Transformative Science Education Through Action Research And Self-Study Practices

Olga Calderon

Graduate Center, City University of New York

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TRANSFORMATIVE SCIENCE EDUCATION THROUGH
ACTION RESEARCH AND SELF-STUDY PRACTICES

By

OLGA CALDERÓN

A dissertation submitted to the Graduate Faculty in Urban Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

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This manuscript has been read and accepted for the Graduate Faculty in Urban Education in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy

Dr. Kenneth Tobin

________________________  ____________________________
Date  Chair of Examining Committee

Dr. Anthony D. Picciano

________________________  ____________________________
Date  Executive Officer

Dr. Kenneth Tobin

Dr. Gillian Bayne

Dr. Konstantinos Alexakos

Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK
Abstract

TRANSFORMATIVE SCIENCE EDUCATION THROUGH ACTION RESEARCH AND SELF-STUDY PRACTICES

by

Olga Calderón

Adviser: Dr. Kenneth Tobin

The research studies human emotions through diverse methods and theoretical lenses. My intention in using this approach is to provide alternative ways of perceiving and interpreting emotions being experienced in the moment of arousal. Emotions are fundamental in human interactions because they are essential in the development of effective relationships of any kind and they can also mediate hostility towards others. I begin by presenting an impressionist auto-ethnography, which narrates a personal account of how science and scientific inquiry has been entrenched in me since childhood. I describe how emotions are an important part of how I perceive and respond to the world around me. I describe science in my life in terms of natural environments, which were the initial source of scientific wonder and bafflement for me. In this auto-ethnography, I recount how social interactions shaped my perceptions about people, the world, and my education trajectory. Furthermore, I illustrate how sociocultural structures are used in different contexts to mediate several life decisions that enable me to pursue a career in science and science education. I also reflect on how some of those sociocultural aspects mediated my emotional wellness. I reveal how my life and science are interconnected and I present my story as a segue to the remainder of the dissertation.
In chapters 2 and 3, I address a methodology and associated methods for research on facial expression of emotion. I use a facial action coding system developed by Paul Ekman in the 1970s (Ekman, 2002) to study facial representation of emotions. In chapters 4 and 5, I review the history of oximetry and ways in which an oximeter can be used to obtain information on the physiological expression of emotions. I examine oximetry data in relation to emotional physiology in three different aspects; pulse rate, oxygenation of the blood, and plethysmography (i.e., strength of pulse). In chapters 3 and 5, I include data and observations collected in a science education course for science teachers at Brooklyn College. These observations are only a small part on a larger study of emotions and mindfulness in the science classroom by a group of researchers of the City University of New York. In this context, I explore how, while teaching and learning science, emotions are represented facially and physiologically in terms of oxygenation of the blood and pulse rate and strength.
Dedication

To every science student that have struggled to achieve his/her goals and persevered against all odds.
ACKNOWLEDGEMENTS

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# TABLE OF CONTENTS

**ABSTRACT** .................................................................................................................. iv  
**DEDICATION** ................................................................................................................ vi  
**AKNOWLEDGEMENTS** ................................................................................................ vii  

**Chapter 1** .......................................................................................................................... 1  
**BECOMING A SCIENCE EDUCATOR** ................................................................................. 1  
  A whole new world ........................................................................................................ 3  
  Carrying another’s burden .......................................................................................... 5  
  I found home! ............................................................................................................... 7  
  The white picket fences in my heart ............................................................................ 9  
  Who is moving my floor? ............................................................................................ 10  
  Face to face with reality ............................................................................................ 11  
  Metamorphosis the evolution of my being .............................................................. 13  
  Arriving at the comfort zone ..................................................................................... 13  
  The mind, body and soul never cease to evolve ...................................................... 14  
  Who is my mother? .................................................................................................... 15  
  Doña Gabriela succumbs to her fate! ........................................................................ 21  
  The beauty of death .................................................................................................. 26  
  The emotions of animals ......................................................................................... 28  
  Gracie’s farewell ...................................................................................................... 29
It takes a village 29

Chapter 2 31

FACIAL EXPRESSION OF EMOTIONS

HISTORICAL BACKGROUND 31

What are emotions? 31

Anatomy and physiology of emotions 34

Emotions in the classroom 43

Reading facial expression of emotion 45

F.A.C.S training 47

Action units and their meaning 50

F.A.C.S on-line 52

Chapter 3 55

EMOTIONAL AWARENESS IN THE SCIENCE CLASSROOM THROUGH THE LENS OF
FACIAL ANALYSIS USING A HUMAN FACIAL RECOGNITION PROGRAM

Brooklyn College study 55

Is Louise just having a “bad” day? 60

Louise’s Déjà vu 63

Emotions reaffirmed 65

Learning from this experience 68

Chapter 4 75

x
OXIMETRY AS A REFLEXIVE TOOL FOR THE DETECTION OF PHYSIOLOGICAL EXPRESSION OF EMOTIONS IN THE SCIENCE CLASSROOM

Historical and physiological background of oximetry ........................................ 75

  Historical background of oximetry .......................................................... 75

  Why use this medical device in class? ...................................................... 77

  The development of the oximeter .......................................................... 78

  Physiology of respiration; cardiac cycle; hypoxia; and pulse oximetry .......... 81

  Special conditions and respiratory deficiencies ....................................... 86

  Assessing changes in blood-oxygen saturation by Plethysmography .......... 89

  Limitations of oximeter ........................................................................... 91

Chapter 5 ....................................................................................................... 93

OXIMETRY – TALES FROM THE FIELD

Research participant experience and intervention ....................................... 93

  What is going on with Zofia? ................................................................. 94

  Physiology of a dream ............................................................................ 99

  Possible implications to our observations .............................................. 102

Chapter 6 ....................................................................................................... 107

CONNECTIONS & IMPLICATIONS ............................................................... 107

  Teachers as researchers ................................................................. 107

  What I learned ..................................................................................... 108

  Emotional awareness ......................................................................... 110
LIST OF FIGURES

Chapter 2
Fig 1 Brain scan showing the subcortex, neocortex ........................................... 35
Fig 2 Facial muscle anatomy of emotions............................................................. 41
Fig 3 Superficial structures associated with facial expression of emotions.......... 49

Chapter 3
Fig 1 Louise facial expression of emotions using FACS........................................ 63
Fig 2 Facial expressions in the moment............................................................... 64
Fig 3 Collective effervescence – laughter........................................................... 70
Fig 4 Emotional contagion................................................................................ 72

Chapter 4
Fig 1 Human respiratory and circulatory system............................................... 85
Fig 2 Oximetry display of oxygen saturation, heart rate and plethysmograph....... 91

Chapter 5
Fig 1 Pulse oximeter output in computer through Bluetooth technology............. 94
Fig 2 Sophia’s oxygen saturation, heart rate and plethysmographic output week 3 95-96
Fig 3 Sophia’s oxygen saturation, heart rate and plethysmographic output week 12 98
Fig 4 Louise’s spO2, heart rate and Plethy pulse oximeter output........................ 100

Afterword
Fig 1 Olga’s oxygen saturation, heart rate and plethysmograph outputs.............. 123-124

LIST OF TABLES
Chapter 3
Table 1 Louise’s emotional profile.................................................................... 62

Chapter 5
Table 1 Pulse oximeter output for Zofia week 3.................................................. 97
Table 2 Pulse oximeter output for Zofia week 12.............................................. 97
Table 1 Oximeter output for Olga.......................................................... 123

LIST OF GRAPHS
Chapter 4
Graph 1 (Renesas Electronics, 2011)...................................................... 81
Chapter 1

BECOMING A SCIENCE EDUCATOR

The individual has always had to struggle to keep from being overwhelmed by the tribe. If you try it, you will be lonely often, and sometimes frightened. But no price is too high to pay for the privilege of owning yourself (Nietzsche, 2013.)

Recently, a few of my colleagues and I were recognized in a special ceremony that acknowledges the scholarly achievements of the past year by the institution where we work. As I celebrated my first scientific publication with my peers, I reflected back on how I used to play being a scientist when I was about six or seven years old back in Colombia. My brother and I designed experiments in the backyard and observed the outcome of the chemical reactions of household and food products that we so enthusiastically mixed and buried under soil. We really did not have any science background. I was in first grade and my brother in second grade, yet it seemed that our interest in science and inquiry had an innate quality. We did not suspect then, that our lives would take the road to science. Our inquisitive minds were not limited to observing the reactions of the solutions we were mixing. We would observe invertebrates, plants, vertebrates and everything that surrounded us. What was the most fun, was trying to make sense of the world and how things worked. I must say it was a very fun childhood. I remember the droughts during the summer months and how they affected our community. Water would be rationed and whatever amount we could get once per week by a delivery truck, had to be saved for cooking and drinking. The water needed for other household chores and bathing, we would have to be carried from a natural aquifer that was located about a half a mile from our house. I remember carrying the laundry with one of my older sisters to a stream that was about a thirty minute walk from our house. For me, the outing always turned into a field day. While my sister
washed our clothes, I was romping around in green fields and exploring the natural surroundings. I recall submerging my feet in the stream and feeling small fish tickling my feet while swimming around me, probably seeing me as a potential piece of food. I also scavenged for fruits. I used to climb up mango trees and watch a white sticky sap emerge as I pulled mangos from their branches. Everything was an object of curiosity and I always wondered if the tree was bleeding like we bleed when we fall and scratch our knees or if the tree was crying, because I pulled one of its fruits. When I am out in the field collecting my insect specimens for my biological research, I think of the headache I had during one of my outings after I disturbed a wasp hive while pulling black and red raspberries from a bush. I must have gotten a dozen stings on my head that day. Indeed, it was a memorable childhood and even though resources were limited, and my father was the only one working to support six children and my mom, we never went to bed hungry.

One day when I was seventeen years old and while finishing eleventh grade, I shared my future aspirations with my mother to attend college. My mother’s response was discouraging to say the least. She said that the only one that was going to be supported to go to college was my brother and that instead we, the five girls, were expected to follow her footsteps of finishing high school, finding a husband and raising a family of our own. This event triggered a spark inside me; I realized that I had to make some decisions that would affect the rest of my life.

As young as I was, I dreamed of building a family of my own, but before that I wanted to accomplish other goals that were important for me. Although, I did not know at that time what career I was going to follow, there was no doubt in my mind that I wanted to obtain a college education. I had ambitions for something different in my life. Yes, I wanted to have all of the things associated with a happy life and it included some of the traditions embedded in my identity. I wanted a lot of the things that I grew up knowing and that were part of my culture. I
thought I had it all figured out. I would work hard, attend college, build a career and eventually find a life partner that could provide emotional stability for our children when they arrived and me. In my mind, the limitations that I was faced with at that point were just hurdles that I needed to overcome to get to that place where I would build my life as an adult. This was also a very crucial moment in the lives of many young people in Colombia. It was the period of the early eighties and drug trafficking was increasing. Drug cartels were recruiting young people to serve as mules that could transport drugs and supply the international demand for drugs. Many people I knew took the opportunity to make money that way. Those that did not have much money growing up seized this opportunity that was offered to them. Money could come easily for those that were willing to get involved in the drug trafficking business. I always wondered what was different between some of the young people my age that grew up in similar conditions to mine and decided to make money through the drug trade. We had similar needs, yet my ambitions were of a different kind. I wanted to learn many more things and be educated beyond high school, so I went to my aunt and borrowed money from her to travel to the United States.

A whole new world

I arrived in the United States on a hot and humid summer night in August. I carried with me a light suitcase with clothes that still had the aroma of the mountains. Together with my clothes I also brought a load of dreams and hopes of finding what I wished for my life to be. I was only seventeen and I was scared and anxious about my unknown future. This was the beginning of my life in a strange country, with a different language to the one I knew. I only knew a few words that I remembered from my English classes back in school. It was a drastic change from the life I knew, but I had made the decision of leaving home, thinking that I could have a different life than the one that was expected of me from my family. I was only seventeen
and the best job I could find according to the skills I possessed at that point, was as a housekeeper. I thought it was an honest job and I earned enough to pay for rent and food. My decision to leave Colombia was just the beginning of a series of decisions against what the typical norm my Latino culture has set for women. According to my culture’s social role for women, I was supposed to be obedient and learn the duties of a good wife and mother. Developing housewife skills would have fulfilled my responsibility and obligations as a respectful woman in the typical Latino social circle. That decision changed my life path and that would turn me into who I am now, “an uppity woman.” I am using the term *uppity woman* to describe how I am often perceived by my ethnic culture. I am a woman of a strong and rebellious nature who lives life against the status quo.

I got acclimated to life in the United States pretty quickly. As much as I missed my mother and siblings, I did not miss the life I had back in Colombia. My father lived in New Jersey and I shared an apartment in New York with one of my older sisters who had come to the US a year before. I did not have my green card, so while I waited for my father to request one for me, I enrolled in English as a second language classes at York College of the City University of New York. I was determined to learn the language and become acculturated into the American way of life. I made it a point to listen to the radio and television in English, read the paper and magazines in English, so that I could enrich my language learning experience, and I did. I was not afraid to speak, even with my heavy accent and wrong pronunciation of words. I was learning and actually getting better at speaking and writing the language. Once I finished with my English courses, I enrolled in a GED program at the same institution. I was determined to pick up where I left off when I left high school back home. I received my GED certification and
continued work while waiting for my legal status as a New York State resident to be resolved. Then I could start my college career.

**Carrying another’s burden**

While I waited for my residency, my father brought my brother and younger sister from Colombia to live with me in New York. My father wanted my brother to come and work here and at the same time go to school, so he could help out with the expenses of the family. My brother had to stop his career of chemical engineering in Colombia, but he intended to continue with it in the US. At this point, I was living with both my older brother and younger sister who was only ten years old. I was working two jobs to keep up with expenses here and I would send money to my mother who was still in Colombia. It was decided that my brother would attend school full-time to learn the language and then he could apply to college to continue his education. Between my father and I, we continued covering the family’s living expenses. One day, my father came to visit us and I had an argument with him about finances. My father decided he was going to take my younger sister to live in New Jersey and pay someone for her care. Before he came to take my sister away I bought a plane ticket and sent my younger sister back to Colombia to be with my mother. My father was furious about what I did. He was so offended that he disowned me and did not want to see me or talk to me. I went to see him and I spoke to him of the reason I did what I did, and why it was the right thing to do. I told him that my little sister was still just a child, she had been separated from her mother, taken to a strange country where a strange language was spoken and I did not think it was in her best interest to live with someone she did not know. My father did not speak at all that day. His dark eyebrows, gray hair and Mediterranean features showed nothing but anger and sadness. My heart was broken, because I loved my father, and I always had such great respect and admiration for him. I felt I
had caused him great disillusionment. My father, the person that had sacrificed his life away from his children and wife to sustain us and give us what we needed, was hurting. I had caused that pain. I did not regret what I had done, but with my heart in his hands I asked him to forgive me. I also promised him that I would bring both my younger sister and my mother one day to the US. I left that day convinced that my father would never speak to me again.

Six months after the incident with my father, I met him for my legal status interview. He barely spoke to me, but at the end of our meeting, I informed him that my little sister and my mother were scheduled to arrive in New York within two weeks. I still remember his facial expression. He was surprised and asked whether what I had just said was true. I reiterated how I had promised him to bring my sister back to the US together with my mother. I do not think my father ever expected me to bring my sister back, much less, to bring my mother too at the same time! My actions six months before that day did not make any sense to him or anyone in my family. For me, it was the right thing to do for my sister’s sake. The entire incident and the dynamics of our father-daughter relationship are quite interesting to me. After that event, my father and I had a very different and mature relationship. We would talk about things that we never talked about before since he lived away from us for a major part of our lives. My father only finished second grade, but he was a very smart man. He was well read and could entertain any type of intellectual conversation---from world events, history, geography, arts, and literature to science. He was an avid connoisseur of nature and one thing that I remember about him, was his love for animals and knowledge. Later on, we would have long talks about what I was learning in my science classes when I started my college education. He was a quick learner and he held a job as a laboratory technician in a company that made plastics for the car industry. We had a great relationship until he died. I feel proud of being his daughter and honored to be
extension of a man with a great heart and love for his family and for every creature that crossed his path.

I finally got my legal status in the mid-eighties; I had filled-out an application for admission at The City College of New York, but unfortunately I had not scored high enough in my math and English skills to be admitted into a CUNY senior college. I was advised to attend a community college where I could equip myself with the skills I needed to move on and eventually transfer to a senior college.

I found home!

Finally in September 1985, five years after arriving in the United States, I was in college! It was a challenging process, because I was still working two jobs to help support my family. I applied for financial aid, but it was denied to me, so I had to pay for my classes out of pocket. This was a good reason to keep my two jobs and continue working full-time. I enrolled in one reading comprehension class at eight in the morning five days per week. I would go to my two jobs after my class every day and get home at eleven o’clock at night. I was so excited about how I was advancing and was so happy about the fact that I finally had made it to college that I did not care what it took for me to make it through.

In the meantime, my brother had quit his career of chemistry at City College and had gone back to Colombia, because he did not like living here. My father and I were basically still supporting him. The demands of school and two jobs started to take a toll on me and in a conversation with my mother, I told her that I could not support my brother anymore and that he was to come back to the US to work and study like I did, so that he could help out with the finances. My mother was adamant about what I was proposing. A hegemonic perception that persists in the region of Colombia where I was born concerns social power and a patriarchal
system that positions men as the central figures holding power and control. The situation is complicated. My experience convince me that, in a number of respects, that the underlying authority is held by women. For instance, for many generations women in my family enable men to feel in control, but the women make life-changing decisions for the family. I struggled with this relationship between men and women, because it involves a codependency; a dialectic relationship between oppressed and oppressor. This relationship is strongly rooted in past generations and it is extremely hard to change. My mother comes in part from a matriarchal social system that provides her with power, which she often uses to the disadvantage of women. That is, she has the power, but uses it to support the “normality” that advantages males over females. For example, her beliefs were that women should be prepared to be wives and mothers, a point of view that disadvantaged me since I was supposed to give up my career and opportunities for higher education for the sake of my brother and his career. Once again, the uppity woman in me came out. I stood my ground and decided against what one of my parents thought, and I withdrew my financial help from my brother. This incident of course, had its consequences for the relationship I had with my mother. She stopped talking to me even though we lived under the same roof. A few months passed before my mother spoke to me again. I think we were both hurt and in her mind I was wrong about what I did. In my mind, I was doing what was right and fair.

I continued taking classes every semester for three years including summers at LaGuardia Community College. One of the prerequisites to graduate from LaGuardia was to complete three working internships in the field of study. I had majored in liberal arts and sciences and although I did not know specifically what field in the sciences I wanted to follow, I had a strong inclination to pursue a degree in biological sciences, so I applied to do all of my internships in the biology
laboratory at LaGuardia. In December 1988, I graduated with my first college degree. I was ecstatic to receive an associate’s degree in liberal arts and sciences. I was the first member of the family to graduate from college! What was even more rewarding was the job offer I received upon my graduation! I was asked to work as a laboratory technician in the Biology lab at LaGuardia, which I gladly accepted. This was the beginning of my professional life as an academic.

**The white picket fences in my heart**

Some of us fall in love with another human being and dream about an ideal life of forming a family, having children and raising them in a house with white picket fences. I was seventeen when I met my daughter’s father. I am not sure whether it was love with him or if was the need to fulfill a dream of having my own family that encouraged me to pursue a relationship with him and remain in this path with him for 10 years of my life. I struggled with this thought for decades, never finding a good answer.

I reflect back on the things we sometimes do to please the person we love, then realize that all along he wanted different things in life to the ones I did. Some of the greatest realizations I ever had about my life and what I wanted, happened during my personal relationship with my daughter’s father. Unfortunately, for the women of my generation, the transition of relationships from the traditional male dominated to the more open gender-equality type, happened very slowly. This transition can drag on even more for people like me that come from cultures where the male figure domination is supported by matriarchal structures that resist sociocultural change. My experiences for 10 years with this person were insightful and the most incredible being was borne as a product of the interaction, my beautiful daughter! Nonetheless, my emotional well-being took a toll from years of neglecting what I really longed for and wanted in a relationship. I
wonder sometimes, why do we hang on to things that are not beneficial to us? It is almost as if we are contradicting some of the laws in natural selection that suggest the elimination of traits that are not beneficial to our survival. My intention in mentioning the person that was once my life partner is not to put him down, but to give a background of the things that I neglected by putting someone else and his interests before my wellness. I tried to have the dream marriage with the house surrounded by white picket fences, the dog, the cat, the garden and all. Yet, in the end, all of that only existed in my heart. After 10 years, my relationship with my daughter’s father ended, and I decided to walk away from my marriage.

Who is moving my floor?

I continued pursuing my dream life. I had a good job related to science; a beautiful child; I was pursuing my bachelors in biology; and all I needed then, was that house surrounded by a white-picket fence and a person inside it to help me hold that life together. I thought that I had found the person that could make my dream reality, but then one day I started feeling really sad and could not understand why I was feeling that way. In my mind I had all I ever wished for at that moment in my life. The sadness in my heart was inexplicable and the worst part was that even the most precious thing in my life could not move my heart or bring a smile to my face. My days were darker than the nights without the moon and stars. My nights were long agonizing moments that consumed my thoughts, leaving my heart and spirit in complete emptiness and desolation. I felt trapped in a place surrounded by an iron fence that I was not able to escape…I felt I was losing myself.
Face to face with reality

*Our human compassion binds us the one to the other - not in pity or patronizingly, but as human beings who have learnt how to turn our common suffering into hope for the future.* – (Mandela, 2000)

The more I live, the more I realize the immense capacity for compassion that exists in the human heart. It is still a baffling issue to me whether compassion towards others is some form of altruistic/beneficial trait that it is innately embedded in our species to preserve and ensure our survival. Some of us try to avoid at all cost dealing with issues that generate pain and disrupt our comfort zones; especially when facing reality. I realized that my life was far from happy and perfect. I had to look very carefully inside my heart and identify the situations and the people close to me that were in one way or another responsible for part of the anguish that I was feeling. This alone can be a very difficult task; yet, the hardest part of this process was admitting that I was responsible for the poor decisions I had made, which had led me to this state of anxiety. For me, dealing with my demons turned into a nightmare. Some people try to escape and seek refuge in drugs, alcohol or any other form of chemical substance that can numb the conscience from the feelings of emotional pain. In my case, I avoided dealing with the issues that bothered me, by storing them somewhere in my brain, so I did not have to deal with them. Unconsciously, I had let life issues and unprocessed emotions build over time. I kept adding more and more stuff in the attic of my brain until one day the ceiling gave in and everything collapsed to the floor. At that point I felt physically sick, confused and did not know how to pick up the pieces or how to put my life back together. One thing I know is that the sense of solidarity I felt from my closest friends and family during this dark moment in my life was pivotal during the process of recuperation and getting back on my feet again. The first step for my recovery was admitting that
I was suffering from depression and that I needed to work on my state of mind. I started psychotherapy in conjunction with anti-depressant drug treatment. The second part of my recuperation consisted on detaching from situations and people in my life that caused me pain.

