekman, 2004), which complements Turner's theory (Turner, 2007). In our hermeneutic-phenomenological interpretive research we use online resources to train researchers to use Ekman's scheme to analyze emotions from facial expressions (<https://face.paulekman.com/face/default.aspx>). We find the framework especially valuable when we use video frames as resources for analysis. Also, we use eMotion software to undertake electronic analysis

of emotions expressed in the face (Sebe et al., 2006). 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 as far as using the software is concerned is that dependable measures can only be obtained from a full face. The software is valid only for situations in which the camera focuses on the full face. For this reason, we use the software most frequently when participants review selected video vignettes as part of a study. In this situation we use the camera from the computer screen to capture full facial images as participants review video events.

Physiological expression of emotions

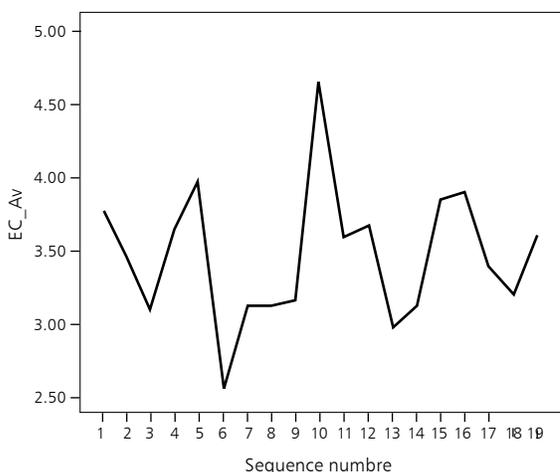
The relationship between emotions and physiology was established in the late nineteenth century (e. g., James, 1884). In our research we use finger pulse oximetry to obtain measures of heart beat rate, percentage of oxygen in the blood, and strength of the heartbeat. Our preliminary results indicate that teachers often have a high heartbeat rate and oxygen levels in the blood fluctuate from 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 participants' emotions as they are measured in-the-moment from facial expression and prosody. Such analyses provide a micro view of ways in which teaching, learning, and expression of emotions are related to wellness. The results contribute to a theory of teaching and learning and provide baseline data that 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 heart beat rate and oxygenation levels to levels particular individuals find acceptable.

Emotional climate

Durkheim (1912) noted that emotions saturate extant social artifacts with which they are associated. These include material and symbolic resources such as location, teacher, question, gesture, body stance, and prosodic features. Activities and events also can be imbued with an associated emotional valence and intensity. We measure emotional climate (EC) at regular time intervals during a lesson. For example, during a recent study involving teacher education candidates at Brooklyn College we used audience response software (i. e., clickers) to rate EC on a five-point scale for each

5 min. interval and transmit them to a laptop computer via Bluetooth. In the 2.5-hour class we obtained dependable EC measures from each of the students in the class and the teacher. Similarly, in ongoing research in Australia time intervals of 3 minutes have proved optimal for measuring EC.

Figure 1.
Changes in EC as a function of time (at intervals of 5 minutes)



Source: Tobin, Ritchie, Hudson, Oakley and Mergard (2013)

Figure 1 provides an example of a typical average EC versus time plot (5=very positive; 4= positive; 3=neutral; 2=negative; 1=very negative). We use spikes in the curve, or peaks and valleys, to identify parts of a lesson that might warrant further research. For example we might decide to analyze vignettes associated with discernible peaks to identify patterns of coherence and associated contradictions. Similarly, we might look at valleys, identifying vignettes for each valley and analyzing them to create patterns of coherence and associated contradictions within valleys.

