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Student Identity Considerations and Implications Associated with Socioscientific Issues Instruction

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Student Identity Considerations and Implications Associated
with Socioscientific Issues Instruction

by

Mitchel James Ruzek

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
Department of Education, Science Education
College of Arts and Sciences
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Keywords: Cultural Identity, Ethnic Identity,
Ethnicity, Scientific Literacy, Nature of Science

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DEDICATION

I dedicate this work to Max. Sorry I spent so much time on this boring stuff. I promise we can now get back to doing cool science investigations. You are very very smart.
ACKNOWLEDGMENTS

I would like to start by acknowledging not only a great collaborator but also a great educator. Without Dr. Scott Applebaum this work would have not been possible. Thank you for your passion, vision, and dedication to your students and the field of science education. You are a treasure to the profession.

I would like to genuinely thank all who contributed so much during the physical production of this text and the data, data analysis, and findings that are contained within. Thank you to all my collaborators, inter-raters, scorers, optimizers, editors, contributors, colleagues, and friends. This investigation would not have been possible without the time, talents, and efforts of Dr. Travis Carter, Wardell Powell, Samantha Hall, Sami Kahn, Dr. Yi-Hsin Chen, and Issac Lee. To all of you who contributed from an editorial, data analysis, or laborious scoring and score-optimizing standpoint, I thank you for your contributions.

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generated the work that marks the beginning of my next chapter. Your guidance is most appreciated and will not be forgotten. Thank-you.
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ABSTRACT

The purpose of this investigation was to explore how aspects of identity, perceived levels of controversy, and the strength of a student’s attachment to their controversial identity relate to conceptual understanding and knowledge acquisition during socioscientific issues (SSI) based instruction in a biology classroom. The knowledge gained from this study will have the capacity to enhance our understanding of the role that attachment to identity plays during SSI negotiation. Additionally, insight was gained into the role played by aspects of identity in conceptual understanding of scientifically controversial topics during SSI based instruction.

This study contributed to the existing knowledge base in science education by illuminating processes involved in socioscientific issue navigation among students of differing perceptions of controversy as well as students who held aspects of controversial identity that may or may not interact with the specific issues chosen. Students demonstrated evidence of variations of reasoning, justification, perception of controversy, and aspects of knowledge gain as they negotiated the issues of marijuana safety and fast food legality. Additionally, evidence was provided that showed general knowledge gain throughout the group during socioscientific issues instruction.

It has been said that one of the appeals of the SSI instructional model is that is serves not only as a context for the delivery of content, but acts as a catalyst for various forms of epistemological beliefs and research into the development of conceptual and psychological knowledge structures (Zeidler, 2013). This investigation supports the deeper understanding of
the contribution of controversy perception to epistemology as well as conceptual and psychological knowledge structures during SSI navigation.
CHAPTER ONE: THE PROBLEM

Introduction

The purpose of this study was to explore how aspects of identity, perceived levels of controversy, and the strength of a student’s attachment to their controversial identity relate to conceptual understanding and knowledge acquisition during socioscientific issues (SSI) based instruction in a biology classroom. The knowledge gained from this study will have the capacity to enhance our understanding of the role that attachment to identity plays during SSI negotiation. Furthering this understanding of identity could benefit the SSI movement by providing greater insight into how SSI are negotiated by cultural subsets or students with varying degrees of cultural or ethnic identification (Klosterman, 2010; Sadler, 2004; Sadler et al., 2007; Zeidler, Sadler, Applebaum, & Callahan, 2009; Zeidler, Walker, & Ackett, 2002). Additionally, insight could be gained into the role played by aspects of identity in conceptual understanding of scientifically controversial topics during SSI based instruction. This could ultimately add to the literature base on meaningful ways to facilitate scientific literacy across multiple individual influences including but not limited to cultures, ethnicities, and identities of people.

In this chapter, connections are made between aspects of identity and SSI that focus on the inherently controversial and discourse-producing nature of SSI instruction. Specifically, a foreground to the theoretical framework is laid out that includes an overview of science education as it relates to SSI and aspects of identity. Relevance for cultural considerations in
science education is provided, as well as research that specifically addresses SSI instruction, scientific literacy, argumentation, and informal reasoning. Additionally, cultural implications of SSI based instruction are explored. Scholarship pertaining to ethnic identity and ethnicity is then reviewed as it relates to and influences individual student held identities. This is followed by a discussion that relates evidence of a culturally based epistemological influence to a potential student identity aspect. Next, developmental features of culture, ethnicity, and components of identity are explored. Finally, the statement of problem is presented. Throughout this chapter, the effect of identity on SSI instruction, knowledge acquisition, and ultimate academic success is also addressed. Additionally, reasons why the strength of a student’s cultural or ethnic identity may or may not be linked to content knowledge and scientific literacy gains during SSI based instruction are discussed. Finally, the research questions, their rationales, and the significance of the study are presented.

**Key Features of the Theoretical Framework**

**Overview of science education as it relates to SSI, culture, and identity.** Science curriculum shifts that occurred in the 1960s and 1970s were responsible for a change of focus from an emphasis on the decontextualized acquisition of scientific knowledge to a slightly more progressive stance that valued generating a familiarity with scientific theories and a discovery of the processes that defined scientific inquiry. A shift during the 1980s and 1990s put more emphasis on society-oriented aspects of science and learner-centered science education that promoted a more active and informed citizenry (Hodson, 1993). In an effort to produce highly qualified science graduates who are well prepared for the challenges of the 21st century and
beyond, America’s secondary school system has recently engaged in several reform initiatives that are aimed at accomplishing the lofty goal of scientific literacy for all Americans (American Association for the Advancement of Science [AAAS], 1993b; Kemp, 2000).

At present, being able to produce qualified, scientifically literate graduates is paramount, since many of today’s employers are looking for people who are critical thinkers, problem solvers, and effective communicators proficient in core subjects and new 21st century content skills (Results that Matters, 2006). A hallmark of this movement is the production of a scientifically literate, responsible citizenry capable of processing and analyzing scientific data and material (Osborne et al., 2008; Ratcliffe, M., & Grace, M., 2003; Zeidler, Sadler, Simmons, & Howes, 2005). However, having the promotion of responsible and active citizens as a goal of science education brings into question the interests and values both within and between societies, ethnic minorities and majorities, and specific cultural or ethnic sensitivities.

Values and identities associated with individual aspects of student composition such as culture and ethnicity may often lead to topics in science curricula or SSI instruction being interpreted as more controversial and having the capacity to produce greater dissonance for different groups. As we proceed through the 21st century, an educational push that values active, responsible, and personal involvement has been furthered by the encouragement of discourse and debate among science learners as they assess, internalize, and process complex science issues (Zohar, 2010). The integration of SSI that encourages learners to apply their own personal experiences and beliefs, creating a more personal relationship with the scientific process, has emerged. An effective way of promoting scientific literacy using this new paradigm has been demonstrated by the use of SSI based science instruction (Sadler, 2004; Zeidler & Keefer, 2003; Zeidler et al., 2005).
Relevance for cultural considerations in science education. The “places” of learners and practitioners of science from non-dominant groups are increasingly a focus in the analyses of science learning and educational reform in the United States (Aikenhead & Ogawa, 2007; Colburn & Loving, 2008; Kincheloe & Tobin, 2009). Typically in US educational settings, these “places” are defined through a discussion of equity that focuses on the representation of one dominant group over that of an underrepresented group with the goal of creating learning environments that will allow students of underrepresented ethnicities and cultures to perform as well as their peers on standardized tests.

More recently, this dialogue has shifted from performance to knowledge of science, technology, engineering, and mathematics (STEM) content and the ability to think critically about this content. There is growing evidence that issues related to epistemology are central to improving the efficacy of STEM learning and knowledge (Project 2061, American Association for the Advancement of Science 2000).

Although minority/majority representation and the ability to think critically about STEM content remain necessary lenses for understanding the challenges facing science education, by themselves they are incomplete because they tend to focus on the goal and not the nature of learning itself. Consequently, minority/majority representations lend themselves to deficit orientations and prescriptions in the form of thinly disguised efforts to get children and parents of color or other minorities to adopt majority practices and orientations (Nisbett, 2009; Zeidler, D.L. [In Press]). This type of educational practice treats learning as acultural. To produce superior science teaching and science-learning environments, investigations that focus on understanding learning and development as a fundamentally cultural process are needed (Cole, 1996; Lee, Spencer, & Harpalaini, 2003).
Historically, initial learning as it pertains to thought and language has been professed to be a socially developed trait where a learner (infant) encounters meanings of words and signs via interaction with its main caregivers (Vygotsky, 1962). This initial learning is strongly influenced by culture or ethnic traditions. In his theory, Vygotsky attributes speaking to development along two lines. These two lines have intimate involvement from a learner’s culture. One line is oriented toward social communication and the other is directed at inner speech. Vygotsky acknowledges that thinking can be possible without language but that thinking is mediated and melded by the language, culture, and interactions present in a young child’s environment as they develop speech and vocabulary. The lingering effect of this inner voice is heavily influenced by culture and has yet to be explored from a contemporary, SSI educational perspective.

There is growing evidence that in addition to normative issues of adolescence concerning biological, cognitive, psychological, and social development (Peterson, 1988, 1993; Steinberg & Morris, 2001), ethnic minority adolescents face stressors arising from their minority status in society (Berry, Kim, Minde, & Mok, 1987; Iwamoto & Liu, 2010; Phinney, Lochner, & Murphy, 1990; Walker, Wingate, Obasi, & Joiner, 2008). Studies of ethnic identity development and acculturation suggest that the impact of these stressors on the psychological adjustment of ethnic minority adolescents may be mediated by the strength of their identification with their own ethnic group (Phinney, 1992) and with the mainstream society (Sam & Berry, 1995). The impact of SSI conflict, content, and discourse and the added feelings of ethnic identification or isolation have yet to be investigated.

Numerous studies have reported that some ethnic minorities can identify with both their own ethnic group and with the mainstream society without evidence of conflict between the two identifications (Banks, 2009; Der-Karabetian, 1980; Hutnik, 1986; Phinney, Dupont, Espinosa,
Revill, & Sanders, 1994; Zak, 1973, 1976). However, other ethnic minority individuals and
groups are unable to integrate as they find identifications with ethnic and mainstream cultures to
be incompatible and conflicting (Banks, 2009; Phinney et al., 1994; Verkuyten & Kwa, 1994;
Zak, 1976). Assimilation into the mainstream society alienates these individuals from their own
ethnic group, while separation alienates them from the mainstream culture (de Domanico,
Crawford, & De Wolfe, 1994). This incompatibility in behavior, attitudes, and values between
the two cultures may cause psychological distress (Berry et al., 1987; Bhurga, Leff, Mallett,
Morgan, & Zhao, 2010; de Domanico et al., 1994).

Integration has been found to be associated with psychological well-being (de Domanico
et al., 1994; Prilleltensky, 1993; Sam & Berry, 1995; Verkuyten & Kwa, 1994), while
marginalization was associated with poor mental health (Berry et al., 1987; Sam & Berry, 1995;
Verkuyten & Kwa, 1994). It may be that findings reveal that it is not only the mental and
psychological health of a student that is affected by such cultural identification. Accordingly, it is
reasonable to infer that knowledge of the nature of science, scientific literacy, and content
knowledge in general may be affected by the inherently controversial and discourse-producing
nature of SSI instruction when ethnic identity or isolation are examined.

With current research suggesting that there is an interaction between cultural and
scientific identities (Zeidler et al., 2013) during SSI instruction, it is imperative that cultural
barriers or novel epistemological approaches associated with individual cultures or specific
student identities are better explored. It is also plausible to infer that if there are differences in
how various cultures approach SSI instruction, then some approaches may produce greater levels
of scientific literacy and knowledge gains, while other techniques may serve as a relative barrier.
By better understanding the diverse peoples, practices, traditions, values, and epistemological
preferences that we find embedded in culture and ethnic identity, we can add valuable
information to better inform both learning and teaching. This may be especially true when the
instructional strategies involve topics or methods that are intentionally controversial in nature,
discourse-producing, and delivered in a pedagogical style that potentially elicits student
responses that may not only be personal but cultural in nature. Once these “kernels” of culture or
student identify that may pose objections or stumbling blocks to knowledge gain are identified
and better understood, we can account for them. For this instance, a kernel would be the aspects,
beliefs, or characteristics that a student identifies with that may serve as alternative evidence or
resources when analyzing data, processing discussions, or producing discourse during a SSI
debate. Following a better understanding of these barriers that may be the result of strongly held
aspects of student identities in response to controversial SSI science context, we may be able to
minimize, account for, and eliminate such barriers or stumbling block inducers from curricula or
classroom contexts. While acknowledging the disputed and often complex definition of culture
and its relation to ethnicity, it is the intention of this investigation to conceptualize culture as the
beliefs, customs, arts, etc., of a particular society, group, place or time. While ethnicity will be
characterized as the fact or state of belonging to a social group that has a common national or
cultural tradition. Ethnic identity is for the sake of this investigation the relationship between a
students own self identified perspective and an ethnicity that they gravitate toward or garner
influence from. In fact, ethnic identity has been succinctly defined in a fitting way for this
investigation as, “one’s sense of belonging to an ethnic group that is a group defined by ones
cultural heritage, including values, traditions and often language”, (Helms, 1990, pp.7). Of
overwhelming importance to this investigation is to clarify that the students self identified or
own sense of belonging to a culture, ethnicity or any other identity-influencing group and any
effect that that may have on their perception of controversy or content gain is the aspect of
interest. Although culture, ethnicity and more specific student identification associations will
undoubtedly be of future interest, it is the intent of this investigation to explore the association of
controversial perception and content gain during science instruction involving inherently
debatable subject matter and topics.

SSI Instruction

Socioscientific issues instruction involves the intentional use of scientific topics that
require students to engage in dialogue, discussion, and debate. Socioscientific topics are usually
controversial in nature but have the added element of requiring a degree of moral reasoning or
the evaluation of moral and ethical concerns in the process of arriving at decisions regarding
possible resolution of those issues. Socioscientific issues have been defined as those issues that
are typically contentious in nature and frequently involve morality and ethics (Sadler & Zeidler,
2002). Examples of SSI include dilemmas derived from topics involving biotechnology,
environmental issues, health effects of diets, and genetic engineering (Kolsto, 2006; Sadler,
Amirshokaohi, Kazampour, & Allspaw, 2006; Sadler & Zeidler, 2002; Zeidler et al., 2009). SSI
scenarios have to be resolved through the interaction of multiple perspectives; in addition, a
socioscientific issue is characterized by conflicting as well as fragile evidence (Sadler, 2007).

A properly administered SSI curriculum requires the use of evidence-based reasoning and
provides a context for understanding scientific information (Zeidler & Nichols, 2009).
Socioscientific issues have been shown to be complex problems that have real world applications
with moral and ethical components (Zeidler et al., 2009; Zeidler et al., 2005). Socioscientific issues are usually value laden, and the juxtaposition of science and ethics can be uncomfortable for scientists, teachers, and students who define science in terms of objectivity (Sadler et al., 2006). This moral and ethical component is not, however, considered anything new to students’ decision-making. It is believed that students generally use morals and ethics to guide their decisions on controversial topics (Kristjansson, 2009; Sadler & Zeidler, 2002). The extent to which a student identifies with certain aspects of culture or ethnicity and how that relationship impacts these guiding morals and ethics has yet to be analyzed.

The cultural root of a student’s morality and ethics needs to be taken into account as we strive to develop students who possess scientific minds capable of processing knowledge necessary to make informed decisions on controversial scientific facts and data. There has been a noted improvement in students’ decision-making skills, reasoning, nature of science conceptualization, and moral development whenever they are exposed to SSI teachings (Bell & Lederman, 2003; Fowler, Zeidler, & Sadler, 2009; Khishfe & Lederman, 2006; Sadler, Chambers, & Zeidler, 2002). While this is the case, little has been studied or reported on as to the effects of SSI on students’ culture, how such reasoning is impacted by cultural influences, and in turn how this cultural effect influences functional scientific literacy. To better serve diverse student populations, a clearer link between SSI instruction and the role of culture, ethnicity, and a student’s identity needs to be made.

**Scientific literacy.** Researchers have been offered varying definitions of scientific literacy since the late 1950s when Paul Hurd (1958) and Richard McCurdy (1958) first used the term in U.S. educational papers. The first attempt at placing a distinct definition on the term
came in 1966 when Pella, O’Hearn, and Gale suggested that scientific literacy comprises an understanding of the basic concepts of science, the nature of science, the ethics that control scientists in their work, the interrelations of science and society, the interrelations of science and the humanities, and the differences between science and technology.

Scientific literacy (SL) has been broadly used to describe a student’s functional understanding of scientific knowledge with respect to real world social issues that go beyond theoretical science, preparing students for life beyond the classroom setting (DeBoer, 2000, p. 174). Scientific literacy means that a person can ask and determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read and to comprehend articles about science in the popular press and to engage in conversations about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies a capacity to pose and to evaluate arguments based on evidence and to apply conclusions from such arguments appropriately (NRC, 1996).

An additional description of what it means to be scientifically literate can be taken from Shamos (1995) and is as follows. A scientifically literate individual is one who is aware of some of the major conceptual schemas (theories) that form the foundation of science, how they were arrived at, and why they are widely accepted, as well as how science achieves order out of a random universe and the role of experimentation in science. This individual also appreciates the elements of scientific investigation and the importance of proper questioning, analytical and
deductive reasoning, logical thought processes, and reliance upon objective evidence (Shamos, 1996).

To help us better address the question of “What is scientific literacy?”, Roberts (2007) created a heuristic framework for understanding the dominant defining ideologies of scientific literacy. Roberts makes a distinction between two ways of looking at the aims and purposes of science education and how they are reflected in differing visions of scientific literacy. He identifies two “visions” for generating conceptions of scientific literacy: vision I and vision II.

Roberts’ framework is a continuum between two extremes, and he has exemplified these extremes by positioning vision I and vision II as opposite poles. According to Roberts, “vision I looks inward at science itself – its products such as laws and theories, and its processes such as hypothesizing and experimenting”, whereas vision II “looks outward at situations in which science has a role, such as decision-making about socioscientific issues” (p. 83). Vision I is science centered and focused on a decontextualized science subject matter. Vision II is student centered and content-oriented with the aim to enhance students’ capacities to function as life-long, responsible, savvy participants in their everyday lives. These visions are underpinned by different philosophies that at their most extreme reflect competing interests that have and continue to influence the content of science curricula (Hodson, 2008). A critical issue for contemporary curriculum makers is whether there can be a balance between vision I and vision II, and if potential scientists need a different balance than everyone else. Roberts states, “Everyone agrees that students can’t become scientifically literate without knowing some science, and everyone agrees that the concept needs to include some other types of understanding about science” (2007, p. 64). In the context of this investigation, we are more concerned with scientific literacy as derived from a vision II perspective.
In preparing scientifically literate students, the infusion of SSI and the discourse that they inherently produce can be a fruitful way of increasing a student’s understanding of the nature of science (NOS) (Zeidler et al., 2005). A student’s grasp of the nature of science has been deemed necessary for making the type of informed decisions about SSI that is the hallmark of SSI based instruction (Lederman, 2007; Zeidler et al., 2005).

Scholars have pointed out that cultural assumptions form the basis for claims in all kinds of science, both good and bad (Harding, 1992; Longino, 1990). Even historic science “blind spots” that are consequential from cultural or ethnic identification in deference to scientific fact or data, so obvious in retrospect, are part of the process of understanding the nature of science (Allchin, 1998). Assumptions about race and gender, for example, are part of all aspects of the scientific process and should always be subject to critical scrutiny (Harding, 1991). Similarly, ethical questions are not confined to the more contentious activities, such as genetics research, but pervade the scientific enterprise. Making visible the assumption behind the science is part of the process of achieving new, ethical, and culturally appropriate forms of scientific “objectivity” (Harding, 1991). It is the goal of this investigation to make visible those assumptions or preconceptions that may be characteristic of student identification with a cultural or ethnic subset.

Some researchers have argued that socioscientific issues have the potential to promote a functional degree of scientific literacy among students (Zeidler & Keefer, 2003; Zeidler et al., 2005). Having a functional degree of scientific literacy has been defined as not only knowing the science terms, but also being able to converse, read, and write coherently using these terms in a non-technical context (Shamos, 1995). In addition to this, scholars have demonstrated that in an SSI context a functional degree of scientific literacy requires a consideration for both the moral
and ethical implications when discussing and navigating socioscientific issues (Zeidler, 2013). Studies have shown that SSI pedagogy has the potential to empower students to consider how science based issues, and the decisions they make concerning these issues, reflect in part the moral principles and qualities of virtues of their own lives as well as the lives of others (Zeidler et al., 2005; Walker & Zeidler, 2007). According to Kolstø (2001), the aspects of scientific literacy essential for dealing adequately with controversial socioscientific issues are involved in understanding science as a social process, recognition of the limitations of science, familiarity with the values of science, and the cultivation of a critical attitude. It is the implication of this research that employment of the SSI pedagogical strategy has the potential to provide students with the skills, knowledge, and technical abilities to actively reflect on and to intelligently reason about ethical issues while at the same time enhancing a student’s ability to morally judge a controversial SSI scenario. This reflection and reasoning ultimately aims to enforce scientific literacy.

SSI argumentation. One component of SSI instruction is SSI argumentation. Argumentation has been described by several (Driver, Newton, & Osborne, 2000; Zohar & Nemet, 2001) as one process used by individuals to make and to justify claims and conclusions. Scholars have divided arguments and argumentation into three distinct categories: analytical, dialectical, and rhetorical. Analytical arguments describe formal reasoning processes and are fashioned in the language of logic. Rhetorical arguments involve the expression of one viewpoint and are persuasive and explanatory in nature. This class of argumentation characterizes the traditional didactic approach to teaching in which an instructor is the sole arbiter of information and presents a static notion of science. Dialectical arguments, also known as dialogical or multi-
voiced (Driver et al., 2000), entail the contemplation of complex issues with multiple perspectives and no clear-cut solutions (Van Eemeren et al., 1996).

Proper argumentation is a critical component of SSI instruction. Socioscientific argumentation relies on and can be identified by the existence of content knowledge. This content knowledge present in SSI argumentation in turn influences the argumentation practices of students (Dawson & Schibeci, 2003). There is research-supported evidence for the link between content knowledge and argumentation in SSI settings (Hogan, 2002; Tyler, Duggan, & Gott, 2001; Zohar & Nemet, 2002). Argumentation in a SSI context involves justifications, counterpoints, and elaboration grounded in scientific data as well as considerations of social, economic, and moral implications (Sadler & Fowler, 2006). SSI argumentation relies on the informal reasoning that is a component of dialectical argumentation. Dialectical argument serves as the language of informal reasoning (Kuhn, 1991). Argumentation during SSI lessons is one expression of informal reasoning and can be used as a measure of a student’s grasp of concepts, content, and understanding of subject matter.

Results of studies involving socioscientific issues have shown improvement in students’ argumentation quality when the students are put in a position of justifying their argument (Driver et al., 2000; Patronis, Potari, & Spiliotopoulou, 1999; Walker & Zeidler, 2007). In addition, there is an observed enhancement in a student’s ability to evaluate evidence whenever they are given opportunities to engage in SSI argumentative practices (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Kolstø, 2001; Sadler & Zeidler, 2004; Zeidler & Keefer, 2003).

**Informal reasoning in the context of SSI.** One component of successful and properly delivered SSI instruction or lessons is that students are compelled to utilize informal SSI
reasoning. Scientific reasoning has historically referred to a formal system of reasoning characterized by rules of logic and mathematics. The formal process of deduction or induction used in traditional science instruction and most often undertaken in classical science reasoning leads thinkers to compulsory conclusions. Positivist philosophers of science argued that these very processes distinguish the scientific enterprise from other ways of knowing the world (Curd & Cover, 1998). Although this type of systematic reasoning may contribute to scientific discovery, it is not the only vehicle for producing scientific progress.

Informal reasoning involves the generation and evaluation of positions in response to complex issues that lack clear-cut solutions. Thinkers are engaged in informal reasoning as they ponder causes and consequences, pros and cons, positions and alternatives (Means & Voss, 1996; Zohar & Nemet, 2002). “Informal reasoning assumes importance when information is less accessible, or when the problems are more open ended, debatable, complex, or ill-structured, and especially when the issue requires that the individual build an argument to support a claim” (Means & Voss, 1996, p. 148).

It has been suggested that most of the reasoning that takes place in a classroom can be considered informal in nature (Perkins, 1985). Informal reasoning is important to students’ performance and learning (Baron, 1991; Kuhn, 1991; Perkins, 1985; Sadler, 2004; Zeidler et al., 2005). Consequently, it is imperative that educators help to enhance students’ informal reasoning abilities. SSI based curricula fosters students’ informal reasoning by encouraging them to make informed decisions about scientific phenomena. Socioscientific issues are, by design, ideal candidates for the application of informal reasoning (Zeidler et al., 2005). Just as scientists employ informal reasoning to gain insights into the natural world, ordinary citizens rely on informal reasoning to bring clarity to the controversial decisions they face. Citizens of societies
built upon science and technology are constantly presented with socioscientific issues, and the processes of informal reasoning allow them to access these issues, to formulate positions, and to evaluate evidence (Kolsto, 2001; Patronis et al., 1999; Tytler et al., 2001).

Informal reasoning present during SSI instruction or navigation has been termed socioscientific reasoning. Students exhibit socioscientific reasoning by various means. During socioscientific reasoning, one or more of the following traits are often displayed by students: recognizing the inherent complexity of the issues studied, examining the issue from multiple perspectives, appreciating that the issue is subject to ongoing inquiry, and exhibiting skepticism when presented with biased information (Sadler et al., 2011; Simonneaux & Simonneaux, 2008).

**Cultural Implications of SSI Based Instruction**

As the student population in the US becomes more diverse and socioscientific issues are delivered on an international scale, there is a growing need to understand how culture, aspects of ethnicity, and the strength of students’ identification with their ethno-cultural identity affect SSI argumentation, reasoning, and knowledge acquisition. The unique challenge encountered possibly more often in the United States than any other country is that science classrooms are made up of a heterogeneous blend of international cultures, traditions, races, creeds, and customs. Possibly more so than anywhere else on the globe, “American culture” is truly a combination of diverse and distant groups. The U. S. science classroom is truly a global microcosm of SSI views, arguments, and opinions. To enhance SSI effectiveness across a global population, there is an increased need to account for the unexplored relationship between strength of identification with a culture or ethnicity and a student’s ability to navigate
socioscientific issues based instruction. Researchers have acknowledged that there have been very few studies that have attempted to measure the relation between SSI based instruction and belief based knowledge (Zeidler et al., 2009). It has been further proposed by Bell and Lederman (2003), as well as Grace and Ratcliffe (2002), that social and political issues, ethical considerations, and personal beliefs influence students’ understanding of the nature of science.