When I started the treatment, my doctor explained to me that: first, I was not crazy; second, the symptoms were caused by a chemical imbalance in the brain and lastly he assured me that I was going to be okay. This was important for me, because I had lived in constant fear for the past few weeks, thinking that I was not going to make it through this crisis. According to my physician, the chemical deficiency was caused by a loss of either: serotonin, dopamine and/or norepinephrine in the brain.

_The first rule is to keep an untroubled spirit. The second is to look things in the face and know them for what they are._ (Marcus Aurelius, 1964)

_The first rule is to keep an untroubled spirit: for all things must bow to Nature’s law, and soon enough you must banish into nothingness, like Hadrian and Augustus. The second is to look things in the face and know them for what they are, remembering that it is your duty to be a good man. Do without flinching what man’s nature demands; say what seems to you must just—though with courtesy, modesty and sincerity._ (M. Staniforth, 1964. Book 8(5))

Cognitive psychotherapy consists of talking about the issues; processing them; assimilating the implications of not dealing with the things that can mediate pain; releasing the issues from my mind and moving on with my life in a new and different direction. It has taking me many years to identify the issues that were the source of my depression and accepting some of my poor decisions as part of the process of growing.
Metamorphosis the evolution of my being

You have power over your mind – not outside events. Realize this, and you will find strength (Marcus Aurelius, 2012)

How can our principles become dead, unless the impressions (thoughts) which correspond to them are extinguished? But it is in thy power continuously to fan these thoughts into a flame. I can have that opinion about anything, which I ought to have. If I can, why am I disturbed? The things which are external to my mind have no relation at all to my mind. – Let this be the state of thy affects, and thou standest erect. To recover thy life is in thy power. Look at the things again as thou didst use to look at them; for in this consist the recovery of thy life. (Long, 2012 Bk. 7, No.2)

I have come a long way in this journey. The psychotherapy intervention allowed me to discover an inner strength that I never imagined I had. It also provided me with the impetus to reflect on the decisions I had to make to have a better quality of life. I have learned throughout these years of therapy to stay focused on the things that are beneficial for my mental and physical health and at the same time, give up on the things that are detrimental and can disrupt my mental and physical well-being. More importantly, I finally gave myself time to grieve what I had lost in my life, so that I could move on and be happy.

Arriving at the comfort zone

Accept the things, to which fate binds you, and love the people with whom fate brings you together, but do so with all your heart. (Marcus Aurelius, 2012)

Adapt thy self to those things which are destined for you by providence, and love those men, with whom it is your lot to live and that with a sincere affection. (Hutchenson, 2008)
I wanted to arrive at a place where I felt comfortable and where I felt that I could be appreciated for who I am. I realized that for many years and in my constant yearning to find happiness I had forgotten about what Olga wanted. I went out of my way and tried to please everyone around me, thinking that I would find happiness with the people I was involved with. I found out that I was looking for that comfort zone in the wrong places. I always gave all I got in my relationships, and in that respect nothing has changed. I always believed that this is the way you are supposed to live, otherwise in my mind, it does not make sense the effort and the time spent living. This however, is not where the problem lies. In life and relationships not everyone is on the same page as I am and that is when things turn sour for me. One of my biggest faults is that I tend to idealize people and relationships. I build castles in the air and then when the castle crumbles and I fall from the cloud, I hit the floor and I face reality and that has always been painful. After many years of solitude and a lot of reflecting, I am more aware of the things in front of me. I know the things I lost and I had come to grips with dealing with losing people I loved. I stopped looking so desperately for that happiness that I craved for. I do know that I am in a comfort zone where I enjoy every minute of my life with what I have and the people I have around me. I enjoy my moments of solitude and knowing that my happiness does not depend on others, but that it really lies inside my heart.

The mind, body and soul never cease to evolve.

After twenty five years of academic growth beyond secondary education, I have completed an Associate’s degree in liberal arts and science, a Bachelor’s degree in biology/geology, a Master’s in Biology, another Master’s in Urban Education and when I finish writing this dissertation I will have my PhD in Urban Education with a specialization in Science Education. Yet, I never thought in my wildest dreams that I would accomplish this level of
education. Education has been one of my greatest achievements and has given me many reasons to live. Obtaining these degrees has empowered me in many ways. It has afforded me a good professional resource that I can use to increase my cultural capital. It has provided me with the skills to seek better career opportunities. For instance, I started working full-time as a college laboratory technician in the biology lab 24 years ago. Throughout my tenure at this institution, I have been promoted to senior laboratory technician; I attained tenure; I have been given the opportunity to teach in my field of study; I was the director of the Mortuary Science program and whenever necessary I wore the hat of Chemical Hygiene Officer of the college. I was promoted again in 2001 to Chief laboratory technician. My responsibility under this latter role entails the supervision of several technicians as well as other administrative duties in the department of Natural Sciences. I never wanted to take over this position, and when it was offered to me, I debated whether I should take it or not, because I was happy working in the lab. My doubts about taking the job vanished after I listened to the advice of one of my mentors about making the best out of this opportunity and using it as a prospect for advancement. I then seized this chance and used it as a stepping-stone to get to my ultimate goal. I have learned even more skills at this new position and it seems that new avenues are opening for me. I have to admit that throughout all the process of maturing and progressing in my life and career, there have been many people that have supported and encouraged me to reach higher. Some of these mentors have retired, but I keep in touch with them, because we became lifetime friends. Others passed away, but I treasure the memories I have of them and how influential they were in my life. I did not do this alone! Friends, colleagues, advisors, mentors and family in no specific order of importance, have been and continue to be an incredible support system in my professional and personal life.
Who is my mother?

In the meantime while I grew professionally, I had a personal responsibility that is perhaps one of the greatest motivations in my life. My daughter Natalia was born to me for reasons that sometimes leave me perplexed. She came into my world in a time when I was going through many emotional changes; she has lifted my spirit and moved my heart in the most profound ways the human heart can be touched. When I held her for the first time in my arms, I felt overwhelmed with tender loving feelings, but I was also scared. I was scared that I would not know how to raise her. She was tiny, only weighing five and half pounds. I cried then, and I prayed in my own particular way (I am not religious at all) to have enough wisdom to raise her well. I wished there was a book then, with instructions that I could follow on how to raise a child. When I reflect now on my emotions that early morning, I think that someone or something must have been listening to my prayers; raising Natalia has been a beautiful journey. I have witnessed her grow and blossom into a beautiful young being. I wanted to provide her with a great childhood, similar to what I had. I remember I used to read to her children books from Colombia every night and tell her stories about my childhood. One day when she was three, I noticed she was reading in Spanish! We were both so excited and I went and got her more books! I also taught her how to write in Spanish. I wanted to instill in her the love for her roots, so I started sending her to Colombia every summer. She would spend two months with my mom who left the United States for a while after my father passed away. Natalia loved the experience of playing with children her age and learning the intricacies of the “paisa” culture. Paisa is a term used to describe the people that are born in the states of Colombia where coffee is cultivated. Paisas are known to have warrior spirits, they are passionate about everything in their life; they are proud; innovative; love food, family and the land where they were born. Natalia learned all of that
throughout her childhood and at the end of every summer, she used to come back speaking with a paisa accent, which is said to be similar to the Catalans (people from Cataluña) in Spain. She learned riddles, children’s stories and games that were familiar to me. She also learned that life is not all about having the latest video games or the most expensive sneakers. I remember she used to pack some of her toys and clothes and give them to the children she played with because she realized they did not have the basic things she had here. Until this day, anywhere she goes, if someone asks her where she is from, she says she is a paisa from Medellin and she speaks of her childhood friends from Colombia. She is an authentic paisa, she knows more about the music and football (soccer) teams than me. Soccer is a sport that Paisas are passionate about and that has been the refuge for them during violent political and economic times.

At the age of five, Natalia started formal education in a New York City public school. Besides her regular classes I enrolled her in art classes at the age of three. She loved dancing and seemed to be passionate about music; she tried piano lessons; drama; ice-skating; and then she discovered ballet! Natalia was never a “genius child,” but she was dedicated student. The best part is that I rarely had to tell her to attend to her schoolwork. I think involving her in extracurricular activities and exposing her to the arts at an early age facilitated the development of self-discipline in anything she does. Her father is a civil engineer; he wanted her to pursue a similar career or at least a career where she would earn a lot of money. I however, tried to plant science seeds at an early age. I remember taking her to the laboratory at work and putting preserved specimens in front of her, to dissect and to learn. I also bought her a little skeleton and taught her the human skeletal system. Then I would test her on the anatomy of different organisms. Nonetheless, I advised her to follow her dreams. She continued taking dance classes and attended a performing arts high school, where she had to complete the curriculum like any
other high school student, but she also had to build a portfolio of her art form. In the end Natalia was free to decide where to attend college. However, she did not follow a career in science or engineering. She was accepted into a dance conservatory, where she majored in ballet and contemporary dance. She went away to college and for four years I was alone with my cats. Natalia graduated in 2011 and she is now a teacher at a dance school in the neighborhood where she grew up in New York. A career in dance is quite competitive and unpredictable. I guess you never stop worrying about your children even when they are independent. I advised Natalia to apply for a job working as a college advisor, so that she has something else that she could fall back on, in the event that the dance teaching does not work out. Somehow she still listens to my advice. She has been working as a college advisor for a few months now. Nonetheless, sometimes I listen to her advice and then I ask myself, who is the mother here?

Many nights while Natalia was still living home, she used to come to whichever room I had fallen asleep studying. She would cover me with a blanket and ask me; did you brush your teeth? The mother-daughter roles have been reversed many times, and more often than not, she is surprised at the things I do. One summer afternoon, after I had been in therapy for many years, I went for a walk in the park with her and her babysitter’s dog Yayita. It started raining heavily and puddles of water formed quickly in the park and the streets. I started jumping on every puddle I found and splashing water all over. I felt like a kid again and the dog seemed to have been enjoying it as much as I was. Natalia, looked at me in a state of concern and she asked; mommy what are you doing? And soaked and wet as I was, I said, try it! It is so much fun! She did, and we basically stepped in every puddle we found along the way home. That day is engraved in my mind forever, because we were just two kids playing out in the rain. I was able to forget about the things that caused me pain and despair and enjoy that hot and humid summer
day with my daughter, walking in the park, playing with Yayita and feeling the refreshing drops of rain on my face. I felt I was finally getting better from the ghost that haunted me every night.

There are different types of mothers in your life, those that give birth and those that adopt you along the way in your path through life. Marta was the latter type of mother for me. She was a few months older than my biological mother. Marta had come from Cuba in 1980 during the Mariel migration. We met when I was working two jobs. There was a great difference in age, but there was instant compatibility between us. We were great friends even after she retired and moved to the south. Marta had been a teacher of Spanish language in Cuba, but I think of her as a life philosopher and one of the most influential people in my life. She was very careful of judging someone and she often spoke words of wisdom. A very lovely woman, who not only loved me like her own daughter, but supported me during difficult times, she encouraged me to continue pursuing my educational dreams and my personal goals. I kept in touch with her and I visited her in the south when her husband was diagnosed with Alzheimer’s. Marta was depressed and since I had experience dealing with depression, I wanted to help her out. We kept in constant contact with each other and our relationship was always the same. She moved to the Midwest to be closer to her son and then her husband passed away. I visited Marta again and I realized she was sick. She had developed an autoimmune disease called Scleroderma. This condition is known for the hardening of tissues, especially epithelial tissues lining body ducts and the epidermis. Marta was a very smart and independent woman. She had one son and she did not want to be a burden for him. She tried being as active as her disease permitted her to be and one day she told me she was coming to visit me in New York. My heart was heavy when I saw her being wheeled off the airplane and she was using an oxygen mask to help her breath. We spent four days together; I would tuck her in at night, as if she was my daughter and would cook baby
food for her, because it was the only thing she could eat. Her esophagus had hardened and the
natural peristalsis muscle contraction of the esophagus to pass food to the stomach was non-
functional. We laughed, we cried, we remembered stories of the years we worked together and
then she left again. I knew she had come back to say goodbye. I knew I was not going to see her
again. We spoke on the phone for the next two months. She told me that she was not feeling well
and she was going to be admitted to the hospital. That same week, I received a phone call from
Marta’s son and I just knew that he was calling to tell me that Marta had passed away. I felt the
need there and then, to write an Ode to Marta.

*We may worry about death, but what hurts the soul most is to live without tasting the water of its
own essence.* – Rumi

*Marta, you lived your life and tasted the essence of the soul*

*Your life was a precious gift for all of us.*

*Biologically you had only your son Justico, who you adored and who is*

*An extension of what you and Justo were, but there was so much love in your heart*

*That you took us: Gerardo, Niurka and myself, and cared for us as if we were your own*

*Yesterday, I lost my mother, my friend, and my twin soul as you once called me!*

*Today I cry, because I can’t avoid feeling, the painful loss in my heart!*

*Today, I also celebrate, because I was so lucky to have known you and have you in my life!*

*What a great woman you were. In spite of your physical pain, you never complained.*

*You had such a strength and love for anyone you met*

*Love and Inspiration is what best describes you*
You touched my life in so many ways, and you are so dear to me

That even though you are physically gone, you will always be very much present in my life.

Today, I rejoice, because finally you have gone to join the love of your life!

Doña Gabriela succumbs to her fate!

I often think of my mother, “Doña Gabriela” and how fortunate she was of having the life she did. She was born in a small town in the paisa country called Fredonia. She was an only child and even though she was poor, her mother always worked to make sure that little Gabriela had all she needed. She grew up in farms drinking fresh milk and enjoying the fruits of the country. When her family moved to the city, she lived in a house that her mother had bought while working for a rich family in the city. Gabriela eventually inherited that house when her mother died. Gabriela finished her elementary school and she stayed home until she started working in a textile factory at the age of 19. At the factory, she met a handsome man who swept her off her feet. She married this man and they decided that she was going to stay home and raise a family. The children started coming when she was 21 years old. Her last child was born when she turned 40 years of age. In total, there were five girls and a boy born to the marriage. Gabriela was a beautiful woman, with a very strong personality, inheriting the character of the typical paisa matriarch. Her husband traveled to distant places to find work because what they paid at the textile factory was not enough anymore to support his wife and children. He would spend sometimes months away from home, and at some point, even years in faraway lands. However, he would always send money home to support his children and Doña Gabriela’s needs. In the meantime, she was raising the children alone, not an easy task when there is not only one or two, but six of them.
Doña Gabriela was a lucky woman to have five girls that could do all the chores at home while she took cooking and manual arts classes. She loved dancing and taught her children and grandchildren the love for music and dance. She also taught us well how to become good housewives. As we got older, two of my older siblings decided to get married. Three of us were still in school, but were expected to finish high school, find a husband and get married as well. She had great expectations for her only son and was determined to put him through college, so he could become a professional chemist. He was the light of her eyes and she not only spoiled him, but also had all the girls cater to him. She was a very strict mother and we were afraid of her. Some of my sisters grew up resenting her because she was very cold with us and used to punish us in a hard manner leaving scars in our bodies, but especially wounds in our hearts. When my mother was 50 years old, she came to live in the United States. She reunited with some of us that had left Colombia in previous years. My father and her had grown apart and decided that their marriage was over. They lived apart for the remainder of their lives. However, he continued taking care of her financially. She, on the other hand, kept busy by taking care of her grandchildren while her daughters worked.

My father died in his sleep at the age of 62. His death left us all in shock, because he was not sick. I had seen him three days before his death. Many years would pass before I could talk about him without feeling pain in my heart and choking with tears. Perhaps it is the way he died, but I feel that he just went away again, as when I was little and he did not have a chance to say goodbye. There is a strange feeling that tells me that he is still alive in me. I had the fortune of having a great relationship with him as a child and as an adult. Every time I am in a bind and I am searching for wisdom and clarity, I think of him and think of what he would have done if he were in my place. Although my parents were divorced, he always took care of my mom. Even at
the time of his death, he left everything he had to her. My mother moved back to Colombia for a period of time after my father passed away. She considered him the only man in her life and she never put her eyes on another man, even when she was young and he was away working. She bought a couple of properties with the money my father had left her and lived a quite peaceful life for 10 years in Colombia. After a while she started getting depressed and sick, because she felt lonely, so she came back to the US where her children and grandchildren surrounded her. She was happy again, her children never really gave her much heartache, or so she used to say. She was not very social, and when asked why she did not have friends, she answered that she only wanted to be with her children and grandchildren and that she did not care about having friends. In her lifetime she only had three close friends. Some of us tried harder than others in making her happy. I would bring her home with me on the weekends and cook her favorite meals. We would talk until late at night, where I would listen to stories when she was young. For many years we would drive in upstate New York and go peach and apple picking. She would pick the biggest apples in the orchard! We also made a tradition to go to Vermont on Columbus Day weekend for many years to celebrate the arrival of the fall season. We never got tired of watching the change in tree foliage. My mom enjoyed that rainbow of reds, yellows, purple, orange and green colors that dress the mountains in the fall and then we would sit in front of a chimney and drink hot apple cider. Ahhh! It is a comforting warm memory!

Years went by and my mother and all of us grew old. Although my mom was generally healthy, the physical pain and inflammation of her rheumatoid arthritis took a toll on her. Her fingers were deformed and she had lost strength in her hands to the point that she could not even lift a cooking pot. Her knees were so severely affected by the inflammation caused by the condition that she had to use a cane to walk. Her inability to do things on her own and on top of
everything finding out that one of her children was a lesbian mediated a state of depression in her. She seemed to have lost her desire to live. All her life she was known for being very sentimental and would cry for almost anything. This quality of her was exacerbated during this period of her life. She was suffering from insomnia; she lost her appetite, so she lost weight. Her anguish was such that she felt scared of being alone. I got her coloring books, magazines and puzzles, so she could keep herself entertained during those long agonizing nights, but she never opened them.

We decided to step in and take turns taking care for her. We got her a home attendant to accompany and help her out during the day, and I developed a schedule that I sent to each of my siblings where one of us stayed every night with her. We did this for over a year. In the meantime, my mom was going to psychotherapy and she started to get better. The depressive state subsided and things got back to a more normal state. Nonetheless, she never recuperated completely and the brightness in her eyes disappeared. She started losing interest about going out and she seemed quiet during family gatherings. I advised my mother several times to make amends with my sisters. To have a dialogue with them and apologize for the way she treated them when they were younger. I said that most likely she and my sisters would walk lighter for the rest of their lives if they got rid of the extra baggage they carried in their hearts. She would always brush me off, telling me that it was too late for apologies or that they were too old to do that. I would respond that it was never too late and that I did not want her to die taking all of that resentment and frustration with her. I remember the last mother’s day she spent with us, we gathered around her to take pictures and she just looked at us with admiration. Even with her bad knees and pain in her joints, she stood up that day and danced with one of my nephews. Some people have difficulty expressing their emotions. My mother was one of those people and she never really admitted causing pain to my sisters or anyone. She used to think that mothers were
to be looked at and be venerated for the mere fact of being “mothers” in spite of how good or bad they treat their children. One day she called all of us for a meeting in her apartment. In front of all of us she designated me to be her executor in the event that she would die. I think she felt she was walking the last stretch of her journey.

Doña Gabriela fell ill and we were all at her bedside. There were very few remnants of the strong woman she had been. All her life she was afraid of death and was afraid of having to go through any type of surgery, because she thought that she would die in the operating room. We took her to the emergency room and the doctor said that she had to be operated or she would die. She had peritonitis; apparently taking prednisone had caused a rupture in her stomach. She went into surgery and she came out of it fine, but two days later she developed pneumonia and she was running a high fever. She never cried during her illness, something that was unusual of her. She also told us that she loved us, something that she did not do when she was young and well. I think this time Doña Gabriela was ready to succumb to her fate. I remember the day that they transferred her to the Intensive Care unit in the hospital, she was still conscious, I spoke to her, but she did not say a word, she only nodded when I asked her if she was in pain. She made a sudden movement extending her hands to me; almost as if someone was taking her away and she wanted me to help her. The nurses restrained her at that point, because she had intravenous fluids and other tubes going in and out of her. That was the last time I saw her conscious. She fell into a coma and her condition worsened as the hours passed. I finished teaching one night and felt the need to pass by the hospital. When I arrived there, the nurse told me that she was not producing any more urine and that the ventilator was doing all the work for her lungs. I knew then, that she was not coming back. I spoke to the doctor and she confirmed my fears. My mother was 77 and her body was too weak to recuperate from the entire trauma she had been through in the last five
days. I called my siblings and we did what we thought was the right thing for my mother. We disconnected the breathing tube and everything else, except for the pain medication. Doña Gabriela expired five minutes later on that summer night. She was surrounded by her children and grandchildren like she always wanted to be. She lived her life the way she wanted to live. Sometimes, I wonder how similar my life would have been If I would have followed in my mother’s footsteps. In the end she demonstrated her love for us in her own special way. I only understood this after she was gone. I also understood the love between her and my father. Both my parents lay next to each other in a green field under a large Oak tree. I hope that if there is a place you go after you leave this earth that they are enjoying their time together. After my mother died, I felt again the need to write something to include in her obituary. These following words are inspired by Khalil Gibran’s writings and what I think my mother would have said to us to say goodbye.

