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Using Video Clips to Implement Multicultural Topics of Science and Nature of Science into a Biological Content Course for Preservice Teachers

An Action Research Project

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Introduction

I feel as if I was conscious of race since elementary school. I was fortunate enough to attend elementary and junior high schools that were very diverse in a big city. However, moving to a smaller, predominantly white town at the start of high school revealed something shocking to me—that I and other African-Americans were viewed more as anomalies than as inclusive members of society. My peers treated me strangely, and the curriculum, including science, seemed starkly bare of any “color”. The only classroom discussion I remember having that included African-Americans involved me defending the Los Angeles riots to my white classmates in an American history class. Even at that time, I knew that this was not normal.

The preceding quote describes the first author’s experience with race as a girl and teenager. These experiences stayed with her until her adult years in graduate school. For the sake of simplicity, she will refer to herself in the first person throughout the remainder of this article.

My desire to integrate multicultural topics in the college classroom spans many years. When the opportunity arose to design an action research project as a graduate student, including multicultural topics seemed completely natural to me. As an instructor beginning to use nature of science (NOS) and science inquiry (SI) in the current course, drawing on these concepts allowed for consistency with the curriculum and seemed an enjoyable challenge to embark on as well. However, I also realized that adding material with racial or cultural issues could be socially

and/or politically controversial, causing potential discomfort for both me and my students (Denning, 2000). Because of this, finding ways to present such material in a non-threatening fashion was necessary. After thoughtful reflection, I felt that using video clips and reflection writing to introduce these issues may be a constructive approach.

Literature Review

Multicultural science education.

United States students are far from homogenous, composed of a broad array of cultures, ethnicities, and socio-economic levels that educators should not ignore (Moore-Mensah, 2009). At the same time, prospective teachers in colleges and universities across the nation are predominantly white (Causey, Thomas, & Armento, 2000). As a way to resolve this concern, definitions from multicultural education experts are broad (Banks, 1995; Nieto, 2000).

Studies highlight the role of multiculturalism in the science classroom (Atwater, 1996; Brotman & Moore, 2008; Brown, 2004; Calabrese Barton, 1998; Carlone & Johnson, 2007; Madrazo, 1998; Tan & Calabrese Barton, 2008). Cooper and Matthews provided one reason for continued research in this area: “Since schools are composed of students and teachers from a wide variety of backgrounds, the best way for the educational process to be most effective for the greatest number of students is for it to be multicultural” (2005, p. 50).

If successful intervention strategies which included multicultural lessons were an integral part of our education, then how would our experiences in the past affect us now as adults?

Reviewing the literature led me to think more about myself and my former white classmates’ experiences. If successful intervention strategies which included multicultural lessons were an integral part of our education, then how would our experiences in the past affect us now as adults? I realized that my teachers missed valuable opportunities to educate us, but I would not do the same. For preservice teachers in particular, this is especially crucial, as they will presumably teach children with different racial and ethnic backgrounds than their own (Causey et al., 2000).

Nature of science and scientific inquiry.

I first began learning about NOS/SI as an epistemology of science in a college teaching course taught by the second author. I learned that employing a curriculum that includes NOS and SI is a key principle emphasized in the National Science Education Standards (National Research Council, 1996). Schwartz described the purpose of including these tenets, stating that “scientific

knowledge is developed through creative and inferential processes of collecting and making meaning from observations of the natural world” (2007, p. 43).

Introducing inquiry in lesson plans is essential to science education and should be the basis of coordinating student activities in the classroom (Lederman, 2004). Scientific inquiry (SI) involves

making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (NRC, 1996, p. 23)

Hence, preservice teachers should have consistent exposure to NOS/SI so that they may teach future students effectively.

Using socio-scientific issues (SSIs) to teach NOS/SI concepts to students is one resourceful approach to teaching students challenging concepts (Sadler, Amirshokoochi, & Allspaw, 2004; Sadler, Barab, & Scott, 2007; Zeidler, Walker, Ackett, & Simmons, 2002). Further, Meyer and Crawford asserted that incorporating a pedagogy that is “culturally relevant” along with a curriculum that emphasizes NOS/NOSI may be helpful in providing an inclusive classroom environment for marginalized groups (2011, p. 525).

In spite of all this, teaching these skills to preservice teachers is remarkably complex. In a study designed by Bianchini and Solomon, for example, preservice teachers were faced with the task of understanding their views of scientific learning and NOS in terms of equity issues (2003). Although they struggled with such concepts initially, they did begin to formulate their own perspectives during the study. Thus, inclusion of NOS along with multicultural topics may be beneficial for all students and affirms incorporation of this pedagogy into my action research project.

Videos in the classroom.

Introducing controversial topics by way of videos is a familiar tool used in educational settings (Baharav, 2008; Rodrigues, Smith, & Ainley, 2001; Roskos-Ewoldsen & Roskos-Ewoldsen, 2001). According to Denning (2000), videos are a “...powerful communications medium which, in combination with other learning resources and instructional strategies, can perform a vital role in modern education” (p. 1).

Denning further asserted that students can learn affectively and are motivated to learn various topics (2000). One important benefit includes relaying critical issues that are important to the student or that fall in accordance with a student's values or morals. Such video clips may facilitate presentation of social and political controversial issues in a way that might alleviate an educator's burden to present it.

Preservice teacher reflection.

Learning affectively through videos cannot be accomplished without reflective thinking on the part of students. Dewey stated, "Reflective thinking is an active, persistent, and careful consideration of a belief or supposed form of knowledge, of the grounds that support that knowledge, and the further conclusions to which that knowledge leads" (*Reflective Thinking: RT*, n.d., Paragraph 2). Scholars acknowledge the importance of preparing preservice teachers to become critical and reflective thinkers (Moore-Mensah, 2009). Studies demonstrate that prospective teachers enter into programs with the naïve belief that "kids are kids" and, therefore, cultural and ethnic differences are not significant when it comes to student learning (Causey et al., 2000, p. 34). Hence, teacher educators must challenge such naïve thinking and aid prospective teachers in initially evaluating their own beliefs and ideas (Causey et al., 2000; Moore-Mensah, 2009). This helps actualize the process of teachers evolving into individuals that strive for equity in the classroom. Moore-Mensah coined this issue as the "principle of ideology" (2009, p. 1043).

Overall Objectives

The question guiding my action research project was as follows: How could I, an African-American female biology instructor, use student reflective writing and video clips to promote multicultural aspects of science in a biology content course that focuses on explicit instruction of nature of science (NOS) and scientific inquiry (SI)? More specifically, how could I accomplish this in a classroom of predominantly white preservice elementary teachers? In the beginning of this project, my objectives were that students have an increased awareness of various cultural issues, though how significant such knowledge would be was questionable. Although not a primary objective, I also expected students to begin forming connections between what they were learning concerning NOS and SI and the presented SSIs. I believed that forming these connections would naturally lead to a deeper understanding of NOS and SI.

Contextual Setting

This research took place in an undergraduate science classroom in a mid-western university for one semester. The class consisted of 25 undergraduate preservice elementary students in an introductory biology content laboratory-based course that was the second class of a two- course sequence on life science for preservice elementary educators. The course teaches key biological

concepts in genetics, molecular and cell biology, and biotechnology with an emphasis on NOS/SI. As stated in the course syllabus, this is done through “open-ended problem solving environments that facilitate insight in the nature of science as an intellectual activity; to explore alternative conceptions of scientific phenomena” (Course syllabus, Spring, 2006). The class was composed of seven males and eighteen females and met twice a week in two-and-a-half hour sessions. There was one African-American male in the class. There were no other persons of color in the classroom besides myself and this student.