In addressing the need to prepare citizens with a functional understanding of scientific knowledge, researchers have argued that an SSI based framework can be used to enhance learners’ beliefs and formal knowledge of the nature of science (Zeidler et al., 2005; Zeidler et al., 2009). By giving learners the chance to apply their knowledge to complex societal issues, an ideal environment is created for students to apply their own understanding to real world issues. In doing so, a student’s individual or cultural biases may play an enhanced role in decision-making and epistemological practices. This ethnic identity may not only be present, but it may be essential to the composition of a student’s personal identity and psychological well-being (Taylor, 2010) and, therefore, should be considered during optimally executed SSI instruction.

We cannot separate students’ culture from the development of their academic skills. In the context of this study, it is of paramount importance to understand how a “student’s culture” may be impacted by multiple factors and influences. Race, ethnicity, heritage, tradition, customs, community, language, religion, and neighborhood are all (but by no means the only) factors that influence a student’s culture. The impact of this cultural amalgamation on a student’s epistemology, knowledge gain, and ultimate scientific literacy has yet to be investigated in the melting pot that is typical of many U.S. classrooms. Therefore, it is imperative that we give more consideration to the effect a student’s culture has on SSI argumentation, reasoning, and epistemological construction during SSI instruction.
**Ethnic identity.** Ethnicity and corresponding ethnic identities are purposely chosen as a descriptor of students in this case, as opposed to the more complex and rigid cultural identifications and descriptors. The reason for this clarification is that in the case of ethnicity or ethnic identity, the qualifying characteristics not only include genetically transmitted features but more broadly included language, religion, place of origin, tribe, region, caste, clan, nationality, or race of one’s parents, ancestors, or population base (Kanchan, 2005). In the following section, ethnicity and ethnic identity as well as possible cultural implications on epistemology will be covered and finally some developmental concerns to culture or ethnicity will be addressed.

**Ethnicity and ethnic identity.** Ethnic identity is separate and distinct from cultural identity. Cultural identity is more complex, and may involve both ethnic identity and another identity or national identity (Phinney, personal correspondence, 2011). Both theoretical and empirical evidence suggests that ethnic identity is a multifaceted construct that includes a number of dimensions (e.g., Ashmore, Deaux, & Mclaughlin-Volpe, 2004; Romero & Roberts, 2003). These dimensions tend to be positively correlated (Lee & Yoo, 2004), but the available empirical evidence is equivocal as to the extent to which different dimensions of ethnic identity constitute a single overarching concept or a combination of distinct aspects that need to be considered separately. Furthermore, ethnic identity is dynamic; it changes over time and context and must therefore be considered with reference to its formation and variation (Phinney, 2003).

Much of the research on ethnic identity has been based on the study of group identity by social psychologists (e.g., Tajfel & Turner, 1986). From this perspective, ethnic identity is an aspect of social identity, defined by Tajfel (1981) as “that part of an individual’s self concept
which derives from his knowledge of his membership of a social group or groups together with the value and emotional significance attached to that membership” (p. 225). This definition suggests multidimensionality of the construct. In a recent review, Ashmore et al. (2004) attempted to identify the major components of group or collective identity and provided a useful framework for understanding ethnic identity in its broadest sense. The review is largely an atheoretical overview of existing empirical evidence. However, it is helpful as a basis for examining aspects of ethnic identity. This proves especially helpful in this investigation. There is a clear attempt in the review to identify what is termed “individual self concept” and to relate that to membership of a larger social group. There is a multidimensionality associated with ethnic identity that takes into account many of the aspects that may be seen in a U.S. science classroom. Factors such as dress, language, ethnicity, custom, and culture all contribute to the basic aspects of ethnic identity.

Culturally based epistemological influence on SSI knowledge gain. Even though studies have reported that some ethnic minorities can identify with both their own ethnic group and with the mainstream society without evidence of conflict between the two identifications (Der-Karabetian, 1980; Hutnik, 1986; Phinney et al., 1994; Zak, 1973, 1976), there is compelling evidence that other ethnic minority individuals and groups are unable to integrate as they find identifications with ethnic and mainstream cultures to be incompatible and conflicting (Phinney et al., 1994; Verkuyten & Kwa, 1994; Zak, 1976). The paradox is that assimilation into the mainstream society alienates these individuals from their own ethnic group, while separation alienates them from the mainstream culture (de Domanico et al., 1994). This incompatibility in behavior, attitudes, and values between the two cultures may cause psychological distress (Berry
et al., 1987; de Domanico et al., 1994). Because of the high focus on discourse-producing, controversial, debatable science topics, there may be a heightened sense of distress in an already ethnically incompatible and distressed student.

Researchers in cultural epistemology have put forth the idea that when certain cultures (e.g., Native American) are involved in science learning, it is better to allow students to navigate multiple epistemologies as opposed to forcing the adoption of a specific epistemology (Bang & Medin, 2010). Student-directed navigation of multiple epistemologies is supported by SSI instruction when students are allowed to synthesize their own epistemological orientations with those of other perspectives. When culturally distinct student populations are given more epistemological freedom there has been a noted increase in academic progress (Bang & Medin, 2010). At the same time, there have also been numerous examples where the cultural identification, norms, or epistemologies of students have potentially hindered academic process (Canino, Rubio-Stipec, Canino, & Escobar, 1992; Marsella, 1993).

In certain cultures (e.g., Southeast Asia, Japanese, and Latino), depression or anger cannot be directly expressed. Such emotions often manifest as somatic complaints. This manifestation is the most prevalent in cultures with a hierarchical family structure, clear gender roles, and a highly developed sense of duty and obligation (Canino et al., 1992; Marsella, 1993). It is possible that the visceral expression of emotion could be at least a contributing or diminishing factor to participation, scientific understanding, and ultimately scientific literacy during discourse-producing SSI lessons. At the very least, a student who has cultural deficits in the emotions of depression or anger will be at a distinct disadvantage during SSI lessons.

Another cultural instance of potential epistemological influence previously reported is that family is often more important than the individual in certain non-western cultures and
religious subcultures (Bilu & Witztum, 1993; Gomez, Gomez, & Ruiz, 1983; Jung, 1984; Marsella, 1993). Yet an additional cultural influence occurs in the case of urban Native American students where it has been shown that the core biological concept of “alive” shifted depending on context (Bang & Medin, 2010). Contextualized SSI scenarios using biological or scientific terms such as alive, life, or lifecycle may be lost or misinterpreted in certain Native American cultures.

Other scholars have demonstrated the ways in which learning mathematics was racialized for a group of African Americans and made the argument that mathematics learning is a racialized experience for all learners (Martin, 2004; Nasir, 2000). Nasir points out that if mathematics is racialized for one subset or population minority then by default it must be racialized for the majority. Furthermore, some scholars have argued that there is an educational debt that is composed of historical, economic, sociopolitical, and moral components that must be addressed for schooling to improve for students who culturally identify with African Americans (Ladson-Billings, 2006). Each of these instances could be viewed as potential cultural stumbling blocks during SSI based science instruction involving heterogeneous cultural groups. Similarly, there most certainly are topics, subject matter, or context applicable to SSI lessons that will trigger similar culturally acute and distinct responses. These culturally based epistemological trends must be explored and accounted for if SSI based science lessons are to be broadly applied successfully in a global manner.

**Developmental model consideration.** Developmental models also support the need for culturally sensitive SSI curricula. For example, Bronfenbrenner’s (1979, 1986) ecological model of human development can be used as an attempt to explain how many culturally isolated
families view and reinforce education and the process of new knowledge acquisition.

Brofenbrenner identified five environmental systems to explain a range of contexts and factors that contribute to the development of the individual. In each environmental system, the child is placed at the center and linkages are shown which potentially influence his or her life. These linkages are assumed to be heavily cultural in nature. An overview of the Brofenbrenner systems of influence includes the microsystem, mesosystem, exosystem, macrosystem, and chronosystem of cultural influence. An example of the cultural relativity of each is:

- **Microsystem** – daily interaction of a person with family members, peers, and teachers and the culture that is represented in this microenvironment.
- **Mesosystem** – influence of the connections among various microsystems. For example, parents who have positive relationships with teachers may be helpful in the child’s learning process.
- **Exosystem** – the influence of other settings that are further removed from a child. For example, state curriculum standards may indirectly shape his or her schooling experiences.
- **Macrosystem** – the sociocultural values and laws of society that influence the development of a child. For example, the lack of role models found in mainstream culture may negatively impact the ethnic and or ethnic identity formation of a young person.
- **Family system** – family relationships and the ecological systems that interact with the family system. This may include past or previous generations ever-present in traditions or customs.
Bronfenbrenner’s ecological system of human development is multi-layered and supports data from different disciplines such as anthropology, sociology, and psychology. The theory explains how individuals interact in various contexts, and through these interactions children develop and mature. These various contexts and multiple layers can, in total, be seen as representative of a student’s culture or cultural influence. For example, a heterogeneous mix of “home cultures” might characterize a culturally diverse student population. Therefore, students are raised to school age in a more isolated setting in which their unique or distinct culture is dominant.

When children attend school with these values and interact with individuals from other cultures, students certainly become more integrated as they assimilate into a homogenous school culture. However, an equivalent argument can be made in which a school population would be viewed as quite heterogeneous with many school subcultures.

It is the lingering core of these deeply held home cultural norms and values that may affect perception and acquisition of discourse understandings from SSI instruction scenarios that are of interest here. The level of cultural reaction raised or cultural discomfort harbored with a particular SSI topic may likely be dependent on the culture, topic, and delivery. It is reasonable to assume that the effects of cultural norms, biases, and beliefs will enter into the epistemological practice of a diverse student population when presented with controversial, discourse-producing science scenarios. The role that these deeply embedded residual cultural norms and values may very well play in the acquisition of scientific literacy and grasp of the science content during SSI based instruction has yet to be explored.
Statement of Problem

While SSI research has shown much promise in the development of epistemic reasoning using contextualized real world scientific issues that personally engaged students, if the influence of identity is not provided for then SSI pedagogy may fail to attain maximum effectiveness. Aspects of student identity may be a greater contributor (or have a greater influence when it comes) to epistemic practices of socially constructed knowledge than contextualized or situationally defined scientific understanding that has been attributed to group discourse in an SSI instructional setting.

Given research from a recent cross-cultural study (e.g., Zeidler et al., 2013), it seems reasonable to infer that identity influences such as cultural norms and traditions, may be a more significant factor in epistemological knowledge construction than that which results from factors limited to group discourse alone. This also implies that identity considerations must be part of purposeful pedagogy in order to realize scientific literacy for all. It is noted that identity most certainly is capable of evolution and may drift or evolve as a student develops physically, emotionally, and intellectually. This suggests that a given student may, at differing developmental points in time, identify more closely with multiple cultures or ethnicities. However, a real time identity snapshot as it pertains to a student’s present identity is significant in that the SSI instruction that occurs in a defined span of time may interact with the current self-categorized identity of the student. For one’s interpretation of the controversial nature of an SSI is not only affected by world events but also by personal, familial, and egocentric aspects of a student’s identity makeup. The effect of this “snapshot in time” student identification along with any cultural or ethnic leanings and norm sets on student epistemology may all work to markedly
affect scientific literacy and scientific knowledge gains. Furthermore, the existence of varying student identities, beliefs, and views may be impacted by specific SSI issues or methodologies.

In addition, cultural contributions to student epistemic practices can likely be seen as distinct and separate from the contributions attributed to group discussion. Classroom application of SSI without the acknowledgment of these cultural biases, norms, and trends will at least lack maximum effectiveness and possibly alienate a segment of the student population. To maximally utilize the pedagogical tool that is SSI instruction, all students should have a fair opportunity to internalize knowledge, participate in discourse, and develop scientific knowledge with as few cultural or identity limitations as possible.

In order to enhance scientific literacy and student understanding, researchers and educators must work to generate SSI based scenarios, questions, discourse, and instruction that is cognizant of students’ identities and influences held sacrosanct by students at the time of instruction. The reach and impact of this powerful educational tool will be limited without a more globally applicable comprehension of how diverse student populations engage SSI lessons. Therefore, the purpose of this investigation is to better understand the impact that SSI based instruction may have on students of varied identities and to examine the ways in which we understand SSI based science epistemological construction in light of a student’s perceived level of controversy regarding a SSI topic.

**Research Questions**

This study is guided by three main research questions that are broken down into appropriate sub questions.
RQ1. What impact does SSI based instruction have on students who have differential strengths of controversial identity?

RQ1A. What different patterns of epistemological reasoning about SSI exist, if any, among differential controversy identified subsets of students?

RQ1. Rationale: Authors have advocated for the incorporation of virtue-ethics approaches in the practice of science teaching in general and the pursuit of SSI in particular (Melville, Yaxley, & Wallace, 2007; Mueller & Zeidler, 2010). It has been reported that justification categories such as fairness, pragmatism, emotive reasoning, utility, and theology have been displayed and recorded when students from varying cultural and ethnic groupings have been exposed to an SSI context that involves allocation of scarce medical resources (Zeidler et al., 2013). It may be the case that similar qualitative categories of justification would be exhibited in other contexts or student population sets. One potential effect of this approach is that science education can focus better on the epistemological foundations of the public understanding of science, including factors related to the non-science reasoning, such as emotive aspects of ethical tensions, as they arise in the practice of science. One aspect of these approaches is that the moral contexts of SSI are primary factors of student decision-making (Sadler, Chambers, & Zeidler, 2004; Zeidler et al., 2009). Therefore, a better understanding of epistemic development is paramount for helping students evaluate how they frame their relationships with others, as well as nonhuman species and physical environments. Consequently, studies of epistemic virtues relative to community and ethnicity would have
something to say about pedagogy and curriculum in science education. The influence of
ethnicity, ethnic identity, and aspects of culture on epistemological construction and the
influence that these characteristics have on controversial perception have yet to be investigated.
Finally, the impact of differential perception of controversy has yet to be analyzed in response to
differential epistemology and differing content knowledge gains during SSI instruction.

RQ2. What relation may exist between students’ prioritized degree of controversy in varied SSI
contexts and their conceptual understanding of scientific content?

RQ2A. What relation may exist between perceived controversy level and content
knowledge gain during navigation of an SSI at the high school level?

RQ2. Rationale: The area of socioscientific issues has generated much interest among
science educators in recent years in part because of its utility in providing a theoretical
framework for epistemological reasoning and supporting pedagogy consistent with that
framework, as well as providing a context for the public understanding of science. The results of
this investigation will help to better understand the nuances of socioscientific reasoning that exist
across ethnicities and student subsets, as well as commonalities in terms of how students
conceptualize context and formulate scientifically based reasoning in light of cultural or ethnic
identities. In this investigation, ethnicity, ethnic identity, and some cultural influences are
examined for their contributions to epistemic practices. This is consistent with current
contemporary notions of not only scientific literacy but the public’s understanding of science
RQ3. What relation may exist between conceptual understanding of scientific content and epistemological patterns of reasoning among differing strengths of identification in self-identified controversy perception subsets of students?

RQ3A. What relation may exist among differential understanding of scientific content and how students frame justifications and evaluate SSI?

RQ3. Rationale: RQ3 and its associated sub-question investigate the potential link between differing strength of identification and conceptual understanding of science content, patterns of epistemology, and types of justifications. As RQ2 sheds light onto the potential relationship of identity group and epistemology, justification, and acquisition of science content, RQ3 addresses these items with regard to strength of identification with a specific SSI controversy.

Significance of the Study

Once factors that mitigate the understanding of identity in the context of SSI are better understood, science educators will be better able to use SSI as a way to promote the informed decision-making which is a key aspect of scientific literacy. One who is scientifically literate uses science content knowledge to make informed decisions, either personally or socially, about issues that have a connection with science. The problem is that we do not have an understanding of potentially critical factors involved in student self-categorization, strength of identity, and the impact these factors can have on the process of conceptual understanding of science and the
ability to make informed decisions. The importance of allowing for self-categorization is that students may identify and ultimately categorize themselves in a manner that differs from traditional cultural, ethnic, or racial categorizations associated with their ancestry, ethnicity, skin color, or similar indicators of cultural or ethnic categorization. In this study, a student’s personal or self-categorized culture, race, or ethnicity and the strength of identity that a student has with this self-categorization is key to beginning to understand the relation between identity and SSI instruction. Furthermore, how an individual perceives the level of controversy surrounding a socioscientific issue has not been investigated. The interaction between aspects of student identity and perceived level of controversy may prove critical in better understanding SSI epistemological navigation.

The use of SSI is important in the United States, but there are global implications as well. The field of science education has become an international community with an increasing amount of research on improving science teaching and learning (Duit, 2007). Research involving SSI occurs not only in the United States (e.g., Zeidler et al., 2005) but also internationally, including countries such as Norway (Kolstø, 2006), Brazil (dosSantos & Mortimer, 2003), Portugal (Reis & Galvao, 2004), the United Kingdom (Hughes, 2000), Australia (Dawson & Venville, 2009), Canada (Bingle & Gaskel, 1994; Pedretti, 1999), Korea (Lee, Chang, Choi, Kim, & Zeidler, 2012), and Taiwan (Liu, Lin, & Tsai, 2011), to cite a few. Furthermore, many countries, such as Taiwan (Center for Science Curriculum Studies, 2006) and most of Europe (Eurydice, 2006), are incorporating SSI into their national curriculum. Because of the global spread of SSI, the ethnic identities of pupils and individual identity components such as controversy perception are becoming more and more important to study within the context of SSI. It is not entirely clear if ethnic or cultural identity plays any stronger role in SSI navigation.
than other aspects of student identity (i.e., religion, gender, race, neighborhood, and socio-economic or familial historical influence).

Finally, we know that factors such as emotions and intuition are used in reasoning out decisions in a socioscientific context (Sadler, 2004; Sadler & Zeidler, 2004, 2005). However, we do not know how these factors may be affected by identity or perceived level of controversy, and therefore impact SSI decision-making and conceptual understanding of scientific content. Examining this will give science educators a more complete picture of how socioscientific issues are navigated by various self-identified students.
CHAPTER TWO: LITERATURE REVIEW

Introduction

The purpose of this chapter is to examine the literature with respect to the research questions. Because this study addresses the use of science content and identity in the context of socioscientific issues (SSI) negotiation, this chapter begins with an overview of the influence of culture or ethnicity on epistemic practices and is followed by a discussion of ethnicity as it has been defined or discussed in the literature.

Overview

Within the SSI framework, students are exposed to moral problems that involve a number of discrepant scientific, social, and moral viewpoints, many of which may conflict with the student’s own closely held beliefs or identity. Central to the SSI approach is the concerted effort to provide opportunities for students to reflect on issues in order to evaluate claims, analyze evidence, and assess multiple viewpoints regarding ethical issues on scientific topics through social interaction and discourse. These opportunities necessarily evoke the nature of science tenets in that SSI discourses are in fact tentative, creative, evidence driven, and culturally embedded (Zeidler, 2008).
Social, Moral, and Cultural Aspects of SSI

In a continuation of this claim, it has been suggested that epistemological stances and nature of science aspects may be developmentally linked to meaningful critical discourse regarding controversial SSI (Abd-El-Khalick, 2003). The scientific knowledge that forms as a result of social knowledge construction and discourse becomes personally relevant and socially shared. An SSI curriculum focuses on scientific knowledge that is obtained from data interpretation, analysis of conflicting evidence, and discourse regarding opposing viewpoints that may conflict with students’ previously held misconceptions (Chinn & Brewer, 1993; Kuhn, 1993; Lin, 2007). The invocation of concepts like social justice and nurturing scientific habits of mind have compelled researchers to consider the role of affect and emotion during discourse with respect to the role each plays in moral decision-making and character formation (Berkowitz, 1997, 1998; Nucci, 2001; Sadler & Zeidler, 2004). It has been established that SSI research and instruction seek to engage the learner in decision-making regarding social issues with moral implications embedded in scientific scenarios and contexts (Sadler, 2004). These social and moral issues further provide the student with a fertile bed in which they are encouraged to engage in active reflection and examination of relevant connections among science concepts, their own lives, and the quality of life in their greater community (Driver, Leach, Millar, & Scott, 1996; Driver et al., 2000). However, even though active reflection and direct relation to a student’s own life is a integral part of SSI based instruction, the distinct and intimate role that culture plays in decision-making and epistemological construction has yet to be investigated in depth. For a complete understanding of the process of epistemological construction during SSI based science instruction, culture and the effect that it has on epistemology must be further
explored. It is culture that plays a larger role in epistemological construction, knowledge acquisition, grasp of the nature of science, and ultimate scientific literacy during SSI instruction than previously identified influences.

There is a very good precedent of SSI selection that has worked well in the past in terms of both pedagogy and research. An example of SSI being used as a successful pedagogical and research tool is Zeidler, Sadler, Applebaum, and Callahan (2009). SSI style issues such as organ transplant allocation, the safety of marijuana, fluoride in water, stem cell research, euthanasia, quality of life issues, and fast food consumption were analyzed from a reflexive judgment perspective. Design of the treatment instruction was informed by a general framework of eight “content transcending” (Kolstø, 2001) themes for examining the science dimension of SSI in science education. The eight themes include: science in the making and role of consensus in science, science as one of several social domains, descriptive and normative statements, demands for underpinning evidence, scientific models as context bound, scientific evidence, suspension of belief, and scrutinizing science-related knowledge claims. In this example, the activities selected were developed and designed for the treatment group in a way that was intended to move students toward a better understanding of scientific concepts and their application to SSI in conjunction with their instructor. In addition, they were also connecting scientific content and concepts developed by the corresponding arguments, debates, and discussion. Similar to this investigation, the issues utilized in Zeidler et al. (2009) were carefully chosen to align with the students’ interests and profiles.
Culture and Group Influences on SSI Argumentation and Discourse

Kelly (2007) has put forth a discussion centered on assembling contextualized or situationally defined scientific understandings through group discourse. It would be this investigator’s contention, based on our research, that the contribution of culture to epistemic practices outweighs that of the group effect encountered in-group discourse during SSI based instruction. Furthermore, it is this investigator’s belief that the influences of culture on epistemic practices can be seen as distinct patterns or testable variances from culture to culture when compared to those contributions attributed to group discourse and situationally defined scientific understandings.

Additionally, while cultural identity has been linked to self-esteem (Taylor, 2010) and self-esteem has been linked to increased academic achievement, cultural identity has been found to be largely unrelated to academic achievement (Whitesell, Mitchell, & Spicer, 2009). This investigator would assert that the rationale for this phenomenon is that the cultural views and norms held by differing cultures may lead to lower levels of self-esteem when confronted with a dissenting majority. This dissent and feeling of cultural isolation may produce the self-esteem generated decline in academic ability due to disengagement of inquiry and discourse caused by feelings of cultural inadequacy or marginalization. Therefore, to maximize the effectiveness and inclusiveness of SSI based science instruction, educators must account for culture as a potential influence on science epistemology in a manner that recognizes culture’s place in the learning process during SSI based instruction. The important role that culture plays in discussion, discourse, debate, and sensitive or controversial SSI topics has yet to be addressed with regard to its role in discussion, self-esteem, and epistemological construction.
Ethnicity and Identity

In the following sections, ethnic identity will be examined in terms of its dimensions or component parts. This will provide a framework for comparing it with other types of group identity, and to better understand the aspect of ethnicity and how such identity relates to individual identity. The components of ethnicity identified in the literature focus heavily on the developmental perspective that has been widely used in the study and measurement of ethnic identity. Ethnic identity has been studied largely with reference to one’s sense of belonging to an ethnic group—that is, a group defined by one’s cultural heritage, including values, traditions, and often language (Helms, 1990).

Ethnicity has been investigated and quantified on a myriad of factors. Phinney (2003) and Ashmore (2004) have defined ethnicity as comprising eight distinct segments. Each of these segments is distinct and plays a role in the overall ethnicity and individual ethnic identity of a subject. The first of these eight components is self-categorization and labeling.

Self-categorization and identity. Identifying oneself as a member of a particular social grouping is considered by Ashmore et al. (2004) to be a basic element of group identity. Measurement of ethnic identity must begin with verifying that the individuals being studied in fact self-identify as members of a particular group. Phinney (1992) previously demonstrated self-categorization and identification with a series of open-ended questions or lists that are appropriately inclusive. For this purpose it does not matter whether the label is an ethnic group or racial group, regardless of how these terms are defined and whether they are broad or narrow in scope.
Individuals may use several different labels or categories depending on the situation; for example, the same person might use the terms Chinese, Chinese American, Asian, or Asian/Pacific Islander; or alternatively, a person may use Mexican American, Latino, Hispanic, or even Mayan. It has been well documented that individuals use different labels at different times (Portes & Rumbault, 2001). The label one uses is influenced to some extent by the context and by how one is seen by others; people cannot easily use labels that are at variance with their appearance. It is often necessary to categorize individuals by ethnic or racial group in order to study differences across groups. Both open-ended questions and checklists can obtain the self-categorization done by research participants. Because they may differ, it is also useful to ask individuals to report the background (ethnic, racial, or national) of both parents (Phinney et al., 2003). This procedure allows for the identification of ethnically mixed individuals who may identify with only one group, and it can also help clarify a respondent’s specific background— for example, in the case of a respondent who considers herself Latina, while both parents consider themselves Mexican. Researchers can then make informed decisions about the criteria to use in categorizing participants for particular purposes.

Nevertheless, the category or label itself is of less importance psychologically than the meaning of the category for the individual. For example, research has shown that the strength of ethnic identification makes a greater contribution to academic achievement than do the ethnic labels used among adolescents from diverse backgrounds (Fuligni, Witkow, & Garcia, 2005). This is why self-identification and not racial or ethnic identification based on appearance is a superior method of identification for this investigation.
Commitment and identity. If the first component of identity is thought to be identification, then the second component of cultural identity, as proposed by Phinney et al. (2003), is commitment or attachment to an ethnic group. A commitment or sense of belonging is perhaps the most important component of ethnic identity. Ashmore et al. (2004) included attachment or affective commitment as a key component of group identity. The term commitment has been used in both social psychology (e.g., Ellemers, Spears, & Doosje, 1999) and developmental psychology (Roberts et al., 1999) to refer to a strong attachment and a personal investment in a group. When the term ethnic identity is used in everyday language, what is most often meant, among the various meanings of the construct, is the idea of commitment. It should be noted that the strength of commitment is not necessarily related to the content of the identity--that is, to the specific attitudes or worldviews held by the individual (Cokley, 2005).