**The Beauty of Death**

*Let me sleep, for my soul is intoxicated with love*

*Let me rest, for my spirit has had its bounty of days and nights*

*Light the candles and burn the incense around my bed*

*And scatter leaves of jasmine and roses over my body*

*Embellish my body with Frankincense*

*And sprinkle my feet with perfume*

*Let me rest in the arms of the Greatest,*

*For my open eyes are tired*
Let the silver-stringed lyre quiver and soothe my spirit

Weave from a harp a veil around my withering heart

Remember me, as you behold the dawn of hope in my eyes,

For its magic meaning is a soft bed upon which my heart rests

The songs of the waves and the hymns of the streams are scattered

And the voices of throngs reduced to silence

And I can hear naught but the music of eternity

In exact harmony with my spirit’s desires

Talk about my departure with love in your hearts

Close your eyes and then you will see me

With each and every one of you forevermore

I was never the most expressive Mother or Mamita with all of you. Your Father-Papito and I gave you life, but all of you gave us many beautiful reasons to live!

You were my life, my little girls: Luz Alba, Glenis, Galia, Olga, Diana, Doris, Carolina, Natalia, Marisol & Sofia. My Little boys: Augusto, Rolando, Manuel, Andrés, Julio, Mario, and Lucas. I love you more than I ever expressed my feelings to all of you.

Thank you all for your patience with me!

I am walking dressed in white, I am comfortable...I am in peace...

K. Gibran, G. H de Calderón.
The emotions of animals

Natalia always wanted a pet-dog, but I tried telling her that because of our busy schedules, it was hard and unfair to leave an animal at home alone for so many hours. One day we visited my friend Rosie at the pet clinic where she used to work. She came out to the waiting area carrying a little ball of fur in her hands. It was a little kitten of white and cappuccino colors. Natalia fell in love with the tiny kitten and named her Gracie right away. Rosie suggested bringing her home with us to see if we liked having her around. She also asked if we could take another kitten, so it will not spend the weekend alone at the clinic. This kitten was a regular Calico, but she had big beautiful eyes that shined in the dark like yellow jewels. We named this one Lacey, and she and I hit it off from the get go. These two kittens were so tiny that when we brought them home, we had to feed them with a bottle. Lacey and Gracie became part of our household and we would take care of them as if they were babies. They on the other hand, developed their unique personalities and as good feline species they became very independent. Nonetheless, I could sense their curiosity and almost compassion when either Natalia or I were sick. They would come around to our room and keep us company. I feel that they were reciprocating the caring feelings we had for them. Also, I feel a special connection with my cats because I think that they like other animals also have emotions. They may not be able to express it in the way humans express it through languages, but animals have emotions of fear, pleasure and pain like us! Some of the ways they express emotions is by rubbing against us, so we brush their fur, or lifting their lower backs for us to rub our fingers through their bodies. Gracie would come to greet me every time I got home from work and she would show her happiness by laying in her back and rolling over from left to right and vice versa, so I could give her some treats. Even with their independent nature, sometimes she would follow me or wait for me to finish
doing whatever I was doing, so I could follow her to her favorite room and just relax with her. Although it may sound silly to someone who never cared for a pet, pets are innocent creatures that inspire feelings of compassion in us. They exude pure innocence; trust, gratitude and they give you unconditional love every day of their lives. My cats have been a source of support and company during times of loneliness. We have shared moments of happiness, playfulness and sadness. I did not want to finish this auto-ethnography without mentioning my pets. My little Gracie developed cancer and after thirteen years of living with us, she died in my arms, a few months ago. “Unfortunately, the loss of a pet is not often recognized by friends, acquaintances or colleagues as a significant or authentic occasion for bereavement,” (Parker-Pope, 2010). Nevertheless, my pets have been through thick and thin with me and they are part of my family. When little Gracie died, a member of my family died. Now it is only Lacey left and I try to enjoy her company as much as I can. I tried giving my pets the best life I can. I provide them not only with food and shelter, but medical care when they have been sick. This is only a small part compared to the things my pets have been and have done for me.

**Gracie’s farewell**

*My little pipo, thank you for all the good times you gave me. Thank you for staying next to me during the long nights of studying and for comforting me in your own special way when I was down. I miss your soft little paws, your beautiful blue eyes and your rosy nose. I am glad I hold you one last time in that embrace as your life drifted away. I know you were ready to go to a special place where you do not feel any pain. I am sure you have many little mousses with pink noses like Bernard to play where you are, and lots of bacon to have a feast. You will always have a special place in my heart, even when you woke me up early in the morning by softly biting my chin, so I can get up and feed you. Your humbleness and unconditional love have touched me*
deeply lifting my spirit when I most needed it. I only hope that one day we will enjoy each other’s company again.

**It takes a village**

When I think of my life as a student and as a professional, the work from Jane Cohen-Fletcher (1999) “it takes a village” (Cohen-Fletcher, 1999) comes to mind. I could not have come this far in my education and academic profession without the incommensurable support and encouragement from individuals such as advisors, professors, mentors, friends, colleagues, family members and institutional support. This type of capital support has been not only important, but also crucial in my personal and professional development. In addition, I have been presented with opportunities for advancement within the institution I work for, where I have acquired new academic and managerial skills. As a single parent and head of household, the responsibilities I face every day can be a source of hardship. Having the type of support mentioned has enabled me to stay strong during many moments of adversity. These support systems have provided the tools I need in one way or another to advance. For instance, the simple adjustment of my work schedule to accommodate the classes I needed to finish my degree is a clear example of how my supervisors have contributed to my success. Another clear example is how my education beyond the associate’s degree has been funded and supported by the institution I work for. This alone represents an invaluable benefit to support my career growth. In addition, there have been times when I was offered a new job role, outside of my area of expertise. I have seized those opportunities as a chance to enhance my knowledge and skill resources in a way that could increase opportunities to continue ascending in my field of work and get closer to my ultimate life goals.
Chapter 2

FACIAL EXPRESSION OF EMOTIONS

Historical background

Interpersonal communication skills are essential for the development of effective relationships of any kind. Such skills are not only based on the richness of the language we use or the tone of voice we utilize to communicate what we want to express, but extends to non-verbal cues such as body movement, hand gestures and facial expressions of emotions. This chapter focuses on three objectives. The first one is to provide a historical background of how emotions have been defined throughout history; second, a brief physiology of emotions in relation to brain function and body response is presented to provide a better understanding of where emotions originate. Finally, a facial expression of emotions recognition program used for the identification of emotions in a teachers’ education class at Brooklyn College of the City University of New York is introduced, exemplifying one of the many applications of emotions in science education.

WHAT ARE EMOTIONS?

“In this treacherous world, nothing is the truth or a lie. Everything depends on the color of the crystal from which one’s sees it – Pedro Calderon de la Barca (Dali, 1973, p.121).

When defining emotion, I want to deviate from the one-sided monologism and instead I want to provide multiple meanings in different contexts, because emotion has been linked to not one, but many different fields of study. Some of those fields include philosophy, physiologic, neurologic-cognitive, environmental and sociocultural to list a few. Limiting the definition of emotions to one single field it is not justifiable, as emotions are complex structures produced through various processes and mediated by many factors. Emotions add significance to our being and are perhaps
at the core of our balanced mental health. Emotions have been considered to be an important part of human development and relationships by early philosophers in history and now by scientists. For instance, Plato in The Republic talks about how emotions are one of the three components of the human mind. In Plato’s philosophy, a well-balanced person should develop wisdom, courage, self-discipline and justice to achieve personal mental harmony. At the base of these qualities are the constituents of the soul (reason, desire and the emotive parts). Plato argued that this development is not just beneficial for the individual, but make him/her “just” good for his/her community/society (Plato, 2012). On the other hand, Bakhtin alludes to the meaning of emotions in linguistic terms by saying that meaning belongs to a word and its position between speakers. He adds, “Meaning is realized only in the process of active responsive understanding” (Bakhtin, 1994, p. 231). In this context we see the meaning of emotion depending on the circumstances of the interaction among speakers and the response to what is being said. It is almost as if emotions do not become alive until a person appropriates them. Emotions are expressed in many ways, and I do not necessarily mean through voice and words, but also through facial expression. On the other hand, the field of Psychology defines emotion as the outcomes of physiological changes in the body. William James refuted this definition in the late eighteen hundreds by suggesting that: “bodily changes follow directly the perception of the exciting fact, and that our feeling of the same changes as they occur is the emotion. Other schools of thought like the “social constructivists argue that what people feel is conditioned by socialization into culture and by participation in social structures” (Turner & Stets, 2005, p. 2.) In addition, constructivists suggest that emotional expression and its origins are independent from any biological factor. Furthermore, neurologists propose that physiological changes generate particular types of emotion regardless of cultural mediation (Turner & Stets, 2005). This latter idea is quite similar
to one posed by evolutionary biologists, which use genetics as a base to describe emotions as innate by nature. Robert Plutchik, for example, proposed in the psycho-evolutionary structural theory of emotion that emotion is an inferred complex sequence of reactions to a stimulus, including cognitive evaluations, subjective changes, autonomic and neural arousal, impulses to action, and behavior designed to have an effect upon the stimulus that initiated the complex sequence. He adds that these reactions are adaptive in the struggle of survival of living organisms (Plutchik, 1991.)

Perhaps the most influential work done on emotions is the research by Charles Darwin in the late 19th century. Darwin published the emotions of man and animals in 1898. His work was revolutionary at the time and continues to be a great theoretical framework for contemporary scientists. He describes universal human emotions in detail by depicting the shared laughter emotional trait among Europeans and the “savages of Australia.” Scientists influenced by Darwin’s evolutionary postulate such as Carroll Izard and Paul Ekman, describe emotions as having not only an evolutionary origin, but also autonomic nervous system activity. Izard and Ekman not only share Darwin’s evolutionary view on emotions, but they agree also with William James in that certain environmental stimuli trigger specific autonomic reactions involved in emotional expression (Thoits, 1989). Jonathan Turner’s stance regarding emotional expression is that it is activated in the body and mediated by cultural norms, beliefs, values and vocabulary (Turner & Stets, 2005). He describes emotions as the arousal of variants and combinations of satisfaction-happiness, aversion-fear, assertion-anger, and disappointment-sadness in individuals (Turner, 2007). In addition, Turner recognizes emotions as being constrained and channeled by sociocultural contexts most of the time, Yet, he relies on physiological evidence to argue that
emotional expression is universal and refutes the idea of emotions being solely the result of social construct, but rather driven by a combination of biological and environmental processes.

**Anatomy and physiology of emotions**

Emotional expression is linked to biological, environmental and sociocultural factors, and there is just simply not getting around describing emotions and their production without mentioning both the biological/physiological aspect and the social aspect. When emotions emerge, the body activates four body systems: the autonomic nervous system, the neurotransmitter, the hormonal and the musculoskeletal system; the later interacting with the former three to generate a response. Next, I describe emotions and their origin based on the evolutionary anatomy and physiology of the brain. You may refer to diagram 1 to see the structures mentioned in the text.

Emotions have a biological foundation, because they are built from the interaction of various biochemical and structural systems in the body. Although much of the research on emotions until the 1970s was done on damaged brains and associated changes in behavior, the mechanisms implicated in normal behavior in terms of emotions in humans had been limited until recently. It is known since the late eighteenth-century that the prefrontal cortex of the brain plays a role in the regulation of emotions (Davidson, 2012). The mammal brain is divided into two parts: the *subcortex* and the *neocortex* areas. Emotions are generated by the *subcortex*, which connects to the *neocortex* (fig. 1) where language and culture reside. The *subcortical* area is the ancient emotion center and it is believed to have evolved before the *neocortical* region of the brain in mammals. Instinctive emotions originate in the subcortical region. Yet feelings arise when the neocortex is stimulated by neuro-pathways connected to the subcortical area. Nevertheless, not all emotional arousal originated in the sub-cortical region reaches the neocortex to become a conscious feeling; this is supported by evidence suggesting that unconscious memories are stored
in the hippocampus, which activates body systems generating emotional responses. In chapter two, a clear example is provided on how past experiences mediate overwhelming emotions; these emotions are unconsciously stored in what most likely is the hippocampus (Turner & Stets, 2005.) On the other hand, the neocortex is associated with the development of culture in humans. The neocortex is divided into four lobes or regions that are associated with emotions: The occipital lobe that is linked to sight; the temporal lobe associated with hearing; the parietal lobe related to touch; and the olfactory lobe with smell.

Fig. 1 Brain scan showing the subcortex, neocortex and emotional arousal associated structures. OC, 2013

Intense emotions are driven by body systems that are activated by the subcortical area. However, when emotions are less intense, social structures can regulate and control them; this is an example of how humans have adapted their emotional display according to their social
upbringing. Social psychologist Paul Ekman has identified this principle as “display rules,” and he defines it as internalized structures that work as a function of an individual’s culture, gender or family background (Ekman & Friesen, 1975). Furthermore, in this chapter social relations theory is informed by William Sewell’s idea on how any type of relationship is governed by underlying social and cultural structures. Sewell states that a proper understanding of the role of events in history must be grounded on the conception of structure; in his context, an important characteristic of social life is a structural view of social action (Sewell, 2005.) Sewell considers structures the canons of social practices, which are constantly being reproduced and transformed over long periods of time (Sewell, 2005.) Sewell’s ideas are further complemented in the work of Kenneth Tobin. Tobin suggests that the dialectic interaction between individuals and the sociocultural milieu are mediated by four central elements: beliefs; goals; behaviors; and the context of action (Tobin, 1996.) However, there is only so much our emotions can be inhibited and Turner asserts that culture never overrides biological systems completely (Turner & Stets, 2005.) This is where Ekman’s theory of the subtle of micro-expression of emotions comes to play. Ekman suggests that emotions can be masked and concealed to a certain degree, and that no matter how hard we try to obscure emotions, they have a way of escaping our consciousness and they are expressed anyway (Ekman, 1975.)

Ekman has work extensively on emotions, and in the late 1970s he developed The Facial Action Coding System (F.A.C.S.) F.A.C.S is a program that assigns codes to specific muscles and structures during facial expression of emotions. Ekman and other researchers suggest that the associations between particular muscular patterns and discrete emotions are universal (Ekman, 1992.) and that they exist very much in the same way in all humans.
In the last thirty years there has been substantial progress on emotional research. Some of the latest research in neurobiology suggests that human mentality is malleable and mediated by a dynamic cultural flux that characterizes social life. Similar studies in animal behavior and emotion suggest that genes may be turned on or may remain off depending on the experiences we are exposed to early during our development. In other words, our double helix may be imprinted with a particular gene that has been passed on for many generations within our families, but the genes in our DNA can be altered by life experiences, either by being silenced or being amplified (Davidson & Begley, 2012.) The notion that the brain is a fixed and solid structure and that the processes taking place in it are fixed is something that is changing with emerging research information in neurobiology regarding the brain and how it functions. Within the geneticist circle, more scientists conducting studies on emotion have been able to develop experiments to support the idea that both DNA and the environment play a role in emotional expression of animals. This plasticity of the brain disrupts the old dogma of genetic determination and moves to the forefront the idea that nurture may undermine nature under certain conditions.

Richard Davidson suggests that the left frontal region of the brain (pre-frontal cortex) is responsible for positive emotions such as: optimism and resilience. Damage to that area of the brain, will possibly lead to a depressive state (Davidson, 2012). Before the late 1970s there were no non-invasive technologies for the study of the brain. It was not until the late 1970s and early 1980s that the first Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET) equipment were built to produce multicolored brain scans that can be used in advanced studies of the emotions and its origins in the brain (Davidson, 2012.) Much of the research on emotions conducted by Davidson has been done using an electroencephalogram, which consist
of sensors attached to the scalp that transmit electrical signals from the brain through electrodes. The advantage of using the EEG is that it gives great resolution even if the electrical signal in the brain last for a few milliseconds. To demonstrate the reliability of the EEG to measure specific brain activity, Davidson used visual flashing lights and tapping on the forearm of the tested individuals and asked them to imagine the stimuli, while he measures the electrical activity in the brain.

For emotions to be displayed physically there is an array of underlying structures and receptors that are activated in the brain, as well as other organs and glands in the rest of the body. The structures in the brain that seem to be linked to emotions are: The amygdala (fig. 1) which is a structure involved in identifying and learning which parts of our surroundings are important. This area of the brain is critical in the production of negative emotions, especially fear (Ledoux, 1995). The pre-frontal cortex (fig. 1) of the brain activates the amygdala and is associated with negative emotions and distress. Its function is snapping to attention when we feel anxious, afraid or threatened (Davidson, 2012). The pre-frontal cortex plays a major role in the regulation of emotion and behavior by anticipating the consequences of our actions. The anterior cingulate (AC) is located in the middle of the brain, right behind the pre-frontal cortex. The AC is linked to attention, consciousness and subjective emotional awareness. There also have been some links of this part of the brain to initiation of motivated behavior. The ventral striatum is believed to be involved in the experience of goal directed positive emotion. The sympathetic and parasympathetic systems, which are part of the nervous system and are connected to the brain through innervation, trigger emotional reactions, for instance, the sympathetic system triggers emotional arousal by: dilating pupils, accelerating heartbeat, inhibiting digestion, stimulating of glucose released by the liver, stimulating of secretion of epinephrine and norepinephrine in the
adrenal gland, relaxing of the urinary bladder and stimulating ejaculation in males. Conversely, the parasympathetic system is associated with calming effects through the contraction of the pupils; it slows down heartbeat, stimulates digestion, the gall bladder, erection of sex organs and contracts the urinary bladder. Even though the rest of the body may show how the person is dealing with emotion, such as sweating, tension of the arms and legs and other body movements, emotions are displayed to others mainly in the face. Furthermore, recent Neuroscience research suggests that human beings have different emotional styles and these are reflected in the way we consistently respond to experiences in our lives. Davidson’s theory is that emotional styles are much closer to underlying brain systems than emotional states or traits, yet they seem to influence the likelihood of feeling particular emotional states, traits and moods. Davidson calls emotional styles the building blocks or the atoms of our emotional lives (Davidson, 2012). Davidson’s and other rigorous empirical research around the world in affective neuroscience have led to the classification of emotional styles into six dimensions: resilience, which points at how slow or quickly you recover from adversity; resilience has been associated with activity in the amygdala (fig. 1) in the brain. Outlook, is defined as how long you are able to sustain positive emotion; This characteristic is associated with the nucleus accumbens (fig. 1), an area located below the pre-frontal cortex (fig. 1); social intuition, how adept you are in picking up social signals from the people around you. The origin of this emotional dimension is linked to low levels of activity in the fusiform gyrus and high levels of activity in the amygdala; self-awareness, is concomitant with activity in the insula and it is defined as how well you perceive bodily feelings that reflect emotions; sensitivity to context has been linked to the hippocampus area of the brain (fig. 1) and it is defined as how good you are at regulating emotional responses while taking into account the context you find yourself in; Finally, attention is concerned with
the ability to keep a sharp and clear focus. *Attention* has been detected as pre-frontal cortex activity. Although all emotional styles may not be apparent to all of us, some may operate on levels that are not always apparent to us (Davidson, 2012.)

In comparison to other animals, facial expression is greater in humans due to the many muscles that insert in the dermis and subcutaneous tissues (Saladin, 2012). Facial expression is accomplished by the activation and functioning of forty independent muscles, which may be attached or not to bone structures. Facial muscles comprise some of the few muscles in the body that are not attached at both ends to bones or not attached to bones at all, like the *Orbicularis oris* that makes up the lips and the orbicularis oculi, which surrounds the eye. Facial muscles are unique in that function and structure may not always correspond. For instance, the *Frontalis* muscle is a single muscle that expands the forehead, yet it is possible to move the inner and outer parts of the muscle independently of each other, allowing for the inner and outer brows to rise when these are innervated (Ekman, & Matzumoto, 2008). Since these two areas of the *Frontalis* require different neural supply, the two strands of the *Frontalis* muscle should be considered as two and not one muscle from the functional point of view. Ekman and Matzumoto suggest that when dissecting facial analysis it is imperative to understand the contraction of the muscle as a functional and not as just structural anatomy. That being said, each functional muscle unit of the face may be innervated at different time, intensity and laterally characteristics. In turn those characteristics allow for the production of the great diversity of facial expressions. Facial muscle action is accomplished by the innervations of the cranial or facial nerve, which emanates from the brain stem between the pons and the medulla and also of the oculomotor nerve. The nerve includes a motor root that supplies somatic muscle fibers to the muscles of the face, scalp and outer ear, enabling the muscle movements that comprise facial expressions. The function of the
sensory part of the nerve is involved in taste and sound (Standring, 2005). The upper eyelid is innervated by the oculomotor nerve. This structure is used in expressions of anger, surprise, and fear. The number of bilateral and contralateral fibers to the muscle varies depending on the face region. The lower part of the face has more contralateral fibers, while the upper part of the face has more bilateral ones. Involuntary facial movement is provided mainly by bilateral fiber activation. Thus, each type of movement has a different activation neural tract (Rinn, 1991).

Fig 2 Facial muscle anatomy of emotions. OC, 2013

Advances in technology such as the development of the encephalogram EEG, MRI and PET for the study of the brain have been vital in research on emotions. To identify facial expression of emotions in the classroom we can use tools that are practical and are less expensive. Ekman’s
F.A.C.S training program provides a complement to what we already know about emotions and their origin. In addition the program enables you to identify facial expressions of emotions in the moment while sensitive science topics are discussed in class. The idea of teacher and student emotion as cultural and social singularities has always found resistance in the field of science. Emotion is considered to be a very elusive topic, something that cannot be measured objectively (Zembylas, 2005), and this factor alone has been a great contributor to the negligence of the topic in research and practice in education. So, as a result of this gap in research, why not explore and investigate emotions in the science classroom? Our research adds important insights to the limited studies that have been done on emotions in the classroom, not only in reinforcing theoretical frameworks, but presenting and confirming the substantial application of different types of technology in science education research.