Conceptual Framework and Methodology

Action Research

Action research is a type of investigation whereby teachers seek to improve their classroom practices (Parsons & Brown, 2002). To a certain extent, teachers naturally practice action research (Miller, 2007). That is, educators must plan interventions that integrate new concepts in the classroom. Such a task also involves observing, reflecting, and devising new strategies based on their findings (Miller, 2007). One key component of action research, however, is the use of a framework on which to conduct a formal type of study (Miller, 2007). It is composed of a cycle of steps comprised of several key elements: a plan of action concerning the central issue in question, execution of the plan, observation of the effects of the intervention, a reflection of the effects, and a strategy that incorporates a new plan of action (D’Oria, 2004; Steketee, 2004).

One problem posed by several scholars, particularly in the context of classroom studies, is the lack of attention some action research models place on the “messiness” of such research (Steketee, 2004, p. 876). This “messiness” is primarily due to the dynamic nature of social interactions; scholars have attended to the need for flexibility by creating frameworks with this in mind (Steketee, 2004). Steketee (2004) referred to her own as a “tentative action research plan” (p. 876). In her model, she incorporated Richie’s multi-layered approach, a model that encourages the integration of topics that surface during the investigation into the central issue for the remainder of the action research project (Steketee, 2004).

Based on this review, the model that guides my methodology in this study borrows from Steketee’s framework as seen in Figure 1. Each cycle included the presentation of a video clip and an associated worksheet for students to reflect on the clip, totaling four video clips (four cycles). After executing the plan, I observed the effects by evaluating data. The reflection phase included further evaluation of prominent themes. Afterwards, incorporation of the new effects or themes would take place in the re-planning phase as needed. Figure 1 shows the new plan associated with each cycle on the left side of the page, while the general action research model is presented on the right side of the page.

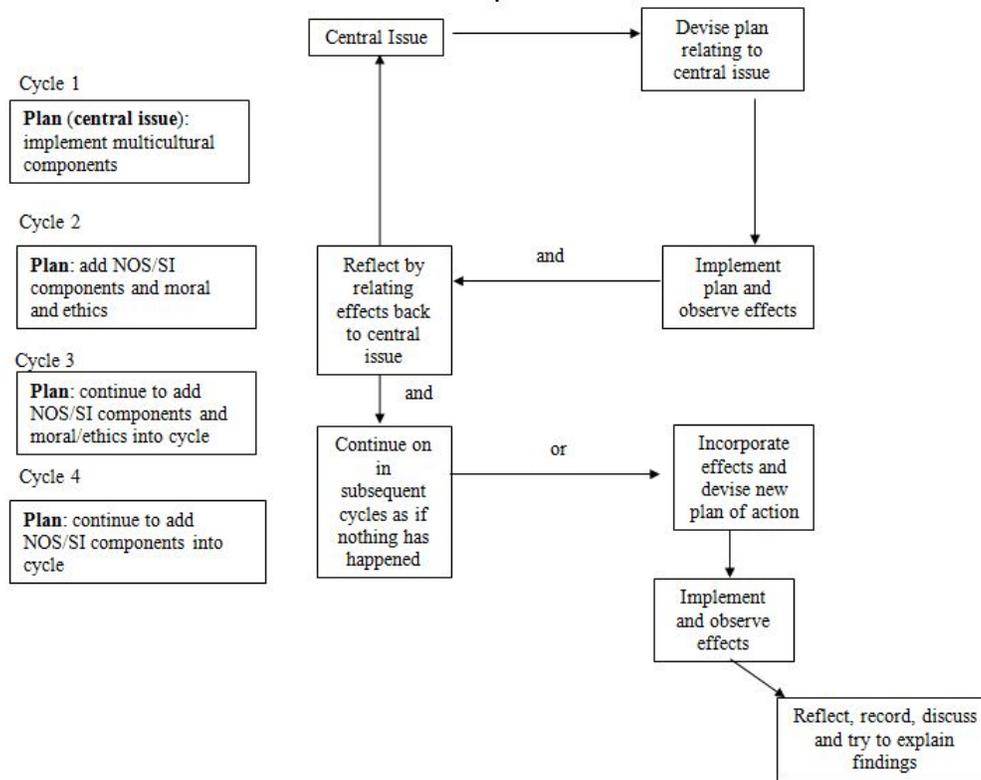


Figure 1. Action research model.

Theoretical framework for video selection and reflection questions.

In choosing video clips and devising reflective questions with multicultural and NOS/SI components, I relied on several frameworks as depicted in Table 1 (Ambrosio, 2003; Banks, 1998; Banks et al., 2001; Akerson, Hanson, & Cullen, 2007; Schwartz et al., 2004). My goal was to create a curriculum that made an impact on student learning, yet still provide space for these concepts to intersect with the complex biological topics introduced in class.

Multicultural component.

Banks outlined four different approaches to implementing multicultural concepts (1998). These approaches range from the easiest to incorporate to the most difficult. Consequently, their impact on student learning ranges from the least to the most effective. The contributions approach is the most popular method used in schools, whereby teachers add in important events,

accomplishments, or noteworthy individuals from various cultural/racial groups who made substantial historical impacts related to the subject (Banks, 1998). However, one major concern is the “trivialization of ethnic cultures, the study of their strange and exotic characteristics, and the reinforcement of stereotypes and misconceptions” (Banks, 1998, p. 37). The additive approach involves the inclusion of various cultural events to an otherwise hegemonic curriculum. This is done without radically changing the course, such as a discussion of the Trail of Tears for Native Americans. Banks contended this model is still not appropriate for effective diversity learning, due to its mainly Eurocentric perspective (1998). The transformative approach enables students to see “concepts, issues, themes, and problems from several ethnic perspectives and points of view” (Banks, 1998, p. 38). It aids in the expansion of students’ understanding of a particular issue or idea (Cumming-McCann, 2003). An example of this method entails the inclusion of perspectives from Native and African-Americans in the Revolutionary War (Banks, 1998). The decision-making/social action approach encompasses all of the facets of a transformative approach, but challenges students to devise or brainstorm solutions to such problems. Students may also decide to enforce such action if necessary.

Effective teaching of multicultural topics may include a combination of all approaches (Banks, 1998). My plan was to incorporate aspects of both the transformative and decision-making/social action approaches in this study. Because the main goal of the latter is to promote critical-thinking skills and empower students to become agents of change, I focused on guiding students to think of alternative courses of action based on the perspectives of marginalized groups, such as African-Americans.

In another conceptual framework, several important assumptions are addressed for immersing teachers and students into diverse multicultural perspectives (Banks et al., 2001):

1. Teachers should develop their own understandings of the various ethnic and cultural groups that are prevalent in the school system.
2. Teachers should take part in professional development programs that emphasize the importance of student diversity, particularly because the majority of teachers have backgrounds markedly different from the students they teach.
3. Teachers should understand the complex role of social class status. As stated by Banks et al., (2001), “...social class is one of the most important variables that mediate and influence behavior.” For instance, although racism affects marginalized groups of every socio-economic level, African-Americans who may be socio-economically disadvantaged bear the brunt of this inequality.
4. Curricular and pedagogical practices must demonstrate to students that knowledge (i.e., scientific) is not separate from its knower, but socially constructed. In particular, students

should understand the role “researchers’ personal experiences as well as the social, political, and economic contexts in which they live” play in constructing such knowledge (Banks et al., 2001, p. 3). This carries heavy implications, particularly because traditional practice involves presenting material from a broad European-American perspective (Banks et al., 2001).

5. Curricular and pedagogical practices must reinforce the complexity of real life, the origin of this nation, and the role that many cultural and ethnic groups have in such events (Banks et al., 2001). From a scientific perspective, educators must present material in class that offers alternative perspectives on the scientific origin of life.