Furthermore, according to developmental models (Marcia, 1983; Phinney, 1989, 1993), commitment alone does not define a confident, mature, achieved identity; that is, commitment may result from identification with one’s parents or other role models that have not been fully internalized by the individual. Such commitments are called foreclosed; individuals who are foreclosed typically lack a clear understanding of the meaning and implications of their commitment. In contrast, the secure and stable sense of self that defines an achieved identity reflects knowledge of an understanding about ethnicity that is based on a process of exploration.

Exploration and identity. Exploration represents the third component of ethnic identity as discussed by Phinney et al. (1993). Exploration, defined as seeking information and experiences relevant to one’s ethnicity, was not discussed by Ashmore et al. (2004), but it is
essential to the process of ethnic identity formation, as discussed below in the section on the development of ethnic identity.

Exploration can involve a range of activities such as reading and talking to people, learning cultural practices, and attending cultural events. Although exploration is most common in adolescence, it is an ongoing process that may continue over time, possibly throughout life (Phinney, 2006) depending on individual experiences. Exploration is important to the process because without it, one’s commitment may be less secure and more subjective to change with new experiences.

**Behavior and identity.** The fourth identified component of ethnic identity by Phinney et al. (1993) is ethnic behavior. The ethnic identity measures developed for specific groups such as, (e.g., Felix-Ortiz, Newcomb, & Myers, 1994), have generally included behaviors such as speaking the language, eating the food, and associations with members of the group. Knowledge and use of an ethnic language, in particular, has been considered by some researchers to be a key aspect of ethnic identity. Behaviors are actions that can express an identity, and ethnic behaviors are generally correlated with other aspects of ethnic identity. However, an ethnic identity is an internal structure that can exist without behavior. Behaviors associated with one’s culture or ethnic group have been studied as an aspect of acculturation, as distinct from ethnic identity (Berry, Phinney, Sam, & Vedder, 2006). For conceptual clarity, behaviors should be considered separately from identity. Research results are likely to be more parsimonious if ethnic behaviors are included as discrete measures in studies of ethnic identity, so that results can be analyzed separately to distinguish the implications of identity per se and the associated behavior.
In-group attitudes and identity. Phinney et al. (1993) have identified the fifth component of ethnic identity as evaluation and in-group attitudes. Theoretically, a strong sense of belonging to a group is assumed to include feeling comfortable with one’s ethnicity and having positive feelings about one’s group membership (Tajfel & Turner, 1986). In the literature on group identity and specifically racial identity, the term private regard has been used to refer to positive in-group attitudes (e.g., Luhtanen & Crocker, 1992; Sellers, Smith Shelton, Rowley, & Chavous, 1998). Positive attitudes about one’s group and oneself as a group member are important because members of minority and lower status groups are subject to discrimination that may lead to negative in-group attitudes (Tajfel, 1978). Virtually all ethnic minority groups have been subjected to discrimination, and negative in-group attitudes have been noted to be present in members of most minority groups (Phinney, 1998). An example of a negative in-group attitude would be the desire to belong to the dominant group. A developmental perspective suggests that the formation of an achieved ethnic identity based on learning about one’s ethnic group and making a commitment to the group leads to the rejection of negative views based on stereotypes (Phinney, 1989). As a Cross and Phagen-Smith (2001) pointed out, many black youths develop identities with positive connotations about being black. An achieved ethnic identity implies that attitudes about one’s group have been examined and evaluated independently and are not simply the internalization of what other people think. Empirically, a number of studies have found positive attitudes such as pride and feeling good about one’s group to be part of an achieved identity (Phinney, Cantu, & Kurtz, 1997; Roberts, Phinney, Masse, Chen, Roberts, & Romero, 1999). Positive feelings for one’s group have been shown to predict happiness on a daily basis (Kiang, Yip, Gonzales, Witkow, & Guligni, 2006).

Umana-Taylor and colleagues have suggested that evaluation of one’s group, either
positive or negative, is a distinct and independent component of ethnic identity (Umana-Taylor, Yazedjian, & Bamaca-Gomez, 2004). Thus, it is assumed that one can be committed to one’s group and yet have negative feelings about the group and wish to belong to another group. In a factor analysis, Umana-Taylor and colleagues found the evaluation factor to be distinct from ethnic identity exploration and commitment. However, the interpretation of this finding is not clear because the evaluation items were all negatively worded, raising questions of method and variance. Furthermore, the promotion of cases in which individuals reported both an achieved identity and a negative evaluation was very low, even when negative was defined as scores below 20.5 on an affirmation scale ranging from 6 to 24. Further research with positively worded attitude items is needed to explore whether positive attitudes are distinct from ethnic identity achievement.

**Values, beliefs, and identity.** The values and beliefs of an individual are the sixth component of ethnic identity as outlined by Phinney and Ong (2007). Many measures of ethnic identity have been developed for specific groups and have included values and beliefs specific to a group (e.g., Felix-Ortiz et al., 1994). The assessment of values and beliefs requires the use of content that differs across groups-- for example, familism for Latinos, filial piety for Asians, and Afrocentric values for African Americans. Research with such items suggests that they are strongly correlated with commitment or a sense of belonging. Values are important indicators of one’s closeness to their group. However, they are limited in that there is not always a group consensus on what values and beliefs should be included in the scale. Even when there is agreement, such measures can be used only with particular groups and cannot be used for comparisons across groups. In addition, values and beliefs may have different correlates from
ethnic identity per se--that is, from a committed sense of belonging to one’s group. Therefore, greater clarity can be obtained by assessing separately one’s values and one’s sense of belonging.

**Minority versus majority identity.** There is a wide variation in the importance attributed to one’s ethnic identity across individuals and groups (Phinney & Alipuria, 1990), with ethnic minority group members attributing greater importance to their ethnicity than do members of the dominant majority. There is also a variation in the salience of ethnic identity over time. Phinney and Ong (2007) identified the importance and salience regarding ethnic identity as the seventh factor comprising ethnic identity. Yip and Fuligni (2002), for example, reported that ethnic identity salience, assessed on a daily basis, was higher for those with a strong ethnic identity. These authors also showed that salience was associated with positive well being on a daily basis for those with high ethnic identity but not for those with a lower ethnic identity. Further research on such variation (both over time and across individuals) would be useful in determining how these variables are related to other aspects of ethnic identity. Phinney and Ong (2007) have predicted that ethnic identity is more stable in individuals with a secure achieved identity than in those who have thought little about the issues and have not made a clear commitment.

Ethnic identity and National (or American) identity comprises Phinney and Ong’s (2007) final component of ethnic identity. For ethnic identity to be fully understood, it is best considered in relation to another prominent group identity of most minority group members, namely their identity as part of their national culture or, in the United States, their American identity. The relationship between ethnic and American (or more generally, national) identity has been debated for decades by scholars of acculturation, with early researchers having suggested that the
two identities were necessarily negatively correlated, whereas in more recent views, researchers have assumed that they are independent and may be positively or negatively correlated or uncorrelated (Barry, 2003). There is substantial research evidence for the latter view. A large international study of over 5,000 immigrant adolescents, ages 13 to 18 years, from 26 cultural backgrounds in 13 immigrant-receiving countries (United States, Canada, Australia, New Zealand, 8 European countries, and Israel) independently assessed ethnic identity and national identity (Berry et al., 2006). The results showed that, across the countries of settlement, correlation between the two identities ranged widely, from .32 to -.28, with many near zero.

**Variation in national and ethnic identity.** In addition to country-level differences, the study (Berry et al., 2006) showed wide variation across individuals. Cluster analysis with 13 identity and acculturation variables (ethnic and national identities, ethnic and national language proficiency and usage, ethnic and national peer contacts, acculturation attitudes, and cultural values) indicated four distinct acculturation profiles. The largest number of immigrant youths, approximately one third of the group, was in the integration profile, in which both identities were strong and positively correlated. A second group, including almost a quarter of the sample, was in the ethnic profile, with a strong ethnic identity and weak national identity. A third group, with less than a fifth of the sample, was in the national profile, characterized by a weak ethnic identity and a strong national identity. A fourth group, termed the diffuse profile, was low on both identities. The four profiles had different correlates in terms of adaptation outcomes; the integration profile is consistently associated with more positive adaptation. The results show that a strong ethnic identity does not necessarily imply a weak national identity and vice versa. Rather, there are varying patterns of relation between the two identities across individuals.
Furthermore, the results suggest that ethnic identity does not operate alone; rather, its implications vary depending on individuals’ identification with their own country of residence.

Other research has indicated that the relation between ethnic and national identities also differs across ethnic groups. For African Americans in particular, attitudes toward and identification with America show wide variation. The statement by DuBois (1903/1989) represents one view: “One never feels his twoness, an American, a negro; two souls, two thoughts, two un-reconciled strivings; two warring ideals on one dark body” (p. 5). A contrasting view is found in a study of African American and Mexican American adolescents (Phinney & Devich-Navarro, 1997). Many adolescents reported feeling part of both cultures, with statements such as, “it doesn’t seem like two cultures [Black and American]”; “I see them as one”; and “Some people think of themselves as just Black; I think of myself as Black American.”

**The Development of Identity**

The range of components of ethnic identity that have been identified raise the question of measurement: Is there a single overarching construct of ethnic identity, or are there various components that should be assessed and studied separately? The literature has presented a somewhat arbitrary answer. Researchers have selected aspects of the concept to assess for particular purposes or added new elements to answer their research questions (e.g., Altschul, Oyserman, & Bybee, 2006; Yip & Fuligni, 2002). The psychological study of ethnic identity development has its roots in the ego identity model of Erik Erikson (1968). For Erikson, identity refers to a subjective feeling of sameness and continuity that provides individuals with a stable sense of self and serves as a guide to choices in key areas of one’s life. Identity is not something
that individuals automatically have. Rather, an identity develops over time, beginning in
childhood, through a process of “reflection and observation” (Erikson, 1968, p. 22) that is
particularly salient during adolescence and young adulthood but may continue through
adulthood, and is expected to lead to a resolution or an achieved identity. An achieved identity
combines childhood influences, individual interests and talents, and the opportunities afforded by
the context in a unified self-structure. It is associated with numerous indicators of psychological
well-being. Not all individuals achieve a stable identity, however, and the failure to do so results
in role confusion and their inability to make progress toward meaningful commitments.

James Marcia (1983) advanced the empirical study of personal identity. He
conceptualized identity formation as involving two processes: exploration and identity issues,
and commitment in relevant identity domains. These two processes can be assessed
independently and they can be used together to define group identity statuses. Individuals may
show evidence of having engaged in neither process, indicating identity diffusion. If they have
made a commitment without having explored, they are in identity foreclosure. Those in the
process of exploring without having made a commitment are in a moratorium period. Individuals
who have explored key identity issues and made commitments are said to have an achieved
identity. Marcia focused on personal identity, involving areas of choice in the formation of an
identity, such as occupational and political identities, and did not study ethnic identity.

Like a personal identity, an ethnic identity refers to a sense of self, but it differs in that it
involves a shared sense of identity with others who belong to the same ethnic group. Ethnic
identity is also an important contributor to an individual’s well-being; individuals derive positive
self-attitudes from belonging to groups that are meaningful to them (Phinney, 1989; Tajfel &
Turner, 1986). Unlike a personal identity (e.g., occupation), ethnicity cannot be chosen by the
individual, but rather it is determined at birth or assigned to one by others on the basis of ethnic background or phenotype. Nevertheless, people have choices in the ways in which they deal with their assigned ethnic categories and in the meanings they hold regarding their group membership. The process of ethnic identity formation involves the construction over time of one’s sense of self as a group member and of one’s attitudes and understandings associated with group membership.

Ethnic identity begins in a rudimentary form in childhood (Ruble et al., 2004). Seminal work on adolescents’ search for identity was presented in Erikson’s (1950, 1959, 1968) theory of psychosocial development. In this body of work, Erickson postulated that the search for identity is a pivotal crisis in the transition from developmental childhood to developmental adulthood. The whole issue of “identity” has played a major role in developmental theories of adolescents (Hill, 1980; Josselson, 1980; Marcia, 1983). Like personal identity (Erikson, 1968) it is assumed to undergo a major developmental change in adolescence and young adulthood through the joint processes of exploration and commitment (Phinney, 1989, 1993). Similar to the identity statuses described by Marcia (1983), individuals are expected to move from ethnic identity diffusion (lack of clear identity) to either foreclosure (a commitment without exploration) or moratorium (a period of exploration) and to ethnic identity achievement, involving a firm commitment to one’s ethnicity based on an exploration that has led to a clear understanding of ethnicity. By adulthood, most people have acquired a relatively stable and secure sense of themselves as ethnic group members (that is, an achieved ethnic identity) but there can be continued exploration of identity issues thought adulthood (Phinney, 2006). In several studies, researchers have used the statuses in the study of ethnic identity (e.g., Phinney & Chavaria, 1992) and the study of racial identity (Yip et al., 2006). However, in the majority of research on ethnic identity, researchers
have used continuous scales, in particular the widely used MEIM (Phinney, 1992), to assess the underlying process of ethnic identity. Principles of the MEIM will be applied to the identity aspects of the present study.

**Summary**

This chapter explored aspects and components of identity and why identity is important to scientific literacy, science content knowledge gain and epistemology. It has been shown that identity is a multifactorial collaboration of social, cultural, ethnic, and unique population components of an individual’s overall environment. Additionally, while identity is formed or influenced by these factors, as a person’s environment changes so do these factors and ultimately so may their identity. Because this identity component may play a critical role in a student’s epistemology, a better understanding of the interplay between understanding identities’ impact on SSI controversy perception and resultant knowledge acquisition is needed. This better understanding of identities’ impact of SSI instruction is especially true in the context that SSI based lesson content knowledge and scientific literacy is essential for gaining a clearer picture of how to achieve a population of informed decision-makers and a scientifically literate citizenry.
CHAPTER THREE: DESIGN AND METHODOLOGY

Introduction

It was the primary focus of this study to explore the relation between the perceived level of controversy of a socioscientific issue, a high school biology student’s strength of controversial identification, and content knowledge gained during their navigation of SSI. This study examined the potential relation that controversy level and strength of individual reaction to the controversial nature of an SSI topic has with aspects of epistemology and content knowledge gain during SSI negotiation. This investigator endeavored to better understand relationships that may exist between strength of controversial identification and SSI in general, as well as specific SSI that have been self-identified as provocative or more controversial to the beliefs, customs, or dogmas of a strongly held student controversial identification.

This chapter gives an overview of the design of the study: a description of the target and accessible populations, instruments used in the study, a description of data collection, and analysis types by research question. The research questions collectively address the role or impact of students’ controversial identification and perception of controversy on SSI negotiation. They further explore interactions among aspects of controversial identification with epistemology, content knowledge, and ultimately how deeply strength of identification with controversy impacts negotiation of SSI based biological science instruction. This investigator used a mixed method approach to explore these processes. Content knowledge and
epistemological scores were evaluated by means of a quantitative test, whereas the other variables of controversial identification, controversy level, and informal reasoning associated with SSI navigation were explored through qualitative analyses.

**Investigation Overview**

Socioscientific issues represent dilemmas that are based on scientific knowledge, products, or applications and can affect, as well as be influenced by, society. Because of the open-ended, complex, and inherently debatable nature of SSI, the consideration and resolution of these issues are necessarily affected by a student’s strength of controversial identification and or perceived level of controversy at the time of instruction. This investigation aimed to determine acute time of instruction strength of a student’s controversial identity as it pertained to perception of controversy and identify potential relations between content knowledge gain during SSI biology instruction and these factors. Although complex multifactorial traits such as culture and ethnicity undoubtedly play into SSI navigation and will be of interest in future research, this first look into student controversial identification and SSI navigation focused solely on strength of this identity as it pertained to specific SSIs and perception of controversy during those SSI. It was the intent of this research to better understand the strength of a student’s unique controversy identification with an SSI dilemma and the relation that may exist between this identification, content knowledge gain, and SSI navigation. The aim of this research was to better understand relationships that may exist between a student’s strength of reaction to an SSI and/or perception of controversy in light of both “general SSI” and “specific SSI” (See Appendix A for definitions) that have been self-identified as provocative or controversial to the beliefs, customs, or dogmas
of a strongly held belief that is part of a student’s identity. A “general SSI” would be an SSI that is not identified to have an extremely high or extremely low controversial orientation to a specific identity clusters of by the sample student population. A “specific SSI” would be an SSI that is identified by a portion of the sample population as extremely sensitive, insensitive or provocatively unique to their controversial identity or identities. In both cases, as is always the characteristic of SSI, the issue was intentionally provocative, scientifically debatable, and inherently controversial. The uniqueness of this investigation is that the “identity specific SSIs” were self-identified by a subset of a student population using the Issue Response Identity Survey (IRIS), an instrument designed for this specific investigation, as comparatively more controversial or extremely lowly controversial to their strongly held controversial identifications than a general SSI (See Appendix B and p. 60 for IRIS description). Because of the uniqueness of this investigation and novel approach where self-reported controversy levels dictate group assignment and student controversy identity descriptions, the creation of a new instrument specific to this task was necessitated. The instrument created with aid from the classroom instructor as well as two science education collaborators was termed the IRIS. Not only does the Issue Response Identity Survey describe the instrument’s aim, but also the metaphoric significance of an iris, or the aspect of mammalian eye pigmentation that differentiates one eye from the next, became a fitting symbol for the intended aim of the instrument. The IRIS is a three-page instrument that includes some background, influence definitions, and a rating scale from 1-10 that allows students to rank the individual level of perceived controversy associated with an SSI. Following ranking, the students are allowed to further identify specific influences and elaborate as to their specific source of controversial orientation or perception. (See Appendix B for more information.)
It was necessary to first determine individual students’ aspects of identified controversy, relative strength of controversial identities, and perception of controversy regarding a specific SSI from a sample population of high school students in one Pinellas county public high school using the Issue Response Identity Survey (IRIS) to assess individual student identifications (See Appendix B for IRIS instrument). Following determination of aspects of individual students’ weak or strong identified controversy level and aspects of controversial perception within the sample population, students were instructed using SSI methodology and pedagogy by a trained SSI instructor over the course of two units. The first unit covered the respiratory system and lasted 19 class periods. The second unit covered the digestive system and lasted 14 class periods. The classroom teacher who is an experienced SSI instructor and researcher taught the lessons. The nature of this investigation is non-experimental and therefore the length of time was less important than the range of responses to SSI and how they relate to aspects of students’ identified controversial issues and overall perception of controversy. Before and after each lesson students were given an instrument (see Appendix C, D) to determine the potential effect that identities and perceptions of controversy may have on strongly controversially identified students versus weak controversially identified students.

The primary aim of this study is to describe how epistemological patterns of reasoning; justifications for decision-making and content knowledge are influenced by controversial identity and perceived controversy level regarding socioscientific issues. The mixed method approach used in this study was not decided until the after student sub-clusters were determined. Content knowledge was evaluated by means of a quantitative test, whereas the other variables of interest (strength of controversial identity, perception of controversy, epistemological patterns of response, patterns of justification, evaluation of SSI information, and patterns between
justifications and evaluation) as they relate to content knowledge were explored through more qualitative analyses.

The remainder of this chapter reviews the research questions that guided the investigation and discusses the research design and data analysis. Issues related to research design include data collection instruments, SSI selection, populations, samples, and data analysis.

**Research Questions**

This study is guided by three main research questions that are broken down into appropriate sub-questions.

RQ1. What impact does SSI based instruction have on students that have differential strengths of controversy identification?

RQ1A. What different patterns of epistemological reasoning about SSI exist, if any, among affiliated controversy identification subsets of students?

RQ2. What relation may exist between students’ prioritized degree of controversy in varied SSI contexts and their conceptual understanding of scientific content?

RQ2A. What relation may exist between perceived controversy level and content knowledge gain during navigation of an SSI at the high school level?
RQ3. What relation may exist between conceptual understanding of scientific content and epistemological patterns of reasoning among differing strengths of identification in self-identified controversy perception subsets of students?

**Elaboration of Research Questions**

The questions that guided this investigation dealt with four major factors or aspects of SSI instruction: relative strength of controversial identity, perceived level of controversy, epistemological patterns of reasoning, and understanding of content material. To better orient the reader, Table 3.1 breaks down the methods used to assess the question as well as the types of appropriate analyses that were used for each research question.

**Research Design**

**Data collection and instrumentation.** Prior to initiation of student data collection or interaction a period of nine months was devoted to generation, modification and optimization of investigation instruments. During this time existing literature supported instruments were sought out and novel instruments were generated where existing tools were found to be lacking. Once the initial templates and forms were created that would eventually produce the investigation instruments potential lessons, activities, examinations and rubrics were generated for each of the 20 potential SSI topics that could potentially be presented during the active student participation portion of this investigation. This time consuming and knowingly unneeded in most cases work
Table 3.1 Research question summary

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<thead>
<tr>
<th>Research Question (RQ1)</th>
<th>Method of Assessment</th>
<th>Analysis</th>
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<tbody>
<tr>
<td>What impact does SSI based instruction have on students that have differential strengths of controversy identity?</td>
<td>Content knowledge scores compared to short answer responses with consideration to controversy orientation and identification.</td>
<td>Mixed method trend data analysis of pre and post controversy rankings and content knowledge averages and median calculation, taxonomic grouping analysis and taxonomic count analysis.</td>
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<tr>
<th>Research Question (RQ1A)</th>
<th>Method of Assessment</th>
<th>Analysis</th>
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<tr>
<td>What different patterns of epistemological reasoning about SSI exist, if any, among controversy identification subsets of students?</td>
<td>Short answer and student responses vs. student sub-clusters. Analysis of short answer epistemological instruments.</td>
<td>Qualitative analysis, taxonomic formation via inductive analysis followed by taxonomic count analysis and epistemological score analysis.</td>
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<tr>
<th>Research Question (RQ2)</th>
<th>Method of Assessment</th>
<th>Analysis</th>
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<tr>
<td>What relation may exist between students’ prioritized degree of controversy in varied SSI contexts and their conceptual understanding of scientific content?</td>
<td>Identity IRIS scores compared to content gain scores</td>
<td>Quantitative analysis of pre, post and delta content exam scores, as well as, short answer epistemological instrument analysis.</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Research Question (RQ2A)</th>
<th>Method of Assessment</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>What relation may exist between perceived controversy level and content knowledge gain during navigation of an SSI at the high school level?</td>
<td>Analysis of IRIS controversy sub-cluster and content knowledge gain scores between high and low controversially perceived SSIs</td>
<td>Qualitative and quantitative analysis including Man-Whitney U test and taxonomic formation via inductive analysis.</td>
</tr>
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<tr>
<th>Research Question (RQ3)</th>
<th>Method of Assessment</th>
<th>Analysis</th>
</tr>
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<tr>
<td>What relation may exist between conceptual understanding of scientific content and epistemological patterns of reasoning among differing strengths of identification in ethnic or cultural self identified subsets of students?</td>
<td>Controversial identification responses and short answer responses compared to content gain scores</td>
<td>Qualitative and quantitative analysis of identity group variables and taxonomic formation via inductive analysis and Man-Whitney U tests.</td>
</tr>
</tbody>
</table>
was undertaken to ensure that following initiation of the investigation in the classroom that there
would be little to no disturbance to the flow of the lesson or cadence of the normal classroom day
for the students. Once instruction began there was no break in what was the normal daily activity
of the students compared to their non-investigation cadence. This prior to student instruction
portion of the investigation was continually optimized and collaborated with the classroom
teacher as well as two science of education faculty.

During instruction, the principle investigator observed all instruction, examination
periods, as well as, the dissemination and collection of research materials. The principle
investigator observed to ensure proper instruction, proper SSI argumentation, and proper
prompting and explanation of research materials. During observations, notes were taken that
detailed classroom setting, student engagement, teacher and student attentiveness, and student
interactions or discourse (refer to Appendix G, Classroom Observation Notes and Checklist).

Students were tracked anonymously by alphanumeric codes designed and agreed to by
the classroom instructor. Anonymous alphanumeric codes were preceded by an M for males and
an F for females in the case that gender became a variable of interest. Student profiles along with
their alphabetic indicators were collected via the student background profile instrument (see
Appendix H). At the onset of the investigation the students were engaged in four days of
discussion, topic presentation, scenario elaboration and general preparation for the investigation
to come. Following this introduction the students were asked to rank the potential SSI topics
from most to least controversial (Table 4.1, Figure 4.1 and 4.2). Four basic instruments with pre
and post-instruction modifications were then used for student data collection: 1) IRIS identity
survey; 2) content knowledge exam; 3) decisions about socioscientific issues; and 4) short
answer questionnaires appendix C and D. These instruments are described below. Each student
proceeded through versions of each of these four instruments in a pattern that followed; Pre-instruction IRIS form, Pre-instruction Appendix C (for SSI1) or D (for SSI2), Pre-instruction content exam, Post-instruction content exam, Post-instruction IRIS, Post instruction appendix C (for SSI1) or H (for SSI2). These instruments were administered in the students’ classroom settings on separate days. The IRIS identity survey was administered first, followed by the short answer follow-ups, decisions about scientific issues questionnaire, and then a pre-instruction content exam. These were followed by appropriate length SSI instruction corresponding to the applicable anatomy and physiology content areas of the respiratory system and digestive system. The SSI topics or scenarios for instruction were not determined until analysis of IRIS instruments was completed. Following instruction, the post instruction content knowledge exam was given. Finally, the decisions about socioscientific issues determination instrument and short answer questionnaire were given again. It was the intent of the investigator to space this out so it could fit in with the classroom teacher’s schedule and not become tedious for the students. However, all assessments were given within a maximum of a four-week period per each SSI scenario in order to maximize the potentially acute relationship between controversy, controversial identity, and student responses. Assessment of the first SSI unit, respiratory system, spanned 19 school days and assessment of the second SSI unit, digestive system, spanned 14 school days.