Paul Ekman as well as other researchers agrees there are six basic emotions across different cultures. Those emotions are: happiness, surprise, fear, sadness, anger and disgust. The list of universal emotions varies in one or two emotions depending on the researcher describing them. Ekman for example added one more emotion (contempt) to the list, resulting in seven universal emotions. Ekman’s theory states that facial expressions can occur in the absence of emotions. During facial expression, one or more muscles may be involved to clearly signal a specific emotion (Ekman, 1992). This view is reinforced by others suggesting that the human emotional system is stimulated outside conscious awareness when exposed to subtle or millisecond glimpses of faces revealing emotions (Turner, 2000).

Ekman’s assessment of facial expression of emotion rests on the premise that, it can occur in the absence of emotions. In the process of facial expression, one or more muscles may be involved to clearly signal a single emotion. Subtle or millisecond glimpses of faces revealing emotional
expression have been documented by others, suggesting that emotions are stimulated outside conscious awareness by the human emotional system (Turner & Stets, 2005).

**Emotions in the classroom**

Emotions are definitely present in every aspect of our lives. A place that we do not often connect or think about in terms of emotions is schools. Yet, emotions experienced by teachers and students as they embark every day in the process of teaching and learning can range from happiness to sadness, frustration and anger. The science classroom in particular is a place that is under-explored in terms of emotional climate. Being unaware of our emotions and those of our students may have negative implications in classroom interaction and learning. While being aware of our and others emotions in the classroom can produce feelings of solidarity among class participants, promoting an environment of comfort while enhancing teaching and learning.

How many times have we walked into our science classes and perceive a feeling of enthusiasm where students’ eagerness to unveil the wonders of science is almost palpable? Then, as we advance into the intensity of the semester we sense feelings of frustration and of being overwhelmed from our students as topics progress in depth and complexity. College science classes are usually taught by scientists who introduce students to theories and scientific principles in a very straight and dry manner. These scientists also guide students during their laboratory experiments using the scientific method. The average college professor is generally not professionally educated in pedagogy, but has an extensive background and expertise in the science s/he teaches and usually is very good at passing on scientific knowledge as facts and principles. However, more often than not, students feel a disconnection with their science professors, almost as if their teacher was from another planet.
The objectiveness of science often sends a message to science students where human emotions are rarely seen or are simply obscured. As the material gets more complex throughout the semester, feelings of uncertainty and frustration often invade students’ minds. Such feelings of hindrance coupled with personal work issues, family life and other responsibilities can yield difficult learning and teaching environments. It is then, when many students get discouraged about learning science and teachers get frustrated with students’ performance. After providing the underlying background of theory of emotion, and a historical perspective; I now describe some of the physiology involved during emotional arousal in terms of brain structure and function.

The role of emotion in the science classroom is a topic that is rarely researched in sociocultural studies. Also, in spite of teacher’s high attrition rates and poor students’ outcomes, emotions are rarely studied in the classroom. One of our research goals is to contribute to the extant scarce literature of emotions in the classroom and the possible impact that it has on teachers’ performance and students’ outcomes. We believe emotional awareness plays a pivotal role in the way teachers perform in their profession and the way students learn. Our research is contingent upon emergent events and structures occurring and arising in the moment during teaching and learning.

It is recommended by the Ekman group to use both the print manual and take the on-line training on facial recognition at the same time. The on-line training is designed for the trainee to recognize subtle expressions of seven emotions: Fear, anger, surprise, sadness, disgust, contempt and happiness. The on-line training includes practice sessions, review of the main differences between expressions, as well as pre-test and post-test exercises that assess your competency in facial expression analysis. On the other hand the manual takes you to a very detailed explanation
of how to assign a measurement unit to each muscle movement involved in the expression of emotions.

The unit of measurement developed for this program is called the Action Unit (AUs) each unit represents activity in those muscles that produce subtle changes in facial appearance. For score variations, there is an intensity scoring scale that can be used to measure the strength of the action; from barely detectable to high levels of detection. For the investigator, it is not only a matter of developing micro-expression identification skills, but also acquiring specific terminology that enables him or her to describe human emotions and use them in a teaching education context.

Each muscle action has been carefully identified and assigned based on the points of origin and insertion of associated muscles. In order to understand the basis of the AUs, it is worth mentioning that when a muscle is contracted, there is a pull towards the point of muscle origin, drawing soft tissue, like skin towards that point and causing bunching or wrinkling of the skin perpendicularly to the line of muscle pull. This muscle action normally occurs bilaterally, in other words it happens in both sides of the face, except for very specific expressions such as contempt, which is manifested in a unilateral fashion (one side of the face). Later in the chapter I describe in detail how F.A.C.S Action Units are assigned to muscle groups and how they are used as a facial measuring system.

**Reading facial expression of emotion**

Research on micro-expressions of emotion suggests that despite the fact that people try to control and conceal emotions during exposure to events, small fragments of expressions have a way of escaping and if captured can be used to identify emotions. Also, micro-expressions can occur when an emotion is just beginning (Paul Ekman Group LLC, 2011). In our research we observed
and study emotions as they develop in the classroom as a result of sociocultural interaction and ideologies between the participants. Participants engage in radical listening and discussions of various controversial topics, while the emotional climate in the classroom exhibits a dynamic fluctuation of low and high moods in what Durkheim has called collective effervescence (Durkheim, 2001). In this study, there is an intersection of multi-theoretical frameworks involving video that facilitates the study of human emotions as these are enacted during teaching and learning. Paul Ekman’s Facial Action Coding System (F.A.C.S.) was developed in the late 1970s and has proven to be an effective, non-expensive and practical method of analysis. F.A.C.S. has evolved over time from videotape recorders, 16 mm motion picture film, and data stored in punched hole cards that was analyzed in mainframe computers to microcomputers, data manipulation and digital video (Ekman, 2002). However, even the most updated F.A.C.S. programs still utilize definitions of Action Units. Facial analysis recognition has diverse applications in an array of fields. There are also various methods that can be used for facial analysis, including a computer-based program called EmoVision. This latter program was developed with the idea of moving beyond basic traditional questionnaires during job interviews and obtaining insights into respondents’ thoughts and emotions. Most facial recognition programs are designed to identify seven displays of emotion: neutral, happiness, surprise, puzzle, disgust, sadness and fear (afraid). Many of the new facial recognition programs build their detection of emotions upon Ekman’s F.A.C.S. While some programs provide 90% of accuracy in their predictions without the need for training for the user (companies, consumers, researchers, etc.), Ekman’s program requires training and review of various manuals to be qualified in the detection of facial analysis.
F.A.C.S Training

Several of us in our Brooklyn College research squad took Ekman’s F.A.C.S on-line training program. The first step before taking the program was to become acquainted with the F.A.C.S manual and the F.A.C.S Investigation guide. In these two books there is important information on the background and the development of the coding system, data on the reliability of the program; the training procedure; F.A.C.S action units (AU) and the overall program in relation to other facial measurement approaches; how to assign scores to different muscle movements; how to translate scoring units into emotion terms and scoring other movements like eye and head (proxemics) as well as conversational facial signals or movements in relation to speech. In addition, the F.A.C.S manual contains detailed terminology of facial anatomical structures and how to interpret the provided muscle illustrations. There is also a well-cataloged list of the action units according to specific areas of the face and a list of structure movement mediated by muscle activity. The changes in facial appearance for each action unit are illustrated using images from still photographs obtained from videos from on-line training courses. Moreover, the manual and the investigator’s guide explain in detail the changes in facial appearance for each of the action units. In addition, there is also a table containing the final scoring for the reference example images and videos. In the manual there are some tips on how to become proficient at reading facial expression of emotions. For instance, while focusing on a particular facial emotion, it is suggested to make the action on your own face right in front of a mirror and make a comparison on how similar and how your facial expression differs from the one you are observing on the images or the videos being used.

The purpose of using the manual is to use it for initial learning and later on as a reference when scoring facial behavior. As we progressed with the training and learned about individual action
units, we learned how to combine two or more action units and the subtle differences between combinations. Scoring two or more units could be challenging, because an action unit may interfere when trying to detect another co-occurring one.

Based on Ekman’s postulate of facial expressions, the exact appearance of change in microexpressions varies slightly from person to person and depending on bone structure, fat deposits permanent wrinkles, shape of features and variations on facial musculature (Ekman, Friesen, & Hager, 2002). Figure 3 depicts superficial structures and features of the face associated with facial expression of emotions. The glabella for example is the area of the forehead between the eyebrows; the root of nose is the beginning of the nose between the eyes; the eye aperture is the degree to which the eye is open; the eye cover fold is the skin between the eyebrows and the palpebral part of the upper eyelid, which folds into the eye socket; the lower eyelid furrow is the place below the eye lid where a line or a wrinkle may appear; the Infraorbital furrow is the place where a line or wrinkle may appear parallel to and below the lower eyelid running from near the inner corner of the eye and following the cheek bone laterally; The nostril wings is the fleshy skin that forms the outside of each nostril; the Nasolabial furrow is a place where a line or wrinkle may appear and which begins adjacent to the nostril wings and runs down and outwards beyond the lip corners; and the philtrum, which is the vertical depression in the center of the upper lip and is directly under the tip of the nose.
Some of the terms used to describe the appearance changes in the lip, eyes and other facial features are: *elongate*, this term is used to describe when the mouth appears to be longer than usual in the horizontal plane; *de-elongate*: the mouth appears to be shorter than usual in the horizontal plane; *narrow*: the red part of the lip is narrower or less visible than usual; *widen*, the red part of the lip is wider or revealed more than unusual; *flatten*, the lips appear to flatten against the teeth; *protrude*, the lips come forward or away from the face more than usual; *tightly*, the lips are not relaxed or loose, but the muscles within the lips have contracted. When describing changes in the appearance of the skin, some of the terms used are: *bulge*, a protrusion of the skin over the eye ball or bone; *bag*, loose skin which wrinkles as it is gathered together or pushed; and *pouch*, a pocket-like shape. The terms used to describe skin marks are: *line*, a surface line with no depth and quite fine in terms of width; *wrinkle*, a line with some depth and
has more width than a surface line; and *furrow*, a place where wrinkles may appear and may deepen with certain muscle action (Ekman, 2002).

**Action Units and their meaning**

In order to do the scoring of the muscles (AUs) involved in a particular emotion, a determination of each independent muscle and its action must be made. Also, one must determine whether each independent muscular action results in a distinguishable facial appearance. Some facial actions may serve the same function and may express the same message; however, even when there appear to be facial synonyms, the analysis should be established empirically not on an *a priori* basis. Another important factor about this type of analysis compared to other approaches is that the determination of the facial expression is made based mostly on the evidence and not just on inferences (Ekman, 2002). F.A.C.S teaches researchers how to interpret facial muscle movement; starting with the origin of the muscle, which is the place where the muscle attaches to a bony structure and it, follows it to the point of insertion or attachment. As the muscle contracts, there is a distinctive pull from the point of origin, drawing the soft tissue in the form of a bulging or a wrinkle perpendicularly to the point of muscle pull.

Each action unit is assigned a number and a name, for instance **AU 4** is *Brow lowerer*. **AU 4** is achieved by the action of three muscle strands. The first strand runs obliquely in the forehead. It emerges near the root of the nose below the glabella and runs up upward to the point of attachment in the forehead above the eyebrow. This strand also pulls the eyebrows together and lowers the brow. The second strand runs more vertically and emerges from the root of the nose below the glabella and fans out in the center of the forehead where it attaches. The third strand runs from the glabella to the medial corner of the eyebrow. The facial appearance due to **AU 4** can show any of the following or a combination of: 1) the inner eyebrow is lowered, sometimes
the central portion of the eyebrow may be lowered as well or it may appear as the entire brow is lowered; 2) the eye aperture is narrowed due to the eye cover fold being pushed downwards; 3) the eyebrows are pulled closer together; 4) there are deep vertical wrinkles produced between the eyebrows at about 45 degree angle; 5) there may be an oblique wrinkle or muscle bulge running from the middle of the forehead above the middle of the eyebrow down the inner corner of the brow. There are also intensities associated with each action unit (AU) and that must be done in order to get the appropriate scoring Intensity terms are: trace, slight, marked, pronounced, severe, extreme and maximum. For example, AU 4 has 5 different variations or possibilities: AU 4A, AU 4B, AU 4C, AU 4D, AU 4E.

AU 4A indicates that the appearance changes for AU 4 are sufficiently present to indicate AU 4, but are insufficiently present to score 4B (for example: a trace of brow lowering and/or a trace of pulling together).

AU 4B presents two possibilities: 1) inner and/or central portion of the brow lowered slightly, pushing down or reducing visibility of medial portion of eye cover fold or 2) brows pulled together slightly, if a movement is not perceived, then there is a wrinkle or muscle bulge between brows. If a wrinkle or muscle bulge is permanent in the neutral face, then it increases slightly during an emotional expression.

AU 4C, the lowering and the pulling criteria of AU 4B are present and at least one is marked one step greater than slight, but the evidence is less than criteria for 4D.

AU 4D the lowering and the pulling criteria of AU 4B are present and at least one is severe, but the evidence is less than criteria for 4E.

AU 4E reflects brow pulling together or lowering is at its maximum (FACS, 2002.)
F.A.C.S on-line

After becoming familiar with the manual and the investigators guide, I took the micro-expression training tool (METT Original training), which estimated completion time is 45 minutes. The METT Original consists of: a pre-test, a training, practice, review and post-test. Facial expression of emotions appears on video and last a fraction of 1/25th of a second.

The pre-test is used to find out how much you know about facial expression recognition before you start the training. An emotion is flashed on the computer screen, you will judge and select the corresponding emotion by clicking a button; the program automatically moves to the next expression for identification. When you have finished choosing each micro-expression, you will get feedback on your accuracy. In the training you are provided with access to a video, which enables you to learn how to distinguish the differences between anger and disgust, between fear and surprise, between contempt and happiness and then between fear and sadness and how they are expressed across the face. During the practice, new faces never seen before appear making micro-expressions and you get feedback on whether you were able to spot the emotion correctly. If you were wrong in your judgment, you have the opportunity to judge the emotion again by clicking the R button to see the expression repeated before you try to judge again. You may flash each expression repeatedly as many times as you wish, until you get it right. You can also choose to click on the F button to flash the expression on the screen or hold that same button down to freeze the expression until you feel you can recognize that emotion. At the end of the practice you will receive a practice score and a breakdown of how you did it. In the review you have a chance to revisit the difference between anger and disgust, fear and surprise, contempt and happiness, fear and sadness on the faces of new people. Micro-expressions are rolled on and off the face with commentaries on clues of what to look for. The expressions in the review are
different from the ones shown during the training. During the post-test you see faces of people you have never seen before. It is advised to take the test at the fastest speed you can. Expressions are flashed before you and you have to select the corresponding emotion by clicking a button. You are automatically moved to the next expression, but you will not get feedback about all of your recognition attempt accuracy until the end of the test. Also, at this time you will get feedback on how much you have improved since the pre-test and how accurate you have been at recognizing the seven types of emotion. At the end of this training program you must score a minimum of 80%. If you do not score at least 80%, you are advised to use the emotion breakdown to determine which micro-expression of emotion you are having difficulties with. Then it is suggested for you to re-do the post-test again. During this training, I scored 85%. I moved on to the micro-expression training tool: METT Advanced.

The METT Advanced features a similar sequence of the training parts the METT Original has. However, here are some of the things that are different in this particular program. 1) You see 84 different people, which do not appear more than once. 2) There are seven males and seven females, each belonging to six different ethnic groups: Black, Middle Eastern, Chinese, Japanese, Korea, Caucasian and Indian Pakistani. 3) The METT Advanced is supposed to help you improve your proficiency in recognizing facial expressions of emotion that are not compressed in time to a fraction of a second. This approach enables you to master the instruction and be prepared to spot emotional expressions without having to think about what you are looking at. 4) It has more practice items and a review session for additional training. 5) It will take approximately 65 minutes to complete. The minimum score for the METT Advanced is 80%. After going through the training and taking the post-test, I scored 93%. This level of training is designed for people who are serious about recognizing micro-expressions of emotions
and whose job requires them to evaluate truthfulness and detect deception. People that usually take this training have jobs in police forces, security, sales, medical professions and education (Ekman, 2011).
Chapter 3

EMOTIONAL AWARENESS IN THE SCIENCE CLASSROOM THROUGH THE LENS OF
FACIAL ANALYSIS USING A HUMAN FACIAL RECOGNITION PROGRAM

Brooklyn College Study

The role of emotions in human conduct is pivotal in any type of human relationship. This reflexive social inquiry study is part of the multi-method and multi-theoretical research project at Brooklyn College of the City University of New York that explores the intersection of emotions and mindfulness in the science classroom. Facial analyses of student-teacher interactions are recorded and analyzed using Paul Ekman’s facial action coding system (F.A.C.S) (Ekman, 2002.) that facilitate the study of emergent and dynamic emotions in this history and philosophy of science education class. Student participants have opportunities to execute their agency, foster reflexivity, and emotional awareness. Also, participants express their perspectives and react to others’ points of view as controversial themes in science are discussed each week. In this chapter, I document how emotions are expressed and how they may influence teaching and learning as we deviate from the traditional ways of teaching and learning in science. We think that facial expression can be used as a medium to analyze emotions in the classroom, based on the premise that facial expression of emotions can provide valuable information about the state of mind of people. We explore this concept and its implications in the teaching and learning environment in a master’s-level class at a public college in New York City. Our hope is that the benefits for the participants extend further to their field of work in their own classroom.

Although our research was primarily set to focus on mindfulness, breathing meditation, emotional climate, coteaching and cogenerative dialogue (Tobin, 2006.) we adopted an emergent and contingent approach with some of our methodology; This focus emerged contingently over a
program that has extended more than a decade. We developed and adapted salient themes that would make the study inclusive of many relevant factors to our transformative pedagogy and that would fill-in the gaps that arose throughout the entire research process. This approach permitted us to include patterns of coherence as well as nuances that make our reflexive social inquiry study a valuable resource for those interested in conducting qualitative research in science education. The goal in the design of this science education course is for students to have first-hand experience teaching the curriculum. Student coteachers’ responsibilities are augmented by allowing them to assume the roles of mediators of the class. Each week one or two groups of students are assigned to present an overview of topics in: history, philosophy, trends and socio-cultural aspects of science. The professor’s goal in the class is to encourage students to execute their agency as participants in a democratic fashion. Alexakos states in his course syllabus “I view the course as one in which each of us, including myself, will collaborate to produce productive and quality learning environments in which we learn from one another. All classes in this course are to be cotaught and each teacher must also be ready to be a learner. Through the use of coteaching and cogenerative dialogue, we will work together to develop sessions that further our understandings of the main topics of the course in a respectful and thoughtful manner, and actively listening to what others are saying and contributing and encouraging everyone in developing their ideas (critical listening) (Alexakos, 2012, p.1)In this way, all participants in the class had the same opportunity to express their voice and contribute their perspectives, creating stimulating and in-depth discussions. The larger themes in the curriculum extended to current issues in science, as well as topics that have been traditionally controversial like evolution, sex and gender in science, eugenics, and ethics with respect to science. The debated topics often threw emotions off balance for the participants. To counteract some of the feelings of anxiety
and frustration that were aroused during class discussions, we introduced concepts of mindfulness and breathing meditation to coteachers and the participant audience.

All fourteen-class sessions were videotaped from different angles of the classroom with the purpose of capturing details of events that could have been missed while taking field notes. Also, we wanted to have good facial close ups of the participants and be able to do analysis of facial expression of emotion. A thorough reviewing of our field notes provided us with information of specific events that we wanted to review further and analyze. In addition to collecting data during class, we also gathered data through informal cogenerative dialogue meetings before and after each class. Our aim was for everyone participating in the class, students, the professor, and researchers to attain certain levels of emotional awareness that would transcend the stereotypical science class dynamics. In other words, we wanted to deviate from the traditional college science class where there is little room for subjectivity, because the present education structure follows the Cartesian-Newtonian-Baconian ideological tradition where Cartesian (objective) science is not only the best way to understand the world, but the only way (Kincheloe, 2003). The only norm for interaction in this class, was to let go of intellectual expression inhibitions and to consider the class a safe place to execute one’s agency and allowing emotional arousal without hindering one’s passion, a factor often absent in the science classroom. Our approach is contingent upon emergent situations that arise from dialogue and class discussions. In this event-oriented research, subtle emotions served as the window to issues that have affected and continue to affect the life of the individuals in a way that extends in magnitude to the collective. We followed the tenets of participatory action research where every partaker in the research provides his/her own perspective on what is being researched; also, where participants experience a sense of solidarity towards one and other, and they feel that they are in a sensible place because
everyone’s contribution is equally important. By taking this approach, we could enrich the science learning experience for everyone involved. Also, we could attempt to tailor and transform learning and teaching science to the needs of the collective, and where students can make connections to the science in the lives.

The research squad was formed by the two principal investigators, Konstantinos Alexakos and Kenneth Tobin, who are graduate faculty and advisors at Brooklyn College and The Graduate School and University Center of the City University of New York respectively. Alexakos was also the class professor. The other members of the research team were six doctoral students: Dorota, Malgorzata, Glaucio, Reynaldo, Andre and me (Olga); and 3 master students: Parvaathy, Natasha, Sandra and Victor, a former high school student of Alexakos.