Hence, my goal was to modify my curriculum to include video clips and questions that would reinforce the above concepts in some way to my students, both as future teachers (as seen in numbers 1 and 2) and as current students (i.e., numbers 3 and 4).

Morals and ethics in multiculturalism and SSIs.

Presenting material and activities from a multicultural standpoint allows students to realize the fallacy of claims stemming from an ideological belief system.

After the second cycle of my research, I found themes in the students’ responses that reflected moral and ethical characteristics. This prompted me to purposefully incorporate such topics in the subsequent cycles.

According to literature, including moral and ethical components is commensurable with multicultural or culturally relevant pedagogies (Ambrosio, 2003). Teachers are obligated to “prepare students to become effective and critical participants in the world” (Nieto, 1999, p. 143). This requires teachers to enforce a pedagogy that centers on the students’ construction of knowledge and their personal experiences (Ambrosio, 2003).

Even more, Ambrosio delineated the relationship among culturally relevant pedagogies, morals, and ethics, stating, “Multicultural education places a high value on critical thinking, on the personal truth making that enables students to challenge the moral and intellectual authority of the dominant culture” (2003, p. 36). That is, presenting material and activities from a multicultural standpoint allows students to realize the fallacy of claims stemming from an ideological belief system. Students must rely on their own personal beliefs to challenge the presented knowledge.

With this information, commensurable with the role socioscientific issues (SSIs) have in eliciting moral perspectives (Sadler et al., 2006; Sadler & Zeidler, 2004; Zeidler, Walker, Ackett, &

Simmons, 2002), understanding that students' responses would be fraught with ethical implications was no surprise.

NOS and SI.

Explicit instruction is an effective way of teaching the complex concepts of NOS/SI (Akerson et al., 2007; Schwartz et al., 2004). This aids students in familiarizing themselves with the acquisition of scientific knowledge (Schwartz et al., 2004). Explicit instruction involves inquiry activities that explicate the role of NOS (Schwartz et al., 2004). Research has explored its effectiveness for preservice teachers (Akerson et al., 2007) and in college biology laboratories (Bautista & Schussler, 2010). As mentioned in the preceding section, this class was a content course taught with an underlying premise of NOS/SI due to the design of the course by the second author. Because of this, it was important that any additional curricular components related to multiculturalism be tied into this conceptual framework effectively.

Commensurable with this is a reflective component used in NOS instruction (Akerson & Abd-El-Khalick, 2003; Akerson et al., 2007; Bautista & Schussler, 2010). Bautista and Schussler (2010) defined this as “[providing] students with structured in-class and out-of-class opportunities to reflect on their understanding of NOS in relation to the course activities” (p. 56). Explicit-reflective NOS activities are effective in improving views and knowledge of NOS/SI to elementary teachers (Akerson & Abd-El-Khalick, 2003; Bautista & Schussler, 2010). Various explicit-reflective activities were already incorporated in the course prior to my modifications and are beyond the scope of this article. However, my challenge was to implement multicultural activities that aligned with these activities as well. Because Akerson et al. described explicit reflection of NOS/SI to include both discussion and written work (2007), I designed reflection questions that included such multicultural and NOS/SI concepts.

NOS contains several tenets associated with its conceptual framework that has been disseminated to national education standards (American Association for the Advancement of Science, 1993; NRC, 1996). In designing my worksheet questions, I used several of these tenets to help facilitate the inclusion of multicultural concepts outlined in the frameworks above (Banks et al., 2001; Schwartz et al., 2004). First, no single scientific method exists, although there are shared approaches to science. Second, science has elements of subjectivity (theory-ladenness) in the construction of scientific knowledge. More specifically, scientists may interpret data and understand scientific knowledge based on their own various backgrounds and experiences. Bonner argued, “The fact remains, however, that every scientist lives in a culture and a time, and holds certain views” (2005, n.p.). Third, scientific knowledge is constructed in a socio-cultural fashion where individuals develop research designs and devise interpretations of science based on their socio-cultural backgrounds.

In regards to scientific inquiry, I included questions in the worksheets that assessed students' ability to recognize elements of SI in the video clips presented, particularly those related to collecting evidence and the consideration of alternative methodologies to investigations.

Description of Video Clips and Reflection Questions

Video selection was based primarily on these criteria: (a) how retrievable the videos were from the World Wide Web, (b) the potential the clip had in presenting multicultural topics, and (c) the potential the clip had in espousing NOS/SI elements. Table 1 provides a list of the video clips and corresponding questions designed for each clip. For clarity, this table also shows the related assumptions from the various frameworks to which these questions align with.

The first video clip in the first cycle is narrated by Bill Nye the Science Guy (Nye, 2008). It introduces the idea of race as a social construct by arguing that there is no biological evidence supporting the claim that genetic differences exist among racial groups.

The second video clip involved a brief discussion on pre-implantation genetics diagnostics (PGD) technology. This procedure allows individuals to look at embryos during the in-vitro fertilization process and detect if there are genetic mutations (BBC, 2006).

The third video clip contained information concurrent to the unit at the time (i.e., DNA, RNA, proteins, mutations). In the previous class session, my class focused on the general types of mutations, particularly point mutations. The students learned that one change in a DNA sequence could cause a detrimental illness. Although a heartbreaking video focusing on a family whose child develops Tay-Sachs disease, this video served to help connect classroom material with the clips and facilitate student thinking about different cultures (NOVA, n.d.).

The fourth clip describes the Tuskegee Syphilis Study (TSS) by way of a unit I concurrently taught in the course. In this unit, I lectured on the non-regulation of laws protecting human experimentation 50 years ago in Africa. This led me to realize a connection to the TSS. In the TSS, which began in 1932, there was no legal legislation that protected human subjects for the African-American male subjects in the study who were poor and mainly illiterate (Curbeam, 2007). Hence, I did introduce the complex role of social class in relation to these African-Americans in the study. I also included this because of my own personal connection to the study—my late uncle was thought to be one of the patients in this study.

Instructor Role

My role in this action research project was as a participant observer in that I was responsible for teaching the course, presenting the video clips, distributing worksheets relating to the video clips,

and guiding potential discussion while noting observations mentally and after class (Creswell, 2003).

Before executing my plan in the first cycle, I realized that I was feeling ambivalent about adding NOS/SI into my action research. NOS/SI concepts were introduced into cycle two as described above when I felt comfortable enough to incorporate it into the video clips.

Instructor’s race and gender.

Throughout this action research project, I pondered the role of my race and gender and the possible tension this would cause, most particularly, how this would affect student responses. As I state in my journal:

These students are new to me and I am new to them. What else would they think except that this African-American female teacher is forcing her views on them, especially since I informed them during my introduction that my main interest in science education is in multicultural studies?

A literature review revealed little about describing experiences of African-American teachers, particularly ones who implement multiculturalism in a predominantly white classroom (Moore-Mensah, 2009). However, Moore-Mensah reminded readers of a quote from Banks, who contended that an African-American teacher’s role is extremely important to white students, even if by only seeing a person of color in a position of “authority and influence” (Moore-Mensah, 2009, p. 40).

Table 1

Video Clips, Reflection Questions, and Associated Theoretical Assumptions

Clips	Reflection Questions	Theoretical framework
Race/social construct	What is the general idea of the clip?	Scientific knowledge is socially constructed (multicultural/NOS); scientific origin of life
	What is your initial reaction to the clip?	Teachers should develop their own understandings of racial/cultural diversity
PGD	What do you think of Dr. Silver’s	Critical thinking skills

initial comments that he has “no doubt” that parents will eventually start to choose this form of technology to pick babies that “go beyond medicine” and focuses on cosmetic and longevity? Do you believe that this is the next natural step for individuals in PGD technology?