**Issue Response Identity Survey (IRIS) identity strength score.** The Issue Response Identity Survey (IRIS) (see Appendix B) is a unique tool designed specifically for this investigation that quantifies not only the level of controversy a student associates with an SSI but also accounts for some of the individual controversial identification-related influences that
produce the reaction to the SSI. The IRIS instrument asks students to rank on a scale of 1 to 10 a list of SSI scenarios presented to them as a part of the IRIS instrument. The list of SSI scenarios of this investigation are: birth defects/genetic testing, terminal illness/euthanasia, abortion, stem cells, drug testing, forensic science, obesity, animal testing, smoking, and fluoride. These issues were developed over the course of one semester by this researcher and the classroom teacher. The issues are designed to be both appropriate for SSI instruction and fit with the courses and curriculum required by the classroom teacher. The level of controversy scale for IRIS varies from weakly controversial (1) to strongly controversial (10). The individual’s score for strength of controversial identity for each SSI screened is also scaled (1-10). The independent variable(s) in this investigation were the student’s selected level of controversy group(s) from weak to strong as well as their relatively chosen components of their controversial identity. There was a potential to have three independent variables for each trait [1. Weak identity 2. Strong identity 3. Neutral identity]. The dependent variable was content knowledge. It was impossible to predict the grouping of student identities until data was collected. To find a representative controversial issue, a mean of the sample population controversy (IRIS) scores was taken for each issue and compared to sub-clusters of strong and weak identity as well as non-controversial and extremely controversial as they pertain to the specific SSI. It was impossible to determine sub-clusters and sample population breakdown prior to issuing the IRIS instrument. Response data produced two distinct clusters based on level of controversy (high and low) or two strength of controversial identity clusters (high and low). Therefore a two-way analysis, such as Man-Whitney U tests, was used to analyze identity clusters variables versus quantitative data such as taxonomic categories that may include justification, patterns of reasoning, student response pattern and or content knowledge gain over the course of instruction.
**Content knowledge assessment test.** Content knowledge assessment was carried out using a test that has previously been shown by the classroom teacher to produce a broad range of content knowledge acquisition and assessment for each SSI content area. This test was further optimized over the prior semester of preparation by this investigator and the classroom instructor to cover the specific content chosen. This test was not determined until IRIS instruments were analyzed and socioscientific issues were chosen. (For multiple-choice questions corresponding to the SSI units delivered via marijuana safety -- respiratory and fast food legality -- digestive systems, see Appendixes K,L,M and N). The pre-instruction and post-instruction content exam consists of: multiple choice, true/false, fill-in-the-blank, and short answer. It was impossible to generate these finished assessments until after IRIS administration and analysis. So, prior to the student interaction portion of this investigation multiple exams covering all potential topics and content areas were generated and prepared according to the SSI topic list (See Table 4.1). Once controversial identification specific and appropriate SSI were identified, the content knowledge exams were selected and conclusively optimized. After two rounds of optimization between the classroom instructor and this investigator, the exams were finally optimized one last time by two additional science education researchers to ensure maximum validity.

RQ2 was investigated by analyzing the content gain data and comparing content gain differences among strongly identified students compared to weakly identified students within controversial identity specific SSI and controversial identity non-specific SSI, and then comparing that relation to those students who either did not identify as strongly identified or were not strongly identified in relation to the identity specific SSI chosen.
Decisions about socioscientific issues epistemological metric. In order to assess students’ justifications, epistemological navigation, and the role that student controversial identification may play in each during navigation of an SSI, students were asked to respond to an open-ended questionnaire regarding the socioscientific issues of marijuana safety and fast food legality. The open-ended questionnaire format has been successfully used for determining qualitative categories of justification, reasoning, and rationales that are used by diverse populations during the navigation of an SSI (Zeidler et al., 2013). The questionnaire follows the sample questionnaire found in Appendixes O and P. This instrument was previously used in a specific research context in which the goal was to tap epistemological reasoning within an explicit context. While focusing on specific contextual reasoning is not the primary research interest of this investigation, the individual student controversial identity clusters’ or sub-clusters’ epistemological reasoning in general is of great interest as they relate to or contrast with one another when controversy identification and perceived controversy identity clusters are compared. This instrument was specifically generated and optimized after the initial controversial identity assessment of the sample population had been done.

Following the assessment of perceived controversy level and relative strength of controversial identity using the IRIS identity assessment tool, a panel of SSI instructors and educators consisting of three members approved a modification of Appendix O, as needed, so it is content and scenario appropriate for this investigation. The panel consisted of the lead investigator, at one science education PhD student familiar with SSI education research, and one science education faculty member with expertise in SSI. Following IRIS administration, this researcher worked to modify the short answer questions in a manner that is consistent with the
SSI of interest. The panel reviewed any subsequent modifications of the instrument. Only after unanimous support was any modified instrument used.

Short answer question qualitative analysis was used to analyze Research Question 1A. Students were asked to respond to four probing questions (found in Appendix O) aimed at revealing more about their epistemological beliefs about the nature of knowledge and knowledge claims. This instrument has been used to gain insight into students’ epistemology and reasoning in previous research about similar settings (Zeidler et al., 2011). See Appendix Q for example questionnaire scoring. The Decisions about Socioscientific Issues instrument could not be modified or produced in total until the content for the SSI was determined by the initial IRIS survey of identity. The scoring resulted in both an overall content knowledge score and a proper science answer or question score. The overall score was based on content knowledge and the proper science question formulation score; together these two scores produced a range from 0 – 12 in which students were awarded 0 – 4 points for each. The scoring went through three rounds of optimization by a panel of four collaborators to ensure accuracy and reliability. Collaborating in the scoring optimization was one science education PhD candidate, the classroom instructor, one science education professor and the lead investigator. The initial three answers on this instrument were scored according to the following rubric. A 0 response was one in which the response attempted was not scientific in nature and included no justification, evidence, or example. A score of 1 was awarded to a response that included justification, evidence, or example. A score of 2 was represented by a response that was scientific in nature. A score of 3 was associated with a response that was scientific in nature and included justification, evidence, or example. A score of 4 was awarded to any response that exhibited all traits of (3) as well as exhibiting or recognizing multiple scientific points of view. The three proper science questions
scoring portion was awarded points for questions that were deemed scientific in nature and followed the following scoring rules for decisions about socioscientific issues. Scientific follow-up questions: 0 = response does not exhibit a scientific basis in nature; 1 = one response attempted, some science content attempted, but justification absent or not clear; 2 = response includes non-specific or general use of scientific content with justification; 3 = response includes specific use (contextualized) of scientific content with justification; 4 = exhibits all traits of (3) while exhibiting or recognizing multiple scientific points of view. Note: each of the three possible questions a student can pose were scored in this manner. Thus, responding fully to only one question would earn them a total of 3 points, while responding fully to all 3 questions would earn them the highest score of 9 points.

Research questions were investigated by comparing the independent variables of student perceived controversial identity clusters with the dependent variables of short answer proper science response and taxonomy groups.

**Socioscientific issue selection.** The research design required participants to make not only judgments concerning a socioscientific issue, but also judgments that may be ethnically relevant, culturally relevant, or trigger emotions that are volatile to a sense of a student’s controversial identity and therefore overall perception of controversy. Aspects of a participant’s controversial identity were challenged with a pair of specifically selected SSI scenarios derived from a list designed to reflect the specific student populations’ perception of controversial issues. In discussion with the classroom teacher and after reviewing the course content covered, it was determined that the SSI issues of marijuana usage and fast food legality (see Appendix I) best represented topics that were likely to be controversial to the students as well as fruitfully
incorporated into the curriculum. Each of those SSI scenarios presented had the propensity to challenge the sensitivities of any combination of controversial identifications’ identified in the student population.

For this investigation, specific SSI were selected as a vector for content knowledge delivery following the analysis of the IRIS identity instrument. These final issue(s) were sample dependent and could not be determined until assessment of controversy identity began. Following analysis of identities of the population, SSI instruction and anatomy and physiology lessons were delivered. Each SSI was of little or no controversy to some portion within the sample population. Similarly each SSI was specifically selected to be provocative to a segment of the population based on their own selected identities and self-generated issues of controversy. In each case, content knowledge gain and epistemological navigation of the issue was compared between students who identified the SSI as controversial per their controversial identification versus students who did not find the SSI controversial per a specific controversial identification. Table 3.2 lists the potential SSI scenarios and outlines their moral and ethical components as well as the corresponding teaching objective for each.

**Teacher selection.** For this study, it was important to select an educator who was familiar not only with the scientific issue being taught but also with SSI methods of instruction. Furthermore, due to the discourse-producing nature of SSI and identity issues being investigated, it was important that the teacher was familiar with and to the students to limit outside instructor bias, shyness, or resistance to express controversial identification-related beliefs or feelings on the part of the students. The selected teacher for this investigation has a track record of both delivering high level SSI instruction and participation in SSI research, and publication of SSI based science education articles. The teacher for this investigation is a 12th year science teacher.
at a public high school in the southeastern United States. In addition to science teaching experience, the teacher has had further advanced training in biological sciences (Advanced Placement in Biology: Florida State University, Pre-Advanced Placement in Biology: University of South Florida). Beyond scientific education and continuing education, the teacher has completed extensive advanced graduate coursework offered at the University of South Florida and is very current and familiar with SSI research, instruction, and methodology. For a full list of the selected teacher’s credentials and publications please see Appendix J.

Table 3.2 Socioscientific Issue elements

<table>
<thead>
<tr>
<th>SSI</th>
<th>Moral / Ethical Component</th>
<th>Teaching Objective</th>
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<tbody>
<tr>
<td>Birth defects / Genetic testing</td>
<td>Right to life / Abortion</td>
<td>Genetics</td>
</tr>
<tr>
<td>Terminal illness / End of life / Euthanasia</td>
<td>Assisted suicide / right to death</td>
<td>Body system, organ or pathway</td>
</tr>
<tr>
<td>Abortion</td>
<td>Abortion, scientific ethics, definition of life</td>
<td>Development, cell biology, reproduction</td>
</tr>
<tr>
<td>Stem Cells</td>
<td>Abortion, scientific ethics</td>
<td>Development, cell biology, reproduction</td>
</tr>
<tr>
<td>Drug Testing</td>
<td>Privacy, confidentiality</td>
<td>Organ systems, digestion</td>
</tr>
<tr>
<td>Forensic Science</td>
<td>Burdon of proof, guilt vs. innocence</td>
<td>Body fluids</td>
</tr>
<tr>
<td>Obesity</td>
<td>Life choices, health costs</td>
<td>Diet, nutrition, organ systems</td>
</tr>
<tr>
<td>Animal Testing</td>
<td>Animal rights vs. human safety</td>
<td>Eye / Vision, immune system</td>
</tr>
<tr>
<td>Smoking</td>
<td>Life choices, health care costs</td>
<td>Lungs, respiratory system</td>
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</table>
Subjects: population and samples. High school biology students were the target population for this study. Although socioscientific issues curricula are appropriate for a wide range of educational levels (including elementary, middle, and college), the high school level was chosen because in order to detect both strength of controversial identity and content knowledge, a heterogeneous student population was needed that has both a depth and breadth of both student identification strengths and biological content knowledge. A usable scale of content knowledge may be difficult to determine in non-high school grade levels. Additionally, the high school-aged biology students may represent a preferable age and developmental range, and the cultural imprinting of home and neighborhood may be stronger than college students, who have had some assimilation into a larger, more diverse campus population.

Sample size consisted of 4 sections of intact high school biology classes with class sizes of 25 (Period 1), 27 (Period 2), 29 (Period 3), and 31 (Period 4) students respectively. Participating students were from Pinellas County, Florida, USA. The investigator had access to 1 honors class and 3 non-honors sections. A prerequisite for honors students includes A’s and B’s in biology and chemistry, though there are no regulations in place that prevent them from enrolling in an honors class without fulfillment of requirements. Only students who participated in all or a relevant independent segment of the investigation were included in the study. The final student population following analysis of participation was 113 students. Final student sample population breakdowns are shown in Tables 3.3 and 3.4.

Personal student identifiers were kept anonymous. Gender was recorded due to its potential importance. Students were linked to their responses and kept track of via an alpha numeric code assigned randomly upon IRIS and first pre-test administration. All students received a three character alphabetic coded identification that consisted of an M for males and F
for females followed by a two-letter code. Students not participating in the entire study or
missing a portion of both SSI units work were dropped from the study, and their data was not
included in the final results. No students were added to the study following administration of the
pre-content exams for each respective SSI lesson.

Table 3.3 Population age (years) demographics

<table>
<thead>
<tr>
<th>Age</th>
<th>Number of Students</th>
</tr>
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<tbody>
<tr>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>6</td>
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<td>17</td>
<td>48</td>
</tr>
<tr>
<td>18</td>
<td>36</td>
</tr>
</tbody>
</table>

Table 3.4 Population grade demographics

<table>
<thead>
<tr>
<th>Grade</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>11</td>
<td>28</td>
</tr>
<tr>
<td>12</td>
<td>70</td>
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</table>
Student interviews.

*Interview conceptual framework.* Central to the approach of SSI instruction is the effort to provide the students an opportunity to reflect on controversial and possibly debatable topics in order to evaluate claims, analyze evidence, and assess multiple viewpoints regarding ethical issues on scientific topics through social interaction and discourse (Zeidler, Sadler, Applebaum, & Callahan, 2008). This process necessarily evokes nature of science tenets in that SSI discourses are de facto tentative, creative, evidence-driven, and culturally embedded. Abd-El-Khalick (2003) has further suggested that epistemological stances and nature of science aspects may be developmentally linked to meaningful critical discourse regarding controversial SSI.

Instruction driven by SSI has been examined regarding its effect on personal epistemological growth (Zeidler, Sadler, Applebaum & Callahan, 2008). Inasmuch as the development of reasoned argumentation is one of several desirable goals of utilizing SSI, a useful method of evaluating the efficacy of a SSI curriculum for epistemological development of students in science classrooms may be found in the Reflexive Judgment Model (RJM), developed and refined through 20 years of research by Kind and Kitchener (King & Kitchener, 1994, 2002; Kitchener, 1983; Kitchener, King, Wood, & Davidson, 1989). Reflexive judgment involves the reasoning patterns individuals use to support their approach to ill-structured problems (Hofer & Pintrich, 1997; King & Kitchener, 1994). The RJM provides an overarching developmental view of similarities in patterns of reasoning that are useful in understanding epistemic trends in reasoning. It is on that basis and that framework that the interview questions and follow-up questions for this research have been generated. The interview protocol was adapted from King & Kitchener’s (1994) protocol.
**Interview protocol methodology:** A series of seven probe questions were asked following a written and read aloud prompt. The initial interview questions were followed by appropriate additional questions (Table 4.5) dependent on the initial response. The prompt and accompanying questions have been modified to fit this study and adapted from Zeidler, Sadler, Applebaum, & Callahan (2009. The prompt was modified slightly to be compatible with one of the two SSI selected for this investigation and was not finalized until the SSI were selected. Both of the interview prompts follow below. This interview methodology was utilized due to its successful usage in past SSI investigations. The method in this instance was not as critical as the results produced. Proper modification of questions were tailored to SSI scenarios that were self-selected by the student population of this investigation.

**Interview prompt for selected issues:**

“During this session, we will be talking about the issue of [marijuana safety / fast food legal limits] that is of general concern and about which most people are at least vaguely familiar. I am not concerned with how much you specifically know about this issue. The focus here is how you think about this issue. For the issue, I will read a statement aloud while you follow along on a card. After I finish reading the statement, I’ll give you a minute or so to think about the issue and then we will talk about it. Are there any questions before we begin?”

**Issue 1.** Marijuana Safety – There has been much debate recently as to the safety and medical applicability of marijuana use. Some studies indicate that chemicals encountered while
using marijuana are unsafe and may lead to diseases such as cancer. Other studies, however, show that the medical and possibly recreational use of marijuana is not harmful and may be a safer alternative to other forms of recreational tobacco or alcohol use. You have had or will have the opportunity to study the issue of marijuana safety. You will now be asked a series of questions regarding your thoughts on this issue.

**Issue 2. Fast Food Legality** – Some researchers contend that obesity has reached epidemic levels in the United States. Because of this, levels of obesity-related diseases and conditions have increased dramatically. Accordingly, there has been debate regarding the safety and availability of high calorie, low nutrition food options. Some researchers, government bodies, and even elected officials have taken a stand that would limit an individual’s access to fast food. Others have argued that it is the responsibility of the consumer to freely choose what to eat and have suggested other options for reducing obesity and its related health concerns. You have had or will have the opportunity to study the issue of fast food legality. You will now be asked a series of questions regarding your thoughts on this issue.

**Interview data analysis.** Responses were evaluated by the principal investigator and by another researcher familiar with the reflective judgment model but blind as to which responses represent pre or post patterns of reasoning. Pre-instructional responses were then compared and analyzed against the same student’s post-instructional responses. In addition, students who were found to orient in a highly controversial nature to the issues selected were compared to those students who ranked the issues as non-controversial or extremely low in controversy to determine if differential patterns of reasoning were present. Finally, taxonomic trend analysis
was done on the interview answers to determine the presence of taxonomic trends, patterns or similarities between and among controversial identification clusters. Unfortunately, interview data were incomplete and were found to be potentially biased due to pre discussion and inter discussion among subjects and while collected and analyzed could not be found wholly credible. Some analysis, observations and analysis was gained by in class real time discussion with students as they were engaged in the lesson.

Table 3.5 Interview Probe Questions

<table>
<thead>
<tr>
<th>Probe Question</th>
<th>Purpose</th>
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<tbody>
<tr>
<td>1. What do you think about the previous statement? (If no thoughts or point of view are offered, ask:) Could you ever say which was the better position? How? Why not? How would you go about making a decision regarding this issue? Will we ever know for sure which is the better position? How / Why not?</td>
<td>To allow participant to share an initial reaction to the problem presented. Most state which point of view is closer to their own.</td>
</tr>
<tr>
<td>2. How did you come to this point of view?</td>
<td>To find out how the respondent arrived at the point of view, and whether/how it has evolved from other positions on the issue.</td>
</tr>
<tr>
<td>3. On what did you base that point of view?</td>
<td>To find out about the basis of the respondent’s point of view, such as personal evaluation of the data, consistency with an expert’s point of view, or a specific experience. This provides information about the respondent’s concepts of justification.</td>
</tr>
<tr>
<td>4. Can you ever know for sure that your position is correct? How or why not?</td>
<td>To find out about assumptions concerning the certainty of knowledge.</td>
</tr>
</tbody>
</table>
5. **When two people differ about matters such as this, is it the case that one opinion is right and one is wrong?** If yes, what do you mean by “right”? If no, can you say that one opinion is in some way better than the other? **What do you mean by better?**

   **Assesses the adequacy of alternative interpretations; to see if dichotomous either/or view of the issues held; to allow the participant to give criteria by which she or he evaluates the adequacy of arguments.**

6. **How is it possible that people have such differing points of view about this subject?**

   **To elicit comments about the respondent’s understanding of differences in perspectives and opinions.**

7. **How is it possible that experts in the field disagree about this subject?**

   **To elicit respondent’s understanding of how he or she uses the point of view of an expert or authority in making decisions about controversial issues.**

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**Analysis of Data**

The following data were collected during the investigation:

1. IRIS strength of identity and controversy perception pre instruction
2. Pre instruction short answer qualitative questionnaire
3. Pre instruction epistemological metric
4. Pre instruction content knowledge exam
5. IRIS strength of identity and controversy perception post instruction
6. Post instruction content knowledge exam
7. Post instruction short answer qualitative questionnaire
8. Post instruction epistemological metric
9. Pre and post instruction interviews (as needed)
Throughout this investigation, several types of data were collected, and several methods of data analysis were possible. While there were instances where nominal quantitative data were gathered, such as gender and age, much of the interest of this investigation is in the analysis of the qualitatively derived ordinal levels. The ordinal values for this investigation are those of perceived level of controversy, short answer scores, and ultimately how those scores relate to SSI instruction. Because ranking strength of perceived level of controversy lacks a clear numeric interpretation and is ordinal in nature, a non-parametric method, Man-Whitney U statistical analysis was used in quantitative analysis. The use of non-parametric methods makes fewer assumptions than corresponding parametric methods and therefore it was expected that it would produce a more robust result. The use of non-parametric measures will be particularly pertinent in this case where there is no clear numerical interpretation of identity clusters and additionally not much is known about the application in question. The null hypothesis for this investigation is: student identity group will have no association with content knowledge gain and epistemological reasoning.

This investigation contained two dependent variables. The dependent variables were change in content knowledge and short answer score(s). The changes in content knowledge scores were derived from multiple choice and short answer scores. Short answer scores included both content exam short answer responses and student responses to the decisions about socioscientific issues epistemological metric. However, additional taxonomic groups were inductively derived from short answer responses. Likewise, the scientific merit or “justification ability” of answers were scored independently from content gain. Change in content knowledge were defined as: pre content knowledge score – post content knowledge score = change in content knowledge. Short answer scores were the result of coding scores, examiner taxonomies,
observed patterns of reasoning, or a combination. Short answer scores can be broken down into the two scores of overall content knowledge and use of science content knowledge to support their answer (justification ability). Scores were awarded not just for the correct answer (content knowledge) but also for a science answer as opposed to a non-science answer (proper science justification). The independent variable in this investigation is the student’s controversy perception group.

Scores from content knowledge assessment tools were compared to strength of student controversial perception scores. A correlation between higher or lower content knowledge gain as well as short answer data was related to the independent variable of higher or lower controversy identity scores. Student participants were differentiated into high, low, and moderate or standard controversy clusters. The high controversy students were students who identified the most controversial issue from the list as their most controversial overall issue. The low controversy students were students who identified the lowest controversy issue from the list as their least controversial issue possible. The moderate or standard students were students who ranked either the high or low controversy extreme issues as somewhere between their own personal highest and lowest ranked controversial SSI. The result will give science educators insight into how strength of student controversial identification relates to knowledge gain and epistemological navigation during potentially culturally, ethnic, or identity sensitive SSIs. In the sections that follow, the trustworthiness of the study will be examined.

Trustworthiness of a mixed methods study like this allows for the investigator and audience to evaluate the value of usefulness of results. For this investigation, the constructs that define trustworthiness will be: credibility, transferability, dependability, and confirmability.
Credibility from the conventional standard is generally thought of as the internal validity of the study. Generally under the quantitative design, credibility addresses the degree to which a measurement describes the defined variable, whereas in a qualitative context, credibility focuses on the degree to which developing data patterns and the interpretations of those patterns accurately reflect the thoughts, behaviors, and decisions of the subjects of inquiry (Lincoln & Guba, 1985). This study utilizes a mixed methods approach and employs several measures to ensure credibility. From a quantitative approach, the value of knowledge gain pre and post test was credibly attained by utilizing a multifaceted exam pre and post to determine student knowledge gain. The exam consisted of up to 20 multiple choice questions as well as at least three multipart short answer portions that are designed to allow students to not only expand on their controversial identity specific aspects of their responses but to demonstrate their content knowledge as well. The exam was generated and vetted by no fewer than three experts in the fields of science education and educational research, as well as the classroom teacher to ensure proper question and format design.

Triangulation is a method of credibility accounting that this study will draw upon in the qualitative context. Triangulation of data involves the use of multiple pieces of information provided by the research participants. Triangulation of outcomes produced by the student responses and follow-up questions were used to assess the influence of student controversial identification on science content knowledge gain and epistemological reasoning. Additionally, the investigator’s role or influence was diminished by the use of investigator triangulation in which multiple scorers would over read and re-review short answer scores to ensure that there was no misinterpretation of data and short answer, written response, and follow-up resonance scoring rigor. During this investigation there was a level of internal review and scoring.
optimization that at least ensures 20% of all responses are scored redundantly and measured against each other for internal credibility of reviewers.

Applicability is generally analogous to external validity and generalizability as conceptualized in quantitative traditions. Whereas generalizability is often a primary goal of studies involving statistical analysis, qualitative investigations are focused on transferability. The audience may be able to debate whether the findings and implications of this qualitative study apply or can be transferred to another context, but the format and measures used herein could easily be applied to a separate situation in the future. Furthermore, this investigator sees no reason that the results and factors that produce the findings would not be comparable. The transferability of this research will depend on the audience’s subject population and the potential investigator’s ability to generate adequate sample SSI scenarios that would be relevant enough to the sample population to produce at least a range of high and low controversy levels within the sample population. If that can be done, the transferability of this approach and research in general should be quite comprehensive.

Dependability is generally analogous to reliability, in which the results of the study or instrument would be replicated given the same sample. In qualitative research, especially in an investigation like this, it is important to understand and recognize that the participants’ interpretations of research instruments are dynamic; therefore, exact replication of results is not an assumption of this investigation. This is especially the case when dealing with such volatile and evolving concepts such as identity and adolescents. Dependability takes into account factors of natural change as well as instability resulting from experimental procedures when placed in a qualitative construct. It was this investigator’s intention to minimize the effects of experiment-induced instability while maintaining an appreciation for progression of individual thought
patterns. Measures to reduce novelty affect and instability included using a sample population that is somewhat familiar with SSI style instruction as well as allowing the familiar classroom teacher to carry out the instruction and instrument delivery in the place of the lead investigator.

Confirmability, generally analogous to objectivity, refers to the degree to which qualitative data and their interpretation can be authenticated. Techniques used for establishing credibility are also important for building confirmability. Credibility of this study is supported with the use of two trials (two SSI units applying the pre and post test scenario). The two trials can then be used to buttress the confirmability of the overall investigation. This investigator also employed an audit process of note-taking and observation during the investigation. The audit process for qualitative research is a comprehensive approach to record keeping and occurs throughout the course of the investigation. The audit trail for this investigation included visual observation notes and data collection notes, and particular attention was paid to any needed modification to analysis or instrumentation.

**Coding of qualitative data.** Qualitative data in this investigation is comprised of short answer responses, follow up questions and student interviews. Qualitative short answer data were scored, optimized and finally recorded by a panel of four researchers. An additional two researchers aided scoring optimization and oversight. An a priori scoring rubric regarding decisions about socioscientific issues has been proven to generate an inter-rater reliability of 97% when using four researchers to score and code short answers (Zeidler et al., 2013). For this investigation, the Decisions about Socioscientific Issues short answers were scored in compliance with this method. Whereas in the Zeidler et al. (2013) investigation every 10th data set was redundantly scored by independent researchers, there was more chance for redundant
coding and internal control in this investigation due to fewer overall short answer response forms. During the course of coding in this investigation there was a 20% redundancy incorporated into the reviewing process. For the total responses graded, 20% were redundantly and blindly reviewed by two reviewers. Those scores were cross-referenced in order to assure coding consistency and reliability between raters.