The research squad responsibility was to prepare the room before class for data collection by setting up video cameras that will record the events during the entire class period; set up computers, microphones, and the pairing of the clickers program and oximeters used by students with computers. We also took field notes, and some of us contributed with feedback in the development of intervention instruments of mindfulness and cogenerative dialogue. In addition, we participated in class discussions and every day before class we met in the classroom to debrief about the plan to follow contingent upon the developments of the previous class. In these debriefing meetings we discussed whether the data collection plan had been effective and should be continued or whether we should change the approach. Furthermore, after each class, we participated in cogenerative dialogue. These cogenerative dialogues were also recorded. Student-researchers from the class were invited to stay to participate and contribute to the cogen discussions.
We collected several hours of video that contained interesting conversations; however, we had to select incidents that were salient to us where we could apply our methods and at the same time we could correlate them to our theoretical framework. We pick out various video clips that caught our attention and that orient our inquiry-based research (Sewell, 2005.) In this chapter, I document a vignette featuring student-teacher, Louise during her assigned coteaching class on “Philosophy of Science.” Together with her coteacher, her goal was to introduce the concepts of normal science and the scientific method to the class for which they planned several group activities in which students were supposed to discuss the role of science in their lives. During this class, many students expressed their disagreement on the way science is presently taught in schools, and they voiced their view on the institutionalized philosophy of science and the evolution of the field in terms of scientific progress. Class participants also articulated their concerns about how science is taught in schools, rarely considering certain relevant topics like indigenous knowledge as part of the curriculum. At that point, Louise mentioned how her Grandma was able to give her the right medicine without being a “formal scientist.” We think that this particular event is where Louise’s emotions combined with the anxiety of being one of the coteachers that day started fusing and building up momentum.

After the class ended that night, we had a cogenerative dialogue as we did every night after class. Louise stayed and took part in the dialogue and contributed her perspectives on what had transpired during class. It was then, that she talked about her grandmother in more detail. We knew at that moment that we wanted to analyze that conversation. Louise’s emotions were intense at times and she seemed to have been making a strong effort to hide what she was feeling. We videotaped the session and that provided valuable data to start our analysis.
Louise is a science teacher assistant in a New York City public school. For our analysis, we chose a two-minute and five-second event where there is clear emotive communication that informs our social inquiry theoretical framework. Emotive communication, as expressed through spontaneous, physical reactions, is non-volitional and results from the need to adapt physiologically to strong emotions (Arndt, 1991). I started the analysis of the vignette by building an emotional landscape of micro-expressions or subtle emotions using Ekman’s FACS program. The first step was to build a grid of the different subtle emotions displayed by Louise during the two minutes and five seconds of the vignette (Table 1). We obtained the recordings from a digital video camera and developed a clip reflecting Louise’s face at 30 frames per second in order for emotions to be easily recognized during the analysis.

**Is Louise just having a “bad” day?**

As we did the first part of the analysis we could see that Louise’s emotional arousal was a mixture of happiness and sadness (pain). At the 34-s mark in the video clip, Louise reminisces about her childhood. She goes on to narrate about how back home; they cut, wash and boil herbs from the backyard to treat injuries. During this time, she smiles and even laughs in the video, an action that is re-enacted and brings back emotions of happiness while she watches. At 40 seconds, Louise becomes thoughtful about the questions being asked, so the expression on her face changes from happiness to sadness. She continues to try and keep a neutral expression in her face. However at 1:12 seconds, when she says, “In my backyard, it was really rocks so we, it wasn’t cement, so we used to fall a lot.” Even with all the restraining she is trying to do, there is a moment of deep insight, as though she was anxious listening to herself and reliving an experience that causes her sadness. She composes her posture, because the very action of referring to her grandmother brings back strong sad emotions that overcome her. She speaks
about how her experience of seeing her grandmother prepare all these home remedies to cure her injuries impacted her in a way that she wanted to pursue a career in science. She thought of that simple remedy as being “so cool,” even though she didn’t know why the solution could cure her bruises (Fig. 1 depicts a breakdown of emotions with keywords). Her grandmother always wanted to be a nurse and partly Louise’s decision of study science had to do with wanting to accomplish her grandmother’s dream in some way. The professor for the class, Konstantinos, a cogen participant, asks Louise whether she sees herself as an extension of her grandmother. Louise responds in a very soft low tone of voice: “yes” as an expression of sorrow invades her face.

We proceeded to analyze Louis’s expressions by assigning F.A.C.S action units (AUs) to different still photographs taken from the vignette. After careful analysis of each expression, we concluded that during Louise’s neutral pose (Fig. 1a) there were no muscle action movements to predict any AUs. During the second photograph (Fig. 1b) AUs 16 + 25 are involved producing a facial expression of sadness. There is an obvious muscle contraction of the *Corrugator supercilli* muscle located under the *Frontalis* muscle. In the third photograph (Fig. 1c) there is a combination of action units; AU 6+AU 12+ AU 25 depicting contraction of the following muscles: *Orbicularis oris, Risorius, Zygomaticus, Levator angulii oris, Depressor angulii oris, Mentalis, Buccinator, Depressor Labii inferioris and Levator Labii superioris*.

The following table (1) depicts Louise’s emotional profile
<table>
<thead>
<tr>
<th>Time stamp</th>
<th>Emotion displayed</th>
<th>Muscle Involved</th>
<th>Action Unit</th>
<th>Key words</th>
</tr>
</thead>
<tbody>
<tr>
<td>:21</td>
<td>Neutral</td>
<td>Insufficient muscle action to predict an AU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>:31</td>
<td>Happy (smile)</td>
<td><strong>Oblicularis oris, Risorius, Zygomaticus, Levator anguli oris, Depressor anguli oris, Mentalis Buccinator, Depressor Labii inferioris, Levator Labii superioris</strong></td>
<td>6+12+25ii</td>
<td>Grandmother- Indigenous science</td>
</tr>
<tr>
<td>:45</td>
<td>Neutral</td>
<td>Insufficient muscle action to predict an AU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>:55</td>
<td>Concern, thoughtful</td>
<td><strong>Procerus, Frontalis, Corrugator supercilli</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:04:00</td>
<td>Sadness</td>
<td><strong>Corrugator supercilli (under Frontalis)</strong></td>
<td>16+25</td>
<td>Reflective-Social condition</td>
</tr>
<tr>
<td>1:10:00</td>
<td>Happy (smile)</td>
<td><strong>Oblicularis oris, Risorius, Zygomaticus, Levator anguli oris, Depressor anguli oris, Mentalis Buccinator, Depressor Labii inferioris, Levator Labii superioris</strong></td>
<td>6+12+25ii</td>
<td></td>
</tr>
<tr>
<td>1:11:00</td>
<td>Sadness, contempt</td>
<td><strong>Corrugator supercilli (under Frontalis)</strong></td>
<td>1+2+4ii</td>
<td>Cuts/bruises - hurt-pain</td>
</tr>
<tr>
<td>1:21:00</td>
<td>Neutral</td>
<td>Insufficient muscle action to predict an AU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:23:00</td>
<td>Sadness</td>
<td><strong>Depressor labii inferioris, Oblicularis oris, Mentalis</strong></td>
<td>16+25</td>
<td>Grandma treating their wounds with the available resources</td>
</tr>
<tr>
<td>1:43:00</td>
<td>Happy (smile)</td>
<td><strong>Oblicularis oris, Risorius, Zygomaticus, Levator anguli oris, Depressor anguli oris, Mentalis Buccinator, Depressor Labii inferioris, Levator Labii superioris</strong></td>
<td>6+12+25ii</td>
<td>Reflective - nurturing environment</td>
</tr>
<tr>
<td>1:48:00</td>
<td>Sadness</td>
<td><strong>Corrugator supercilli (under Frontalis)</strong></td>
<td>1+2+4ii</td>
<td>Reflective - grandmother - childhood</td>
</tr>
<tr>
<td>1:49:00</td>
<td>Sadness</td>
<td><strong>Corrugator supercilli (under Frontalis)</strong></td>
<td>1+2+4ii</td>
<td>Reflective - grandmother - childhood</td>
</tr>
<tr>
<td>2:04:00</td>
<td>Neutral</td>
<td>Insufficient muscle act. to predict an AU</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Louise’s Déjà vu

To increase the dependability of our findings, I decided to have Louise watch herself in the video while I videotaped her again. At this point I had done the facial expression analysis of her using FACS, but I did not share the results of my analysis with Louise until she had a chance to watch herself in the video and until after I had a chance to interview her and she could give me feedback on what her feelings were at the moment she spoke about her childhood and her grandmother.
I positioned Louise in front of the video camera, so that I could catch a full-frontal face shot and I could identify subtle facial expressions as they happened; also, I was hoping that I would not need to edit in a neutral face in post-processing.

I was able to catch a neutral pose (0.06 sec) (fig. 2 neutral) as the video started streaming. She was trying to contain laughing and seemed a bit embarrassed while looking at the video. She pressed her lips to avoid laughing, and took long thoughtful breaths as she watched herself talking in the video. It was almost as if her breath was taken away by the reminiscence of those childhood memories. It was clearly a bit uncomfortable for her to see that she was laughing in the video. Louise seemed to be trying really hard to conceal to what appeared to be strong emotions. She then, places a hand on her cheek, holds her earlobe and starts playing with it.
while she continues watching the video. Somehow she wanted to divert her attention to something that could provide comfort, like when a child searches for her childhood blanket to feel its warmth and softness.

**Emotions reaffirmed**

When looking at Louise watching the first video, I noticed that she had a smirk on her face and there was a point when she felt as if someone was staring at her, so she turned to her left as if she was going to take some notes, but she did not. It was clearly rough for her to see that she was expressing certain emotions in the video. She then, places a hand on her cheek, holds her earlobe and starts playing with it, while she continues watching the video. At 0.34 seconds, Louise narrates and laughs about how her grandmother used to cut, wash and boil herbs from the backyard to treat injuries. During this time, she smiles and even laughs in the video, an action that is re-enacted and brings back emotions of happiness and pride while she watches herself narrate her childhood story (Louise smiles Fig. 2 happiness). At 40 seconds, Louise becomes thoughtful about the questions being asked, so the expression on her face changes from happiness to a more thoughtful one. She continues to try and keep a neutral expression in her face because according to her she is trying to restrain her emotions. However, at 1:12 seconds, when she says “my backyard was not cemented, so there were rocks all over and we, me and my sister, used to fall a lot.” She continues her story while I continue to record her saying: “We always had bruises and small cuts all over our feet and arms. I was always amazed to see how fast my grandmother’s home remedies heal our injuries.” Even with all the restraining she is trying to do, there is a moment of deep sight; almost as if she was anxious to listen to herself re-lived that experience that cause her to feel sad (Fig. 2 sadness expression). As she progresses watching the video and she mentions her grandmother, Louise composes her posture, because the
very action of referring to her grandmother brings back strong emotions that overcome her. She speaks about how her experience of seeing her grandmother prepare all these home remedies to cure her injuries impacted her in a way that she wanted to pursue a career in science. She thought of that simple remedy as being so cool, even though she didn’t know why the solution could cure her bruises.

That day, I interviewed Louise and I discussed my analysis with her and correlated my results with her view on what had transpired. I realized that powerful things were happening as I conversed with Louise about her emotional awareness. I had gained her trust and she was able to open up to me about her restrained feelings, which are mostly due to the norm of her culture and her grandmother’s legacy of having to be strong in order to survive and raise five children of her own. Louise explained that she often tries to inhibit overwhelming emotions she is experiencing in the moment by distracting herself with something she has at hand, in this case playing with her left earring, or by redirecting her emotional awareness to another part of her face. She tries to restrict her facial emotional expression from others, because her cultural background deems the expression of certain expressions as a sign of weakness. This expression regulation sustained by Louise has been coined by Ekman as display rules, which are characteristic behaviors of cultures and are usually learned early in life. Display rules are meant to regulate our automatic impulses during emotional arousal in social environments. According to Ekman and Friesen, there are ways that people can regulate facial expressions. 1) Emotions can be expressed as they are; 2) emotions can be amplified, in other words they can show more than what is actually felt; 3) they can be neutralized to show nothing; 4) can be qualified by combining and showing and showing with other emotions; 5) can be masked or concealed, so that the emotions expressed are different to the ones actually felt; 6) emotions may be simulated or shown when are not felt at all (Ekman,
According to Louise’s accounts, she was encouraged to be strong and not to demonstrate any sign of vulnerability to others when she has overwhelming emotions. Louise speaks about the social forces that limit her emotional expression, but also she speaks about how she is now aware of such limitations, where these shortcomings originate and how they mediate her interaction with others. Louise reflected on how she represses her emotions in every social circle to maintain the status quo. She opened up to me about her inhibited emotions, which it is not always the case with student-teacher interactions in the science classroom. Different cultures may prohibit the open expression of emotions in certain social contexts, while others may mask or qualify the original emotion to keep certain social appearances. Studies conducted by Ekman on how cultural norms for expressions differ among Western (Americans) and Eastern cultures (Japanese and Chinese from Hong Kong), shows that while Americans believe that expressions should be amplified, the Eastern cultures believe certain emotions should be masked. In other instances, this regulation of emotion applies to class. Emotional expressions such as anger, disgust and contempt need be regulated when with a higher status person.

Facial expression of emotions may be identified using other methods of analysis. My colleague Andre used a computer interface program (EmoVision) to analyze the same video-clip I analyzed featuring Louise’s facial expression of emotions. We had kept each of the results of the analysis to ourselves and did not share our findings with Louise until she had a chance to watch herself in the video and could give us feedback on what her feelings were at the moment she spoke about her childhood and her grandmother. After all the data were collected and analyzed, we decided to look at each individual analysis and correlate them with Louise’s accounts of her feelings while watching the video. Not only did we want to corroborate our individual findings and how close we were in the identification of emotions using each method of analysis, but we wanted to
confirm that emotions are resonance structures that when we experience re-enactment of past situations, we are very likely to experience the same emotions experienced when we first live that experience.

There are multi-methods of analysis to detect different aspects of emotions. In this analysis I use two methods; Ekman’s F.A.C.S and ethnographic narratives through an interview. I learned that the analysis of Louise’s facial expression of emotions recorded during cogenerative dialogue after class is consistent with her accounts during the interview of the recollection of emotions she felt during that event that night. The data also correlate with post-interviews conducted with Louise after the analysis. I also observed when I interviewed Louise, that there was emotional resonance of sadness during the time she watched herself on video while telling her story and during the interview. The data and observations obtained during this analysis are significant enough to consider them for further research.

Learning from this experience

Finally, as a researcher, I should consider asking: why conduct this type of investigation using this method? Ideally the answers to that question would lead to identifying some of the benefits of doing facial analysis in the science classroom or any classroom may include: 1) Explore how emotions affect our students behavior, learning & attendance; 2) Recognize and label feelings; 3) Acknowledge feelings; 4) Manage Feelings: Think about feelings and what to do about them; 4) Develop strategies on how to manage our emotions and those of our students within the classroom.

Recent studies by Richard Davidson suggest that the brain has a property he call neuroplasticity. Davidson has ample evidence that the brain can change its ability and function in substantial
ways. This neurological change can be attributed to responses to experiences we have as well as the thoughts we have (Davidson, 2012.) Neuroplasticity provides new light on the dogma that everything that we are is genetically based. Although our emotional style seems imprinted in us, it does not have to be that way. We are provided with sufficient evidence that the brain is a malleable organ and change is possible. Facial emotion recognition and the tools that are available to help us become aware of our emotions and that of others can be a powerful instrument to build and enhance human relationships of any kind. Although the application to this new concept seems to be more appropriate for cognitive studies, it is a valuable idea to be applied in the classroom. Through this type of analysis, Louise and I became aware of her facial expression and the socio-cultural structures that prompt various types of emotional arousal. After my interview with her, we talked about how as much as we want to conceal our emotional expressions, they can escape our consciousness and possibly reveal some evidence of how we feel. We also talked about the significance that the skill of learning facial expression recognition has in our lives and in the way we perceive other’s emotional expressions.

The impact that we, as teachers have on students and that students have on us is unprecedented and influences greatly the path in education that students take. Whether our students end up loving a career field or hating anything that has to do with it, is related to the type of relationship and interactive experience we develop in the classroom. The teaching profession is very much ever day filled with emotions. Not only do we deal with our students’ intellectual development, but also with their emotional state. More often than not, we distance ourselves from how the issues that we dealt with everyday affect our own emotional state. The fact that we, as science teachers, follow an objective school of thought and scientific philosophy does not make us invulnerable to emotional arousal. Neither does it make science students strangers to positive and
negative emotional fluctuations. Facial recognition of emotions can help us as teachers become aware of the limitations of our students and also our own emotions.

Transmission of emotional state can occur in the classroom setting as well as in any other place. How we feel as the facilitator of instruction could very well impact on how that instruction is received. This ripple effect is called *emotional contagion*. *Emotional contagion* has been described by Schoenewolf as: “a process in which a person or group influences the emotions or behavior of another person or group through the conscious or unconscious induction of emotion states or behavioral attitudes” (Schoenewolf, 1990). Emotional contagion has shown to influence people moods in groups, but also to be important to group life. Emotional contagion has also been shown to influence subsequent group dynamics for both the individual and the collective (Barsade, 2002). In the Brooklyn College research I found that there was collective mood
effervescence during various moments during class. For instance, when one of the student-teachers included a funny remark as part of his/her presentation, the class participants were in synchrony laughing or smiling with the student-teacher (pic 3). On the other hand, when the same student-teacher that same night presented a video on student bullying, the mood was really somber and unhappy in the class. The student-teacher’s facial expression embodied the emotions of the bullied student on the video the class was watching (pic. 4). We capture one of those moments in camera, where the facial expressions were very much the same across the room. This emotional contagion was also reiterated by the class clickers’ responses on what they perceived as to be the mood of the class at that moment. It is during class events like the bullying episode when some degree of emotional mindfulness in the classroom setting may have positive outcomes for all class participants.

Innately humans have evolved ways to communicate and interpret facial expression of emotions. In an attempt to correct cultural biases during facial analysis, researchers have developed technologies that can aid us in the interpretation of emotions. Computers can repeat tasks reliably and consistently without the encumbrances of nuance. However, the existing technology developed for this purpose is far from being perfected. For instance, resting your head in your hands changes the shape of the face; this change could be misinterpreted by a computer system.
Emotional contagion is illustrated here during a segment of the class watching a bullying video – note unhappy and somber facial expressions of coteachers in solidarity with the speaker in the video.

Even though computers can do wonderful things numerically or computationally it may take us many years for a computer to duplicate or even master what humans can presently do. Conversely, a human analyst may misinterpret something he/she sees based on culture, personal experience, or even mental fatigue. Analysis of facial expression may be complex. We must look at nuance factors in the detection of emotion. For example, subjects often change their behavior because they know they are being recorded. This suppression or repression of emotions may manifest itself in another, more subtle way unrelated to the face. Future research could include refinements and improvements to the methods employed in this study. Among them may include a more modular camera setup to ensure the highest possible emotion recognition accuracy, the inclusion of gaze tracking in order to identify stimuli, and the use of prosodic (voice) analysis.

Ekman and Friesen propose that understanding emotional experience does not apply only to relationships you have with others in different contexts. He suggests learning and understanding
micro-expressions of yourself can have a significant impact on your life. Learning how to identify micro-expressions in the science classroom can be a powerful skill that may have positive implications for both teachers and students in the science classroom. As teachers learn facial blue-prints, they can become aware of students’ emotions of attentiveness, confusion, concentration or boredom (Ekman, 1975). Thus, they can cultivate their ability to recognize emotions in students and modify their teaching styles, in ways that can enhance student interest and learning of complex subjects, and that are often the underlying principles of more intricate ones.

Our research on emotional awareness in the science classroom has ramifications for all involved. It was through the analysis and discussion of emotional states that both, the researched and the researchers have come to realize that teacher emotion is the product of cultural, social and political relations (Zembylas, 2005). This concept can have positive and negative implications in the classroom for students, if we as teachers do not know how to regulate and find a balance to deal with both our emotions and those of our students. Fortunately emotion regulation is part of teacher training and provides teachers with strategies on how to help them with emotion goals (Schutz, 2007.) However, the reality is that having gone through emotion regulation training does not guarantee success dealing with emotional stress in the classroom. As teachers, we may set emotional goals in the overall structuring of the teaching environment, yet if a teacher’s felt emotions are not congruent with the pedagogical emotional goals, then the teacher will have to put forth great effort to display the desired emotion (Schutz, 2007). Some of the strategies used by teachers when repressing negative emotions is pausing and reminding themselves they are teaching children. Suppression is a type of emotional regulation and while teachers may be able to modify their anger and frustration by forcing themselves to be calm, it may eventually result
in negative feedback for the teacher in regards to well-being. The use of suppression of emotions as a strategy has been linked to feelings of inauthenticity and depression.
Chapter 4

OXIMETRY AS A REFLEXIVE TOOL FOR THE DETECTION OF PHYSIOLOGICAL EXPRESSION OF EMOTIONS IN THE SCIENCE-CLASSROOM

Historical Background of Oximetry

The role of pulse oximetry as an intervention tool for detection of emotions is part of a larger study-taking place at Brooklyn College of the City University of New York. The study focuses on the exploration of emotions and mindfulness in the science classroom. The pulse oximeter is a common instrument used in medical and aerospace fields. Yet, its uses may expand to other fields where there is human interaction and where its physiological outputs reflect fluctuations mediated by arising emotions. This device provides important physiological information about a person’s oxygen concentration (or oxygen saturation – SpO$_2$) in the blood and his/her heart beat as his/her emotions change. We adopted the oximeter as a reflexive tool to detect emotions emerging among participants of a graduate History and Philosophy of Science Education course offered in the spring of 2012. My role was of an observer when the project began. I was there to learn data collecting methods and other intricacies of qualitative research. In addition, I was going to serve as a peer de-briefer for some of my colleague researchers. When I attended the first class, I realized that I was not only learning about research in the classroom, but I had become part of the research.