PGD is an expensive form of technology. In the future, if parents choose to have “designer babies,” only the rich could afford such a procedure. Dr. Silver presented his own take on what this would mean for our society in response to the commentator’s statement, “Class differences [between the rich and poor] could become genetic differences.” What do you think this would mean to our society in terms of the diversity of individuals? Is this okay?

Teachers should develop their own understandings of racial and cultural diversity; teachers understanding of the complex role of social class status/transformational approach

When we discussed the characteristics of Nature of Science, we mentioned that one characteristic is that science has a socio-cultural component (societal pressures) to it. On that note, why do you believe that it is currently illegal to add genes into embryos?

Scientific knowledge is socially constructed (multicultural/NOS)

Tay-Sachs

Give one piece of evidence that you believe scientists had to collect to help discover the Tay-Sach’s disease.

SI

Please think of one positive and one negative aspect of having parents tested for the Tay-Sachs gene before they have children.

Moral/ethics

Tay-Sachs is known to occur at a

Complexity of real life,

	higher rate in Ashkenazi Jews, certain individuals of Cajun descent in Louisiana, and the Amish community. How can this be explained? Does this contradict Bill Nye's earlier video on race?	scientific origin of life (multicultural)
TSS	Find a reputable website that gives symptoms of the late stages of syphilis.	Background information/SI
	What were the moral and ethical problems associated with this study, in your opinion? Why did it go on for so long?	Moral/ethics of multiculturalism & SSIs
	How does subjectivity (characteristic of NOS) play a role in the conduct of these doctors? Remember that subjectivity involves a person's own experience and background.	Scientific knowledge is socially constructed (multicultural/NOS)/subjectivity and theory-ladenness of research/complex role of social class in lieu of race
	Please describe an alternative methodology (SI) that the scientists, doctors, and nurses may have used that would have treated these patients effectively and provided the research information they needed.	SI/transformative approach/decision-making and social action approach/NOS – use of alternative scientific methods

Data Collection

Data sources included student reflection worksheets, students' bioethics papers, classroom/field observations, and my personal reflection journal. The bioethics papers were assigned as a way for students to explore major socio-scientific issues. Students were to give both an oral presentation and a written paper that discussed the nature of the socio-scientific topic, including the pros and consequences of the issue. Using this source was not expected, as I came upon certain findings while grading student papers.

As another source of data, attempts were made to videotape classroom discussion. However, due to technological difficulties and other issues, this was not the most reliable source of data. I

commenced to relying on field notetaking to record any observations of the students when at all possible, most particularly instances that seemed relevant to the action research project.

Primarily, the reflection journal was used for personal reflection as well as a tool to organize themes and emerging patterns in the data. My personal reflection included any thoughts and feelings I had throughout the action research process. I wrote my thoughts down at any time and place in the journal.

As an organizational tool, I used the journal to record each cycle of my action research. More specifically, in each cycle, I divided the journal into subsections that listed the goals of the cycle, plan, and a description of the actual action. The goals described what I intended the students to learn from the video clips, whereas the plan listed how this would be accomplished in detail (name and type of video clip, reflection questions, etc.). I then used the observations and reflection subsections to notate themes and subthemes, and patterns in the data.

Alternative assessment of NOS/SI concepts.

Although assessment of NOS/SI concepts typically involve questionnaires such as VNOS to determine student learning, particularly because of their high construct validity (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002), advocates of other forms of alternative assessments claim the latter “closely [matches] the types of understandings, skills, and abilities that science students should be expected to learn” (Lawrenz, Huffman, & Welch, 2000). Alternative assessments such as portfolios, worksheets with open-ended responses, and creative projects offer many benefits. Among them, they aid students in developing essential critical thinking and problem-solving skills (Lawrenz et al., 2000), provide opportunities for understanding concepts in a real-world context (Bastanfar, 2011), and teach students to evaluate and contest certain knowledge claims (Clary & Wandersee, 2010).

These assessments are not without their own problems, however. Among them is a high susceptibility for researcher bias and subjectivity (Alpine, 2002). However, this course already contained formative assessments which tested these concepts. The primary goal of my research was to incorporate multiculturalism for the first time into a biology content course. Thus, although I was aware of the researcher bias I introduced into the design, I still believed that my assessment of the students’ open-ended responses on the reflection worksheets was sufficient. This analysis involved me evaluating open-ended responses to determine if students tied in such concepts effectively to the information in the videos. Coding techniques distinguished responses that were comprehensive (i.e., utilizing NOS/SI concepts that related well to the information in the video) versus those responses that did not properly use NOS/SI concepts when explaining such information.

Data Analysis

Analysis of data involved general procedures for qualitative research (Creswell, 2003). I performed analysis of student responses, discussions, and personal reflections to look for common themes in each cycle. I evaluated each type of data separately. I did this by first breaking down responses into general “meaningful segments” to get an overall understanding of the types of responses, observations, and other reflections from each source (Creswell, 2003, p. 148). Since I considered the student responses a primary source of data, I began to systematically substantiate themes found in the worksheet with those from the other sources, including the bioethics papers. Throughout the study, I continued to note overall themes and patterns. For NOS/SI concepts and moral ethical themes, responses were evaluated to assess if students could generally comprehend them in relation to the particular issue. Analysis took place after each cycle to plan the next cycles. Final analysis included organizing all student responses and observations as evidence to emergent themes.

Findings and Discussion

Table 2 provides an outline of themes and subthemes prevalent throughout all four cycles. Student responses often contained more than one theme and are reflected in the percentages.

Table 2

Percentage of Student Responses with Prominent Themes (Bold Case) and Subthemes (Regular Case) in Student Responses

Cycle One	Cycle Two	Cycle Three	Cycle Four
*Multicultural	*Multicultural	*Multicultural (58%)	*Multicultural (21%)
Race is social construct (59%)	PGD will cause less diversity (91%)	Classroom connections (17%)	Moral/Ethics
Adds uniqueness (4%)	Moral/Ethics	Moral/Ethics	Subjects lied to or tricked (43%)
Vague/Confused (36%)	Perfect baby not natural (56%)	Genetic testing helpful (75%)	No access to healthcare (21%)
	PGD against nature/God (46%)	Genetic testing not helpful (58%)	*Multicultural, NOS and subjectivity (33%)
	PGD risks (17%)	SI (100%)	SI (78%)

NOS	Video connections	Vague/Confused
Understanding concepts (92%)	Contradicts Nye (38%)	NOS (22%)
Confused (8%)	Does not contradict (42%)	SI (13%)
Vague/Confused (26%)		

Note. *Multicultural themes are those relating to diversity, race, and social injustice due to race (Banks, 1998; Banks et al., 2001).

Multicultural Theme

Based on Banks (1998) and Banks et al. (2001), issues relating to race, class, diversity, and racial injustice were considered multicultural themes in these findings. Overall, students felt comfortable discussing diversity/race issues, but there was possible discomfort toward the beginning of the semester as indicated by student responses. For instance, in cycle one, when asked about their initial reaction to the clip concerning race as a social construct, 36% of students seemed to give neutral or “safe” responses that could not be easily discerned. One female student remarked, “I thought this was very interesting. It definitely goes outside the box in terms of what I have grown up knowing. I would have to hear additional outside information to decide which group I think is right.” Such reticence on the part of this white student is noted in literature (Moss, 2008; Schaefer, 2008). In attempting to discuss race to preservice teachers, Moss found by explicitly discussing this topic in the classroom, preservice teachers realized their knowledge and experience about race and racism was severely limited, prompting them to want to explore this topic further. The desire to research the biological notion of race is a good first step into challenging students’ previous ideas on this topic.