A high inter-rater-reliability during this investigation is ensured by the use of internal review and rater uniformity measures. The first of these measures is that raters used for the scoring of the short answers have undertaken a similar scoring task in the recent past. Each is a trained SSI instructor, educator, published expert, or a combination of these credentials. The scorers consist of the principal investigator, one science education PhD student, a non-education graduate student, a journalism graduate student, as well as oversight and over reading by a science education faculty member and second science education PhD student. In addition to their preexisting qualifications, scorers were trained in the specifics of this investigation over the course of an introduction and orientation to the research. Participating scorers underwent two optimization trials in which a method of consistent and transparent scoring was agreed upon. Following training, raters conducted an optimization-scoring round to ensure high interrater-reliability. If the reliability was not 95% or better, a second, third, or fourth round of optimization and scoring rubric enhancement would have been conducted until interrater-reliability is at least 95%. Once interrater-reliability was at the acceptable 95% threshold, one more internal control was utilized during scoring. For every 5 short answers reviewed per scorer, at least one was redundantly scored by a second independent scorer. Scores of the redundant reviewers were compared to ensure stringency of inter-rater-reliability.
Summary

The purpose of this study is to explore how aspects of controversial identification and perceptions of controversy relate to conceptual understanding and knowledge acquisition during socioscientific issues based instruction in a biology classroom. One hundred and thirteen students drawn from high school biology classes in Pinellas County Florida completed an IRIS instrument, pre and post short answer follow ups, pre and post epistemological metric responses, pre and post content knowledge exams. Subsets of these students were identified in one or both of two specifically selected SSI scenarios. The scenarios were selected to maximize the observed scope between students who perceive high controversy and students who are less controversially responsive to selected SSI scenarios. During instruction, observer notes and annotations were kept regarding discourse, teaching methodology, student interactions, and non-verbal or recorded phenomena. Participants had the opportunity to navigate two SSI scenarios followed by a chance to display knowledge gain and expand on answers or points of discourse with additional short answer and follow up questioning, as well as interview prompting to expand on potentially relevant points or findings. Content exams, short answers and researcher observations were analyzed both qualitatively and quantitatively to assess how individuals selected SSI and interacted with specific SSIs in light of their controversial identification with the selected SSI. The study was designed to explore student identity and the impact of controversy perception in light of SSI instruction. The qualitative analysis of short answer data and student observations enabled the researcher to investigate patterns of informal reasoning, moral decision-making, and patterns of reasoning that may be unique to strongly held student controversial identification or clusters of these identities.
CHAPTER FOUR: RESULTS

Introduction

Given the mixed methods approach of this study and the qualitative emphasis of much of the findings, the presentation of data is necessarily embedded in a description of the findings qualitatively as well as a more overt analysis of the quantitative findings. This chapter presents results and analysis of the context of the meaning of these results. The following presentation of data is organized according to the research questions, which have served to guide this investigation. Each question is restated and sub headings are provided where appropriate or necessary for clarification. Finally, relevant findings associated with the applicable question are then presented and discussed.

The intent of the research questions and their associated sub questions focused on how individuals holding differing orientations to a specific socioscientific issues dealt with aspects of these socioscientific issues and how there resultant content knowledge gain was affected or influenced in a high school science classroom setting. Of additional interest was how these student or student clusters, that held differing orientations to each SSI, proceed through socioscientific issues instruction involving explicitly selected issues. More specifically, this study investigated the extent to which a students perception of controversy before, during and following SSI instruction relates to content knowledge gain, aspects of epistemology and evaluation or justification of SSI information. As described earlier, this investigation used SSI
topics specifically chosen to accentuate existing levels of controversy perception or controversially oriented clusters of students found within the student population. The selected SSI were chosen following extensive analysis of the selected student population and were intended to be uniquely controversial topics that were distinctively oriented to this investigation’s student population. Based on previous recent work, a framework of epistemological construction or pattern analysis (Zeidler D., 2013), short answer reasoning and taxonomic classifications were employed to assess qualitative aspects of the student responses. In addition, content knowledge change assessment was addressed by means of content knowledge examinations given prior to (pre-instruction) and following periods of (post-instruction) high school anatomy and physiology SSI instruction.

It should first be reported that prior to initiation of investigation activities and instruments, students were engaged in three days of discussion covering topics and potential topics that could be not only perceived as scientifically controversial but also contained applicable content components to the anatomy and physiology course being taught. To specify, a suitable SSI for this investigation consisted of at least three needed characteristics. Each had to be inherently controversial, scientifically debatable and capable of delivering appropriate science content for this specific high school anatomy and physiology course. Prior to engagement of research a list of twenty SSIs had been identified for potential inclusion by the lead investigator and the classroom teacher for use in this investigation. The initial list was pared down to reflect items or topics of content that were covered in the time needed for proposal defense and therefore removed from the initial list. From discussion with the students and the classroom instructor, 15 potential SSIs and associated high school anatomy and physiology content areas were selected for use in the initial phase of this investigation. The SSIs are listed below in no
Figure 4.1 represents a comprehensive list of SSI topics that were introduced and discussed by the sample population in order to determine potential controversially orientated specific SSI topics for the investigation.

Table 4.1 SSI Potential Topics.

<table>
<thead>
<tr>
<th>Issue Number</th>
<th>Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Genetic Testing</td>
</tr>
<tr>
<td>2</td>
<td>Euthanasia</td>
</tr>
<tr>
<td>3</td>
<td>Tobacco Legality</td>
</tr>
<tr>
<td>4</td>
<td>Fast Food Legality</td>
</tr>
<tr>
<td>5</td>
<td>Intelligence of Genders</td>
</tr>
<tr>
<td>6</td>
<td>Mandatory Drug Testing</td>
</tr>
<tr>
<td>7</td>
<td>Animal Testing</td>
</tr>
<tr>
<td>8</td>
<td>Stem Cells</td>
</tr>
<tr>
<td>9</td>
<td>Marijuana Safety</td>
</tr>
<tr>
<td>10</td>
<td>Sexual Preference</td>
</tr>
<tr>
<td>11</td>
<td>Mandatory Organ Donation</td>
</tr>
<tr>
<td>12</td>
<td>Obesity Penalties</td>
</tr>
<tr>
<td>13</td>
<td>Population Control</td>
</tr>
<tr>
<td>14</td>
<td>Drinking Age</td>
</tr>
<tr>
<td>15</td>
<td>Age of Responsibility</td>
</tr>
</tbody>
</table>
Following determination of the above listed issues (Figure 4.1) and three days of classroom discussion, development and scenario elaboration, the students were asked to rank each of the issues on a scale of 1 to 10 based on the students’ individual perception of controversy. The controversy-rating instrument utilized during this investigation was a researcher-generated survey called the issue response identity survey or I.R.I.S. (Appendix B and p.60). A rank of 1 indicated that the student perceived no controversy and a rank of 10 indicated that the student attached the most controversy to that issue and furthermore identified it as the most controversial issue on the list. A rank of 1 or no controversy was representative of an issue that the students were not passionate about, would not care to debate in a lively manner, were not threatened by, felt no specific gut response to or would be ambivalent to at best, regarding care or concern for decisions, policies and statements made on that issue. A rank of 10 would be assigned to an issue or issues that produced a primal, visceral, impassioned response derived from one or more student controversial identification aspects. A rank of 5 indicated that the students felt somewhat controversially oriented toward the issue, recognized that others may have contrasting opinions of this issue and that they would be open to but not necessary passionate about debate or discussion regarding this issue.

After initial assessment and issue development the students were asked to rank the issue that they oriented to the most controversially from the potential list (Table 4.1). The following figures (Figure 4.1, 4.2) indicates the students’ ranking of the fifteen potential SSI topics that could be integrated into a high school anatomy and physiology course. In Figure 4.1 the Y-axis displays the number of students from the population that selected each SSI as the most controversial from the list of potential issues. The X-axis displays numerically the fifteen potential SSI. For issue names related to numerical values refer to Figure 4.1.
Analysis of the student responses and IRIS, Issue Response Identity Survey form (APPENDIX B) indicated that marijuana safety (issue #9 from Figure 4.1) was identified most frequently by the sample population as the most controversial issue. The issue of marijuana safety was identified eighteen times by the sample population as most controversial. Eighteen selections as most controversial represents 16% of the student population. Like marijuana safety (issue #9 from Figure 4.1), sexual preference (issue #10 from Figure 4.1) was also selected as highly controversial by the sample population. In discussion with the classroom teacher and consultation of the curriculum that needed to be covered the remainder of the school year it was determined that an SSI unit that utilized marijuana safety to instruct on the respiratory system was preferential to using the SSI of sexual preference to deliver other content knowledge. Following determination of the most controversially perceived issue on the list the students were evaluated to determine which issue they felt was the least controversial (Figure 4.2). In Figure
4.2 the Y-axis displays the number of students from the population that selected each SSI as least controversial. The X-axis displays numerically the 15 potential SSI.

![Bar Chart]

**Figure 4.2 Least Controversial Issue Selections.** For SSI names associated with each Y-axis number refer to table 4.1.

By analyzing student responses and figure 4.2 it is clear that issues 4, fast food legality and 5, gender intelligence differences were selected the most frequently as being the least controversial. After analysis of IRIS responses and further discussion with the classroom instructor the issue of fast food legality, issue #4 from Figure 4.2, was ultimately identified as the least controversial issue. It can be seen from figure 4.2 that the potential issues of fast food legality (issue #4 from Figure 4.2) and intelligence comparisons of genders (issue #5 from Figure 4.2) were each highly selected by the student population as being the least controversial.

However, after discussion with the classroom teacher and analysis of the available curriculum remaining to be taught it was determined that fast food legality as an SSI to deliver instruction and content knowledge on the digestive system was more favored than the SSI selection of
differing intelligence levels between genders to deliver other content knowledge. The sample population identified the issue of fast food safety twenty times as the least controversial issues on the list of issues. Twenty times represents 17% of the population identifying fast food legality as the least controversial issue discussed among the fifteen issues possible.

Following the selection of the SSI it was then possible to define the identity or controversy clusters that would be investigated. The eighteen students whom chose marijuana safety as their most controversial issue would serve as the group of highly controversonally oriented students. The student group labeled highly identified would be defined by their selection of SSI number nine, marijuana safety as the most controversial issue of the potential topics or lessons discussed. The group of twenty students whom chose fast food legality would serve as the low controversially oriented students. After analyzing overall student responses, it was clear that marijuana safety was a much more controversially perceived SSI than fast food legality by the student population. From the pre instruction IRIS scores of perceived controversy, marijuana scored an average of 7.8 out of 10 across the entire sample population where 10 was the most controversial and 1 was the least controversial. Fast food legality scored a 4.2 average ranking of controversy on the same scale for the total sample population. For clarity and simplicity, from this point on in the investigation marijuana safety will be referred to as SSI lesson 1 (or SSI1), and fast food legality will be referred to as SSI lesson #2 (or SSI2), to reflect the order in which they were taught to the students. All students whom did not choose marijuana safety as the most controversial during lesson 1 or fast food legality as least controversial during lesson 2 will be referred to as general class population. The remainder of this chapter will present and address each research question and the data collected that supports each research question respectively.
Research Question 1 and Sub-Question

The questions that guided this investigation dealt with four major factors or aspects of SSI instruction: relative strength of controversial identification, perceived level of controversy, epistemological patterns of reasoning, and understanding of content material. Research Question 1 endeavors to uncover the impact that SSI based instruction has on differing subsets of students that have been identified based on their self-reported levels of controversial perception regarding specific SSIs. The impact of SSI instruction is being investigated in two ways during research question one. One aspect investigated will be, is there a measurable or observable difference between high and low controversy perception students and the second will be how the same differential affects aspects of epistemology and patterns of reasoning.

RQ1. What impact does SSI based instruction have on students that have differential strengths of controversial identification?

RQ1A. What different patterns of epistemological reasoning about SSI exist, if any, among controversy identification subsets of students?

RQ1: Perception of controversy shift over time. To initially investigate RQ1, the phenomenon of controversy perception shift over time of instruction was considered (Figures 4.3, 4.4). This analysis provides insight into how initial perception of controversy persists or changes throughout the course of SSI instruction. This addresses the questions of differential strengths of controversially perceived identification as seen in self reported controversy
perception by investigating how overall controversy ratings shifted pre and post instruction in the entire population. Figure 4.3 and 4.4 do not separate out high and low controversially oriented students from each other or the average students. In figures 4.3 and 4.4 the entire sample population is assessed as to their perception of controversy before and following SSI instruction. Figure 4.3 analyzes controversy perception shift among the sample population during SSI lesson 1, marijuana safety.

<table>
<thead>
<tr>
<th>Class Period</th>
<th>Pre IRIS</th>
<th>Post IRIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.1</td>
<td>6.2</td>
</tr>
<tr>
<td>2</td>
<td>6.4</td>
<td>6.1</td>
</tr>
<tr>
<td>3</td>
<td>7.3</td>
<td>5.9</td>
</tr>
<tr>
<td>4</td>
<td>6.5</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Figure 4.3 SSI marijuana safety pre instruction IRIS controversy rankings compared to post instruction IRIS controversy rankings.
Figure 4.3 speaks to the questions of, does SSI instruction potentially produce a more, less or balanced view of controversy over time of respiratory system SSI instruction. Marijuana safety, SSI1 represented the high controversy SSI during the investigation. From analysis of figure 4.3 it can be seen that in two class periods (2 and 3) the perception of controversy of the higher controversy SSI, marijuana safety, lowered from an average of 6.4 to 6.1 (class period 2) and from 7.3 to 5.9 (class period 3) respectively. Class period 4 had a very slight 0.5 IRIS unit gain in controversy perception form an average of 6.0 to 7.0 and class period 1 had an almost static perception of controversy level with a gain of only 0.1 on the IRIS scale of self reported controversy perception. Overall, the sample population had a slight controversial perception decrease for SSI1, marijuana safety, of 0.3 units on the IRIS scale of self reported controversy perception. This suggests that following SSI instruction, the total population of students perceived the issue of Marijuana Safety as less controversial than they did prior to SSI instruction. However, for this highly controversially perceived SSI issue, there was a slightly mixed modification of controversial perception before and after SSI instruction.

The same analysis was conducted using pre and post iris scores from the entire student sample broken down again by class period for the relatively perceived lower controversially SSI of fast food legality (Figure 4.4).
Figure 4.4 displays data that investigates whether SSI instruction potentially produces a more, less or balanced view of controversy over time during high school SSI instruction. The specific content delivered covered the human digestive system and incorporated the legality of fast food as the SSI. Fast food legality, SSI2, represented the low controversy SSI during the investigation. From analysis of figure 4.4 it can be seen that all three participating class periods exhibited a rather substantial increase in the perceived level of controversy following instruction of the fast food legality SSI lesson. Class period one did not complete the entire SSI2 unit during
this investigation and their data were not used to complete averages. These results suggest that as a total population the students in this study perceived the issue of fast food legality as much more controversial following SSI instruction than they did prior to SSI instruction using fast food legality as a topic for delivering content on the digestive system. The entire sample population displayed a uniform increase in controversial perception. This is different when compared with the controversially perception shift data displayed in the higher controversially perceived SSI of marijuana safety. For the lower controversially perceived SSI of fast food legality, class period two saw a 2.9 IRIS unit increase. Class period three exhibited an increase of 1.5 IRIS units and class period 4 presented an increase of controversy perception of 1.2. IRIS units. Overall the entire sample population exhibited an average increase in controversial perception of 1.87 units on the IRIS self reported controversy scale.

**RQ1: Controversial perception effect on understanding content knowledge during highly controversially perceived SSI.** To investigate what relationship if any may exist between initial perception of controversy and average content knowledge gained during instruction the level of pre instruction IRIS controversy rating for marijuana safety, SSI1, were grouped and compared to content knowledge gain associated with each IRIS controversy level from 1 to 10. Content knowledge scores were generated from pre and post content knowledge exams (Appendixes; K and L). In figure 4.5 the initial pre iris scores of 1 to 10 are displayed according to the median content knowledge gain that a student possessing that pre IRIS controversy rating displayed. It can be seen that students who possessed a higher level of initial or pre instruction controversy perception regarding the SSI of marijuana safety exhibited slightly higher content gains on average during the course of the SSI instruction. Average content
knowledge gain is measured in points gained post – pre instruction exam and listed on the Y-axis. Initial IRIS or Pre instruction IRIS controversy ranking is listed on the X-axis. This relates initial perception of controversy to content gain over the course of SSI instruction. Pre instruction IRIS controversial orientation ranking is measured by student responses on the IRIS Pre instruction instrument. Initial analysis of this group of data was undertaken using mean scores to report trends. Although mean trends did show interesting findings it was necessary to corroborate the average data with median analysis as well.

The statistical implications of basing data analysis on overall class or controversial orientation group was not overlooked during data analysis. It was acknowledged that groupings based on overall class or controversial orientation group may not represent actual statistically relevant findings without account of variance, sample size and existence of extreme outliers within these populations. Therefore, for each of figures 4.5, 4.6, 4.7, 4.8, 4.9 and 4.10, were analyzed using the median scores for each IRIS value within the student population. The analysis adds validity to the results and finding displayed by the average class content knowledge data (mean data not shown). This statistical analysis helps to support the average data analysis findings of the content knowledge data as it relates to IRIS rankings.

For figure 4.5 it can be seen that in the median student data there are peaks of increases content knowledge scores seen at each the 4-5 and 8-9 IRIS controversy levels. After deeper inspection, it can be seen that low n values seen at the IRIS controversy levels of 5 and 6 may be skewing data somewhat. In the case of IRIS level 5 there was only a sample size of 3 and one of two of these specific individuals scored extremely high on their content knowledge exams producing a higher median value. In the case of IRIS level 6 there was only one individual in the sample making median reporting somewhat irrelevant. However, the trend seen in figure 4.5 that
shows higher content knowledge associated with higher level of perceived controversy is supported by both the median and mean score data.

Figure 4.5 Pre instruction, SSI, Marijuana Safety, IRIS controversy perceptions vs. content knowledge gain

As another means of assessing the impact that SSI based instruction has on students possessing differential perceptions of controversy it was important to examine the levels of perceived controversy following SSI instruction in respect to the content gain associated with each level of perceived controversy. To accomplish this analysis the post instruction IRIS controversial orientation perception levels reported were compared to their content gain represented by each level of perceived controversy. This aided in understanding if students’ final perception of controversy following SSI instruction had any relationship to their average content knowledge gain during SSI instruction. As can be seen in figure 4.6 there is a very slight
decrease in the level of average content gain as the post instruction controversy ranking being reported by the students increased. Again this figure represents data from the most controversial SSI unit instructed on, SSI 1, marijuana safety. In Figure 4.6, average content knowledge gain is measured in points gained post – pre instruction exam and listed on the Y-axis. IRIS post instruction controversy ranking is measured by self-reported student responses on the IRIS post instruction instrument. This relates students’ final perception of controversy to content understanding or gain over the course of SSI instruction. Figure 4.6 represents the median score values. The median scores are used again in an attempt to account for variance and sample size.

![Figure 4.6 Post instruction, SSI1, marijuana safety, IRIS controversy perception vs. content knowledge gain](image)

*Figure 4.6 Post instruction, SSI1, marijuana safety, IRIS controversy perception vs. content knowledge gain*
The median score data of figure 4.6 provides evidence for the idea that there is a little to no decrease in content knowledge as student perception of controversy increases post instruction for SSI1. The extreme peak seen at IRIS level one, representing extremely low controversial perception, is cast into doubt by the fact that the sample size of the average and median data consists of only one student. By removing this single, extremely low, value from the data set, a virtually consistent level of average and median content knowledge is seen in relation to post IRIS controversial orientation values.

As a last step in the analysis of the potential relationship that SSI based instruction has on students that have differential strengths of identity in a highly controversial SSI unit, the change in controversy perception over the course of instruction was compared to the content gain for each level of controversy change reported during the SSI unit. Figure 4.7 displays data that represents what relationship a students ability to change their perception of controversy regarding an SSI has to content knowledge gain during SSI instruction incorporating that specific SSI. More simply stated, Figure 4.7 displays the level of content gain associated with individual student’s clusters that display an increased, static or decreased perception of controversy regarding that issue during SSI instruction.

In Figure 4.7, median content knowledge gain is measured in points gained post – pre instruction exam and listed on the Y-axis. Delta IRIS scores were calculated by subtracting initial IRIS or pre instruction IRIS values from post instruction IRIS values. Initial IRIS or Pre instruction IRIS controversy ranking is listed on the X-axis. Figure 4.7 relates students’ initial perception of controversy to content gain over the course of SSI instruction. It can be seen that there are two clear peaks of increased content knowledge gain. The points represented on the ends of the scale represent a greater ability to change perception of controversy. As can be seen
on Figure 4.7 the median content knowledge increases are roughly equal for both a positive and negative change in controversial orientation rating. It further appears that the increase in content understanding is not limited to either an increase or a decrease in students’ controversial perception. Because, there seems to be a relationship between larger increased levels of content knowledge gain displayed during either a rise or fall of controversial perception. Therefore, there is some evidence to suggest that the students’ ability to change their perception of controversy, in either direction, is indicative of larger average content gains when utilizing SSI instruction.

\[ \text{Figure 4.7 Delta IRIS, SSI1, marijuana safety, controversy perception change over time vs. content knowledge gain} \]

The median data of Figure 4.7 points to a larger increase in content knowledge as students’ shows a proclivity to be open to change concerning perceived level of controversy.
Stated differently, it appears that an increased content knowledge gain is attributed to students who report a larger change in controversial perception.

**RQ1: Controversial perception effect on understanding content knowledge in a lower controversially perceived SSI.** The previous three figures (Figures 4.5, 4.6 and 4.7) all related to data associated with the more controversial SSI unit, marijuana safety. To continue the investigation of what impact SSI based instruction has on students who have differential strengths of identity, the lower controversially perceived SSI (SSI 2), Fast food legality was analyzed. Initially, the levels of pre instruction IRIS controversial perception rating were compared to content knowledge gain (Figure 4.8). The associated content knowledge scores for Fast food legality, digestive system, were generated from pre and post digestive system content knowledge exams (Appendixes; M and N). In figure 4.8 the initial pre iris scores of 1 to 10 were displayed according to the content knowledge gain that a student possessing a self reported pre IRIS controversy rating displayed. In figure 4.8 it can be seen that from the student data that a student who reported a higher level of controversial perception regarding this lower controversy SSI exhibited very minimally higher content knowledge gains, on average, during the course of SSI instruction. Content knowledge gain is measured in points gained post–pre instruction exam and listed on the Y-axis. Pre instruction IRIS controversy ranking is measured by student responses on the IRIS Pre instruction instrument. Pre instruction IRIS controversy ranking is listed on the X-axis. This relates initial perception of controversy to content gain over the course of SSI instruction during the low controversy SSI unit and in this case displays a very slight increase in content knowledge gain as perception of controversy is increased.
Figure 4.8 displays median scores associated with each representative pre IRIS level of controversial identification. The data reveal a trend representative of a very slight increase in content gain during the course of SSI instruction for SSI2, fast food legality.

Another means of assessing the impact SSI based instruction has on students who have differential strengths of controversial perception, the post instruction IRIS controversy levels reported were compared to their content gain represented by each level of perceived controversy for the lower controversial perceived SSI, fast food legality. As can be seen by the trend line in figure 4.9 there is a slight increase in the level of content gain as the post instruction controversy ranking being reported by the students increased. This stands in contrast to the higher controversially perceived SSI, marijuana safety (figure 4.7).
For Figure 4.9 median content knowledge gain is measured in points gained post – pre instruction exam and listed on the Y-axis. Delta IRIS controversy ranking is measured by subtracting pre instruction student controversy levels on the IRIS instrument from post instruction iris controversy levels. Delta IRIS controversy ranking is listed on the X-axis. This relates final perception of controversy to content gain over the course of SSI instruction and in this case demonstrates a very slight increase in content knowledge gain associated with increases in controversial perception.

![Figure 4.9 Post instruction, SSI2, fast food legality, IRIS controversy perception vs. content knowledge gain](image)

Lastly, to analyze the potential relationship between content knowledge gained and perception of controversy on a lower controversially ranked SSI unit, the change in controversy
perception over the course of instruction was compared to the content gain by the students after instruction of the fast food legality SSI unit. Figure 4.10 displays what relationship a student’s ability to change their perception of controversy regarding an issue has to content knowledge gain during instruction on that issue.

For figure 4.10, median content knowledge gain is measured in points gained post–pre instruction exam and listed on the Y-axis. Pre instruction IRIS controversy ranking is measured by student responses on the IRIS Pre instruction instrument. Delta IRIS or changes over time of instruction IRIS controversy rankings are listed on the X-axis. As can be seen again (much like in figure 4.7), there appears to be a slight increase in content gain over the course of the unit when a student displays a greater ability to change their mind on the level of controversy perceived regarding the topic. Students who stay static or rigid in their initial positions tended to have slightly less content knowledge gain on average, than did those students who modified their perception of the issue. There is a slight plateau associated with students who reported no change in their initial positions that extends out to +/-2 IRIS units of controversy perception.

The median data of figure 4.10 further points to two peaks of increased content gain as a student tends to migrate toward a greater change in controversial identification. This is supportive and similar to the same findings from SSI1 and the idea that there is an increased tendency to gain content knowledge over the course of an SSI lesson if a student shows a greater ability to change perception of controversy as it relates to a specific issue. The findings further suggest that the controversial nature of the SSI in this case may be less of a factor on content gain than the students’ ability to change perception of controversy.
RQ1: Controversy perception rigidity. To further identify what impact SSI based instruction may have on students that have differential strengths of controversial perception, the level of initial controversy perception was analyzed for how it affects the students’ ability to change perception of controversy. In succinct terms, is a student more or less likely to be resistant or open to change if they hold a high, neutral or low level of controversy perception initially regarding an SSI? Figure 4.11 displays the relationship between a student’s initial perception of controversy and their ability to change perception over the course of SSI instruction.

![Figure 4.10 Delta IRIS, SSI2, fast food legality, controversy perception change following SSI instruction vs. content knowledge gain](image-url)
The SSI topic for this figure was SSI #1, high controversy, Marijuana safety. The Y-axis displays the pre instruction or initial IRIS ranking for the topic while the X-axis displays the relative change in controversy perception (post IRIS rank – pre IRIS rank over time of SSI instruction.) From the data displayed in figure 4.11 it is apparent that a student who enters into a
lesson with an initially high perception of controversy or equally low perception of controversy, is ultimately more likely to change perception of controversy. For either students whom chose 10 or 1 for their initial levels of controversy, there was a 3-unit change (+ or -) of controversy perception following instruction. For students who chose the middle or moderate level of initial controversy (IRIS ranks of approximately 7 – 5), there was only a single unit change on average following instruction in the case of the more controversial SSI of marijuana safety. For students who chose an initially moderate but lower overall perception of controversy (IRIS values 2-4) there was, at most, a 2.29 IRIS unit change in controversy perception change.

Next, the less controversial SSI of fast food legality was assessed for initial perception of controversy and ability to change perception over the course of SSI instruction. This analysis addresses the question of, is a student more or less likely to be resistant or open to change if they hold a high, neutral or low level of controversy perception initially regarding an SSI? The results of this comparison are displayed on figure 4.12.