I became interested in aspects of the research that dealt specifically with emotions, their analysis and their origin. Coming from a biological philosophical background, the subjectivity of the methods of analysis looked quite appealing and posed a new perspective for me. I noted from the beginning that this project reached beyond collecting and reporting data, because there was a sense of axiological transformation for me and others involved. One of the factors
that attracted me was the intersection of sociocultural themes that emerged every night as a result of the discussions in the classroom. Class discussions coupled with diverse emotional and physiological experiences and responses from all participants (researched and researchers) as the course curriculum was being enacted, was quite revolutionary to me. The emergent and contingent style of our research depended upon the developments of class events. This approach enabled us to incorporate methodologies that were discussed on a day-to-day basis during cogenerative dialogues. Cogenerative dialogue has been described by Kenneth Tobin, as a practice whose membership represents all stakeholders’ groups that talk about specific incidents occurring in the classroom. Their purpose is the improvement of schools and learning environments (Tobin, 2005). Cogenerative dialogues took place before and after each class and in a formal weekly meeting, at the CUNY Graduate School and University Center. Here, new ideas on the course of the research were contemplated. This research structure, gave strength to the methods, data collection and emergent situations during the research process. In addition to data collection using video recorders to capture events for facial, voice and proxemics analysis, we also used digital clickers to collect responses from the participants on what they perceived as the emotional climate being experienced in the classroom. Coteachers and researchers used finger pulse oximeters during class presentations and discussions, which provided in the moment physiological data that were used to make participants aware of their physiological measures related to their emotions. The physiological data were in turn used to introduce the practice of breathing meditation as an intervention activity that could ameliorate the physiological stress participants were experiencing. Moreover, at least two heuristic instruments on coteaching and mindfulness were developed and tested by the participants. The inclusiveness of such
diverse, yet complementary methods of analysis provided reinforcement to the research process and a strong platform where developed instruments intersect, providing new and valuable information to research in science education. In the next chapter, I document oximeter data collected for two student teachers enrolled in a history and philosophy of science education course at Brooklyn College in the spring 2012. These two participants presented unusual spikes in the curves for oxygen saturation (SpO2) and heart rate on the days they were scheduled to coteach. I became interested in learning how the pulse oximeter worked and how it could be used in the classroom as an intervention tool to become aware of changes in physiology as emotions change, especially since the curriculum in this class is designed to discuss sensitive science-related issues. Also, I wanted to explore what strategies coteachers might employ to enable other class participants to express their agency freely and still maintain a sense of respect, tolerance and compassion among all class participants. The data we collected gave us important insights into the application of oximeters in the classroom and possible benefits for the overall wellness of teachers. Our research is perhaps one of a few of this kind, where the use of multi-methods is employed to explore emotions and mindfulness as a transformative approach to teaching and learning.

**Why use this medical device in class?**

The finger pulse oximeter slips onto your fingertip and measures arterial oxygen saturation (oxyhemoglobin) by shining red and infrared light through the tissue. It measures arterial pulsations and pulse rate at 18-300 beats per minute (BPM). Its accuracy is within 2% (Furgang, 2012). After World War II, many of the scientific advances reached in aviation medicine transferred over to respiratory physiology in hospitals and the general medical field. One of the first reported uses of the oximeter was during a surgical anesthesia procedure to
control anoxemia. The development of oximetry has transformed the diagnostic accuracy of oxygen saturation in the blood. We often do not think of the classroom as a place that can have an effect in our health. Alexakos and Ken Tobin developed the idea of utilizing oximetry to monitor emotions in the science classroom and use it as a resource to improve teachers’ praxis. Tobin had used an oximeter on himself and some of his graduate classes to explore its applications in education. He realized that since its development, numerous applications in military aviation and the medical field have proven to save lives in flying missions as well as in the operating room and improving patient safety. After looking at the effective use that pulse oximetry has had in these fields, Tobin and Alexakos thought of expanding its practical application by incorporating the instrument as part of our multilevel research methods in the science education research at Brooklyn College.

The development of the oximeter

The development of oximetry is the result of an accumulation of science discoveries in the physical properties of blood, the physiology of blood vessels, the respiratory system and the transmission and absorbance of infrared light by blood through skin. This accumulation of discoveries dates back to the nineteenth-century, when scientists researched and built on light transmission, optical density and gas laws. These and other developments in the physical sciences coupled with advances in biological molecular structure and function are the baseline for the development of the pulse oximeter. George G. Stokes discovered that the colored substance in blood was the carrier of oxygen. By the end of the 19th century, Felix Hoppe-Seyler had isolated and crystalized such pigmented substance and named it “hemoglobin.” In his experiments, Hoppe-Seyler was able to prove and conclude that hemoglobin was the cause of absorption of blue and green light from the solar spectrum and that its absorption changed
when he shook the solution with air. He also showed that oxygen and hemoglobin formed a
dissociable compound which he called “oxyhemoglobin.” At the same time that these
discoveries were happening, Kurt Kramer used the relationship of light transmission and
optical density, also known as the “Lambert-Beer Law” to measure the saturation of oxygen
in hemoglobin by the transmission of red light through unopened arteries (Severinghaus &
Astrup, 1986). This procedure was later enhanced by introducing a second wavelength of
green or infrared light that is insensitive to saturation to compensate for blood volume and
tissue pigments. The majority of these advances were being done in Germany. Yet, the value
and possible application of such concepts had awakened the interests of researchers around
the world; hence experiments and scientific collaborations sped up the process of
development of an instrument to measure dangerous levels of oxygen limiting conditions. An
industry that was extremely interested in the new advances was the military. Before World
War II (WWII), Military aircraft did not have pressurized cabins and lacked oxygen when
flying above 10,000 feet of altitude. At high altitudes habitation is inhospitable for sustained
human life. The primary factor is barometric pressure that decreases exponentially with
increase altitude. At sea level barometric pressure is approximately 29.92 inches of mercury
(in Hg). At high altitudes barometric pressure can decrease to 1/3 of the values at sea level.
Because oxygen makes up 21% of air at any altitude, the partial pressure and availability of
oxygen decreases with altitude (Huey, 2001). Such conditions could create dangerous hypoxic
conditions for pilots, called hypoxic hypoxia or altitude hypoxia. Hypoxic hypoxia is
characterized by decreasing amounts of oxygen available on ascent in the atmosphere
(Furgang, 2012). As a plane ascends, the pressure decreases and there is less concentration of
oxygen in the air. Thus less oxygen is available for pilots. The low partial pressure of oxygen
at this altitude reduces the alveolar oxygen tension in the lungs; therefore there is less oxygen for the blood to carry to tissues, including the brain. This condition can lead to sluggish thinking, dimmed vision, unconsciousness and ultimately death. Depending on the health state of the person, especially individuals with heart and lung disease, symptoms may start at an altitude as low as 5,000 feet (Furgang, 2012). In 1945, researchers at the University of Pennsylvania were investigating the supposed alveolar-to-arterial oxygen tension gradient. They were able to show that human hemoglobin was 98.5% saturated. This was important because it meant that there is almost no measurable oxygen gradient between the alveolar gas and arterial blood. At the same time it was discovered that Carboxymoglobin (blood rich in carbon dioxide) was transparent to infrared light and in contrast hemoglobin had about half the absorption of oxyhemoglobin in the band from 900 to 1,000 nanometers (nm). This was a critical piece of information because it indicated an increase in pulse oximeter signals well above the isosbestic point (The isosbestic point refers to a specific wavelength at which both hemoglobin and carboxyhemoglobin absorbance cross each other) (Severinghaus & Astrup, 1986). Today’s pulse oximeter measures light at only two wavelengths: 660nm and 940nm, which is more of a red or near infrared wavelength. The ratio of the absorbance at the two wavelengths is the basis for the oximeter calculating oxygen saturation. The pulsatile absorbance corresponds to arteriolar contributions to absorbance above the tissue and venous background and primarily reflects arteriolar hemoglobin absorbance (Wright, Lewander & Woolf, 1999).

The original use and applications of oximetry to measure the saturation of hemoglobin oxygen in blood spread quickly to the medical field. Before the pulse oximeter was introduced to the medical field the hemoglobin–oxygen saturation measurement was done through arterial
blood gas analysis, a slow, expensive and painful diagnostic method to detect hypoxemia (Witting & Lueck, 2001.)

The invention of the modern pulse oximeter has caused a decrease in the use of arterial blood gas analysis; though this procedure is still used in the medical setting when there is suspicion of hypoxemia or hypercapnia. During hypercapnia, the pulse oximeter is not able to detect hypoventilation or high levels of arterial carbon dioxide (CO₂) on patients breathing supplemental oxygen (O₂). Hypoxemia is generally defined as: hemoglobin oxygen saturation of less than 70 millimeters of mercury (PaO₂ < 70 mm Hg) and hypercapnia as carbon dioxide-hemoglobin saturation of more than 50 millimeters of mercury (PaCO₂ > 50mm Hg) when the readings are taken at sea level (Witting & Lueck, 2001).

**Physiology of respiration; the cardiac cycle; hypoxia; and pulse oximetry.**

The heart, respiratory and circulatory systems work together in the delivery of gasses in and out of the human body. Both the heart and the lungs function through automatic rhythmic cell
processes. The rhythmic system in the heart is driven by a specialized group of cells called the pacemaker, which fire up an action potential through its cells’ membranes in between heart beats. In other words, they are the determinants of the heart rate. However, there are no analogous cells or structures known that trigger the rhythmic action of respiration. We know that respiration happens because of repetitive nerve impulses coming from the brain that trigger muscle contraction of the thoracic muscles and the neck (Saladin, 2012). The primary function of the respiratory system is to obtain oxygen (O2) through inspiration or inhalation for use by cells in the body and expiration or exhalation of carbon dioxide (CO2) that cells produce as a product of cellular respiration. These two actions make a complete respiratory cycle. Oxygenation in the body occurs as oxygen enters the respiratory system reaching the alveolar sacs in the lungs that connect to capillaries and where gas exchange of incoming oxygen and outgoing CO2 takes place by diffusion. Incoming oxygen leaves the lungs through associated vessels (pulmonary veins) and reaches the left ventricle and left atrium of the heart. As oxygenated blood passes through the heart, it is pumped through the aorta and distributed to tributary arteries feeding both the upper and lower parts of the body in what is called systemic circulation. Oxygenated blood reaches every organ in the body, unloading oxygen used during cellular metabolism and loading CO2, a product of cellular respiration. Conversely, deoxygenated blood (oxygen-poor, but rich in carbon dioxide) returns to the heart via the venous system. Once deoxygenated blood enters the heart though the right ventricle and right atrium, it leaves via pulmonary circulation involving the pulmonary trunk, which branches into blood vessels that end in the lungs, and ultimately reach the alveolar sacs where gas exchange takes place.
Every constituent of the cardiac cycle and respiratory system is designed for a specific purpose. For instance, arteries and veins are different anatomically; on one hand, pulmonary arteries, which carry de-oxygenated blood, have thin distensible walls with less elastic tissue than systemic arteries. This fact plays an important role for the entire process of respiration. The implications of these factors are that blood flows more slowly through the pulmonary capillaries, allowing more time for gas exchange. Pulmonary veins have a blood pressure of 25/10 and a capillary hydrostatic pressure of approximately 10 mm Hg (mercury) in pulmonary circulation. This is a low blood pressure when compared to capillary systemic circulation, which is on average 17 mm Hg. Blood may back up in the pulmonary circulation system causing a condition called hypoxia (Saladin, 2012).

Hypoxia is the deficiency of usable oxygen or the inability to take advantage of the oxygen that is present in the body. Hypoxia may vary from subtle to deadly (Furgang, 2012) and may be caused by: strenuous physical activity; increase in atmospheric pressure and high emotional arousal, among other factors. Later in this chapter, I illustrate how some of our research participants in the Brooklyn College study experienced this respiratory condition, during high levels of stress and emerging emotions, as they presented and discussed sensitive and controversial sociocultural topics in the classroom. The site of gas exchange in the lungs or alveolar sacs measure approximately 0.2 to 0.5 mm in diameter. These pouches are covered 95% by thin squamous epithelial cells. Again, the design of the cells allow for rapid gas diffusion between air and blood. The other 5% of the epithelial cells are cuboidal epithelial cells whose function is to repair damaged alveolar epithelium and secretion of a mixture of phospholipids and a protein that coats the alveoli and small bronchi and prevents them from
collapsing as one inhale. Other cells called alveolar macrophages serve as a barrier for dust particles and opportunistic bacteria that may be pathogenic.

It is important to mention that there are different “species” of hemoglobin. Also, respiration can take different forms according to the species of hemoglobin present in the circulatory system. The measurement of one hemoglobin species by pulse oximetry can be affected by the presence of any abnormal levels of any other hemoglobin species (Feiner & Bickler, 2010). Some of the abnormal respiratory and oxygen saturation conditions in the blood of some of our class participants may have been mediated by the presence of any of these types of hemoglobin. Even though, we do not have the blood composition of every one of our participants in the study; we know that certain hypoxic conditions due to genetic predispositions in certain races may contribute to respiratory and circulatory disorders. In the Brooklyn College class we had a diverse group of participants. The class included individuals of Latina, Asian, African American and White descent. It is possible that some of our participants had any of the types of blood mentioned here.

1. **Deoxyhemoglobin (HHb)**: Hemoglobin with no oxygen bound to it

2. **Oxyhemoglobin (HbO₂)**, one or more molecules of oxygen attached to hemoglobin.

3. **Carbaminohemoglobin (HbCO₂)**: Combinations of 5% CO₂ bound to amino groups of plasma proteins and hemoglobin.

There are also several muscles involved during the cycle of respiration. It is not just restricted to the diaphragm. During inspiration a group of muscles in the neck, the sternocleidomastoid elevates the sternum and the scalene elevates ribs 1 and 2. The *Internal intercostals*, which are located right below the ribs, elevate ribs 2-12 and widen the thoracic cavity, while the *Pectoralis minor*, right below the chest, elevates ribs 3-5. The intercartilaginous part of the
*Internal intercostals* helps elevate the ribs and the diaphragm descends and causes an increase in depth of the thoracic cavity. Conversely, during forced expiration, the *Internal intercostals* depress ribs 1-11, narrowing the thoracic cavity; the diaphragm ascends and reduces the depth of the thoracic cavity; the *Rectus abdominis* and the *External abdominal oblique* located in the abdomen depresses the lower ribs and pushes the diaphragm upward by compressing the abdominal organs (Saladin, 2012). Of course all these structures, blood vessels and muscles come together to bring about respiration through orders of the command centers in the brain. Three pairs of respiratory centers in the brainstem, specifically in the medulla oblongata and the pons control unconscious or automatic breathing.

![Fig 1 Human respiratory and circulatory system](http://www.mhhe.com/biosci/esp/2001_saladin/folder_structure/ab/m1/s6/abm1s6_1.htm)

These centers issue nerve signals that travel through the spinal cord and the phrenic nerves to the diaphragm muscle and intercostal nerves to the *Internal intercostals* muscles. The contraction of
these muscles causes expansion of the rib cage and inspiration (Saladin, 2012,). As we can see there is a connection between several systems that bring about the process of respiration. A very important aspect of respiration is how our brain provides feedback to the muscles and systems mentioned earlier to adjust to breathing the right amount of oxygen needed by the tissues in our bodies. This aspect of our physiology becomes crucial when we are experiencing hypoxic episodes, because we can opt to practice breathing meditation as an intervention therapy. Studies on breathing meditation, suggest that by executing this exercise, we can train the way our brain recognizes certain signals that may be detrimental to our well-being. The same way we have the capacity to adjust our brains to recognize situations, we can also adjust our brains to respond to situations. In our study, we ask our participants to practice breathing meditation as a high grade intervention to the hypoxic levels some participants were experiencing during specific stressful situations. Our participants were able to bring their oxygen saturation to a normal level, at least for a while, after their breathing meditation exercises.

**Special conditions and respiratory deficiencies**

The pons and the medulla are the respiratory centers in the brain that receive feedback from different areas of the nervous system, consequently they respond to physiological needs of the body. For instance, anxiety may prompt overwhelming hyperventilation. This condition is characterized by the expelling of CO₂ from the body at a rate faster than tissues produce it. This process yields a drop in the levels of carbon dioxide in the blood and an increase in its pH, which in turn causes cerebral arteries to constrict, resulting in a reduction of cerebral perfusion and causing dizziness or fainting. Hyperventilation is a controllable process, by rebreathing the expired CO₂ from a paper bag (Saladin, 2012.) During hypoxia systemic
arteries dilate in response to local hypoxia and improve tissue perfusion. Conversely, pulmonary arteries constrict and not enough carbon dioxide reaches the lungs (Saladin, 2012). A more in depth study of oxygen deficiencies in the group of participants we analyzed in this study, may provide relevant information on possible factors that could have mediated the pulse oximeter output obtained during data collecting. Some of the student teachers in our research seemed to have experienced inadequate pulmonary gas exchange during their coteaching experience that is consistent with hypoxemic hypoxia. The following are conditions that may cause hypoxia, yet they are not necessarily representative of the hypoxic conditions experienced by our students. Carbon monoxide has greater affinity with hemoglobin than oxygen does. When carbon monoxide and oxygen are present in the same space at the same time, carbon monoxide outcompete oxygen, leaving it unable to bind to the heme group in hemoglobin; this is what is known as carbon monoxide poisoning. We also know that cigarettes are a source of carbon monoxide and cyanide. We are aware that some of our research participants smoke cigarettes. Although we are not certain of the factors that caused hypoxic events in our students, it is significant to mention some of the possible sources and conditions that may have prompt or exacerbated hypoxic episodes. Exposure to substances such as carbon monoxide and cyanide causes loss of elasticity in the alveoli, where gas exchange of oxygen and carbon dioxide occurs. A few of our participants in the study are of African American descent. A condition that is known to prevail in this ethnic group is sickle cell anemia, which results from the inability of blood to carry adequate oxygen to tissues. This condition is characterized by sickle shaped red blood cells and their inability to carry 4 molecules of oxygen to tissues. Histotoxic hypoxia, is an acute condition, usually caused by a toxic compound that inhibits tissues from using oxygen, an example of that is
cyanide poisoning and its effects on cellular respiration (Saladin, 2012). Methemoglobinemia refers to the oxidation of ferrous iron (Fe++) to ferric iron (Fe+++), within the hemoglobin molecule (oxidation of a molecule refers to the losing of an electron). Oxidation impairs hemoglobin from carrying oxygen and CO₂, leading to tissue hypoxia and ultimately death. This condition may arise from genetic, dietary, exposure to an oxidizing agent and sometimes from unknown causes (Wright et al., 1999.)

Other respiratory system disorders include: *Apnea*, which is the characterized by the cessation of one or more breaths; *dyspnea*, referred to as grasping breathing, or shortness of breath; *hyperpnoea*, is the increase rate and depth of breathing in response to exercise or pain; *hypoventilation*, is reduced pulmonary ventilation, in this case there is an increase in the level of carbon dioxide in the blood, and it is not expelled rapidly enough in comparison to the rate it is produced. *Kussmaul* respiration, is rapid breathing, usually induced by diabetes mellitus; *orthopnea*, is *dyspnea* when a person is lying down, usually occurs in heart failure, asthma and emphysema; *Respiratory arrest*, is the permanent cessation of breathing. *Tachypnea* is characterized by accelerated respiration.

Carboxyhemoglobin (HbCO) is a combination of carbon monoxide and hemoglobin. The compound is formed when carbon monoxide (CO) is inhaled through cigarette smoking, inhaling engine exhaust and fumes from furnaces and space heaters. CO has greater affinity with hemoglobin than oxygen does, because it can bind to the ferrous ion of hemoglobin 210 times as tightly as oxygen. For this reason when CO is available for binding it makes haemoglobin unavailable to oxygen, depriving tissues from getting oxygen for cellular metabolism and ultimately causing carboxyhemoglobinemia, also known as carbon monoxide poisoning or death (Saladin, 2012.)
Assessing changes in blood-oxygen saturation by Plethysmography

In our study we were interested in obtaining data that provided us with in the moment information about the emotions of class participants based on their oximeter physiological output. The pulse oximeter not only displays blood-oxygen saturation as a percentage, it also displays heart rate at beats per minute (bpm), which in a normal adult is 60-80 bpm and a plethysmographic representation of arterial pulsation (pic.2). The plethysmograph (Plethy) is an electric-optic component of the pulse oximeter that measures the cardiovascular pulse wave (Shi et al., 2009.) The Plethy’s curve indicates how accurately the device is detecting the blood flow through the finger, ear, and the bridge of the nose or nares. In order to obtain an accurate reading of blood flow using the oximeter, it needs to be placed where emitters and detectors face each other through approximately 5-10 mm of tissue that experiences pulsatile blood (Callahan, 2008). Respiratory variations in pulse oximetry plethysmographic waveform amplitude are related to respiratory variations in pulse pressure (pulse pressure is the difference between systolic and diastolic pressure) (Cannesson, 2007). Pulse readings are interpreted as happening in two different phases. The first is the rising phase concerned with systole or contraction of the heart, and the descending phase concerned with diastole or relaxation of the heart and wave reflections from the periphery (Shi et al., 2009.) Together the contraction and relaxation of the heart produce the heartbeat. The heartbeat shown in figure 2 is 57 bpm; a heartbeat that is less than 60 bpm signifies a slow heart rate. When analyzing the contour of the plethysmographic wave output (fig. 2), one must consider that the first peak (pk.1) corresponds to a direct forward-travelling pressure wave from the heart to the finger where it produces a change in arterial diameter and consequently in volume while the second peak (pk. 2) corresponds to the backward travelling reflective pressure wave and it is called
the dicrotic wave (Shi et al., 2009). The volume pulse wave form changes with age and vascular disease. A well-defined dicrotic wave (Pk 2) is usually present in healthy individuals, while the disappearance or diminution of the dicrotic crest in the overall wave form is an indication of overt arteriosclerosis or hardening of the arteries (Millasseau, 2006). Figure 2 depicts the pulse wave of one of our young coteacher in our research wearing the oximeter during a student-teacher presentation. Heart rate anomalies will be reflected in the plethysmographic wave output as interruptions in normal heart rate curve. For instance, during the cardiac cycle a premature ventricular contraction (PVC) may occur. This PVC is also known as a ventricular extrasystole (VES). A premature ventricular extrasystole may be a relatively normal event in which the heart beat instead of being initiated by the normal heart beat initiator - the sinoatrial node; it is initiated by the Purkinje fibers in the ventricles. This ventricular extrasystole is benign if it occurs only occasionally and may be present in healthy individuals. It may be perceived as a skipped beat or felt as palpitations in the chest. However, if several ventricular extrasystoles occur in a row, it becomes a type of ventricular tachycardia, and may progress into a fatal cardiac arrhythmia.