Any time a participant clicks a clicker s/he does so as an individual who is interconnected with multiple collectives. The individual presupposes the collectives and vice versa. Accordingly, each click is saturated with membership of all social categories that apply to the individual, including race, ethnicity, languages, religion, etc. Each click represents a person's perceptions of the valence and magnitude of extant emotions in a given period. Emotional climate structures a field, along with other structures such as time, space, characteristics of conversation, history, etc. That is, EC is dialectical—a whole comprised of all structures that define a field, as it is historically constituted. Importantly, EC can be reproduced at a later time when individuals encounter/experience structures that bear a

family resemblance to those originally associated with a given EC. The reproduction of EC in this way is beyond the full control of participants and is an example of social resonance, whereby structures create autonomous conditions that afford historically constituted knowledge to come to hand fluently, i. e., when they are timely, appropriate, and anticipatory.

EC data are statistically dependable for differentiating participants and generalizing over time intervals. Typically, the reliability coefficients for this purpose exceed 0.9. This is an indication that whatever a click represents, respondents are consistent in their clicks throughout a lesson. In contrast, the reliability coefficient for differentiating time intervals and generalizing over students is typically much lower, a sign that suggests caution in using these measures in statistical analysis to respond to questions that compare time intervals. We do not employ inferential statistics to test hypotheses about EC but use clicker data along with numerous other resources in a hermeneutic-phenomenological project. Typically we create a plot for the average of all participants for each time interval so that students can compare their individual ratings to the class average. Such comparisons can point to patterns and contradictions that can focus dialogue and define events for event-oriented inquiry.

Intervening to transform individuals and institutions

A low-grade intervention to increase mindfulness

Based on research in social neuroscience we were interested in aspects of wellness in teaching and learning. As I mentioned earlier there were examples in our research that suggested that high emotional intensity might be deleterious for teachers and students. Classes did not seem to be sufficiently mindful and that was cause for concern. We predicted that an increase in mindfulness would enhance wellness. For example, Davidson et al. (2003, p. 564) reported that mindfulness, involving meditation, produces demonstrable effects on brain and immune function. Meditation can be associated with obtaining control over the body and the mind, often through focusing on some aspects of the body, such as breathing. In addition, Davidson's (2010) research in neural processing and mindfulness suggests that participation in focused activity is beneficial to the structure and functioning of the brain. A concern expressed by Brown and Ryan (2003) arises when individuals do not focus during activity and are distracted by multiple tasks and anxieties grounded in past experience and possible futures (i. e., they do not exhibit mindfulness). That is, attachment to emotions can reduce focus, productivity, and physical well-being.

Table 1.

Characteristics included in the mindfulness in education heuristic

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

Source: Powietrzynska and Tobin 2003

Brown, Ryan, and Creswell (2007, p. 212) described 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). Mindfulness can be contextualized in ordinary daily activities such as eating, sitting, walking, breathing, stretching, seeing, and hearing. 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.

We regard mindfulness interventions as advantageous for mental health, well-being, physical health, self-regulation, and interpersonal conduct. We developed a "Mindfulness in Education heuristic" to be used as a low-grade intervention to make science classes more mindful. The mindfulness heuristic consists of 29 characteristics (Table 1) initially derived from validated mindfulness surveys (e. g., Baer & Sauer, 2009) and our ongoing studies situated in science teacher education and an international study of mindfulness in science education. We expect an increase in mindfulness to

ameliorate ways in which emotions play a part in the teaching and learning of science. We plan to use the mindfulness heuristic in planning lessons, doing interpretive research on what happens in science classes, and considering changes to participants' roles and practices.

The first step in planning a low-grade intervention is to create a heuristic for the activity to be enacted, including salient characteristics and a 5-point rating scale so that respondents can assess the frequency of occurrence of each characteristic. A heuristic can be used to survey participants' perceptions concerning the occurrence of the characteristics, providing a landscape and allowing for contextualization of responses, raising awareness, and affording changes of practice. A heuristic fleshes out a social construct to reveal some of its characteristics and thereby affords the process of coming to know the construct in ways that facilitate reflection and catalyze changes relating to salient aspects of social life. In the development of heuristics we thought that a good place to start involved creating what would look like a survey. We would explicate characteristics of a construct such as mindfulness in short statements about the construct with the purpose of covering the field of the construct in a selected context (e. g., a science classroom). The short statements serve the purpose of bringing particular characteristics to the awareness of those who use the heuristic. Use of a Likert scale affords participants connecting each characteristic to their perceptions of its frequency of occurrence in a specific field. A heuristic pays attention to difference as well as central tendency. Care is given to making sure that characteristics that are "the essence" of a construct are included in the heuristic. We try not to be repetitive, but instead include characteristics to stimulate thought about a valued social construct. 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 shape for contexts of interest. Characteristics chosen for the heuristic depend on circumstances considered salient in the context.