The Y-axis displays the pre instruction or initial IRIS ranking for the topic while the X-axis displays the relative change in controversy perception (post IRIS rank – pre IRIS rank over time of SSI instruction.) In the case of fast food legality, students who had initially chosen a higher level of controversial perception displayed a -3 unit change in controversy perception, which is consistent with the data from SSI lesson 1, marijuana safety. However, even more extreme, than changes observed during the high controversy SSI of marijuana safety, students who displayed the lowest levels of controversial perception in ranking the SSI fast food legality exhibited an average of +4 change in perception following SSI instruction. The students who initially indicated a moderate rank of controversial perception again displayed perception rigidity as they collectively displayed a -1 to +2 swing in controversy perception for any individual
possessing an initial controversy perception of 7 – 3. All previous analysis and discussion pertained to RQ1. The below segment begins to analyze the data relevant to RQ1A.

Figure 4.12 SSI2, fast food legality, average IRIS deltas grouped by Pre IRIS scores
RQ1A: Potential patterns of reasoning and justifications. To determine the extent that SSI impacts or interacts with epistemological reasoning on differing levels of controversial identification, it was first important to determine if there were epistemological patterns of reasoning and/or justifications of the SSI used in this study that could be detected within students’ responses. To determine possible characteristics or reasoning’s that may be employed by students’ possessing differing strengths of controversial perception during SSI based instruction responses from Appendix C Short Answer Epistemological Metric and Appendix H Short Answer Follow Up Questions were analyzed for emergent taxonomic patterns. The qualitative analysis was performed on the combined data for SSI 1, marijuana safety and SSI 2, fast food legality. The decision to combine the data for SSI 1 and SSI 2 was premised on the fact that post hoc justifications of responses, follow up investigation and scientific questioning was required from both instruments. An inductive analysis of short answers and written justifications from the data from each student produced nine initial taxonomic qualitative categories consisting of: 1) Personal, 2. Scientific, 3. Familial Influence, 4. Emotive -Empathetic, 5. Apathetic, 6. Social Influences, 7. Unsupported Statements (S.W.A.G.), 8. Religion; and. 9) Multiple Scientific View Points. (For an expanded version of these taxonomies and examples of each please refer to Appendix U, Dissertation Data Taxonomic Classifications.) A brief definition and example(s) of each of these taxonomic clusters is found in Table 4.2 below.
Table 4.2 Taxonomic Classifications, Descriptions and Examples.

<table>
<thead>
<tr>
<th>Taxonomy #1</th>
<th>Personal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Characterized by logic or rationale centered on consequences, effects or experiences that are personally relevant and or self-focused.</td>
</tr>
<tr>
<td>Student Example #1</td>
<td>“… an illegal substance like marijuana would be equally harmful and as an athlete I take respiratory health very seriously and would not do anything to harm my respiratory system.”</td>
</tr>
<tr>
<td>Student Example #2</td>
<td>“It doesn’t affect me. I don’t care if it’s legal or not because I could care less, if it doesn’t bother me which it doesn’t if its illegal than I’m neutral. I do not use marijuana and I never will so it doesn’t affect me.” Male1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Taxonomy #2</th>
<th>Scientific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Logic and rationale present is centered around scientific, medical or health related themes.</td>
</tr>
<tr>
<td>Student Example #1</td>
<td>“I like to know that the information I find is true and supported by evidence and not just rumors. Scientific information research provides proof of the safety or dangers of marijuana use. With accurate information I can formulate my opinion more accurately” Female1</td>
</tr>
<tr>
<td>Student Example #2</td>
<td>“Scientific data is my main factor. If the data shows that there is an effect from a cause with no outside disturbances (influences), than one must cause the other.” Male2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Taxonomy #3</th>
<th>Familial Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Justifications and or logic use family members or aspects of family history.</td>
</tr>
<tr>
<td>Student Example #1</td>
<td>Example: “My dad does drug busts and arrests the person that is growing marijuana. Knowing that you can get arrested for even possessing marijuana it has always made me very anti marijuana”. Female 2</td>
</tr>
<tr>
<td>Student Example #2</td>
<td>“My uncle is mentally different after many years of use. Slurred speech, little teeth left, socially insensitive and unaware, lowered total brain power.” Male 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Taxonomy #4</th>
<th>Emotive-Empathetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Emotive or empathetic characteristics are present in responses and justifications or rationale express emotional or empathetic tones.</td>
</tr>
<tr>
<td>Student Example #1</td>
<td>“I believe the effects of marijuana are negative, and even if they don’t necessarily hurt you, you could do something stupid while using it and hurt someone and that would be not only sad but as bad or worse than hurting yourself.” Female 3</td>
</tr>
<tr>
<td>Student Example #2</td>
<td>“The side affects of using marijuana are destroying peoples lives. People can get addicted to it and soon it will consume their lives.” Male 4</td>
</tr>
<tr>
<td>Taxonomy #5</td>
<td>Apathetic</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Responses display patterns of apathy, defeatism or a general sense that the problem, issue or topic is beyond the scope of what is scientific, personally or academically approachable. There is a sense of apathetic detachment from the issue in a manner that suggests there is no use concerning oneself with its discussion or resolution.</td>
</tr>
<tr>
<td><strong>Student Example #1</strong></td>
<td>“People are going to use this drug anyway so know how much they can have in one use might stop abuse” Male 5</td>
</tr>
<tr>
<td><strong>Student Example #2</strong></td>
<td>“How can the government make something natural illegal? It grows naturally and isn’t chemically altered so how bad can it be vs. genetically modified food readily available at practically every intersection?” Female 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Taxonomy #6</th>
<th>Social Influences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Examples or logical decisions are based on at least a portion of personal influences that include friends or non-familial acquaintances.</td>
</tr>
<tr>
<td><strong>Student Example #1</strong></td>
<td>“Friends and peers were my main source in influence. Smoking marijuana isn’t horrible if you practice self-control. Plenty of my friends smoke and they are not brain dead.” Female 5</td>
</tr>
<tr>
<td><strong>Student Example #2</strong></td>
<td>“I know people who smoke on a daily basis and run cross country and get low times on 5K’s.” Male 6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Taxonomy #7</th>
<th>Unsupported Statements (S.W.A.G.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Scientific or quasi-scientific statements are made with little or no justification, evidence or supporting follow up. Statements tend to contain scientific terminology, units or verbiage but little supporting data or evidence.</td>
</tr>
<tr>
<td><strong>Student Example #1</strong></td>
<td>“There have been many studies that have declared marijuana as a natural and excellent medication for many patients, that have problems with prescription drugs that got off due to marijuana. Studies show that marijuana can have benefits to your health in various ways.” Male 7</td>
</tr>
<tr>
<td><strong>Student Example #2</strong></td>
<td>“It lowers IQ and negatively affects ALL OF THE BODY SYSTEMS” Female 5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Taxonomy #8</th>
<th>Religion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Theology or religious ethics, morals or dogmas are presented as an influence factor in negotiating the issue.</td>
</tr>
<tr>
<td><strong>Student Example #1</strong></td>
<td>“My largest influence is religion. My religion says that it is important to have a healthy body and mind and that marijuana goes against that.” Male 8</td>
</tr>
</tbody>
</table>
Table 4.2 (Continued)

<table>
<thead>
<tr>
<th>Taxonomy #9</th>
<th>Multiple Viewpoints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td><em>The student acknowledges that there are more than one side to the issue and identifies points, evidence or scientific arguments that could both support or refute a stance on the issue. Evidence may be presented that both supports their or any position on the issue while both or either agreeing with or disagreeing with evidence in a scientific manner.</em></td>
</tr>
<tr>
<td>Student Example #1</td>
<td>“…There is a general lack of confirmation in the studies. Most studies contradicted each other, Ex. One concluded that marijuana causes learning deficiencies, while another says there was little difference between users and non users.” Female 6</td>
</tr>
<tr>
<td>Student Example #2</td>
<td>“Scientific studies show that it (marijuana) changes your behavior and causes brain damage. Other studies show it helps with glaucoma and MS. Marijuana’s benefits or detrimental affects are what make it healthy or unhealthy in the opinion of the user or researcher. Male 9</td>
</tr>
</tbody>
</table>

**RQ1A: Taxonomic trends among high and low controversial oriented students.** By analyzing the student short answer responses (obtained from instruments found in Appendix C and Appendix D), short answer taxonomic trends and patterns of epistemological reasoning began to emerge revealing interesting aspects within the high and low controversy identified students. There was a higher instance of Personal, Family / Familial Influence and Emotive–Empathetic taxonomies displayed in students who chose to rank the SSI of marijuana safety as the most controversial when they were compared to the remainder of the sample population. (Refer to Table 4.3). Additionally the same group of students whom held this highly controversial orientation to marijuana safety displayed a lower instance of Scientific and Multiple View Points taxonomies when compared to the remainder of the sample population (Refer to figure 4.1).

Table 4.3 displays the observed taxonomic counts for the lower controversy SSI, fast food legality. The students who did not identify fast food legality as the least controversial issue
are represented in the first and fourth columns. The students who selected fast food legality as the least controversial SSI overall are represented as, least controversial issue 4 (LCI4) in columns 2 and 5.

*Table 4.3 Taxonomic Observances for SSI #1 Marijuana Safety Pre-instruction, Post-instruction in both highly controversially oriented students (MCI9) and general class population (Gen. Class).*

<table>
<thead>
<tr>
<th>Taxonomy</th>
<th>Pre instruction Taxonomic Observances</th>
<th>Post instruction Taxonomic Observances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gen. Class</td>
<td>MCI9</td>
</tr>
<tr>
<td>#1 Personal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>#2 Scientific</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientific</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>#3 Familial Influence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Familial Influence</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>#4 Emotive-Empathetic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotive-Empathetic</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>#5 Apathetic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apathetic</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>#6 Social Influence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Influence</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>#7 Unsupported Statements (S.W.A.G.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsupported Statements (S.W.A.G.)</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>#8 Religion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Religion</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>#9 Multiple View Points</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple View Points</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 4.4 Taxonomic Observances for SSI#2 Fast Food Legality Pre-instruction and Post-instruction in both lowly controversially oriented students (LCI4) and general class population (Gen. Class).

<table>
<thead>
<tr>
<th>Taxonomy</th>
<th>Pre instruction Taxonomic Observances</th>
<th>Post instruction Taxonomic Observances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gen. Class</td>
<td>LCI4</td>
</tr>
<tr>
<td>#1 Personal</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>#2 Scientific</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>#3 Familial</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>#4 Emotive-Empathetic</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>#5 Apathetic</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>#6 Social Influence</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>#7 Unsupported Statements (S.W.A.G.)</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>#8 Religion</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>#9 Multiple View Points</td>
<td>6</td>
<td>0</td>
</tr>
</tbody>
</table>

After analysis of taxonomic trends observed within SSI2 and comparison of both SSIs for taxonomic frequencies there is a decrease noted of the taxonomic observances of Personal as well as Emotive -Empathetic. However, when comparing the least controversial SSI with the most controversial SSI there is a large increase in the instances of Social Influence being shown in the lower perceived controversy SSI.
RQ1A: Evaluation and justification trends among high and low controversial oriented students. Additionally, as short answer responses were scored by the panel of scorers for how students evaluate and justify SSI information interesting trends began to emerge. The resulting scores of this analysis are displayed in Table 4.5. It was observed that students whom initially ranked either the SSI of marijuana safety or fast food legality high (pre instruction) were scored as using more evaluation and justification responses that were less scientific in nature. That is, when students were asked to provide additional questions that they would like to know regarding the topics, there was a significant decrease in the numbers of high controversy students who responded with science questions. A larger portion of the non science follow up questions came from the students who self identified as high controversy by their choosing of either marijuana safety or fast food legality as the most controversial issues. Lower relative scores in Table 4.5 represent a lack of scientific logic, reasoning or rationale.

Table 4.5 displays total average score for epistemological instruments Appendix C and Appendix D. Students who did not identify at the relative extreme ends of controversy perception are seen to have a distinct decrease in total average score compared to students whom identified more neutrally with each SSI. Both pre and post instruction average scores are higher for the general class population when compared to either the students who selected marijuana safety as the most controversially perceived issue and for students who selected fast food legality as the least controversial issue.
Table 4.5 Epistemological Construction Scores for Scientific Basis of Reasoning, Rationale and Questioning.

<table>
<thead>
<tr>
<th>SSI Lesson and Student Group</th>
<th>Epistemological metric app. C Pre Instruction score</th>
<th>Epistemological metric app. C Post Instruction score</th>
<th>Change in app. C score</th>
<th>Epistemological metric app. D Pre Instruction score</th>
<th>Epistemological metric app. D Post Instruction score</th>
<th>Change in app. D score</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI #1 Marijuana Safety Non MCI9 Class Average</td>
<td>14.30</td>
<td>17.72</td>
<td>3.42</td>
<td>x</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>SSI #1 Marijuana Safety MCI9 Student Average</td>
<td>11.84</td>
<td>15.63</td>
<td>3.79</td>
<td>X</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>SSI #2 Fast Food Legality Non LCI4 Class Average</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>9.70</td>
<td>14.06</td>
<td>4.36</td>
</tr>
<tr>
<td>SSI #2 Fast Food Legality LCI4 student average</td>
<td>X</td>
<td>x</td>
<td>x</td>
<td>6.59</td>
<td>10.24</td>
<td>3.65</td>
</tr>
</tbody>
</table>
Research Question 2 and Sub-Question

To review, research question two consisted of one overarching question and was further broken down into one sub question. Both questions, 2 and 2A, endeavored to better understand any potential relationship between perception of controversy and content knowledge gain during SSI instruction in a high school anatomy and physiology classroom.

RQ2. What relationship may exist between students’ prioritized degree of controversy in varied SSI contexts and their conceptual understanding of scientific content?

RQ2A. What relationship may exist between perceived controversy level and content knowledge gain during navigation of an SSI at the high school level?

RQ2: Investigating potential relation between conceptual understanding and controversial perception. We will initially explore the results relating to RQ2 and further explore RQ2A later in the text. To initially investigate this question the content knowledge exam scores both pre and post were analyzed by class period for the overall high controversy SSI, unit 1, and the overall low controversy SSI, unit 2 (Figure 4.13). This analysis helped to determine if indeed content knowledge gain was accomplished in each of the two SSI units delivered during this investigation.
In figure 4.13 the Y-axis indicates the average number of points awarded on pre and post content knowledge exams per each participating class period. SSI 1 Pre, blue bar = Pre instruction Marijuana Safety SSI content exam. SSI 1 Post, Red bar = Post instruction Marijuana Safety SSI content exam. SSI 2 Pre, green bar = Pre instruction Fast Food Legality pre instruction content exam. SSI 2 Post, purple bar = Post instruction Fast Food Legality post instruction content exam. X-axis indicates class period. Class period 1 did not participate in SSI 2 Fast Food Legality and therefore had no scores to report. The initially evident finding is that in both the instances of SSI 1, the high controversy SSI, marijuana safety unit and SSI 2, lowest...
RQ2: Effects of content understanding on perception of controversy. To determine if there was any link or association between content knowledge and a student’s proclivity to rank the marijuana safety issue as the most controversial the scores pre, post and change in content knowledge were compared between students who ranked marijuana as the most controversial issue and the other students in the population (Figure 4.14).
Figure 4.14 Highly controversially oriented students (MCI=9) vs. standard classroom students (other) content knowledge pre, post and gain over time of instruction, SSI1 Marijuana Safety.

For Figure 4.14 the Y-axis represents the content knowledge level of each group. The X-axis displays average content knowledge exam times and average change in content following SSI instruction. Delta content average is the change relative to pre and post instruction exam. As can be seen from the figure above there was a slightly higher incoming content knowledge (0.79 points per exam average) associated with the subset of students whom ranked SSI unit 1, marijuana safety as the most controversial. This content knowledge level of the highly controversially oriented subset is again seen in the post-content exam scores (3.27 points per exam average). There is a furthermore a greater gain in content knowledge (2.64 points per exam average) as seen on the post content exam – pre content exam change in content knowledge.
scores when comparing the MCI = 9 students to the general population or “other” students. The increased content knowledge of the higher controversially oriented students is seen as consistent from average pre, post and delta scores.

To examine if these findings were unique to the subset of students in general (MCI9 students) or SSI dependent the exact same group of students that selected marijuana as the most controversial issue were examined for pre, post and change in content knowledge over the course of the second SSI unit delivered, fast food legality (Figure 4.15). The students in the MCI = 9 subset did not orient as a group or as highly controversial toward the issue of fast food legality. Figure 4.16 performs as a type of control to determine if the MCI9 students performed better on all subject matter.

For Figure 4.15 the Y-axis represents the content knowledge level of each group. X-axis displays average content knowledge exam times and change in content following SSI instruction. In the above figure (Figure 4.16) students who selected marijuana safety as their most controversial issue were compared for content knowledge during the fast food safety SSI unit pre, post and change over time of instruction. The results showed that students who selected marijuana safety had a higher pre and post level of content knowledge than did the other students. When comparing delta content knowledge over time instruction the students who did not select marijuana safety as their most controversial issue had a slightly smaller gain in content knowledge (delta content knowledge) on average. When comparing the gain in content scores between the MCI9 students from SSI 1 and SSI 2 it can be seen that even though there is a greater content gain in the MCI 9 students for each SSI, the gain in content is greater in SSI 1, marijuana safety which is the SSI that this group of students (MCI9) related more controversially to. Because in both figures 4.14 and 4.15 there is a greater level of overall content knowledge

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displayed by the MCI9 students there is the possibility that this subset of students, the underlying reasons that they relate more controversially or their interaction with SSI may be related to both the subset of students as well as perception of overall science content understanding.

![Content Knowledge Scores](image)

**Figure 4.15** Highly controversially oriented students (MCI=9) vs. standard classroom students (other) for content knowledge pre, post and gain over time of instruction for SSI2 Fast Food Legality.

<table>
<thead>
<tr>
<th></th>
<th>Pre Content Average</th>
<th>Post Content Average</th>
<th>Δ Content Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCI=9</td>
<td>10.27</td>
<td>17.13</td>
<td>5.42</td>
</tr>
<tr>
<td>Other</td>
<td>6.09</td>
<td>10.72</td>
<td>4.63</td>
</tr>
</tbody>
</table>

Similar to figures 4.14 and 4.15 students who selected fast food legality as the least controversial issue were analyzed for pre, post and change in content knowledge patterns during both the marijuana safety SSI unit (figure 4.16) and the fast food legality unit (figure 4.17). In figure 4.16 students who ranked fast food legality as the least controversially SSI (LCI4) were
compared, on average, to the remainder of the class for pre post and change in content gain relative to the remainder of the class that did not choose fast food legality as the least controversial SSI during the first SSI unit, marijuana safety.

Figure 4.16 displays comparison data of the lowest controversially oriented students (MCI=4) vs. standard classroom students (other) for content knowledge pre, post and gain over time of instruction for SSI 1 Marijuana Safety. In Figure 4.16 the Y-axis represents the content knowledge level of each group. X-axis displays average content knowledge exam times and change in content following SSI instruction. For figure 4.16 the content knowledge and change in content knowledge was compared for students who selected fast food legality as the least controversial SSI against the remainder of the population or “other” for the first SSI unit delivered, marijuana safety. This would give an indication, similar to a control, when compared against figure 4.17 if there was an average greater or lower level of content knowledge in the group that chose fast food legality as their least controversial issue. Figure 4.16 shows that overall the group that chose fast food legality as their least controversial SSI had slightly less incoming knowledge, post knowledge and a lower gain in knowledge for the SSI unit marijuana safety that covered lung and respiratory anatomy.

Figure 4.17 compares the average content knowledge exam performance of the students who selected fast food legality as their least controversial SSI (LCI4) against the remainder of the student population during fast food legality SSI unit. This figure, when used in comparison with figure 4.16 can help to determine if there is a similar lower performance overall for the LCI4 students independent of SSI.
Figure 4.16 Time of instruction and content knowledge gains, SSI1, Marijuana Safety.

For Figure 4.18 the Y-axis represents the content knowledge level of each group. X-axis displays average content knowledge exam times of examination and change in content following SSI instruction. Figure 4.18 displays the content knowledge pre, post and change over time of instruction for students who selected fast food legality as their least controversial SSI during the fast food legality SSI that covered the digestive system. The results of this comparison show that like figure 4.17 covering content knowledge during SSI 1 and the respiratory system students who selected fast food legality as their least controversial SSI had, on average, a slightly lower
level of content knowledge both pre and post instruction during the second SSI unit covering the digestive system. However, interestingly the students who chose fast food legality as their least controversial issue displayed a larger content gain on average when compared to the remainder of the population or “other”. This is a different pattern than was displayed in the same student cluster during the first SSI unit marijuana safety that covered the respiratory system. This may support the idea that students who report variable controversial orientation to specific SSI topics may display a varied pattern of content gain during SSI instruction depending on their specific controversial orientation to the issue.

![Graph showing content knowledge scores over time of instruction](image)

**Figure 4.17** Lowest controversially oriented students (MCI=4) vs. standard classroom students (other) content knowledge pre, post and gain, SSI2 Fast Food Legality.

<table>
<thead>
<tr>
<th></th>
<th>Pre Content Average</th>
<th>Post Content Average</th>
<th>Δ Content Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCI=4</td>
<td>7.58</td>
<td>14.21</td>
<td>6.00</td>
</tr>
<tr>
<td>Other</td>
<td>10.08</td>
<td>16.77</td>
<td>4.86</td>
</tr>
</tbody>
</table>
RQ2A: Relation between perceived controversy level and content knowledge gain.

In addition to the qualitative and trend data reported quantitative Man-Whitney U quantitative analysis was performed on the content gain scores per individual low or high controversially identified student cluster. Man-Whitney U tests were favored due to their more conservative nature and the apparently ordinal characteristics of the data sets. A p value of 0.05 was use as a basis for acceptance or rejection of the null hypothesis that controversial perception would have no affect on content knowledge. Four test were conducted comparing highly controversially oriented students to the remainder of the class in both pre and delta content knowledge for both SSI 1, marijuana safety, as well as, SSI2 fast food legality. For SSI 1, marijuana safety, the highly controversially oriented students were compared for differences in pre content knowledge and change over time content knowledge compared to the remainder of the class. For SSI2, fast food legality, low controversially oriented students were compared for differences in pre content knowledge and change over time content knowledge compared to the remainder of the class. The first comparison examined pertains to SSI1, marijuana safety, pre exam between the two clusters of highly controversially identified students and the remainder of the class.

For SSI1, marijuana safety, pre content examinations the results of Man-Whitney U statistical analysis produced a p-value of 0.547 with an n of 102 total (Table 4.6). The n size included 19 students in the highly controversially identified student group and 83 in the general class population. The median value of the highly controversially identified group was eight while the median of the remainder of the class was 9. The p value of 0.547 does not statistically support that the more controversially identified students preformed better on the SSI1, marijuana safety, pre-instruction content examinations.
Table 4.6 Mann-Whitney U test between student clusters of pre instruction exams for SSI 1 marijuana safety

<table>
<thead>
<tr>
<th>Mann-Whitney Pre Instruction Content Understanding Data SSI 1, Marijuana Safety</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Controversially Oriented Students</td>
<td>n = 19</td>
<td>47.84</td>
</tr>
<tr>
<td>Non Highly Controversially Oriented Students</td>
<td>n = 83</td>
<td>52.34</td>
</tr>
<tr>
<td>p value</td>
<td></td>
<td>0.547</td>
</tr>
</tbody>
</table>

The same finding is not supported when analyzing quantitative data regarding the lower controversially perceived SSI2, fast food legality findings. Students were compared quantitatively for performance on pre-instruction content examinations. For the Man-Whitney U statistical analysis of two divergent controversial oriented student clusters the total sample size was 86.

Table 4.7 Mann-Whitney U statistical analysis of pre instruction exams for SSI2 fast food legality

<table>
<thead>
<tr>
<th>Mann-Whitney Pre Instruction Content Understanding Data SSI 2 Fast Food Legality</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Controversially Oriented Students</td>
<td>n = 19</td>
<td>26.47</td>
</tr>
<tr>
<td>Non Highly Controversially Oriented Students</td>
<td>n = 67</td>
<td>48.33</td>
</tr>
<tr>
<td>p value</td>
<td></td>
<td>0.001</td>
</tr>
</tbody>
</table>

From analysis of Table 4.7 and processing of pre instruction content exam data for both the low controversially oriented subset of students against the remainder of the class population
there is statistical support that the populations are the same against the alternative hypothesis. It can be statistically supported using this metric that there is a relationship between differing performances and controversial orientation clusters during the lower controversially rated SSI of fast food legality.

Table 4.8 analyzes the change in content exam knowledge between pre and post instruction performance on the marijuana safety content exam between the group of highly controversially oriented individuals and the remainder of the class.

**Table 4.8 Mann Whitney U statistical analysis of delta content knowledge SSI1, Marijuana Safety**

<table>
<thead>
<tr>
<th>Mann-Whitney Delta Content Knowledge Data SSI 1, Marijuana Safety</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Highly Controversially Oriented Students</em></td>
<td>n = 18</td>
<td>51.19</td>
</tr>
<tr>
<td><em>Non Highly Controversially Oriented Students</em></td>
<td>n = 59</td>
<td>35.26</td>
</tr>
<tr>
<td><em>p value</em></td>
<td></td>
<td>0.008</td>
</tr>
</tbody>
</table>

In Table 4.8 there is a total sample population of 86 that contains 59 individuals in the general class population and 18 individuals whom chose marijuana safety as the most controversial issue possible and therefore serve as the highly controversially identified subset. The p value of 0.008 represents another finding that can be used to support, statistically, that any differences between the two subsets is quantitatively supported in this case. Therefore it can be stated, based on this finding, that there may be a statistically verified variation in change in content knowledge when comparing change over time scores between highest perceived
controversy student performance and the remainder of the class during a generally high controversy SSI.

Table 4.9 represents the Man-Whitney U analysis for the change in content knowledge over time between the lowly controversially oriented group of students and the remainder of the class in the second lower controversially oriented SSI, fast food legality. The total sample size is 84. The group breakdown consists of 65 individuals in the larger general class population that is not extremely lowly identified with the SSI. There are 19 individuals in the group that represent the lowly identified group of students. These 19 students all selected the SSI of fast food legality as the least controversial issue possible.

**Table 4.9 Mann Whitney U statistical analysis of delta content knowledge SSI 2, fast food legality**

<table>
<thead>
<tr>
<th>Mann-Whitney Delta Content Knowledge Data SSI 2, Fast Food Legality</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Controversially Oriented Students</td>
<td>n = 19</td>
<td>38.42</td>
</tr>
<tr>
<td>Non Highly Controversially Oriented Students</td>
<td>n = 65</td>
<td>43.69</td>
</tr>
<tr>
<td>p value</td>
<td>0.400</td>
<td></td>
</tr>
</tbody>
</table>

The p value represented in table 4.9 of 0.400 and, therefore, there is not enough statistical support to not reject the idea that the differences in content exam knowledge scores over time of instruction can be attributed to anything statistically or quantitatively significant. There does not seem to be statistical support for any content knowledge performance difference over time during a relatively lower perceived SSI between extremely lowly perceived controversial students and the remainder of the class.
Research Question 3

To review research question three consisted of one overarching question and was not further broken down into sub questions. Research question 3 endeavored to better understand potential relationships between conceptual understanding of scientific content, epistemological patterns of reasoning and any relationship that these factors may have with perception of controversy.