Research studies on emotions suggest that cardiovascular response triggered by autonomic arousal varies during different emotional states (Prkachin et al. 1999.) Blood pressure varies directly with heart rate, cardiac output, total peripheral resistance and stroke volume (SV is the volume of blood pumped from one ventricle of the heart with each beat.) In healthy adults stroke volume is equivalent to 60-80 ml of blood in each stroke). Also, systolic blood pressure is always greater during any emotion arousal compared to a neutral emotional output. Previous studies suggest that systolic blood pressure increases to a greater degree during negative than during positive emotions (Prkachin, 1999.) The rationale behind this
physiological process is that emotional states like anger, fear and sadness are accompanied by sufficient beta-adrenergic drive to raise blood pressure to levels that exceed those triggered during happiness or positive emotions (Prkachin, 1999.) although pulse rate increases with any emotional arousal, the body of literature suggests that heart rate during sadness is higher than during any other emotional arousal (Prkachin, 1999.) In the next chapter, I document results of plethysmographic waveform outputs of two student-teachers collected during coteaching.

Fig.2 Oximetry display of oxygen saturation, heart rate and plethysmograph. PPG-plethysmograph, SpO2-oxygen saturation, HR- heart rate, Pk1-peak 1, Pk2- peak 2, Hp- pulse amplitude from the base to maximum during cycle, Tp- total pulse duration, Hn- distance from baseline to notch minimum; this small dip in the curve coincides with the aortic valve closure during systole.

Limitations of Oximeter

Functioning of some pulse oximeter models may be affected by physical and physiological factors. Although oximetry is a valuable tool in many settings by providing important physiological information in the moment, it is not to be used as a sole source to diagnose abnormal physical conditions. Some of the shortcomings of the instrument include sensitivity to motion and light. For instance, if the transmitted light is not detected by the detector accurately due to inappropriate strapping of the instrument to the area of the body selected for
arterial pulsation reading, then the device may be susceptible to malfunction. Similarly, over exposure of the detector to ambient light may interfere with accurate readings. In addition, physiological factors such as decrease perfusion, hypotension, hypothermia and vasoconstriction can also affect pulse oximeter outputs. These conditions can lead to unsatisfactory signals that will trigger an inaccurate reading or no reading at all. Also, during high partial pressure of oxygen in arterial blood (PaO<sub>2</sub>) there are very minor changes in oxygen-hemoglobin saturation levels (Callahan, 2008.) This means that at lower levels of partial pressure of oxygen in arterial blood, small decreases in oxygen tension can lead to rapid decreases in oxygen saturation. For this reason a partial pressure of oxygen in arterial blood (PaO<sub>2</sub>) of 75mm Hg is correlated with 95% oxygen saturation (SpO<sub>2</sub>), and a PaO<sub>2</sub> of 50% is correlated with 80% SpO<sub>2</sub> (Callahan, 2008.)

Newer oximeter models are improving the nuances present in the older models through the use and application of new algorithms. Also, new technologies are adapting reflective light instead of absorbed light (Callahan, 2008). The pulse oximeter is an affordable, painless, non-invasive instrument that can provide important physiological information to clinicians, pilots, educators or any person that wants to have a sense of his/her physiological well-being. In the next chapter, I describe how oximeter outputs in some of the participants of our research at Brooklyn College, may have been mediated by internal body and exogenous conditions. Although further tests would need to be performed to know the exact culprit facilitating the abnormal pulse oximeter measures of our participants, we could say that it may be appropriate for them to look further into these breathing irregularities obtained during their coteaching experience.
Chapter 5

OXIMETRY AS A REFLEXIVE TOOL FOR THE DETECTION OF PHYSIOLOGICAL EXPRESSION OF EMOTIONS IN THE SCIENCE CLASSROOM

Oximetry - Tales from the field - Research participant experience and intervention

The last chapter provided important information on history and physiology of oximetry. In this chapter I present the application of oximetry in a context and place where the instrument is not traditionally used, “the science classroom.” I decided to broaden the application of oximetry and utilize it as a reflexive tool for the detection of physiological expression of emotions. The participants in this research were in-service and pre-service teachers taking a class on the history and philosophy of science education.

In New York City teachers’ attrition rate continues to be an issue of concern for the Board of Education. Teachers enter the field and many of them quit within the first three years of entering the job. Many factors seem to affect their decision of looking for other sources of employment that are more fulfilling and less stressful. One of the many reasons of teacher attrition is not being able to deal with the high accountability for the success and failure of students by administration. Such responsibility produces an incommensurable pressure that can be counter-productive to the well-being of teachers, affecting their effectiveness as teachers. In addition, if teachers have pre-conditions to certain medical disorders, these can be exacerbated by the demands of the job and what teachers deal with in the classroom on an everyday basis. Using the oximeter as an intervention device during the arousal of intense emotions in the classroom can be a powerful instrument for the monitoring of emotions, awareness and mediation to ameliorate emotional fluctuations and maintain a less stressful outlook about arising situations. In this chapter, I will talk about two examples of student
teachers from the Brooklyn College study that wore the oximeter as they co-taught in the spring of 2012. To have a better idea of the examples presented here, let me note that the normal percentage of oxygen saturation (SpO₂) is between 92 and 100 % (Furgang, 2012).

![Fig 1 Pulse oximeter output in computer through Bluetooth technology](image)

**Case 1: What is going on with Zofia?**

The first student-teacher (Zofia) was coteaching with another two student-teachers for the first time when they taught the topic of the philosophy of American schooling. Zofia appeared to be nervous since the beginning of the presentation. She was wearing an oximeter (File: Nonin OEM 120214 174228) during her first presentation and her heart rate readings started at 100, which is quite high. On the other hand, her oxygen saturation (SpO₂) in the blood was at a low 90. During her turn presenting, she tried avoiding eye contact with the audience; she appeared to have a rapid chest rise and fall, as well as shallow breathing. Zofia’s voice was quivering and 30 minutes into the presentation her SpO₂ dropped to 74% and her heart rate to 92 bpm. The
oximeter output continued at this level for approximately 5 more minutes. One of the researchers noticed the unusual readings Zofia’s oximeter was sending to the computer screen, so she decided to approach Zofia and asked her to take deep breaths. After a few minutes of breathing exercise intervention, Zofia’s SpO₂ started increasing and oscillated between 78%, 85% and 87% and remained at that level after post presentation. Zofia’s heart rate reading oscillated between 80 and 111 beats per minute. These fluctuations in the output coincided with the times when the assigned articles for that night’s topic were discussed. The discussion topics were on corporal punishment in different educational systems, as well as other forms of violence besides physical. As a result of these concerning oximeter outputs, Zofia decided to be pro-active about her health and obtained a pulse oximeter to monitor her heart rate and SpO₂ more often. Zofia also started practicing some of the interventions introduced in the class, such as mindfulness, radical listening and breathing meditation exercises.
Sophia’s oxygen saturation, heart rate and plethysmographic output in a 3 minute - week 3 - File No. OEM 120214 174228

During Zofia’s second presentation on the topic of Evolution; we observed a pulse oximeter output (file: OEM 120501 0501) with a greater heart rate fluctuation (91-127) than that of the first presentation. Zofia’s heart rate towards the end of the evolution class was 76 bpm, which is normal compared to standard heart rate readings. However, her oxygen saturation (SpO₂) levels remained low, below the minimum threshold of 92% for most of her presentation. Her range was between 84% and 99%, yet there is a point that her oxygen saturation dropped to 79%. These readings seem to indicate that she was experiencing a certain level of hypoxia or that she was experiencing an unusual respiratory/circulatory condition. My educational background is not in the medical field; for that reason I do not imply or suggest that Zofia has a health problem based on the oximeter data obtained in this research. Nonetheless, I strongly believe that the use of the oximeter in any situation can provide useful feedback on the physiological state of emotions. Having the opportunity to become aware of our emotions through the use of this simple instrument can be beneficial when used as an intervention tool during interactions with others.
Zofia’s unusual oximeter readings deviated greatly from the standard percentages that are considered normal in healthy individuals. Whether Zofia was nervous about presenting in front of an audience or she was upset about the controversial topics being discussed, it is evident that her emotions were running high and were affecting her physiological state. Although, her SpO₂ output was still below the minimum threshold of 92%, Zofia’s oximeter output during her second presentation was a few points above her pulse oximeter output when compared to the first presentation at the beginning of the semester. This is reflected in the increase in the 79% SpO₂ compared to her lowest 74% SpO₂ output during the first semester presentation. Some factors such as being more aware of her physiology as she wore the oximeter and monitoring it more often; the practice of breathing meditation since it was introduced to the entire class after her first presentation may have mediated the small improvement in her physiology output. The pulse oximeter output was sent to a computer monitor through blue tooth technology. When we noticed that Zofia’s heart rate and SpO₂ were abnormal, we approached her and asked her to practice breathing meditation exercises to see if she could get her heart rate, heart beat and
oxygen saturation to a more comfortable level. The practice of mindfulness, radical listening and other intervention concepts throughout the semester, may have help Zofia’s mediate her emotions and become aware of her physiological output using the oximeter.

Fig 3 Sophia’s oxygen saturation (SpO₂), heart rate (bpm) and plethysmographic output in 5 minutes - week 12 – File No. OEM 120501 0501
Physiology of a dream

Louise, our second student teacher had low SpO2 outputs during her first class presentation compared to what is considered a normal SpO2 output (92%-98%) for healthy adults. The topic she presented on “race and education” was not only controversial, but the mood in the class felt inhibited and there was reluctance from the majority of the participants in the class to contribute to the discussion. As a side note--the demographics of the class were diverse. The class was composed of students of Latino, Asian, White, and Black backgrounds from the United States and from various Caribbean Islands. Louise’s SpO2 pulse oximeter output (Nonin OEM 120313 161338.CSV) ranged between 100-78 % for the majority of the class session, remaining mostly between high 80 and low 90% outputs. There is an important spike in the curve regarding Louise’s SpO2 as the class formed groups to discuss the overrepresentation of minorities in special education and about distribution of resources. Louise’s SpO2 reached a low of 72%, which is an outstanding 20-point difference below the normal for healthy adults! On the other hand, Louise’s heart rate started with a reading of 103 as the coteachers addressed the class. One of our researchers talked to Louise about practicing breathing meditation. Her heart rate dropped from 103 to 91. However, as soon as Louise continued with the presentation, her heart rate jumped back to 109 and 115, eventually reaching 132. Louise’s heart rate ranged from 98 – 137 during her coteaching presentation. Yet, it remained mainly above 130 for most of the class period. Louise’s breathing patterns seemed to change as well as her tone of voice, when she introduced the story of nine African American students involved in the desegregation of Little Rock Central High School. During this part of the presentation, Louise’s heart rate looked like a rollercoaster. It dropped from 111 to 106, then to 96. It jumped back again to 114, followed by
120 and then back down to 102. After she finishes her presentation her heart rate started falling from 115 to 111, 109 and under 100.

Fig 4 Louise’s spO2, heart rate and Pleth pulse oximeter output

Louise’s second coteaching presentation was on “philosophy of scientific progress.” During this class she wore the oximeter (Fig 4. File: Nonin OEM 120403 171236.CSV) to measure her heart rate and SpO2 as she did for her first class presentation. Her heart rate started with a 98-103 output. An interesting phenomenon occurred during this presentation, in that Louise and her co-presenter were in synchrony the majority of the time in terms of their heart rate and for most of
the presentation it remained below 120. During a discussion on indigenous knowledge and science, Louise shared a story of her childhood in Haiti and growing up with her grandmother. In this moment, Louise’s heart rate jumped to 161 and later dropped to 61. Her SpO₂ was below 92%, and fluctuated between 82 and 88%. When we brought it to her attention, she responded: “I stop breathing to focus.”

The 161 heart rate spike in the curve lifted a red flag for us and when asked about how she felt about her grandmother after class in our cogenerative dialogue, she said: “I get so emotional when I talk about her.” “She died by heart attack in her sleep – December, I still get too emotional around that time, 1995. We slept in the same room. It was a heartbreaking experience.” As Louise told her story, we could see her emotions spilling out, as if there was suddenly an overflow of restrained emotions letting lose. Her bottom lip was quivering and she said: “I am holding back tears.” Louise continued, “She didn’t know how to read and write. On the island education wasn’t for women. Women had to take care of men and do their chores. The grandmother started school at 45; this is when she learned to read and write. Louise: she always said: “The best thing to do is go to school.” I didn’t realize then that she was my first exposure to science. I never got sick with her (I only got my shots prior to coming here. I never went to the doctor.” “She took care of me, and she knew what to make to keep me healthy. She impacted my choice for science - I want to accomplish her dream.”
The dynamics of the topics discussed in the classroom coupled with the audience presented challenging moments for Louise. Her emotions took over her physiological functions and these were represented in the fluctuations of the outputs, both of her heart rate and the (SpO₂) amount of oxygen taken into the lungs for respiration. Louise is an African American student from Haiti. She is also a biology teacher assistant in a New York City Public school.

**Possible implications to our observations**

Educational research where oximeter data is obtained in the moment in the classroom appears to be a practical and useful way to become aware of emotions and possible health conditions that we may not be aware of. Whether we are mindful or not of certain classroom situations, our approach to classroom issues can have implications that can easily affect our relationship with our students, as well as the way they perceive us and the world around them. From the educator’s point of view, the experience of researching in one’s own class can provide great insights on how students perceive knowledge presented through different lenses. It can also afford important understandings of social structures within the class, so that we as educators can adjust teaching and moderating strategies conducive of effective learning environments. In addition, because the educator himself/herself is a participant, the learning experience becomes transformative. When educators become aware of their own limitations and vulnerabilities, their axiologies can be transformed in many possible ways. There are some limitations to the information we can obtain from an oximeter. One of them is that we are not able to obtain the levels of carbon dioxide saturation in the arteries at any time using the device. Having high levels of carbon dioxide in the blood can be a sign of something abnormal in the body. The oximeter should not be used as a sole diagnostic test for any respiratory or circulatory condition. In addition, one must take into account possible factors
that affect pulse oximeter outputs, like moving the device while wearing it and not having it appropriately strapped to the wrist.

Schools are perhaps the second place and very often the one place that instill the greatest social influence in a person’s life. In schools, people acquire knowledge, academic and social skills that enable them to navigate in a world of competitive survival. Furthermore, today’s schools seem at times to occupy niches where neoliberal ideologies based mostly on statistical measures of accomplishment, guide how we teach and learn. However, as teachers and as the people directly involved in the education of thousands of students, deal with numerous issues on a day-to-day basis that go beyond statistics and that influence our students and their perceptions of the world they experience. Even when we are to follow a set curriculum and prescribed pedagogy, knowledge is affected and constantly evolving by emotional output of class participants. In light of this, education for new generations of students and teachers should not be restricted to the prescribed curriculum. In the same way our classrooms are being updated with the latest technological gadgets, microcomputers and devices, we need to update our personal approach and the way we learn and teach in the classroom. Although I agree that much attention and resources must be invested in building a strong academic force, we must not depart from the idea that the success of building such social structures depend on the way we interact with each other. Our interactions are charged with positive and negative emotions that shape the way we perceive and respond to social phenomena. As individuals, we carry our convictions and idiosyncrasies wherever we go. Very often, we are not completely conscious that a simple word, response or gesture can impact students’ own views; how students feel about the world around them; the place they have in it; and of what they are capable of achieving. We go in the classroom to accomplish what we set out to do; teach a
theory without really thinking of the implications and practicalities that such theory has on the people we are teaching. It is apparent that this new/old outdated approach to teaching and learning is not the most effective for all students and teachers. I often ask myself, why if everything else around us is changing, are we still following teaching and learning methods that we used two hundred years ago? Teachers and students are much more than statistics. Teaching and learning involve not only instructing and receiving information. They involve personal interactions where human emotions are stimulated and expressed through different perspectives and dialogue. It is because of the great influence we exert on individuals that we, as educators, must review, revise and transform our pedagogy where needed. In the sciences especially, there is an almost dogmatic way of thinking that permeates the minds of those that enter the field and that must be passed along new generations of scientific thinking. Nevertheless, in my opinion there is no reason why we must depart from what makes us unique among creatures, which is the ability to reason, have compassion and sensibility to the emotions of others as they execute their agency for what they believe. Crucial factors that involved radical listening, compassion and social intuition (Davidson, 2012) in general are often missing in the classroom. I often talk to students and peers about their interactions with others in the science classroom or in the science field, they express dissatisfaction about the science culture in terms of insensibility. Their accounts regarding the hostility they experienced in the science class reminds me of the way some of the most brilliant professors I had in college would talk to us. They would answer some of our questions with a touch of arrogance and sarcasm. It feels very often as if becoming a scientist was reserved for only a few privileged individuals; and that one of the conditions for becoming one was to have a cold and superficial attitude towards the rest of the world. Similarly, I remember some of my
classmates feeling frustrated as a result of the cold and unwelcoming attitude they experienced from some of their science professors. Very often, this was the reason why, students gave up their educational goals in science, making career moves to places where they felt welcome. On the other hand, teachers tend to experience negative emotions, such as frustration, anger and disappointment in response to student’s poor academic performance (Ritchie, et al., 2013). A transformation of the world that surrounds us will not take place; unless we take the first step to enable change to happen. Educational research is rarely done inside the researcher’s own practice. There are even regulations in certain schools that prohibit teachers doing research as part of their own praxis. While the rationale behind Institutional Review Board regulations are based on the avoidance of biases and conflict of interest, action research and self-study practices can have a powerful and transformative effect in the science classroom. For Alexakos and I, there was a profound transformation in the way we think of how we talk to our students, how we listen to our students and how we deal with emotions, as students and we express them during controversial and sensitive class discussions. In a traditional class, students’ input is not often taken into account as part of the learning process. It is not enough anymore to collect data in schools and make published research available to educators. The traditional way of educational research leaves out teachers and learners and their vibrant contributions to formulating research questions and methods to the field of research education. In our Brooklyn College classes, we tried listening and learning from our students and from their interactions with one and other. It was by fostering this type of environment that we could have a productive learning experience. Developing new teaching and pedagogical methodologies such as the use of instruments like the oximeter are necessary to improve and create an educational infrastructure that is highly effective for students and
teachers. When we consider learning science through multiple perspectives, we are opening new avenues of understanding about differences in our points of view. It is by grounding our teaching practice in conjunction with educational research that we have the potential to observe the areas where we need to improve.
Chapter 6

CONNECTIONS & IMPLICATIONS

Teachers as researchers

*If teachers don’t know their students, what they know and don’t know, their fears and their
dreams, their failures and success, they cannot help them construct a compelling and in depth
view of the world and their role in it. - When teacher researchers know their students, become
experts in subject matter and are adept knowledge workers, they are beginning to put together
the skills that will help them become great teachers who motivate and inspire their students*
(Kincheloe, 2003, p. 21).

This multi-theoretical and multi-logical study explored how action research and self-
study practices in science education can serve as a transformative avenue for science educators
and students in building connections that are often missing between science and society. The
scholarship that informs the chapters in this dissertation treats the emotional experience of the
participants as a window to look into the physiological and sociocultural structures that trigger
emotional arousal of various kinds. Particular attention is paid to socioeconomic, gender and
minority status of the participants including those of the author. Although, I explore the role of
emotions as I perceive them, I can relate my observations to some of Richard Davidson’s
dimensions of his “emotional style” theory such as: resilience, social intuition and sensitivity to
context with the ultimate goal of providing transformative pedagogic tools for teaching and
learning science.

Instruments such as pulse oximeters and a facial micro-expression of emotions program
are used in the science classroom through the use of instruments that allow the researched and
the researcher to become conscious of sociocultural structures that truncate and afford teaching and learning science. An important outcome of teachers as researchers is that they learn to look at the world from a reflective perspective and can choose to really make a positive transformation in their praxis. As teachers, our knowledge pursuit does not end when we obtain a PhD. We also do not become “good teachers” because we are proficient in a particular subject or because we teach that particular subject every day. Good teaching is charged with positive emotion. It necessitates radically listening to students, and instilling the passion for learning through the use of creativity, challenge and joy (Hargreaves, 1998.) Teaching is a lifelong learning profession that transforms not only students’ lives but teachers’ lives as well. Joe Kincheloe writes in his book “Teachers as researchers” about engaging in complex and critical research in our own classrooms, rediscovering our professional status, empowering our practice in the classroom and most important, improving the quality of education for students (Kincheloe, 2003).