Abdominal breathing as a high-grade intervention

Based on research undertaken by Davidson and his colleagues (2003) we introduced meditation practices using abdominal breathing; for three minutes at the beginning and in the middle of each lesson in a teacher education program. The purpose of the intervention was to provide urban science teachers with a tool they could use to mediate emotions and quiet the mind—to increase mindfulness. We prioritized a value that learning environments should be healthy for all participants. The intervention was intended to make all participants aware of relationships between well-being, emotions, and physiology. Abdominal breathing addressed a potential problem that strong negative emotions could disrupt science learning and in the long term catalyze disease.

In addition to the high-grade interventions undertaken at a whole class level we used abdominal breathing as an intervention when pulse rates exceeded a threshold level (advising teachers when their pulse rate exceeded 120 bpm). Similarly, when oxygenation dropped below 92% we informed the teacher with the suggestion to use abdominal breathing to increase the level of oxygenation. We used two former students from the class to enact the abdominal breathing intervention at a whole class level. One student gave instructions while facing the class and modeling abdominal breathing. The other person showed the class a side view of her body to highlight abdomen expansion and contraction with the in-breath

and out-breath respectively. The oral instructions suggested participants sit comfortably on a chair, place their feet flat on the floor, and spread their hands across their abdomen. When participants breathed in their abdomens expanded and when they breathed out their abdomens contracted, pushing back to the spine. Participants were told to concentrate on their breath and when a thought came to them to label it as a thought and return their focus to the breath. If participants experienced an emotion they were asked to label it (e. g., annoyance) and refocus on the breath. Participants were advised not to judge the quality of their abdominal breathing, just to do it and try to retain focus.

Cultural Studies of Science Education

At the moment of writing this paper we have just published Issue 3 of Volume 7 of *Cultural Studies of Science Education* (CSSE). Already we have published in excess of 7000 pages focused on the goals of the Journal, plus we have a book series with the same name. In 2005 I met with Wolff-Michael Roth to plan a new journal that sought to publish papers to embrace theoretical frameworks from cultural studies and address science education in broad terms used to conceptualize science and education. The problem we perceived was that an increasing number of science education journals catered to a mainstream associated with conceptual change and its advances. We did not abhor the mainstream and work published in those journals, but wanted CSSE to give priority to theoretically rich research that was grounded in myriad disciplines that incorporate sociocultural theory. The journal was established to be different from the status quo, to create novel forms of scholarship that often were extinguished in their embryonic forms because they did not fit comfortably in the mainstream flux. The pressure to conform to the mainstream was relentless and we were committed to nourishing new areas of scholarship and scholars who employed frameworks associated with cultural studies of science education.

Representing research as an article

We wanted to encourage researchers to represent their research authentically. We took the stance that authoring of an article should be the prerogative of authors rather than editors, but in the open (i. e., not blinded) peer-reviewed process we employed, authors would rethink ways in which they infused theory, others' research, and methods employed. Our value stance is that each of these should be woven into an unfolding research text when and as needed. We are opposed to a tradition of frontloading, whereby authors place this important information before presenting their results and associated discussion. As an alternative we envision articles that provide results (i. e., what is learned from the study) in ways that integrate with prior relevant research, salient theory, methods employed, and implications of what was learned for various forms of practice. Research literature that is salient to a study would be connected with specific details that illuminate the research and show how the study being reported is situated in the larger scholarly literature. We discourage use of generic labels for important sections of a paper such as: Introduction, Literature of Review, Theoretical Framework, Methods, Results, and Conclusions. Our strong preference is for headings to be relevant to the substance of the material contained in a section or subsection. All citations are to be substantive and contribute to a paper that is dialogic in its basic structure and deeply respectful of others' scholarly work. We adopt an educational

policy to disallow all examples of symbolic citation in which it is not clear what each cited resource contributes to the research.