RQ3. What relation may exist between conceptual understanding of scientific content and epistemological patterns of reasoning among differing strengths of identification in self-identified controversy perception subsets of students?

To better understand the relationship that may exist between perceived controversy level and epistemological navigation of an SSI at the high school level Man-Whitney U tests were performed to compare the change in epistemological metric scores between the two clusters in each SSI unit delivered. To review, SSI 1, marijuana safety consisted of two sub-clusters. The clusters were highly controversially identified students (MCI9 students) and the remainder of the student population or students who selected the most controversial issue to be marijuana safety and the other members of the student population. SSI2, fast food legality, also had two sub-clusters. The clusters were LCI4 students and the remainder of the student population or students who selected the least controversial issue to be fast food legality and the other members of the student population. In the following figures the quantitative results of the non-parametric, more conservative Man-Whitney U tests are displayed. Man-Whitney U tests were favored due to their
more conservative nature and the decidedly ordinal characteristics of the epistemological metric data sets.

**RQ3: Effect of controversial perception on knowledge construction.** Table 4.10 represents Man-Whitney U statistical analysis data of the marijuana safety SSI unit. The data displayed represents performance between the two student clusters on the short answer epistemological metric, appendix C. The results specifically compare epistemological score change over time data between each of the two clusters of students, highly controversially identified and the remainder of the student population.

*Table 4.10 Mann Whitney U statistical analysis of epistemological metric Appendix C, SSI1, marijuana safety*

<table>
<thead>
<tr>
<th>Mann-Whitney Epistemological Metric Data Analysis, SSI 1, Marijuana Safety</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Controversially Oriented Students</td>
<td>n = 19</td>
<td>48.84</td>
</tr>
<tr>
<td>Non Highly Controversially Oriented Students</td>
<td>n = 85</td>
<td>53.32</td>
</tr>
<tr>
<td>p-value</td>
<td></td>
<td>0.556</td>
</tr>
</tbody>
</table>

Table 4.10 displays a total sample size of 104 students. 19 of these students represent the highly controversially oriented or identified students and 85 represent the remainder of the class population group. The p value of 0.556 represents no statistical significance for the claim that differences in epistemological metric change over time scores can be statistically recognized and relevant between the two clusters. This finding suggests that there
is no significant contribution from controversial orientation between clusters of differing controversial identities or identification concerning epistemological navigation when progressing through a highly controversial SSI.

Table 4.11 makes a similar comparison as Table 4.10. In Table 4.11 Mann-Whitney U statistical analysis is undertaken on the short answer epistemological data of SSI2, fast food legality. The short answer epistemological scores are representative of student performance on Appendix D. In this lower controversy SSI there are two student clusters represented, lowly controversially identified and the remainder of the class population.

**Table 4.11 Mann Whitney U statistical analysis of epistemological metric Appendix D, SSI2, fast food legality**

<table>
<thead>
<tr>
<th><strong>Mann-Whitney Epistemological Metric Data Analysis SSI 2, Fast Food Legality</strong></th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Highly Controversially Oriented Students</em></td>
<td>n = 16</td>
<td>34.04</td>
</tr>
<tr>
<td><em>Non Highly Controversially Oriented Students</em></td>
<td>n = 65</td>
<td>42.73</td>
</tr>
<tr>
<td><em>p value</em></td>
<td></td>
<td>0.176</td>
</tr>
</tbody>
</table>

Table 4.11 represents Man-Whitney U data for SSI2 and consists of 81 total students in the sample population. That total incudes 65 members of the student group that did not identify fast food legality as the least controversial issue. There are also 16 students displayed that represent the extremely lowly controversially identified students. The 65 students represent the remainder of the class or general population. The p value of 0.176 does not allow for statistical significant conclusions regarding the relatedness of the data. Therefore the differing
epistemological metric results between sub-clusters in this lower identified SSI cannot be directly quantitatively supported via this statistical analysis.

Figure 4.19 makes a comparison of students who ranked Marijuana Safety as the most controversial (MCI=9) and all students who ranked Marijuana Safety as something other than the most controversial issue (other) for performance on Appendix C pre and post instruction as well as change over time instruction during the marijuana safety unit.

![Graph showing comparison of epistemological performance and perception of controversy, SSI1, Marijuana Safety](image)

**Table 4.18** Comparison of epistemological performance and perception of controversy, SSI1, Marijuana Safety

<table>
<thead>
<tr>
<th></th>
<th>SSI 1</th>
<th>Pre C</th>
<th>Post C</th>
<th>Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
<td>14.30</td>
<td>17.72</td>
<td>3.42</td>
<td></td>
</tr>
<tr>
<td>MCI=9</td>
<td>11.84</td>
<td>15.63</td>
<td>3.79</td>
<td></td>
</tr>
</tbody>
</table>

It can be seen that there is a slightly better average performance on the short answer epistemological metric instrument (Appendix C) both pre and post instruction by the students who did not react as controversially or rank marijuana safety as the most controversial issue from
the list of controversial issues. However, there was a slightly higher increase in performance seen in the students who did orient the most controversially to the issue of marijuana safety (MCI9 students).

Figure 4.20 acts as somewhat of a comparison control data set to figure 4.19. In figure 4.19 students who selected marijuana safety as the most controversial issue were compared against the remainder of the student population for average performance on the short answer epistemological metric, Appendix C, that was given pre and post-instruction during the marijuana safety unit. To ensure that the decreased performance on the epistemological metric given during the marijuana safety unit was not due the subset of students and more likely due to their orientation to the unit or perception of controversy regarding the SSI these same students were compared for how they performed on the second unrelated to marijuana safety epistemological metric (Appendix D) that was given pre and post-instruction during the fast food legality unit.

Figure 4.20 compares students who ranked marijuana safety as the most controversial issue to the remainder of the class in short answer epistemological instrument scores. For Figure 4.20 the red bar represents students who ranked marijuana safety as the most controversial issue, a blue bar represents the remainder of the class. Interestingly enough in figure 4.20 you see a reverse result of figure 4.19. What is displayed is the opposite performance by the same group of students on a similar epistemological metric instrument. In figure 4.19 the students who selected marijuana safety as the most controversial (MCI9) performed less well on the epistemological metric Appendix that related to the marijuana safety unit than did the other or remainder of the class. However, when looking at the same group of students (MCI9) and their performance on the second epistemological metric, Appendix H, which related to the fast food legality SSI the
same group of students performed better on both the pre and post-instruction instrument. Therefore, there may at least be some link between perception of controversy related to an issue and epistemological construction associated with thinking about, questioning and discussing that issue.

![Graph](image)

**Figure 4.19** Highly controversially oriented SSI1 students (MCI=9) vs. standard students (other), Appendix D pre and post instruction as well as change over time instruction during SSI2, fast food safety unit.

Figure 4.21 displays the results of the pre, post and change in epistemological score for students on the Appendix H instrument that relates to the SSI unit, fast food legality. LCI4 students are the students who selected fast food legality as the least controversial issue of the listed possibilities (Figure 4.1). The “other” students refer to the remainder of the class or any student who did not select the issue of fast food legality as the least controversial issue on the list (Figure 4.1).
Figure 4.20 Low controversially oriented students SSI2 (LCI=4) vs. standard student (other) for performance on Appendix H pre and post instruction as well as change over time instruction during SSI2, Fast Food Legality unit.

Figure 4.21 shows that the students who selected fast food legality as the least controversial issue performed less well on each the pre post and change over time aspects of the epistemological metric. The “other” or remainder of the class population who did not choose fast food legality as the least controversial issue on performed better in each aspect of epistemological metric, Appendix H, measurement.

Figure 4.21 again serves as a type of regulator to ensure that the performance of the students in figure 4.20 is not the result solely of the sample of students identified as choosing the issue of fast food legality as the least controversial issue and at least potentially influenced by the perception of controversy. In this case the analysis is to determine if the performance on the
epistemological metric, Appendix H, that relates answers to the fast food legality unit in figure 4.20 is due to the sample of students or the perception of lack of controversy with an issue.

![Graph showing pre, post, change scores of Appendix C Short Answer Epistemological Instrument](image)

<table>
<thead>
<tr>
<th></th>
<th>Pre instruction C</th>
<th>Post instruction C</th>
<th>Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI 1</td>
<td>13.82</td>
<td>17.69</td>
<td>3.88</td>
</tr>
<tr>
<td>Other</td>
<td>14.10</td>
<td>15.95</td>
<td>1.86</td>
</tr>
</tbody>
</table>

*Figure 4.21* Low controversially oriented students SSI2 (LCI=4) vs. standard student (other) for performance on Appendix H pre and post instruction as well as change over time instruction during SSI1, Marijuana Safety SSI unit.

In figure 4.22 we see a similar pattern of average epistemological score as was seen in figure 4.20. Therefore it is less conclusive to determine if the performance is due to sample students or their perception of lack of controversy with the issue of fast food legality. At least it is valid to say that the perception of extremely low controversy may not be as potent of a factor as it affects epistemology, reasoning and follow up discussion as a highly controversial SSI such as marijuana safety is.
RQ3: Potential relation between perception of controversy and justifications of answers. To investigate the way in which students frame justifications and understand science content in SSI contexts that differ in controversial perception appendix C and H were compared versus pre IRIS rankings of each SSI. This analysis investigates any potential relationships between perception of controversy and how a student understands and justifies answers for their understanding regarding each SSI. Initially SSI 1, marijuana safety is analyzed per student performance on short answer epistemological instrument Appendix C (Figure 4.23). Figure 4.23 examines a student’s pre-instruction IRIS or pre-IRIS rank compared to how they scored on the Appendix C instrument.

In figure 4.23 the Y-axis = Pre instruction IRIS rankings. The X-axis = pre instruction appendix c epistemological metric scores. For figure 4.23 it can be seen that there is a very slight trend of decreasing score on appendix C as IRIS rank decreases from 10 – 1. Overall, there is very little relationship between any IRIS ranking or trend in ranking and appendix C scores. The highest appendix C score average was for the students who ranked marijuana safety as a 2 on the IRIS scale. The lowest appendix C score average was for students who ranked marijuana safety as a 10 on the IRIS scale. What this suggests is that if there is any relationship between controversial perception of and SSI and epistemological navigation of the issue there is no clear cut finding from analysis of appendix C and H of this investigation when compared to high or low controversially oriented students.
Figure 4.22 Comparison of Pre IRIS ranks and total points on Pre Appendix C short answer epistemological instrument.

Figure 4.24 compares pre IRIS ranks with the average appendix post instruction score that is associated with each IRIS rank.
In Figure 4.24 the Y-axis = Pre instruction IRIS ranking scores. The X-axis = post instruction appendix C epistemological metric scores. For figure 4.24 it can be seen that there is an increased appendix C score associated with a higher Pre instruction IRIS ranking. This is in contrast to figure 4.23 where there was little to no correlation between pre instruction IRIS score and pre instruction appendix C score. For figure 4.24 the highest average appendix C score was seen in students who ranked the issue of marijuana safety as 10 in the IRIS scale. The lowest
average appendix C score was associated with the students who ranked the issue of marijuana safety a 1 on the IRIS scale.

![Graph showing the comparison of Pre IRIS ranks and Pre Total Appendix H short answer epistemological instrument scores.](image)

<table>
<thead>
<tr>
<th>Average of Pre Total Score</th>
<th>Pre IRIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.00</td>
<td>1</td>
</tr>
<tr>
<td>8.50</td>
<td>2</td>
</tr>
<tr>
<td>8.89</td>
<td>3</td>
</tr>
<tr>
<td>10.55</td>
<td>4</td>
</tr>
<tr>
<td>9.76</td>
<td>5</td>
</tr>
<tr>
<td>11.11</td>
<td>6</td>
</tr>
<tr>
<td>11.33</td>
<td>7</td>
</tr>
<tr>
<td>6.86</td>
<td>8</td>
</tr>
<tr>
<td>6.25</td>
<td>9</td>
</tr>
<tr>
<td>4.00</td>
<td>10</td>
</tr>
</tbody>
</table>

Figure 4.24 Comparison of Pre IRIS ranks and Pre Total Appendix H short answer epistemological instrument scores.

Figures 4.25 and 4.26 compare pre iris rankings with pre and post appendix H scores for the second, low controversy SSI unit, fast food legality. Appendix H was again the counterpart to appendix C for the first lesson. Appendix H was designed to deliver the same information in a
new format for the students so that they were not biased or conditioned after progressing through the first SSI unit in this investigation.

In Figure 4.25 the Y-axis = IRIS ranking. The X-axis = Pre instruction appendix H average total scores grouped per IRIS scores. Figure 4.25 displays a decreased performance on the appendix H instrument as the average pre IRIS rank decreases. The highest score average for appendix H was 11.33 for students who ranked the SSI of fast food legality a 7 on the IRIS scale. The lowest associated average appendix H scores of 4.0 were associated with students who rated fast food legality as a 10 on the IRIS scale. This suggests that for the lower controversially perceived SSI of fast food legality the relatively lower one’s perception is regarding the controversial nature of the issue the relatively worse they performed on average during the epistemological metric instruments.

Figure 4.26 displays the result of analysis between the pre IRIS ranks for students during the fast food legality SSI and their associated post instruction appendix H total score averages as grouped by IRSI ranks.

In Figure 4.26 the Y-axis = IRIS ranking. The X-axis = post instruction appendix H average total scores grouped per IRIS scores. Figure 4.26 post instruction appendix H scores compared to pre IRIS ranks displays a similar relationship to figure 4.25 that compares pre IRIS ranks to pre appendix H scores. There is an increased performance recorded on the appendix H instrument as students IRIS ranks of perceived controversy decreased. The highest recorded average appendix H scores are attributed to the students who ranked the issue of fast food legality as a 7 on the IRIS scale. The lowest average appendix H scores are attributed to the students who ranked the issue of fast food legality as a 10 on the IRIS scale. However, there is an
overall trend that as the IRIS rank decreases the total average score of the appendix H instrument increases.

Figure 4.25 Comparison of Pre IRIS ranks and post instruction total Appendix H short answer epistemological instrument scores.
Summary

The data produced in this study supported the notion that the perceptions of controversy and individual controversial identification considerations were important for high school science class decision-making, content knowledge acquisition and aspects of epistemological construction. However, these identity considerations could not be necessarily isolated as independent components of either content knowledge gain or epistemology. Rather than subscribing to a model of content knowledge gain or epistemology that delineates perception of controversy and other forms of student identity these data were more consistent with a model in which controversy perception and aspects of individual identity are integrated within and throughout the SSI content knowledge gain and SSI epistemological process. Students displayed several modes of controversy perception and controversial identification composition. Participants frequently relied on combinations of these identity forming characteristics and influences as they worked to navigate, resolve and gain knowledge from individual socioscientific issue scenarios.

The extent to which perception of controversy and ultimately controversial identity influence content gain and epistemology was empirically difficult while theoretically important and relevant. The trends, patterns and emerging taxonomic groupings can continue to be explored and defined.

The findings suggest possible linkages for students who possessed a strong controversial identity orientation to specific patterns of reasoning, content knowledge acquisition or predictable aspects of epistemological justification. However, trends from both within high and
low controversy clusters and between clusters did emerge that suggested patterns of both content knowledge gain and aspects of epistemological construction.

The two clusters, perceived controversy level before and after instruction, did differ in terms of taxonomic classification frequencies as well as controversial perception reporting. Although levels of controversy perception as measured by the Issue Response Identity Survey (IRIS) was the primary means of defining the two clusters, there may be other characteristics that systematically differed between the clusters. However, both qualitative and quantitative evidence suggested that controversial identification contributes to the differences displayed in the patterns of reasoning and their justification. Furthermore, this investigation suggests that the level of controversial perception associated with a specific SSI is possibly contributory to content knowledge gain during SSI instruction.

Notable Findings and Results Overview by Research Question:

RQ1 –

- During a higher controversially perceived SSI topic controversial perception remains high and non-uniform amongst a student population following instruction. Figure 4.3
- During a lower controversially perceived SSI topic controversial perception increases uniformly a crossed the sample population following instruction. Figure 4.4
- Less content knowledge gain is associated with students whom display a greater amount of controversial rigidity pre vs. post SSI instruction. Figures 4.5 – 4.10

- 9 qualitatively identified taxonomic patterns of reasoning were identified in the short answer responses supporting convergent or uniformity in how a student justifies and supports SSI reasoning. Table 4.2

- Patterns emerged between controversial perception levels and epistemological construction when comparing justification and taxonomic trends between the high or low controversial perception students. Table 4.3

RQ2 –

- Learning did occur in each instance among all groups of controversial orientation overall throughout the investigation. Figure 4.13

- There were no clear associations identified between controversial perception and pre post or change over time increases of content knowledge. Figures 4.14 – 4.18

- Statistical analysis did not support any relationship between pre instruction content knowledge and controversial identity in a highly controversially perceived SSI. Table 4.6

- Statistical analysis did support a relationship between pre instruction content knowledge and controversial identity in a lower controversially perceived SSI. Table 4.7

- Statistical analysis did support a relationship between controversial perception and gain in content knowledge in a highly controversially perceived SSI. Table 4.8
• Statistical analysis did not support a relationship between controversial perception and gain in content knowledge in a lower controversially perceived SSI. Table 4.9

RQ3 -

• There were no apparent epistemological trends associated with controversial perception as seen on the epistemological metric for either a highly perceived SSI or lower perceived SSI pre or post instruction. Figures 4.19 – 4.22

• When comparing a highly controversially perceived SSI and a lower controversially perceived SSI there was a relationship apparent in the way student justifies a highly controversial SSI response following instruction as well as in a lower controversially perceived SSI pre and post instruction. Figure 4.23 – 4.26
CHAPTER FIVE: DISCUSSION

Social, Moral and Cultural Aspects of Student Controversial Identification and Socioscientific Issues

According to Zeidler (2013), and evidenced by the decade long undertaking of the United Nations Educational Scientific and Cultural Organization (UNESCO), it is important for science educators to integrate principles, values, and practices that promote world sustainability and prudent development into teaching and learning, in a sense rethinking all conventional aspects of teaching and learning (UNESCO, 2012). This effort and philosophy is not only important or noteworthy for this specific investigation but more broadly for SSI education in general. Central to the themes proposed in the UNESCO resolution and stated by Zeidler are an emphasis on curricula and teaching practices that promote values-based learning, interdisciplinary and holistic approaches (in contrast to only subject-specific learning), and emphasize critical reasoning over memorizing. This mode of teaching and instructional practice is seen in well-delivered SSI instruction and therefore SSI may prove to be a critical component to the rethinking of conventional science education. This effort and the continued evolution of improved SSI surely cannot be accomplished without a better understanding of individualized aspects or characteristics of a student’s decision-making and epistemological processes such as morality, ethics, justice, and controversy perception during SSI navigation. The UNESCO effort additionally encourages the use of multiple instruction methods that include debate and
participatory decision-making (UNESCO 2012). Student participation in discussion, discourse, debate, participatory decision-making aided by evidence, input, and personal identity are critical aspects of SSI navigation. This entire intergovernmental effort justifies a better understanding of specific student identity aspects that influence perception of controversy and how controversial perception affects learning. The core of these perceptions and controversial identifications must at least include aspects of justice, ethics, and morality. All of these items are present during SSI instruction.

Science educators, for some time, have suggested that socioscientific issues necessarily involve moral considerations (Pedretti, 1999; Zeidler & Keefer, 2003; Zeidler et. al., 2002). In fact, it has been argued that the explicit inclusion of morality is a distinguishing characteristic of socioscientific issues instruction (Zeidler et al., 2002). There is no arguing that morality and potentially controversy perception can undoubtedly be a very malleable and / or individualistic characteristic. Previous empirical work with elementary aged individuals has supported the notion that decision-makers generally consider socioscientific issues as involving morality (Pedretti, 1999). Specific to the age group utilized during this investigation, Fleming (1986) documented morality in decision-making displayed by high school students in response to issues related to nuclear power and genetic engineering. Zeidler and Shafer (1984) reported the moral implications of reasoning regarding environmental issues among college students. To complete the span of ages, Bell and Lederman (2003) confirmed the significance of morality in the decisions made by adults in response to a variety of socioscientific issues including dilemmas involving biotechnology, medical research and the environment. Hobson (2006), Saunders and Rennie (2011), Wu and Tsai (2010), and Zeidler (in Press) have highlighted the central claim that SSI by design accesses personal values, emotions, moral-ethical principles, and matters of
social importance as a matter of definition. Zeidler has stated that, “Just as scientific literacy serves as the overarching concept connecting SSI to science education, a virtue ethic account of morality provides the overarching concept in which the practice of SSI is realized” (Zeidler, In Press, p. 5). It is then apparent that when utilizing an SSI framework, student justifications of moral actions tend to result from classroom discussion and SSI argumentation accentuated by different values and identity types present in the student population (Zeidler, 2013). These values, morals, and ethics that make up the individual components of controversial identity and / or controversial perception may play a larger role in SSI content gain and justification than previously attributed. Many if not all of these studies support the contribution or influence that individual student identification with an issue in general or group identification with a particular SSI may play an epistemological or SSI reasoning role during the navigation of SSI. This is shown in the personal or societal value, ethical, moral, intimately personal derivation of logic, rationale, and justification when navigating an SSI. Each unique taxonomy or pattern of epistemological response must at least be derived from individual student identity, student group, or sub group and most certainly contains aspects and influences that constitute their individuality (or in the potential case of creed, race, ethnicity, or social grouping, their individual societal group). From this work it is apparent that an understanding of individual, moral, ethical, and controversial aspects of a student or student population make-up contribute on some level to potentially enhanced content gain and reasoning during SSI instruction. The results of this present study substantiate these previous findings. High school students recognized the moral, ethical, and inherently controversial nature of socioscientific issues in different manners somewhat dependent on their varied perception of controversy as they negotiated scenarios involving marijuana safety and fast food legality.
The primary purpose of this study was to better understand the impact SSI based instruction may have on students of varied controversial identities and examine the ways in which we understand SSI based science epistemological construction in light of students’ perceived level of controversy regarding an SSI topic. Throughout the course of this investigation aspects of controversy identification appear to have played a role in both epistemological navigation and content gain, revealing how the context of the SSI and its malleable controversial perception is integral to the decision maker’s negotiation of the moral and ethical issues that define SSI. In terms of the applicability of this conclusion to science education, it suggests that science educators who chose to use SSI pedagogical techniques need to maintain a critical awareness of their students’ controversial identifications and perceptions of specific issue controversy. Educators should use their students’ controversial orientation, with respect to the particular SSI at hand, to help determine the appropriateness of issues to be incorporated into instruction.

This opening section served to revisit the social and moral aspects of SSI that were examined in relation to controversy perception. Throughout the remainder of this section, the data and results will be examined against the literature base that supports this work. Additionally, new research and insight gained during the course of the investigation will be addressed and discussed where relevant. Accordingly, the following four broad issues are discussed: 1) Controversial Identity Group Culture, Group Influences, and SSI Argumentation and Discourse; 2) Content Knowledge and Perception of Controversy; 3) Taxonomic Patterns, Aspects of Epistemology, and Perception of Controversy, and; 4) Controversy Perception, Identity, and SSI Navigation. These themes are clustered together because of the interconnections among sub-
topics. Finally, study limitations, future recommendations, and an overall summary are presented.

**Controversial Identity Group Culture, Group Influences, and SSI Argumentation and Discourse**

As an educator or researcher, one of the more appealing aspects of the SSI instructional model is that it serves not only as a framework in which content can be delivered, but also acts as a catalyst for various forms of epistemological beliefs. There is relevant recent support that when examining differing identity subsets of students (controversy group or otherwise) there would be differential reasoning patterns or trends observed. Liu, Lin, and Tsai (2011) recently investigated the assumption of relationships between scientific epistemological views (SEV) and how students tend to reason while making decisions regarding SSI. The results of this work presented categories of preferred reasoning modes that were dependent of identity group. The patterns of reasoning included: ecological, ethical-ascetic, scientific-technological, and social economic perspectives. As in this current work, the researchers found that there were statistically supported reasoning modes present between subgroupings of students. It was not claimed that these controversial perception subsets or controversy groupings constitute an established culture or defined identity; however, there is at least support that the groupings based on several student sub cultures or categorizations display biased or trend-like patterns of reasoning, justification, and SSI navigation that may be comparable to controversy groups and subgroups.

Additionally, the idea of context specific reasoning has been explored by King and Kirschner. The data reveals that students do not simply advance their epistemological reasoning
uniformly across all contexts (King & Kirschner, 1994, 2002, 2004). In one contextualized case (for example, chemical additives in food) students may not make advances to higher levels of reasoning in the area of religion or science. This example demonstrates the clear effect of deeply entrenched core beliefs on student’s evaluation of evidence and the highly contextualized nature of SSI reasoning. This contextual nature of SSI reasoning may play a divergent role during varying controversy groups SSI navigation. This phenomenon may indeed be present within differing perception controversy grouping of students.

While it was not the focus of this study to examine controversy group influences or interactions during SSI instruction, there were some findings worth noting. During observation and note taking it was noted that students who ranked the issue of either marijuana safety or fast food legality as lower controversially perceived exhibited a much greater observed instance of apathy or agreeability when it came to SSI discourse and debate. The following statements were attributed to students who ranked either SSI as lower controversially perceived: “I don’t care. I didn’t even read all of this. This was my lowest ranked controversy issue”; “This is stupid. Why would you think its controversial”; and, “I could care less about this one, I just read enough to get the answers.” Where in the observations attributed to higher perceived controversially grouped students the overheard verbal statements were strikingly different. Some examples include: “You would care about this if you had read this (followed by a reference)” ; “I looked up stuff on another website (followed by evidence). You don’t care about this because you don’t understand”; and, “Are you crazy? This issue made me the most mad. You don’t care because you don’t understand (followed by facts, data and evidence).” As stated previously, it was not the focus of this study to examine controversy group interactions and effects of student controversial orientation or group affiliation with discourse. However, it was noted that a student’s perception
of controversy at least qualitatively was observed to influence discourse, the style of argumentation, and definitely the strength of argumentative nature in general. It was noted by this researcher that group interaction both within similar controversy groups, between controversy sub groups, and intra controversy sub groups would be a worthwhile future study and may shed light on content knowledge gain, epistemological construction, and SSI navigation in a heterogeneously divided class controversially identified student population.