Sixty percent of students agreed with Bill Nye’s clip that society seems to create clear lines of race, despite biological evidence that demonstrates such lines are significantly more blurred (Nye, 2008). For instance, one white female student responded in this fashion:

My initial reaction is that this video makes perfect sense. The color of [the] skin does not show anything but what color you are. Your race does not make you any less or more of a person. This video seems to grasp the real definition of the word “race.” We are all “One Race,” the “Human Race.”

This student chose to erase the racial boundaries that society constructs as she describes the need to view our world as consisting of only “one human race.” I wondered what sort of personal and social life to claim seemingly positive, it is possible “color blind” approach adopted (Husband, 2011, p. 365). This on race. Although it may appear the surface, Husband warned approaches may “actually work schools and society” (2012, p. 365). Future studies may allow time for discussion or interviews to clarify such responses.

A part of me also questioned the role my race played in the students’ answers.

of only “one human race.” I experiences she had in her this initial reaction. Though that she chose to follow the by some childhood educators position assumes a neutral stance to be a safe position to adopt on that these “politically neutral” to exacerbate racial oppression in

At the time of the study, I felt encouraged by the results of the student responses. It seemed as if they were open to accepting alternate views on race as well as evaluating other multicultural and socio-scientific issues. Also based on Banks et al.’s framework, the students were starting to negotiate their own understandings of cultural and racial diversity. I state in my journal:

I really underestimated my students’ reactions to the Nye video. I think that I walked into this project with biases as an African-American female teaching a mostly white class and assumed that these students would hold fast to their beliefs. I guess I should remember that this is a younger generation and that we currently live in a country where African-Americans are not only allowed to run for the presidency; they also have a very good chance of winning.

However, a part of me also questioned the role my race played in the students’ answers. Were my students telling me what they believed I wanted to hear because they could not trust me yet as their new teacher? The literature has very little to say about the effect African-American teachers have in their white classroom, both in student behavior and classroom performance. Instead, previous studies analyze the influence of white teachers and African-American teachers in their same-race classrooms on these factors (Dee, 2004; Hunter-Boykin, 1992; Mayer, 2011; Maylor, 2009). I chose to continue to implement aspects of race and diversity in the subsequent cycles for further clarity.

In the second cycle where I presented the PGD video clip, the students had opportunities to explore the complex role of social class and its relationship to diversity within the context of PGD (Banks et al., 2001). The students also had opportunities to gain insight on what this would mean for those from lower socio-economic levels, a facet of the transformative approach (Banks, 1998). Ninety-one percent of students expressed in some fashion that having diversity in society was positive. For instance, one white female student remarked:

I do not agree with this at all. This is a clear disadvantage to the less fortunate. It says that money will save you from disease, “second class” living, and different morals. I feel like this will rob people of their individualism. This will bring an obsession on perfection. Once again, I feel this is tampering with principles of God.

In the TSS clip, students expressed responses relating to racial injustice with the help of the NOS characteristic of subjectivity. Although my question contained elements of subjectivity, the social construct of scientific knowledge, and the complex role of social class, students mainly focused on the role of race. In particular, 33% of students explicitly acknowledged that the scientists’ and health professionals’ racist backgrounds were an example of the NOS characteristic, subjectivity. One student remarked:

I know that during this time African-Americans were still fighting for equality, and that is the only reason that I can come up with that it lasted for 40 years. This made the doctors feel that their testing was okay because it was being done on people that were “not equal.” It is very sad and makes me feel ashamed that many white people felt this was okay.

Question 4 of this clip included elements of the transformative and decision-making/social action approach (Banks, 1998). Based on the transformative approach, students were exposed to the horrific events that poor rural African-American males faced in regards to medical care. They were then invited to brainstorm other safer methods as a form of social action, a characteristic of the decision-making/social action approach (Banks, 1998). For instance, one student proposes, “They could have studied and taken observations on people with the disease, while helping them to fight and cure the disease at the same time.”

Overall, I was pleased with how I implemented multicultural concepts into the curriculum. Based on the frameworks proposed by Banks (1998) and Banks et al. (2001), the efforts made in this course were effective attempts at introducing these concepts to this class. However, promoting classroom equity involves drastic administrative and curriculum changes which strive to provide equitable science education to all (Rodriguez, 1998). Still, Nieto argued that introducing ideas and experiences that challenge prospective science teachers to discuss issues of equity and diversity are helpful in education programs (2000). The preservice teachers in my class were exposed to such challenging concepts. From my perspective, being able to simply introduce these topics in a classroom where I taught for the first time was significant. Discussing social injustice with students, though in a historical context such as with the Tuskegee Syphilis Study, was still a massive undertaking.

Moral and Ethical Components

Implementing moral/ethical questions after the second cycle worked well for the remainder of my action research project. I did not consider my student responses to be right or wrong, but hoped that students would make connections with their own beliefs as found in current literature (Causey et al., 2000; Moore-Mensah, 2009). I found that my students did a good job making such connections, overall providing clear and articulate responses that shed light on their beliefs.

When asked to describe the moral and ethical implications surrounding the TSS in cycle four, one student responded, “They were taking and abusing people’s lives for their own benefit, which is morally wrong. It is like they were being tortured with the disease and then only low doses of medicine were given.”

In this case, the student relies on her own personal knowledge and experiences to discuss the moral implications of the historical study. The student vocalizes the injustice for those comprising the African-Americans. Ambrosio remarked that such realizations are important in student learning within a multicultural context (2003). Allowing prospective teachers to evaluate their own beliefs is also the first step in establishing equity in their classroom (Causey et al., 2000; Moore-Mensah, 2009). Because of this, I believe that I will emphasize this component from the beginning of the class in the future.

NOS and SI

In this action research project, introducing NOS/SI concepts explicitly in relation to SSI issues was helpful for me as a novice instructor of NOS. I state in my journal towards the end of the semester:

In the beginning of this semester, I admit that I was anxious at the thought of teaching biology in a way that accurately reflected the nature of science. Having to incorporate it into my action research project seemed even more challenging. However, as I am creating questions for these clips relating to NOS and scientific inquiry, I realize that I am gaining a stronger understanding of these concepts myself! I don’t feel as if I am merely regurgitating the characteristics of NOS; I can honestly find strong relationships between NOS and these SSIs, particularly with regards to designer babies and the Tuskegee Syphilis Study.

My revelation highlights current literature that finds SSIs are valuable in facilitating learning of NOS/NOSI concepts (Sadler et al., 2004; Ziedler et al., 2002). In this respect, my action research project may have jumpstarted my own understanding of NOS.

For my students, I found that my class generally understood NOS/SI as it related to the video clips. In the designer babies clip (cycle two), explicit mentioning of the socio-cultural component involved in NOS resulted in clear and articulate answers from the students. In the first question, a

link between NOS and morals and ethics of society occurred. Only 8.3% seemed confused in regards to this question. In cycle three, all students were able to give clear answers when asked about types of evidence scientists must collect to gain information on Tay-Sachs. Explicit reminders of characteristics of NOS and SI in the fourth cycle gave mixed results, as seen in the previous section, however. Still, 78% gave a good example of alternative methodology, which was accurate to SI. Revisiting a quote from earlier that discussed African-Americans in their fight for equality, the student also connected subjectivity with the reasoning of why such unethical behavior lasted for years in the Tuskegee Syphilis Study:

I know that during this time African-Americans were still fighting for equality and that is the only reason that I can come up with that it lasted for 40 years. This made the doctors feel that their testing was okay because it was being done on people that were not “equal.” It is very sad and makes me feel ashamed that many white people felt this was okay.