We carefully reconsidered the purposes of publishing research. We regard texts as contributions to an ongoing conversation that begin at some earlier point in time and continue long after publication of present texts and associated Forums. Accordingly, we expect authors to expand a conversation in their texts rather than to converge on “settled” issues. We embrace a framework in which difference is a resource for learning and value highly forms of inquiry that do more than identify patterns of coherence on which strong claims are made about what is learned from research. Instead we request authors to nuance claims and attend carefully to difference as well as coherence.

Peer review is open and not blind

To the extent possible we level the playing field as far as power is concerned in the review process. We adopt a policy of not using titles such as doctor or professor, preferring instead to communicate using first names. Also, we endeavor to maximize the autonomy for authors —making suggestions to potentially improve the paper, identifying issues to consider, and suggesting issues to pursue in a Forum associated with the paper. We seek to adopt radical listening whereby we use a hermeneutic approach to making sense of the manuscript and identify its strengths before we address what we consider to be weaknesses.

As an editorial board we endeavor to be open to a variety of frameworks, guarding against privileging our own preferences. Instead, we expect and require clear explication of theoretical frameworks and methodologies. These are to be well developed and used to the advantage of the research. Just how this is done is the prerogative of the author.

Some of the very worst review practices imaginable occur under the cloak of double blind peer review and other forms of blinding reviewers and authors. Often anonymous reviewers are uncaring, privilege mainstream perspectives and practices, and adopt deficit perspectives in regard to nonalignment and non-compliance. We insist that peer review improves the quality of research and includes diverse perspectives. Consistent with our view of research as dialogue we regard authors, lead editors, reviewers, and readers (of the journal) as coparticipants in ongoing dialogue. As long as a manuscript is consistent with the mission of the Journal, the purpose of review is to assist authors to present their research in a robust and viable form. We do not stipulate limitations on length and leave the decision for accepting and rejecting manuscripts with lead editors and editors-in-chief. Reviewers do not vote to decide what will be published in the journal —this is a decision for editors. The results so far are encouraging, although the process is time demanding because manuscripts go through many iterations before they are ready for publication. Also, our stances with respect to peer review are dynamic rather than static. We ask reviewers to provide feedback to authors to improve the quality of the published manuscript while beginning a Forum article that expands the dialogue initiated in the original paper. It is often the case that reviewers see their role in a Forum as highlighting flaws in the original paper rather than expanding the conversation around the tenets developed in the original paper. In such cases we stick to our stance and insist that the chief purpose of the Forum is to expand the dialogue. Although we expect and encourage participants in a Forum to present different points of view we also see value in them embracing “radical listening” and building on the possibilities addressed in the original paper.

The inclusion of a Forum for each published paper is consistent with the stance that research is multi-voiced and can be explicated by stakeholders occupying different niches in social life—representing an area of scholarship in texts, metaphors, symbols, and images that reflect their life worlds (i. e., research is polyphonic). Furthermore, robust, alternative perspectives can reflect different realities concerning what is happening and why it is happening. These differences are not to be resolved by negotiating consensus but to push hermeneutically to learn from submitted papers and expand understandings of each advanced perspective. A Forum embraces polysemia and the goal is not to produce a winner but instead to lay out robust alternatives regarding issues that flow from the original paper along with their rationale.

Initially we endeavored to produce and publish interactive Forums involving authors of the original paper, lead editor, and reviewers. However, such Forums did not align well with the reward structures of the Academy, which favor single authored papers that look like a paper rather than dialogue. Accordingly, a preference evolved for the Forum to consist of 1-3 review essays with a rejoinder from the authors of the original paper. This model has potential hazards in that review essays might pick holes in the original paper and try to present a superior, rather than alternative, perspective. Also, a rejoinder might reiterate what is already in the original paper in an effort to defend “turf”. If either of these scenarios occurs we regard the situation as not a good use of journal pages in the sense that the goals of the journal are not met.