**What I learned**

The first lesson is on the value of writing an auto-ethnography. I discovered that an empowering way of expressing emotions is through writing. Jon Van Maanen (Van Maanen, 2011) provided me with useful tools to explore my own emotions and connect them to what science means to me and my life from childhood to present. I traveled back in time, reflecting on my lived experiences and reproduced situations and structures that have contributed to me becoming a scientist. Through the writing of my auto-ethnography, I realized that science for me is not that separate pragmatic culture that I always thought it was. Science is in me, and there are no dichotomies as far as other areas of my life and science. It is a journey, like life is and the very things that were the cause of awe as a child, still produce amazement in me. The Brooklyn College study on
emotions in the science classroom provided me with an opportunity to learn, observe and experience in the moment emotions in the classroom of pre-service and in-service teachers as they co-taught traditionally sensitive topics that triggered emotional arousal of various kinds. Changing deficit perspectives in science education is not an easy task. However, if we want to educate consciously well-rounded individuals, we must depart from the idea that classrooms are cooperative learning places, and that as much as our students benefit from our teaching, we can benefit tremendously from becoming emotionally literate in the classroom by learning from our students’ emotions and becoming aware of our own. Emotional literacy (EL) is a source of personal power that is indispensable for success in today’s world (Steiner, 2003, p. xi). EL involves speaking about our emotions and what causes them; developing our empathetic/compassionate capacity; taking responsibility and apologizing for the emotional damage caused by our mistakes. While in our society being emotional is often looked on as a weakness and as an undermining state, Claude Steiner suggests using emotions as a tool to empower and enrich our life and those around us. This concept becomes particularly important for science education, because it is a field that promotes objectivity and since emotions are considered subjective they are associated with a high degree for bias. The idea of rationality or objectivity is at the core of the philosophy of science. Such notion is embedded in everything related to science, including the way we teach science. The experience of teacher emotion has been shaped by socio political and cultural structures that have defined emotion as a topic that is not deemed worthy of serious consideration (Zembylas, 2005). This socio political and cultural view of the role of emotions in teaching represents a problem in education in general, where emotional rules have been constructed to shape power relations in the classroom. It also has shaped the ideology of expression of emotions, by permitting teachers to feel some emotions and
by prohibiting the experience of others (Zembylas, 2005). Teacher burn-out is probably the main cause in the high rate of attrition in the field of education. Emotional stress has been linked to teachers in their first few years of labor as one of the factors that affect their decision of staying or leaving, the teaching profession early. Feelings of anxiety, depression, fatigue, and job dissatisfaction are some of the symptoms expressed by educators (Vandenberghe, 1999.) Based on this alone, it is important to explore emotions in the classroom and how they mediate teacher retention and job satisfaction. Perhaps the first and most important aspect of a science educator is to develop an outlook that fosters positive and meaningful connections between him/her and students and between science and students. Such tasks are not achieved by everyone who teaches science. To achieve a vibrant environment in the classroom, teachers must learn skills that will allow them to understand their own emotions and those of their students. In addition, teachers must have the dexterity to manage situations in the classroom that are prompted by positive and negative emotional arousal. Furthermore, teachers must know how to control their own emotions. How is this achieved when teachers are not even aware that an emotion is emerging?

**Emotional awareness**

Here is where our methodology and instruments become an important part of research in science education. The Brooklyn College study multi-methodology includes heuristic instruments on mindfulness and coteaching, designed to generate inquiry about emotions experienced in the classroom in the moment. The purpose of using these instruments was to elicit awareness of emotions in relation to sensitive curriculum topics and in-class discussions. This alone triggered a response of attention to others’ perspectives and emotions and produced environments associated with volatile emotions. Participants took time to reflect on the questions asked on the mindfulness, coteaching and dialogic inquiry heuristics. This tendency is unparalleled with other
studies in science education, where emotions and emotional awareness are not considered in any way in the process of science instruction and learning. Statements such as: *I am curious about my feelings as they rise and fall; I find words to describe the feelings I experience; I recover quickly when I am unsuccessful; I pay attention to my moment-to-moment sensory experiences; I am aware of the relationship between my emotions and breathing pattern; I am aware of changes in my emotions and pulse rate; I feel compassion for others when they are unsuccessful*; prompted responses from all participants in the research. Understanding our emotions whether in terms of vulnerabilities or strengths are fundamental for developing teaching strategies. In our Brooklyn College research, our in-service student-teachers expressed their discontent with the little support and high degree of accountability they have from their school administrators. They expressed their frustration with the way the system deals with the many issues that affect them and their students.

Emotions in the classroom have been looked at in terms of psychological and philosophical bases by portraying teachers’ ways of managing their classes a matter of preference, personal choice, commitment and responsibility. Yet, little attention is paid to the sociological, political and institutional forces that shape and reshape emotional landscapes in the classroom (Hargreaves, 1998). The present education structure has adopted the Cartesian-Newtonian-Baconian ideological tradition where Cartesian (objective) science is not only the best way to understand the world, but the only way (Kincheloe, 2003). Joe Kincheloe denotes this approach to epistemology as a means of insuring ethnocentrism in the classroom. He further affirms that ethnocentrism in the classroom promotes a lack of diversity, multiple perspectives, criticality, difference and multiculturalism (Kincheloe, 2003). Unfortunately, it is the way our policy makers have and continue to design curriculum and management of our schools. The new
standardized tests are a clear example of such a design. In a positivistic educational context, human-created knowledge is considered almost as a physical substance that is to be passed from one individual to another through the process of teaching (Kincheloe, 2003.) The adaptation of this broad epistemological approach leaves little or no acceptance of other knowledge production methods and wisdom of human kind. As teachers try to derail from this positivistic approach, they are bullied by their administrators and they feel that they must swallow their emotions and follow the delineation traced by their supervisors. On the other hand, because teaching involves a high degree of emotional understanding (Hargreaves, 1998.) our place in the classroom is not only strategic in the production and reproduction of knowledge, but in the transformation and development of the intellect of future generations of individuals. A powerful advantage of teachers as researchers is that we can identify the issues in our own practice that pose little or no benefit to teaching and learning, and we can make modifications and adjustments and transform the classroom into an effective place for change. Teachers that do research in their own classroom become aware of how the sociocultural and political frameworks mediate their students and their own interactions in the classroom. These aspects of life cannot be left outside of the classroom, because they are embedded in the identity of every individual participant in that room. When teaching and learning embraces all aspects of an individual’s life, teaching and learning becomes more vibrant, challenging and interesting, because connections are made between theory, experience and relationship with the world outside the classroom, then we as teachers, can become catalysts for transformation and change. Teachers deal every day with a plethora of emotions in the classroom. Knowing how to identify all types of emotions is almost as important as having teaching certification. Denzin describes the significance of the ability to
interpret others’ emotions as central to the emotional understanding of another’s emotional experience (Denzin, 2007).

**How can we transform our practice?**

Considering all of the nuances teachers are up against, one may think that it is not possible to mediate significant change in our classrooms and that copious amounts of capital must be invested to achieve creative and productive learning environments. However, the resources are at anyone’s reach. It takes rethinking and reconstructing ourselves in the way we approach our students and our place in the classroom. It takes looking into our own emotions; how we respond emotionally to students’ positive academic outcomes and more importantly, how we respond when our students do not meet our academic expectations. Our outlook regarding our place in the classroom and how we mediate emotional arousal of all types in our students can be a powerful pedagogical tool that affords effective learning environments. Trying to understand others’ emotions is not an easy task. It is even more difficult to keep an open outlook when we have twenty or more students in the classroom and they all come from different socio-economic backgrounds. However, observing the emotional reactions of our students to different situations and curricular topics in class can be a great resource mediating teaching practices. Ritchie and Tobin illustrate this theoretical framework and state that purposeful reflection on emotionally charged events, even low intensity ones, could help teachers develop better supervisory practices for students engaged in inquiry activities (Ritchie et al., 2013).

**Learning more than science**

The inter-subjective process by which teachers and students share positive and negative emotions in the classroom is called *empathy*. *Empathy* is considered by social psychologists, a structure that promotes social interaction. Also, developmental theorists assert that empathy plays a crucial
role in moral development and that it inhibits aggression towards others (Decety, 2008). Empathy is a quality that can be encouraged in classrooms by teachers and that students can develop as a skill that may be used in every aspect of their lives. Empathy is a quality that can be weaved into science lessons through the introduction and practice of radical listening, mindfulness and conversations that foster compassion for every participant in the classroom.

**Managing our emotional style to prevent sickness**

In chapters 3 and 5, I focused on deficit perspectives only to identify and illustrate the issues that exist and that can elicit emotional upheaval in the classroom. We are aware that emotions if not dealt with in a conscious manner, can trigger health issues that eventually will be manifested physically. For instance, when faced with the stress of everyday and not paying attention to the symptoms, Reynaldo, a former chemistry teacher in a New York City public school became ill. The stress associated with continually resisting what he regarded as poor decisions of administrators began to mount. Evidence of stress often was apparent in the way Reynaldo interacted with students, school administrators, and colleagues. He found that he got upset frequently and when he did so he felt tired and unable to work with the high energy he preferred to bring to his job. He began to experience dizziness and lack of energy, but he ignored these signs of failing health. The stress level he dealt with every day in a Bronx science classroom was exacerbated by the minimal support he had from the school administration. Dealing with issues in school and not being aware of the adverse effects of those stressful situations, took a toll on Reynaldo’s heart (Tobin & Llena 2012.) Reynaldo is a passionate chemistry teacher, however the same emotional intensity that he brings into his work, sent him to the emergency room, because he did not seem to know how to manage his *emotional style*. *Emotional style* is a consistent way of responding to the experiences of our lives. It is governed by specific,
identifiable brain circuits and can be measured using objective laboratory methods. According to Richard Davidson emotional styles influences the likelihood of feeling particular emotional states, traits and moods. Davidson’s theory is that emotional styles are much closer to underlying brain systems than emotional states or traits. He calls them the building blocks or the atoms of our emotional lives (Davidson, 2012.) Davidson’s and other rigorous empirical research around the world in affective neuroscience have led to the classification of emotional styles into six dimensions: resilience, which points at how slow or quickly you recover from adversity; outlook, how long you are able to sustain positive emotion; social intuition, how adept you are in picking up social signals from the people around you; self-awareness, how well you perceive bodily feelings that reflect emotions; sensitivity to context; how good you are at regulating emotional responses to take into account the context you find yourself in; attention, how sharp and clear your focus is. Although all emotional styles may not be apparent to all of us, some may operate on levels that are not always apparent to us (Davidson, 2012.) Reynaldo is only one of many examples of educators that are faced with leaving the profession they love because there are structures in the education system that hinder their job performances to a degree that eventually staying in the job becomes detrimental to their well-being. As researchers, we are constantly searching for ways to improve the quality of education in the science classroom, we believe that this type of research and practice of becoming aware of our emotions and learning how to manage our emotional styles can have great benefits for teaching and learning science and making the connections that are often missing between students and science.

Neuroplasticity and our malleable brain

My research looks at human emotions in different contexts and how emotions mediate experiences and dialectical relationships among us and sociocultural fields. I specifically
researched a science education class and the issues that emerged in the classroom in a microlevel context through emotional arousal of class participants. This approach is unique in that itfacilitates teaching and learning science by engraining in a humanistic and sociocultural milieu.In addition, this research on emotions is informed by several theoretical frameworks that look atdiverse ways of analyzing, understanding and mediating emotional arousal in the scienceclassroom. Ekman’s facial analysis of emotions and the use of oximetry, allowed me to get a sense of the emotions experienced in the moment in the classroom. Nonetheless, the goal of this research is not limited to just developing the skills to be able to identify and read what the emotional expression or the physiology of emotion is. My ultimate goal and standpoint on authenticity criteria was to enable every participant in the classroom to benefit from the research as a result of his/her participation in it (Tobin, 2011). The information I obtain through the use of these tools is only half of the work. My goal is to promote change in the science classroom through interventions that are available to educators and students. The interventions used in this research aim to enhance openness and freedom of emotional expression of every participant in the science classroom as emotional arousal is experienced in the moment and to the next, while trying to inhibit any kind of judgment. At the same time we work on developing empathy and a sense of compassion towards ourselves and others. Additional interventions not documented in this dissertation, but that are part of the greater study at Brooklyn College, such as the adaptation of breathing meditation practices in the classroom were done with no other intention than to focus on the experience of the moment. Breathing meditation is an example of a physiological exercise that when we focus on it, allows us to be aware of it. Breathing meditation and other cognitive practices have been shown to have beneficial effects on mental training. Although empirical scientists were reluctant for decades to accept the idea of meditation as a topic of
scientific study, nowadays, there is greater acceptance of the complementary relationship between Western science and the insights of ancient Eastern philosophies. So great is the acceptance that the National Institutes of Health provide substantial funding for research on meditation, something that was unheard of ten years ago (Davidson, 2012.) One of the first steps in neuroscience research has been understanding the characteristic patterns of brain activity that underlie the emotional traits and states that define each of us (Davidson, 2012.) Research on affective neuroscience by Davidson provides evidence that mental training through meditation practice can alter patterns of activity in the brain to strengthen compassion, empathy, optimism and a sense of well-being. In addition, Davidson has been able to show that the higher order cognitive function in the brain plays an important role on emotion as the limbic system does, and it is these higher order reasoning sites that hold the key to altering patterns of brain activity (Davidson, 2012.) Luckily, advances in neuroscience and technology, allow us to build up on previous knowledge and we are able to restructure what we knew as being set or fixed knowledge in terms of how we learn and how the brain functions. For many decades, the brain was considered to be a static structure with little or no possibility for change. In terms of emotional styles, we thought that it was impossible to adjust and change personality related characteristics in individuals. However, current research in neuroscience indicates that certain brain features can be changed by training specific brain areas through the practice of meditation exercises (Davidson, 2012.) The brain is a malleable structure and the perception of being handicapped for life in certain cognitive areas has changed through the concept of neuroplasticity, which is the ability to change the brain structure and function in significant ways throughout life. That change can happen in response to experiences we have, as well as the thoughts we think (Davidson, 2012.) What is powerful about this concept is that we can train our brain to do things
that we never thought it was capable of doing. What is even more exciting about this model is that anyone can do it as long as they are conscientious, disciplined and constant about the practice. One of the first steps is to identify our emotional styles and where we fall in each of the six dimensions. Some of the assessment consists of being perceptive about our own behavior and emotions, something that can be done by answering questions about situations or experiences that arise every day in life (Davidson, 2012.) To elicit neuro-stimuli of emotions in the classroom where emotions arise from a neutral state several stimuli were used. Curriculum topics were developed with themes that present controversy. Words that to a certain degree represent taboos such as race, evolution, eugenics were part of the regular class discussions embedded in class topics. The names of the topics alone caused the arousal of emotions in the classroom, because in those topics the students’ lives are represented in the form of pain, discomfort of living in a world that is still filled with prejudice and social injustice.

Part of adapting to this pedagogy, is to accept who we are and be willing to transform the areas we need to change (Davidson, 2012.) In order to become aware of our emotions, we must identify their sources and what triggers their arousal. In other words, we have to find the roots of our discomfort pull them off from the depths of where they are buried and deal with them. It is normal to come to a classroom with preconceptions and biases towards what is unknown, and even be afraid to talk about certain themes, because we are fearful about how others may perceive our point of view. In the Brooklyn College class many instances were representative of those situations, in which class participants were hesitant to participate in class discussions. I believe that inhibitions to express our true feelings about such important sociocultural topics rob us from a holistic way of learning.
Biologist, chemists and physicists are not traditionally educated in the undercurrents of pedagogy. Yet, many of them end up becoming teachers or university professors. I believe it is of paramount importance to weave in sociocultural themes with special attention to emotional awareness into the science curriculum as we prepare future generations of scientists and science educators. Science is entrenched in every aspect of today’s world and we as educators have the responsibility to provide tools to students that can improve the routes of navigating scientific epistemology. If we as science teachers do not allow ourselves the experience of truly being in the classroom emotionally, how can we expect for our students to be attentive and take away with them 100 percent of the classroom experience?

This participatory action research brings optional strategies for researched and researchers (including the author) to find emotional awareness in the classroom. Throughout this study low and high-level intervention tools were introduced to the research participants, which included use of a finger pulse oximeter and a five minute breathing meditation practice. This research is inclusive of factors that may be related to the ways in which emotions are constituents of classroom environments and structures that afford learning. Just how emotions relate to learning is undoubtedly complex and much more research is needed at micro and meso levels. Given the recent research in neuroplasticity it is possible that greater awareness about emotional styles and the creation of tools to ameliorate emotions when and as necessary can positively mediate brain function, development and wellness.
Afterword

Writing this dissertation has been an enlightening and transformative experience. Yet, there is much more to learn about emotions and how they mediate situations in our lives and in science education. Part of this research explored emotions as experienced and represented by prospective science teachers while coteaching in a science education class with the purpose of illustrating how emotions mediate teaching and learning. My research group and I were interested in learning about the expression of emotion and how emotions could be studied in the moment, historically as they were imbued in the social artifacts of a science teacher education course at Brooklyn College. Besides the methods of facial expression analysis and finger pulse oximeter used, the ongoing research at Brooklyn College examined emotions as they were expressed in proxemtics, including gestures, eye gaze, head orientation, and body orientation and movement. In addition some of the researchers studied prosody in relation to emotions, identity and emotions, and ways in which participants in the class could increase their mindfulness. In addition to multi-methods and multi-theoretical approaches, we adopted an authentic inquiry approach to ensure that what we learned from the study was shared with the non-conformists in the class for the purpose of improving the quality of learning. We created several interventions to improve different aspects of teaching and learning, including breathing meditation, which was designed to use deep abdominal breathing to calm the emotions and allow participants to obtain focus and increase mindfulness at the beginning and middle of many of the classes. Similarly, we designed heuristics that heightened awareness of important aspects of emotions and emotional climate, including mindfulness in education, the uses of dialogic inquiry, coteaching, and cogenerative dialogue. These heuristics consisted of characteristics for constructs such as mindfulness, and as participants completed a rating scale for each characteristic they made
personal connections, thereby fueling reflexive processes that included becoming aware, considering possible changes, and thinking through the implications of making adjustments and acting differently. This reflexive process contributed to the research having a positive transformative dimension to it. The ongoing research also embraces participant oriented methods in which a number of participants get involved in doing research, writing about it, and meeting regularly to discuss what is being learned from the research.

Each of these methods seems promising in providing valuable information on emotional expression and the way emotions can be represented. Furthermore, when it comes to research on emotions, taking a multi-method approach has greater advantages. I learned throughout my doctorate studies that a multi-logical approach fits best with my research philosophy and how I view the world. These aforementioned methods can help me look at different issues and answer important questions about research on emotions. I am a college educator and I am interested in the possible influence that this type of research can have in my own practice. Informed by the authenticity criteria proposed by Yvonna Lincoln and Egon Guba, I will continue my research with the purpose of benefiting everyone involved. With this purpose in mind, I want to explore potential strategies that might enable me and other college educators to transform the power dynamics that currently exist in the science classroom to a more multi-dialectical method, which will enable class participants to feel free about expressing their agency and feeling that their perspective matters. Also, I want to encourage a sense of respect, tolerance, and compassion among class participants. In other words, I do not want to just teach science, I want my students and me to look into the infinite capacity of the human heart for compassion and develop empathy in our lives. Although I did not address the use of breathing meditation in this study, I would like
to explore breathing meditation as an intervention tool to modify or ameliorate negative emotional arousal when detected by the finger pulse oximeter.

Richard Davidson’s work on emotional styles is an excellent resource that provides crucial and new information about the brain, emotions and neuroplasticity. I believe Davidson’s research can be used to train our brain to build new neuro-pathways that help us manage emotions in our lives and also as a transformative pedagogic tool for teaching and learning science. As educators we are involved in fostering intellectual development of students, and although emotional development is not officially stated in classroom curriculum, it is fundamentally present in teaching, because teaching and learning are saturated with emotions.

**Possibilities for transformation**

I taught history and philosophy of science education course at Brooklyn College in the spring of 2013, I had the advantage of having attended Alexakos’s class the previous spring. Of course, I had a different group of students, which had been introduced to some of the research concepts in the previous semester. The curriculum to follow was slightly modified during two weeks in the semester, but I essentially followed the curriculum Alexakos had executed the previous year. I had the opportunity to continue practicing useful interventions I had learned in Alexakos’s class. I practiced mindfulness, radical listening, and breathing meditation as intervention tools, facilitating the interactions I had with my students during highly stressful curriculum discussions. I will admit that the mood in the class was quite stressful at times for students as well as for me. I tried to foster an environment where everyone in the class could feel free to execute their agency. However, I could sense students holding back and not wanting to participate during certain class discussions that were sensitive in nature. One day, Alexakos visited my class and I was wearing the finger pulse oximeter. He sat across from me and could
clearly see the computer positioned behind me that was receiving the raw data coming from the oximeter I was wearing. As we discussed the events of that day after class, he said to me: “I was surprised to see how calm you were throughout the entire class in relation to the oximeter output. There were no spikes in the curve.”

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Table 1 Oximeter output for Olga’s File No. OEM 130513 165426

Table 1 reflects 925785 data points obtained during a period of 3 hours and 27 minutes while I was wearing the oximeter. The mean for oxygen saturation (SpO2) was 96 percent. The mean for heart rate was 82 bpm. The standard deviation was skewed by off readings during spontaneous movements of the hand and arm where the oximeter was worn. Graph # 1 shows the distribution of SpO2. The greatest SpO2 output range between 95 and 97 percent.

Research involving mindfulness and meditation suggest that one of the benefits of the practice is greater awareness of our surroundings, increased mental concentration and improved selective attention (Davidson, 2012.). In addition, individuals who practiced meditation regularly seemed to develop a greater compassion towards others.
Fig 1 Olga’s oxygen saturation, heart rate and plethysmograph
Outputs during a 3-minute teaching interval

What lies ahead?

Being well emotionally is very important for me, because it affects every part of my life. There are several events that have taken place in my life in the last two years. I am aware that some cycles or stages in my life have closed, while others are opening. The first one is the graduation of my daughter and the fact that she is an independent person and has moved away from home. The second one is the death of my mother and not having to worry about and care for her. I am entering a period of stability because of the near culmination of my studies and I have found a partner in my life for the first time that not only wants similar things to what I want in life, but also challenges me intellectually and loves me for who I am. I feel extremely lucky to have accomplished so much since I left Colombia. Yet there is much more that I need to do. When I see my students struggling to complete their associate’s degree, I want to be a source of
support for them, the way I found support when I needed it. My goal is to be that teacher who motivates and encourages students to love, explore and develop their full potential around their science careers, instead of being intimidated by the field of science. I look forward with enthusiasm to learning and growing as a scholar, and being the advisor to people who are pursuing their educational dreams while fostering an impartial sociocultural view about life. What is most important for me is to continue pursuing my well-being, because if I am okay, I am able to accomplish many things I set out to do and help others accomplish their goals along the way.
REFERENCES FOR
TRANSFORMATIVE SCIENCE EDUCATION THROUGH
ACTION RESEARCH AND SELF-STUDY PRACTICES

Abstract

Chapter 1


**Chapter 2**


Chapter 3


**Chapter 4**


Chapter 5


**Chapter 6**


**Afterword**