From this student’s perspective, it is clear that subjectivity in science is related to the personal experiences of an individual (McComas, 1998). Thus, she was able to relate the societal mores at the time with the individuals’ personal experiences (i.e., common discrimination against African-Americans) to explain why such an event could not happen today. This also represents critical reflection on the part of the student, because she was able to make a connection according to the historical, political, and social context of the time (Dewey, 1933).

NOS, multicultural education, and SSIs.

Inclusion of SSIs is extremely relevant for prospective teachers, particularly when encouraging such educators to “teach for social change” (Rodriguez, 1998, p. 590). Teaching NOS along with SSIs is beneficial (Sadler et al., 2004; Sadler et al.; 2007; Zeidler et al., 2002) and NOS with multicultural education is helpful (Meyer & Crawford, 2011; Tan, 2011). However, limited literature discusses NOS, multicultural education, and SSI issues collectively (Zeidler, Sadler, Simmons, & Howes, 2004). Zadler et al. devised a conceptual model for use in research and practice when considering how to teach SSIs in the classroom (2004). They contended that four areas are necessary in this instruction: NOS, cultural topics, discourse issues, and case-based studies (2004). However, future research could add to the scarcity of present studies.

Confused Responses and Missed Connections

Overall, students generally articulated their viewpoints clearly on the worksheets. As explained before, this was assessed by ascertaining the difficulty of deciphering answers or the flow of a student’s thought or idea. There were several instances when the students did not express themselves very well. Hence, I placed these responses in categories under confused/don’t know or no answer. For instance, this occurred in cycle two on question one, when 26% of students

wrote confused responses when asked to describe their thoughts on the future of designer babies. Literature states that such confusion is common in the classroom. Aikenhead (1998) discussed the common issue of ambiguous undergraduate student responses. He states that three possible reasons for this could be: misinterpretation of the questions by the students, differences in how student and teacher interpret terms in the question, and the students' inability to articulate their answers.

Several students also had a difficult time relating NOS/SI with the SSIs in the study. In the TSS cycle, 22% of students wrote perplexing responses to the subjectivity question, and 13% of students seemed unsure of the question relating to alternate methodology and SI. Below is one example from a student who seems to misunderstand the NOS/subjectivity question:

Subjectivity means that there is no right or wrong answer and NOS basically means what science is. In science, you make observations, you collect data by experiments, and then you have a conclusion on what the results you found. First the doctors were making observations, and then they wanted to experiment and test what they were thinking. So they did an experiment on the men and tested their blood. The doctors never came up with a conclusion for what they were experimenting with.

After reading these responses, I immediately wondered if the confusion on the part of these students was something that I could have prevented. Concerning NOS concepts, I wrote in my journal:

Maybe I was too vague when writing out my questions. Or maybe I didn't teach NOS in a way that was understandable for some of my students. I wonder if adding NOS/NOSI concepts into this project is the right thing; I could be overloading my students with too much information on these worksheets.

However, previous work indicates that being able to incorporate NOS/SI into one's schema is a complicated process, one that involves conceptual change (Abd-El-Khalick & Akerson, 2004; Akerson et al., 2009; Clough, 2006). Bearing this in mind, I knew that I could not expect students to understand the complex nuances of NOS/SI in one semester. More importantly, I was encouraged by the remaining responses that aptly demonstrated the elements of NOS/SI when discussing the clips.

Classroom Discussion

Nilson explained the benefits of classroom discussion. She stated that this practice "...surpasses the lecture in changing students' attitudes, helping them transfer knowledge to new situations, and motivating them to further learning" (2003, p. 105). With regards to class discussion in this project, I did not facilitate formal discussion until cycle three. This was unlike the original plan

in which I intended to initiate discussion from the very beginning. During the first cycle, I decided not to implement discussion after assessing the comfort level of my class, and because I felt nervous. I was also struggling with teaching the concepts as a novice educator.

Discussion came rather easily by cycle three with little prompting from me. As I stated in my journal:

This is because as I noticed students finishing up, I could hear students start talking amongst themselves. I simply asked a random student to repeat what I had said. This student then started talking about how I had just explained to a fellow student that I did not believe that there was any sort of contradiction to the Bill Nye video because intermarriage within this community was so prevalent, thus any rate of mutation would be high. Several other students from another table exclaimed that they had actually felt the same way. These students went on for several minutes discussing why they agreed that it was more of a social aspect than one that really dealt altogether with genetics. One student said that because intermarriage was common in these communities, the social aspect was more of a factor on why there was higher incidence of Tay-Sachs, versus a genetic factor. I remarked that it was an interesting point that I had also read myself, but was interested in other viewpoints. I called on a couple of other students who had met my eyes...[but] I seemed to have had some trouble creating a comfortable classroom environment from which students can easily share their views.

During the fourth clip, discussion was not planned due to the brevity of time. However, informal discussion began when several students made comments about the atrocity of the video clip after I began to talk about the TSS homework. Several students revealed their own information on injustices of humans because of their ethnic groups. I also introduced other horrendous incidents such as medical experimentation during the Holocaust against Jewish people and experiments that Japan performed on Chinese prisoners of war so as not to focus only on whites (Freyhofer, 2004; Perni, 2005). I wrote in my journal:

Wow, what a great unplanned discussion! I know it helps that my students feel comfortable with me at this point, but race is always a touchy subject for me. This is partly because I am so sensitive about any sort of injustice in general, and partly because I cannot pretend that I am an African-American woman who is not somehow affected by this. Although I keep thinking that it is important primarily to remain objective in discussions for the comfort of my students, a part of me doesn't think it is all that necessary. When prompted by my students, I was able to voice my opinions without sounding passionate, but still steer the class to voice their own opinions. Although we had to end our discussion after a while to move on to other class business, my class—and myself—were disappointed that it had to end!

Limitations

There were several limitations in this study. First, although I did have several sources to draw from (i.e., reflection journal, field/observation notes, student worksheets, and bioethics papers), the study lacked the use of videotapes that would have aided in capturing other instances of social interaction between myself and the students. I may have missed some opportunities in the classroom discourse that revealed certain multicultural elements and NOS/SI connections to the video clip.

Another limitation was the lack of official additional reviewers of the data. Although the data was presented at a professional conference, and in front of departmental colleagues, official review of the data from fellow graduate students or faculty members could have aided in the substantiation or the uncovering of additional findings.

Also, students were not interviewed to assess the reasoning for their responses regarding the multicultural and NOS/SI concepts. These interviews could have helped reveal enlightening information on the confused NOS/SI responses, for instance. Assessment of NOS/SI responses related to this project did not involve pre- and post-assessments, which could have substantiated findings relating to the students' understanding of NOS/SI.

Other limitations of this study include adding more cycles in this project. Additional data would have substantiated the results and conclusions already stated. Also, ensuring that classroom observations include videotaping would have been more accurate in reviewing the behavior of me and the students. Also, although I tried my best to maintain neutrality in this project, researcher bias may have occurred as I primarily interpreted and analyzed the data.

Time restraints were another limitation in this project. This, in part, was due to my inexperience in teaching the introductory class. This also limited the amount of time to find more relevant video clips.

Conclusion

Implementing multiculturalism in the classroom is essential, but highly complex. This action research project was a massive undertaking, but there were several lessons different audiences could learn in this study that we will discuss briefly.

First, the first author felt she was able to understand the subtle nuances involved in action research, and the importance of relying on the interdependency of concepts in order to teach multicultural/NOS/SI concepts. She also learned how personal the action research project was to her. Just like life in general, this type of research is uneven, flawed, and not straightforward.