The reach of CSSE is envisioned as international and we afford this goal through the appointment of an editorial board that is global. In addition, we strongly encourage authors from around the world and at all levels of the career ladder. Also, we address English imperialism by inviting authors to publish an Executive Summary in a language other than English. The rationale is that the availability of an Executive Summary in a language other than English facilitates dissemination of research that embraces the perspectives published in the journal. Whether an Executive Summary is written is appropriately a decision for authors of the original and Forum papers. Similarly, authors can opt to publish an Executive Summary in multiple languages. Editorially we set the default position as having an Executive Summary, to send a signal that CSSE embraces languages other than English. Unfortunately, due to policies of the publisher, we are unable to publish original articles in languages other than English.

When we began the project of the CSSE Journal, we regarded the community that would potentially contribute to the Journal as diverse. The Journal was a place for scholars to learn from one another.

Accordingly, we invited science educators (broadly defined), scientists, and scholars with a background in sociocultural theory to contribute to CSSE. Of course the focus of articles is on science education, although relevance to science education is judged in terms of the original paper plus the Forum papers, not on the focus of separate papers considered in isolation.

Adapting to pushback

Since CSSE went to press we have been highly successful in attaining our goals of attracting and publishing cutting-edge research, recruiting the best scholars to participate in the editorial board from an international community, and meeting the annual page quota of 1000 pages a year without creating a backlog of manuscripts awaiting publication. We have decentralized decision-making to include all members of an expanding editorial board as Lead Editor's, and all lead editors have the chance to produce special issues on topics of interest. In addition, we have created an annual conference to initiate new directions and address priorities in science education. At the same time we have experienced significant pushback from the establishment.

Countries like Australia instigated a system of ranking journals, which heavily favored mainstream journals and resulted in CSSE being relegated to a lower ranking than more established journals. Significantly, journals that were not included in the Thomson ISI-Web of Science database were not ranked in the top tier and junior scholars were warned only to publish in top-tier journals. Even though Australia discontinued its ranking system it is still used de facto in Australia and many other countries in the world. Even more disturbing is that many the tenets associated with the rationale for the ranking system of the stipulation that inclusion in the Thomson ISI-Web of Science database is the sole criterion of top tier has spread almost worldwide, dramatically increasing pressure to conform to criteria for inclusion in the Web of Science database. Inevitably this creates pressure to increase rejection rates and adhere to other criteria that probably count against inclusion by those making decisions about acceptance by the Web of Science. The most obvious example is the adoption of double blind peer review—but this would violate the reason for CSSE existing in the first place. As we move forward we must strive to improve while addressing the contradiction that out and need to be different militates against our acceptance as top-tier.

On the road ahead

Research in science education has failed to impact policy and practice writ large. Furthermore, in

(almost) 50 years I have been involved in science education there has been an inertia associated with a mainstream that embraces many of the tenets of positivism and methodological scientism (Kincheloe & Tobin, 2009). All manner of pressures are applied to scholars to align with mainstream practices that favor a status quo that is manifestly impotent—a reactive institution that is unable to mediate policy and practice. The pressure to align and conform crosses boundaries associated with key elements of the Academy including publishing, getting funded, and earning tenure. What is important to adherents of sociocultural perspectives such as those described in this paper is a necessity to thrive in an environment that is somewhat hostile while inviting scholarly critique that is necessary to produce a robust methodology enriched by dialogue, difference, and radical doubt. It is important for new methodologies to be dynamic and embrace hybrid vigor built around multi-disciplinary frameworks and methodologies and a willingness to transcend social levels that extend from global to molecular. At the bottom line science education researchers must be learners who are flexibly adaptive.

About the author

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