For instructors, including multicultural clips in a science content curriculum is an effective way to introduce relevant aspects of multiculturalism, such as: the appreciation of diversity, the concept of socially constructed scientific knowledge and its associated consequences, and the moral and ethical implications of certain multicultural topics (Banks et al., 2001). These clips may also be helpful in facilitating learning of NOS concepts for the students as well as educators. Videos that portray the social, political, and cultural tensions of the period through historical events (as in the last cycle) may highlight NOS characteristics such as subjectivity and tentativeness. In this project, the acquisition of scientific knowledge during the TSS provided an opportunity to showcase the subjectivity of both the scientists and health practitioners. Likewise, adding a personal anecdote to such videos may aid in facilitating discussion with the students.

Incorporating multicultural video clips is not without risks. As evident in the first clip, students may feel overwhelmed and confused when presented with highly controversial information about race initially. One suggestion is that the instructor could present clips from least to most controversial during the length of the study.

Action researchers should evaluate their own anxiety levels in presenting any type of controversial material, allowing themselves flexibility if they do not feel ready at the start of research. This discomfort may disappear or lessen over the course of the study period as it did for the first author.

Overall, this project proved to be a successful undertaking in incorporating initial elements of multiculturalism into a biology content course for preservice teachers.

Implications for Further Research

Further questions that we would like to explore with this project are the inclusion of more underrepresented groups. We would like to include clips that are gender-based, as well as discuss individuals with learning and physical disabilities and students who speak English as a second language. We are also interested in adding more to the scant research studying NOS/NOSI, SSI, and multicultural concepts. Additionally, we think adding more classroom activities to further engage students would be a worthy area to study. This is because incorporating such classroom activities will further involve students and thus be more effective for student learning (Denning, 2000). Additional research in all these topics will undoubtedly support national educational standards that encourage promoting equity and multiculturalism in the science classroom.

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References

- Abd-Khalick, F. S., & Akerson, V. L. (2004). Learning about nature of science as conceptual change: Factors that mediate the development of preservice elementary teachers' views of nature of science. *Science Education*, 88, 785-810.
- Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education*, 22(7), 665-701. Retrieved from www.scopus.com
- Aikenhead, G. (1988). An analysis of four ways of assessing student beliefs about STS topics. *Journal of Research in Science Teaching*, 25, 607-629.
- Akerson, V. L., Buzzell, C. A., & Donnelly, L. A. (2009). On the nature of teaching nature of science: Preservice early childhood teachers' instruction in preschool and elementary settings. *Journal of Research in Science Teaching*, 47(2), 213-233.
- Akerson, V. L., Cullen, D. L., & Hanson, T. A. (2007). The influence of guided inquiry and explicit instruction on K-6 teachers' views of nature of science. *Journal of Science Teacher Education*, 18(5), 751-772.
- McAlpine, M. (2002). *Principles of assessment*. Glasgow: University of Glasgow, Robert Clark Center for Technological Education. Retrieved from <http://www.caacentre.ac.uk/dldocs/Bluepaper1.pdf>
- Ambrosio, J. (2003). We make the road by walking. In G. Gay (Ed.), *Becoming multicultural educators: Personal Journey toward professional agency* (pp. 17-41). San Francisco: Jossey-Bass.
- Atwater, M. M. (1996). Social constructivism: Infusion into the multicultural science education research agenda. *Journal of Research in Science Teaching*, 33, 821-837.

- Baharav, E. (2008). Students' use of video clip technology in clinical education. *Topics in Language Disorders*, 28(3), 286-298.
- Banks, J. A. (1995). *Handbook of research on multicultural education*. New York: Macmillan Publishing.
- Banks, J. A. (1998). Approaches to multicultural curricular reform. In E. Lee, D. Menkart, & M. Okazawa-Rey (Eds.), *Beyond heroes and holidays: A practical guide to K-12 antiracist, multicultural education and staff development* (pp. 242-263). Washington, D.C.: Network of Educators on the Americas.
- Banks, J. A., Cookson, P., Gay, G., Hawley, W. D., Irvine, J. J., Nieto, S., Schofield, J. W., & Stephan, W. G. (2001). *Diversity within unity: Essential principles for teaching and learning in a multicultural society*. Seattle: Center for Multicultural Education, College of Education, University of Washington.
- Barton A. C. (2001). Science education in urban settings: Seeking new ways of praxis through critical ethnography. *Journal of Research in Science Teaching*, 38(8), 899-917.
- Bastanfar, A. (2011). *Alternatives in assessment*. Retrieved from <http://www3.telus.net/linguisticsissues/alternatives>
- Bautista, N. U., & Schussler, E. E. (2010). Implementation of an explicit and reflective pedagogy in introductory biology laboratories. *Journal of College Science Teaching*, 40(2), 18-23.
- BBC (Producer). (2006). *Designer babies – Comments by Princeton professor Lee Silver* [Online video]. Retrieved from <http://www.youtube.com/watch?v=TN9ep4B9Hw0&feature=Playlist&p=E514855BEF6DCBB0&playnext=1&index=2>
- Bianchini, J. A., & Solomon, E. M. (2003). Constructing views of science tied to issues of equity and diversity: A study of beginning science teachers. *Journal of Research in Science Teaching*, 40(1), 53-76.
- Bonner, J. (2005). *Nature of science*. Retrieved from <http://www.indiana.edu/~oso/ISTEME/NOS.htm#subjectivity>
- Brotman, J. S., & Moore, F. M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching*, 45, 971–1002.

- Brown, B. (2004) Discursive identity: Assimilation into the culture of science and its implications for minority students. *Journal of Research in Science Teaching*, 41(8), 810-834.
- Calabrese Barton, A. (1998). *Feminist science education*. New York: Teachers College Press.
- Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44(8), 1187- 1218.
- Causey, V., Thomas, C., Armento B. (2000). Cultural diversity is basically foreign to me: The challenges of diversity for pre-service teacher education. *Journal of Teaching and Teaching Education*, 16, 33-45.
- Clary, R. M., & Wandersee, J. H. (2010). Scientific caricatures in the Earth Science classroom: An alternative assessment for meaningful science learning. *Science and Education*, 19(1), 21-37.
- Clough, M. P. (2006). Learners' responses to the demands of conceptual change: Considerations for effective nature of science instruction. *Science & Education*, 15(5), 463-494.
- Cobern, W. (1994, March). *Worldview theory and conceptual change in science education*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Anaheim, CA. Retrieved from <http://www.wmich.edu/slscsp/SLCSP124/SLCSP-124.pdf>
- Cobern, W. (2000). The nature of science and the role of knowledge and belief. *Science and Education*. 9, 219-246.
- Cohn, F. G., Shapiro, J., Lie, D. A., Boker, J., Stephens, F., & Leung, L. A. (2009). Interpreting values conflicts experienced by obstetrics-gynecology clerkship students using reflective writing. *Academic Medicine*, 84(5), 587-596. Retrieved from www.scopus.com
- Cooper, J., & Matthews, C. (2005). A decade of concern: A review of multicultural science education issues in the Science teacher. *Science Teacher*. 72(3), 49-52.
- Creswell, J. W. (2007). *Qualitative inquiry & research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: SAGE.
- Cumming-McCann, A. (2003). Multicultural education connecting theory to practice. *National Center for the Study of Adult Learning and Literacy*, 6(B), 9-12.

- Curbeam, D. (Producer). (2007). *The Tuskegee Syphilis Study* [Online video]. Available from <http://www.youtube.com/watch?v=YQ5yMRQ-vrg>
- D'Oria, T. (2004). *How I improved my teaching practice in grade 9 boys' physical education to increase students' participation and enjoyment* (Master's thesis). Retrieved from http://www.nipissingu.ca/oar/reports_and_documents-Tony_D-Oria.htm
- Dee, T. S. (2004). *The race connection: Are teachers more effective with students who share their ethnicity?* Retrieved from [http://www.thefreelibrary.com/The race connection: are teachers more effective with students who...-a0114479064](http://www.thefreelibrary.com/The+race+connection:+are+teachers+more+effective+with+students+who...-a0114479064)
- Denning, D. (2000). *Video in theory and practice: Issues for classroom use and teacher video evaluation*. Retrieved from <http://ebiomed.com/downloads/VidPM.pdf>
- Dewey, J. (1933). *How we think*. New York: D. C. Heath.
- Freyhofer, H. (2004). *The Nuremberg Medical Trial: The Holocaust and the origin of the Nuremberg Medical Code*. New York: Peter Lang Publishing.
- Howe, E., & Rudge, D. (2005). Recapitulating the history of sickle-cell anemia research, *Science & Education*, 14, 423-441.
- Hunter-Boykin, S. (2004). Responses to the African-American shortage through the teacher preparation program at Coolidge High School. *Journal of Negro Education*, 61(4), 483-495.
- Husband, Jr., T. (2012). "I don't see color": Challenging assumptions about discussing race with young children. *Early Childhood Education Journal*, 39(6), 365-371. Retrieved from www.scopus.com
- Khishfe, R., & Abd-El-Khalick, F. (2002). Influence of explicit and reflective versus implicit inquiry oriented instruction on sixth graders' views of nature of science. *Journal of Research in Science Teaching*, 39(7), 551-578.
- Lawrenz, F., Huffman, D., & Welch, W. (2000). Policy considerations based on a cost analysis of alternative test formats in large scale science assessments. *Journal of Research in Science Teaching*, 37(6), 615-626.

- Lederman, N. G. (2004). Syntax of nature of science within inquiry and science instruction. In L. B. Flick & N. G. Lederman (Eds.), *Scientific inquiry and nature of science* (pp. 301-317). The Netherlands: Kluwer Academic Publishers.
- Lederman, N., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching*, 39(6), 497-521.
- Lemke, J. L. (2001). Articulating communities: Sociocultural perspectives on science education. *Journal of Research in Science Teaching*, 38(3), 296-316.
- Madkins, T. C. (2011). The black teacher shortage: A literature review of historical and contemporary trends. *Journal of Negro Education*, 80(3), 417-427. Retrieved from www.scopus.com
- McComas, W. F. (1998). The principle elements of the nature of science: Dispelling the myths. In W. F. McComas (Ed.), *The Nature of science in science education: Rationales and strategies*, Chapter 3. The Netherlands: Kluwer Academic Publishers.
- Maylor, U. (2009). "They do not relate to black people like us": Black teachers as role models for black pupils. *Journal of Education Policy*, 24(1), 1-21. Retrieved from www.scopus.com
- Mensah, F. M. (2009). A portrait of black teachers in science classrooms. *The Negro Educational Review*, 60(1-4), 39-52.
- Mensah, F. M. (2009). Confronting assumptions, biases, and stereotypes in preservice teachers' conceptualizations of science teaching through the use of book club. *Journal of Research in Science Teaching*, 46(9), 1041-1066.
- Meyer, X., & Crawford, B. A. (2011). Teaching science as a cultural way of knowing: Merging authentic inquiry, nature of science, and multicultural strategies. *Cultural Studies of Science Education*, 6(3), 525-547. Retrieved from www.scopus.com
- Miller, C. A. *Action research: Making sense of data*. Retrieved from www.coe.fau.edu/sfcel/sensdata.htm
- National Research Council. (1996). *National science education standards*. Washington, D. C.: National Academy Press.

- Nieto, S. (1999). *The light in their eyes: Creating multicultural learning communities*. New York: Teachers College Press.
- Nieto, S. (2000). *Affirming diversity: The sociopolitical context of multicultural education*. New York: Longman.
- Nilson, L. B. (2003). *Teaching at its best: A research-based resource for college instructors*. San Francisco: Jossey-Bass.
- No author. (n. d.). *Reflective thinking: RT*. Retrieved from <http://www.hawaii.edu/intlrel/pols382/Reflective%20Thinking%20-%20UH/reflection.html>
- NOVA (Producer). (n.d.). *One wrong letter* [Online video]. Available from <http://www.teachersdomain.org/resource/tdc02.sci.life.gen.onewrong/>
- Nye, B. (Producer). (2008). *The eyes of Nye, or how to brainwash U.S. children* [Online video]. Retrieved from <http://www.youtube.com/watch?v=eOeJr-cMQhg>
- Parsons, R. D., & Brown, K. S. (2002). *Teacher as reflective practitioner and action researcher*. Belmont, CA: Wadsworth/Thomson Learning.
- Perni, H. (2005). *A heritage of hypocrisy*. Union Dale, PA: Pleasant Mount Press.
- Ritchie, R. (1995). Constructive action research: A perspective on the process of learning. *Educational Action Research*, 3(3), 305-322.
- Roskos-Ewoldsen, D. R., & Roskos-Ewoldsen, B. (2001). Using video clips to teach social psychology. *Teaching of Psychology*, 28(3), 212-215.
- Rodrigues, S., Smith, A., & Ainley, A. (2001). Video clips and animation in chemistry CDROMS: Student interest and preference. *Australian Science Teachers' Journal*. 47(2), 9-16.
- Rodriguez, A. J. (1998). Strategies for counterresistance: Toward sociotransformative constructivism and learning to teach science for diversity and for understanding. *Journal of Research in Science Teaching*, 35(6), 589-622.
- Rossouw, D. (2009). Educators as action researchers: Some key considerations. *South African Journal of Education*, 29, 1-16.

- Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, 41, 513-536.
- Sadler, T. D., Amirshokoohi, A., Kazempour, M., & Allspaw, K. M. (2006). Socioscience and ethics in science classrooms: Teacher perspectives and strategies. *Journal of Research in Science Teaching*, 43, 353-376.
- Sadler, T. D., Barab, S. A., & Scott, B. (2006). What do students gain by engaging in socioscientific inquiry? *Research in Science Education*, 37(4), 371-391.
- Sadler, T. D., Zeidler, D. L. (2004). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education*, 88(1), 4-27.
- Schaefer, K. M. (2008). Nursing students' reflections on racism. *Holistic Nursing Practice*, 22(2), 111-118. Retrieved from www.scopus.com
- Schwartz, R. S. (2007). What's in a word? How word choice can develop (mis)conceptions about the nature of science. *Science Scope*, 31(2), 42-47.
- Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education*, 88(4), 610-645.
- Shapiro, J., Kasman, D., & Shafer, A. (2006). Words and wards: A model of reflective writing and its uses in medical education. *Journal of Medical Humanities*, 27(4), 231-244. Retrieved from www.scopus.com
- Steketee, C. (2004). Action research as an investigative approach within a computer based community of learners. In R. Atkinson, C. McBeath, D. Jonas-Dwyer, & R. Phillips (Eds.), *Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference* (pp. 875-880). Retrieved from <http://www.ascilite.org.au/conferences/perth04/procs/steketee.html>
- Tan, A. (2011). Home culture, science, school and science learning: Is reconciliation possible? *Cultural Studies of Science Education*, 6(3), 559-567. Retrieved from www.scopus.com
- Tan, E., & Calabrese, B. A. (2008). From peripheral to central, the story of Melanie's metamorphosis in an urban middle school science class. *Science Education*, 92(4), 567-590.

Wald, H. S. (2011). Guiding our learners in reflective writing: A practical approach. *Literature and Medicine, 29*(2), 355-375. Retrieved from www.scopus.com

Zeidler, D. L., Walker, K. A., Ackett, W. A., & Simmons, M. L. (2002). Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas. *Science Education, 86*(3), 343–367.