**Content Knowledge and Perception of Controversy**

This study produced statistical evidence to suggest that individuals with distinct levels of controversial orientation to a socioscientific issue produced an impactful effect on content knowledge acquisition during SSI instruction in two instances. In the case of the higher controversially perceived SSI, marijuana safety, it was shown that there was a statistical significance observed between students who perceived the issue as the most controversial and the remainder of the class (Table 4.8). Additionally, it was shown that when analyzing students' pre content exam knowledge there was a statistically significant supported difference regarding incoming knowledge between students who selected the issue of fast food legality as the least controversial vs. the remainder of the class (Table 4.7). Moreover, there was some support for the claim that students possessing differing levels of content knowledge perceive, justify, and informally reason in different manners when analyzing taxonomic data and short answer responses. The findings suggest that employing more or less controversial socioscientific issues during SSI instruction will likely lead to changes in content knowledge gain and may also be evidenced by navigation and reasoning variations among the sample population. These results
are seen as being at least partially specific SSI topic and perception of controversy dependent. These findings are somewhat perpendicular to research into content knowledge, knowledge transfer, and SSI reasoning where no statistical quantitative or qualitative relationship among content knowledge and specifically moral reasoning was reported (Sadler & Donnelly, 2006). However, there are previous examples of research that promote an observed difference in content knowledge and reasoning about SSI in other cases (Sadler, & Zeidler, 2004; Klosterman, & Sadler 2010).

Quite extraordinarily there was also a suggestion that students who are capable of a greater perception of controversy change during SSI instruction display more content gain during SSI instruction than comparative students who are more stagnant in their controversial perception level. Figures 4.7 and 4.10 suggest that students who display a larger increase or decrease of controversial perception following SSI instruction also display a higher level of content gain. This phenomenon is seen more distinctly during the higher perceived SSI of marijuana safety in Figure 4.7. However, there is evidence that this notion holds true in the overall lower controversially perceived SSI of fast food legality as well (Figure 4.10). This may be explained in that students access or rely on patterns of reasoning, values, morals, ethics, and decision-making during SSI navigation that are patterned, cross cultural, and reliably reportable during analysis of short answers and student work (Zeidler, 2013).

**Taxonomic Patterns, Aspects of Epistemology, and Perception of Controversy**

The mixed method approach employed during this investigation provided a broad swath of data and feedback for analysis. One such data stream was a wealth of short answer and follow-
up student response data. These responses were read, scored, and analyzed for taxonomic patterns of reasoning and ultimately represented by Table 4.2, as well as Tables 4.3, 4.4, and 4.5. The inductive analysis of short answer and written justifications uncovered nine taxonomic groups of answer configurations that emerged from the student data. The presence of the nine defined, apparent, and repeated taxonomies supports the notion that there are patterned responses, reasoning, and logic applied to SSI navigation. This finding echoes what was seen in the cross cultural work put forth by Zeidler (2013) where patterned taxonomies were displayed cross culturally amongst students navigating a distributive justice SSI. Furthermore, this investigation suggests that this patterning may be influenced by the controversial orientation to a particular issue by a specific student. It was observed that in the higher controversially perceived SSI of marijuana safety there was a higher instance of personal / egocentric, family / family history, and emotive / empathetic taxonomies by the student respondents than when compared to the lower perceived SSI of fast food legality. However, within the highly perceived controversial SSI of marijuana safety there was a lower observance of the taxonomies of medical / health / science, as well as a lower reporting of recognition of multiple scientific points of view. Concerning the lower perceived controversial SSI of fast food legality, there was an increase of the taxonomies of personal / egocentric as well as emotive / empathetic when compared to the more highly perceived SSI. Contrarily, there was a much higher instance of the taxonomies of friends / personal influence being reported in the generally lower perceived controversially SSI when compared to the more highly perceived SSI. The evidence of taxonomic increase or decreased frequency dependent on or related to perceived level of controversy in and of itself at least lends itself to the notion that there are aspects of controversial identities active when undergoing informal SSI reasoning and during navigation of SSI lessons. This phenomenon
suggests a more critical look at how controversy, controversial perception, and student controversy orientation interact during navigation of SSI lessons.

**Controversy Perception, Identity, and SSI Navigation**

While it may be expected that similarities and variances would occur among students exhibiting differing perceptions of controversy toward a specific SSI topic, a closer examination of the data reveals interesting findings about the relative emphasis placed on certain patterns of epistemological reasoning, justifications, and prioritization of scientific evidence in light of controversial perception. In many ways these findings show a degree of epistemological similarity among the student population comparable to what has been suggested in recent research (Zeidler, 2012). In reviewing Research Question 1 for example, inductively deriving and then examining the qualitative taxonomies of SSI patterns of reasoning and justification (Table 4.2), it can be seen that there is a unity of common themes across the four class periods. Students from periods 1, 2, 3, and 4 displayed a striking commonality of taxonomic reoccurrence when responding to the SSIs. The nine major taxonomic categories consisting of: (1) Personal; (2) Scientific; (3) Familial Influence; (4) Emotive-Empathetic; (5) Apathetic; (6) Social Influences; (7) Unsupported Statements (S.W.A.G.); (8) Religion; and (9) Multiple Viewpoints were all well represented in each of the four class periods. Moreover, there were no discernible differences in terms of how the students from each of these class periods presented their beliefs in the sub categories of each of the nine major categories. It appears that students displayed a high degree of congruence with respect to how they frame their reasoning on these SSI as well as their justification for their epistemological beliefs. Collectively, these findings add support to the
claim that there are common underlying elements of epistemological beliefs (Yang & Tsai, 2012; Zeidler et. al., 2009) that either cut across or perhaps transcend individual student identity aspects, including now controversial orientation, in terms of individual framing, justification, and revealing socioscientific reasoning patterns on SSI.

While it may be expected that similarities and differences would be present among students who hold differing perceptions of controversy, a closer analysis reveals interesting findings about the relative emphasis placed on certain types of evidence, controversy preferences, and patterns of reasoning while navigating the SSIs of marijuana safety and fast food legality. Reflecting on the qualitative epistemological taxonomies portrayed by the students in this study (Table 4.2) provides insight about the variance among their choices of reasoning and rationale by displaying nine researcher defined and observed rationale and / or reasoning patterns that were consistently shown while reviewing the student short answer responses.

By analyzing the student short answer responses (Appendix C and D), short answer taxonomic trends and patterns did emerge that were common to the entire student population. Further analyses showed that there were interesting aspects of high and low controversially oriented students taxonomic frequencies. For marijuana safety, students who ranked the issue as the most controversial displayed a higher instance of Personal and Emotive-Empathetic taxonomies when compared to the remainder of the student population who did not rank marijuana safety as the most controversial SSI (Table 4.3). Additionally, the same group of students who held this highly controversial orientation to marijuana safety displayed a lower instance of Scientific and Multiple View Points taxonomies when compared to the remainder of the student population. This suggests that perception of controversy is a mitigating factor in patterns of justification and reasoning during SSI instruction.
Conversely, after analysis of taxonomic trends observed within the lower controversially perceived SSI, fast food legality, there was a decrease noted for the taxonomic frequencies of Personal as well as Emotive-Empathetic. Moreover, when comparing the least controversially perceived SSI with the most controversially perceived SSI there is a large increase in the instances of Social influence being shown in the lower perceived controversy SSI. This supports the idea that controversial perception is a contributing factor to patterns of justification and reasoning during SSI navigation and further leads one to conclude that controversial perception may be tied to core identity aspects such as emotion, compassion, rationale, and justification of thought.

Additionally, as the panel scored short answer responses for quality of science questioning, interesting trends began to emerge. The resulting scores of this analysis are shown in Table 4.5. It was observed that students who initially ranked either the SSI of marijuana safety or fast food legality as highly controversial were scored as using more evaluation and justification responses that were less scientific in nature. That is, when students were asked to provide additional questions that they would like answered regarding the topics, there was a significant decrease in the numbers of high controversial oriented students who responded with questions that were scored as being scientific in nature by the panel of reviewers. A larger portion of the non-science follow-up questions came from the students who self identified as high controversy by their choosing of either marijuana safety or fast food legality as the most controversial issues. Lower relative scores in Table 4.5 represent lack of science, logic, reasoning, or rationale. Students who identified at the relative extreme ends of the controversial perception spectrum were seen to have distinct decreases in total average epistemological construction scores when compared to students whom identified more neutrally with each SSI.
(Table 4.5). Both pre and post instruction average scores for the more neutrally oriented class population were seen as higher when compared to either the students who selected marijuana safety as the most controversially perceived issue and for students who selected fast food legality as the least controversial issue. Overall, the findings seem to support recent work that suggests that there is a link in science comprehension, epistemological construction, and personal identity (Richards, 2013; Lin, 2013; Cavallo, 2003). Furthermore, this work suggests that there is at least an aspect of personal identity related to perception of controversy during an SSI unit that contributes to epistemological construction, justification, patterns of reasoning, and content knowledge gain. Therefore, it may be that controversial perception is at least one component of personal identity or identity group. Furthermore, the link between controversial perception of an SSI, science comprehension, and epistemological construction may be a larger contributing factor to SSI navigation than previously thought.

Limitations

The design of this study, as in any study, necessarily imposes certain constraints on the research. Sample selection in this study provides an example of this type of constraint. High school students comprised the sample and therefore the navigation of SSI instruction of younger or older students was not explored. In order to develop a more robust understanding of how individuals who hold differing levels of controversial perception and varying aspects of controversial identity negotiate socioscientific issues, future work designed to explore interaction, orientation, and reasoning patterns of other target populations is necessary. Given the importance of socioscientific issues curricula for the middle school classroom (Chiappetta &
Koballa, 2002; Trowbridge, Bybee, & Powell, 2000), studies with middle school students may be the next prudent sample population to investigate.

The socioscientific issues represented in the study presented another necessary constraint. Although the issues of marijuana safety and fast food legality were specifically selected to accentuate the controversy orientation of this sample population, these each represent only one set of socioscientific issues. Other issues and scenarios may elicit different orientations, patterns of reasoning, justifications, and reactions, but the data cannot represent to what extent these patterns are described regarding other socioscientific issues. Additional empirical work utilizing different socioscientific issues would be valuable in determining how the observations revealed in response to marijuana legality and fast food legality relate to other socioscientific issues. This suggested work, along with the results presented in this investigation, may be integrated to form a more generalized model of socioscientific issue navigation by contrasting level of controversy orientation.

Additionally, in this specific instance the actual scenario or narrative context of the issue that is used to deliver the content may be of great importance and impactful in how a student perceives controversy and relates independently to the issue. The unique nature of this investigation is intended to get at the root of identity-centered interaction with the issue. Therefore, a small modification of the scenario to make the issue more personal, real, threatening, or overall impactful may be helpful in generating a broader understanding of how student identify and SSI may interact to produce differing models of content gain, reasoning, and rationale. For instance, if the subject of a fictional SSI scenario is gender specific and that gender does or does not intersect with a real world example central to a student’s self identity, there may be major modifications to the student’s reasoning, rationale, and justifications that lead to the
participant’s content knowledge scores. The current study did not attempt to account for differences such as these.

Another limitation of this study was the lack of attention paid to potentially important student identity factors such as race, religious affiliation, and gender. Information on these and other variables was collected in order to better describe the sample, as well as for future investigation. However, during this investigation the investigator did not attempt to control such variables. Given the aim of this study, it was not possible to control for every personal characteristic that might contribute to a person’s reasoning and resolution of the SSI. However, potentially fruitful research projects in the future could address how conceivably strong controversial identification factors such as race, religion, and gender contribute to controversial identification and ultimately epistemological navigation regarding SSI.

The identification of groups chosen for the interviews represented another limitation. The investigator defined groups that would participate in interviews based on controversy orientation to the issues selected. Individuals with the greatest reaction to the scenarios of marijuana safety and fast food legality were selected. Because of this strategy, results were produced that only took into account variances between the two extreme student subgroupings or clusters of high and low controversy rated students. Future studies with less drastic differences in self reported controversy ratings might be useful. The present study supports the notion that observed and expected taxonomic groups are related to controversy perception. However, questions of how much controversial orientation is needed to impact a student’s reasoning, justification, and rationale that is indicative of the varied taxonomic groupings remains unanswered.
Additional Recommendations for Future Research

In addition to the recommendations for addressing study limitations, the results highlighted the need for further research in at least the following areas. Results concerning the relationship between content knowledge, SSI navigation, and aspects of identity that include controversy perception highlight the need for information regarding the developmental appropriateness of different socioscientific issues for students of varying ages and/or developmental stages. No materials other than isolated studies conducted with a particular age (like this study) explicitly designed to help educators select appropriate issues for their student populations currently exist. Research efforts to determine the developmental appropriateness of multiple socioscientific issues and specifically socioscientific issues scenarios would be useful.

Although for the sake of this investigation three forms of controversial orientation were often implied (High, Medium, and Low), the presence of specific identity-based orientation was generally clear when scoring short answer and written responses. When identified and expressed by the respondent, the controversy level or identity aspect was generally seen to opt other patterns of reasoning and was frequently the primary determinant of the decision maker’s ultimate conclusions and decisions. Given the unique characteristics that make up the basis for perceived controversy and identity formation, future studies should be undertaken to address whether the detailed foundations of controversy perception and identity aspects can be better defined and connected to navigation of socioscientific issues instruction.

Finally and possibly most importantly, several authors have suggested that socioscientific issues can be used as vehicles for teaching important science content (Cajas, 1999; Pedretti, 1999; Zeidler et. al., 2002; Klosterman & Sadler, 2010; Wongsri & Nuangchalerm, 2010), and
the results of this study indicate that increased understanding of science content knowledge is associated with SSI instruction regardless of perception of controversy. These observations lead to the following questions: How can learning goals, both the development of content and skills associated with informal reasoning, discourse, and debate, be maximized when using socioscientific issues related instruction across diverse student populations? Are these goals and intentions maximized when socioscientific issues are introduced to students who hold differing, extreme, or moderate orientations to the issues and scenarios being presented? Studies designed to address these questions would be useful to classroom teachers, curriculum designers and science educators as well.

**Summary**

This study has sought to contribute to the existing knowledge base in science education by illuminating processes involved in socioscientific issue navigation among students of differing perceptions of controversy as well as students who held aspects of controversial identity that may or may not interact with the specific issues chosen. Students demonstrated evidence of variations of reasoning, justification, perception of controversy, and aspects of knowledge gain as they negotiated the issues of marijuana safety and fast food legality. Most of the individual participants displayed at least some of the characteristics of controversial identification, influence group, or taxonomic theme patterned informal reasoning and justification. Although explicit differences in content knowledge were not definitively found between or among all controversial identification clusters, evidence was produced that would suggest at least variation in reasoning and rationale that produced content gain during
socioscientific issues instruction can be attributed to controversial identification. Additionally, evidence was provided that showed general knowledge gain throughout the group during socioscientific issues instruction.

Participants with a more pronounced controversial reaction to a socioscientific issue during an overall higher perceived controversial SSI demonstrated patterned reasoning and justification as they navigated the social and moral aspects of SSI instruction. Individuals who held a more controversial view of the particular SSI displayed more instances of personal / egocentric, family / family history, and emotive / empathetic taxonomies when short answer responses and follow up questions were scored (Table 4.1). Individuals who held a less controversial orientation to an SSI presented contrary high instances of medical / health / science and exhibition of multiple scientific points of view taxonomies (Table 4.1). During the lower overall perceived controversial issue of fast food legality there was a decreased notation of the taxonomic categories of personal / egocentric as well as emotive / empathetic when compared to the more highly perceived SSI unit. However, during the lower perceived controversial SSI of fast food legality there was a large increase in the instances of friends / personal influence from student responses when again compared to the higher perceived SSI unit. These results highlighted the need to ensure that science classrooms that engage in socioscientific issues pedagogical techniques and philosophies account for specific controversial orientation or relationships to issues used during delivery of SSI instruction.

To provide a fuller account of socioscientific reasoning and epistemological construction, some of the study’s limitations should be addressed empirically. The constraints that could be examined in other research contexts included different target populations, different or additional issues / scenarios, more subtle differences in content knowledge, and more attention to personal
differences among the individuals who comprise the sample. The findings also identify novel research foci including strategies for promoting both content knowledge and reasoning skills determination of the developmental, demographic, and controversial identity group appropriateness of the various socioscientific issue options in respect to the target population, with follow-up explorations of intuitive informal reasoning.

It has been said that one of the appeals of the SSI instructional model is that it serves not only as a context for the delivery of content, but acts as a catalyst for various forms of epistemological beliefs and research into the development of conceptual and psychological knowledge structures (Zeidler, 2013). This investigation supports the deeper understanding of the contribution of controversy perception to epistemology as well as conceptual and psychological knowledge structures during SSI navigation.
REFERENCES


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APPENDICES
APPENDIX A. Definitions

General SSI – A “general SSI” would be an SSI that is not identified as specifically controversial or uncontroversial to a specific subset of the sample student population.

Specific SSI – A “specific SSI” would be an SSI that is identified by a portion of the sample population as sensitive or provocative to their unique controversial identification or specifically uncontroversial to their unique controversial identification.

MCI9 or MCI = 9 – Most controversial issue 9. This abbreviation is used often to refer to the 18 students in the study who selected the ninth issue on the list (Figure 4.1) as being the most controversial. The ninth issue on the list was marijuana safety.

LCI4 or LCI = 4 – Least controversial issue 4. This abbreviation is used often to refer to the 20 students in the study who selected the fourth issue on the list (Figure 4.1) as being the least controversial. The fourth issue on the list was fast food legality.

I.R.I.S. – Issue Response Identity Survey. The IRIS is an exclusive controversy identity survey utilized during the data collection and analysis of this investigation. For further information on the IRIS please see Appendix B.
APPENDIX B. Issue Response Identity Survey (IRIS)

Issue Response Identity Survey (IRIS)

Intro:
Please read the following material and react according to your unique identification with the issues presented. There are no correct or incorrect responses or reactions to the following issues. If needed, please use the extra space provided to elaborate on your responses.

Background:
"Socioscientific issues (SSI) are topics that connect to science, social, and personal issues and may be controversial to some individuals. The topics that follow are examples of socioscientific issues.

For the following list of socioscientific scenarios, you will be asked to rank the potential influence certain groups may have on your thinking about the SSI issues.

On the following pages you will be asked to rate on a scale of 1 – 10 how controversial each specific issue is for you personally. A rank of 1 signifies a topic that is not controversial to you; a rank of 10 indicates a topic that is extremely controversial to you.

You will also be asked about the extent to which certain groups may influence how you think about these issues. For example, such groups may include: family, religion, ethnic group, friends / peers, science, and potentially other personal or unique individual aspects of your identity.

Please read and react to the following issues and base your individual response on your own unique identity. Additionally, please provide feedback as needed to clarify your response, reaction, or identification with the issues.
IRIS Instrument Definitions:
To better help you understand the identity descriptors used in this questionnaire, please refer to the list of definitions below as needed

**Family**: Any individual or group of persons whom you consider to be part of your family unit or group.

**Religion**: Any group, organization, or belief system that provides you with spiritual, moral, or ethical guidance. This may include any religious group, theological body, and aspect of spirituality or belief system that you adhere to or are a member of.

**Ethnic Group**: An ethnic group is a group of people whose members identify with each other through a common heritage, consisting of a common culture and including a shared language or dialect.

**Friends / Peers**: Your social group, a person attached to another by feelings of affection or personal regard, or a person who is equal to another in abilities, qualifications, age, background, and social status.

**Science**: Knowledge of the physical or material world gained through observation, experimentation, or systematic study.

**Other**: Any other personal influence regarding your identity that has not been mentioned. Please be specific and elaborate as much as possible. Keep in mind: there are no answers that are more or less correct. Each answer is specific and unique to you, so please elaborate appropriately in order to communicate your response or reaction clearly.
How controversial is this topic to you? Please circle a level (1 – 10) from the scale below:

Aspects of identity often influence our reaction to and interaction with topics. For the socioscientific issue above, please rank the potential aspects of your identity that influence your view of the issues. A rank of 1 signifies no influence; a rank of 10 signifies an extremely strong influence.

<table>
<thead>
<tr>
<th>Influence</th>
<th>Specify or elaborate</th>
<th>Level of influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family</td>
<td></td>
<td>1 - 10</td>
</tr>
<tr>
<td>Religion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnic Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friends / Peers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Influence and Issue: ________________________________________

Additional Response:

Please use the following space to extend your responses as needed. Please indicate in the initial blank the influence and SSI issue that you are writing about. Use the remaining space to elaborate or discuss your responses.

Influence and Issue: ________________________________

Additional Response:
APPENDIX C: Short Answer Epistemological Metric (Marijuana Safety)

Student Identifier __________________

Decisions about Socioscientific Issues

Directions - Please fill in the two blanks with the SSI issue you have chosen, read, and then respond to the questions that follow:

1a) For the issue of Marijuana Safety please describe what factor was the most influential to you when forming your argument. Please explain or justify as needed.

Factor:

Explanation or justification:

1b) Please describe two examples of data, information, knowledge, or specific influence that the factor in question 1a provided you. Please explain or justify as needed.

Example 1:

Example 2:
2) If you were allowed to search for more information regarding answers to questions involving the issue of Marijuana Safety please name three sources that you would utilize. If you do not know the specific name of a source, please describe the source type to the best of your ability. Sources could be print, virtual, people, or any type of knowledge source. Whether or not you actually have access to this source is not relevant to your answer. So, for example, if you wanted to ask a restricted, deceased, or unavailable source, please list any and all areas you would look.

Source 1:

Source 2:

Source 3:

3) If you had the opportunity to find out more information concerning the SSI issue of Marijuana Safety, what are 3 scientific questions you might ask to help you find out more? State a reason for asking each question.

Question 1:

Reason 1:

Question 2:

Reason 2:

Question 3:

Reason 3:
APPENDIX D. Short Answer Epistemological Metric (Fast Food Legality)

Student Identifier __________________

Decisions about Socioscientific Issues

Directions - Please fill in the two blanks with the SSI issue you have chosen, read, and then respond to the questions that follow:

1a) For the issue of Fast Food Legality please describe what factor was the most influential to you when forming your argument. Please explain or justify as needed.

Factor:

Explanation or justification:

1b) Please describe two examples of data, information, knowledge, or specific influence that the factor in question 1a provided you. Please explain or justify as needed.

Example 1:

Example 2:
2) If you were allowed to search for more information regarding answers to questions involving the issue of Fast Food Legality please name three sources that you would utilize. If you do not know the specific name of a source, please describe the source type to the best of your ability. Sources could be print, virtual, people, or any type of knowledge source. Whether or not you actually have access to this source is not relevant to your answer. So, for example, if you wanted to ask a restricted, deceased, or unavailable source, please list any and all areas you would look.

Source 1:

Source 2:

Source 3:

3) If you had the opportunity to find out more information concerning the SSI issue of Fast Food Legality what are 3 scientific questions you might ask to help you find out more? State a reason for asking each question.

Question 1:

Reason 1:

Question 2:

Reason 2:

Question 3:

Reason 3:
APPENDIX E. Scoring Rubric for Justifications on Decisions about Socioscientific Issues
(Appendix C and D, Short Answer Epistemological Metric Issues)

• Decisions about Socioscientific Issues questions 1a, 1b, and 2.

0 = response attempted is not scientific in nature and includes no justification, evidence, or example.

1 = response includes justification, evidence, or example.

2 = response is scientific in nature.

3 = response is scientific in nature and includes justification, evidence, or example.

4 = exhibits all traits of (3) + exhibits or recognizes multiple scientific points of view

• Decisions about Socioscientific Issues question 3 (3 potential responses for Scientific Questions)

0 = response does not exhibit a scientific basis in nature.

1 = one response attempted, some science content attempted, but justification absent or not clear.

2 = response includes non-specific or general use of scientific content with justification.

3 = response includes specific use (contextualized) of scientific content with justification.

4 = exhibits all traits of (3) + exhibits or recognizes multiple scientific points of view.

Note: Each of the 3 possible questions a student can pose will be scored in this manner. Thus, responding fully to only one question would earn them a total of 3 points, while responding fully to all 3 questions would earn them the highest score of 9 points.
Appendix F. Example Scores for Appendix C:

4 – Response includes specific use of contextualized scientific content with justification and or exhibits or recognizes multiple scientific points of view regarding the subject.

Example: “…There is a general lack of confirmation in the studies. Most studies contradicted each other, Ex. One concluded that marijuana causes learning deficiencies, while another says there was little difference between users and non users.” FAL2 1a

Example: “There are both positive and negative sides to why marijuana should or should not be legalized. In the packet of reading there were some studies that talk about the positive and some about the negative. Many studies disprove other studies.” MAS4Q1a,b

Example: “Scientific studies show that it (marijuana) changes your behavior and causes brain damage. Other studies show it helps with glaucoma and MS. Marijuana’s benefits or detrimental affects are what make it healthy or unhealthy in the opinion of the user or researcher. Scientific studies prove it or disprove it depending on what benefit or detriment is being looked for.” MMD4Q1a,b

Example: “Patients have found marijuana to release their pain and it helps them with nausea. Scientists have done studies where there have been negative affects on the brain. Scientists are still not sure if the use of marijuana is beneficial medically or if it is a major harm to the brain.” FVJU4Q1a,b

Example: “Many articles said that the studies were inconclusive, unreliable or inconsistent. Several studies or researchers use vague terms like “long term”, “short term” and “heavy user”. One article compared groups where users are not necessarily using the same amount. Both sides argue benefits or risks, but results of studies are to unclear to for sure prove either side.” FAB4Q1a,b

3 – Response is scientific in nature and includes justification, evidence or example. Or, Response is scientific in nature and the use of contextualized scientific content is included with justification.

2 – Response is scientific in nature and may include non-specific or general use of scientific content.

1 – One response attempted. Response includes justification evidence or example.

0 – Response attempted is not scientific in nature and includes no justification evidence or example.
APPENDIX G. Classroom Observation Notes and Checklist

Classroom Observation Notes and Checklist

During each class day covered by this investigation, the principle investigator observed all instruction, examination, and interactions. The following notes detail aspects of instruction, engagement, and learning environment that may impact the investigation.

Description of terms:

SSI instruction – Socioscientific issues instruction involves the intentional use of scientific topics that require students to engage in dialogue, discussion, and debate. Socioscientific topics are usually controversial in nature but have the added element of requiring a degree of moral reasoning or the evaluation of moral and ethical concerns in the process of arriving at decisions regarding possible resolution of those issues. Socioscientific issues have been defined as those issues that are typically contentious in nature, can be considered from a variety of perspectives, do not possess simple conclusions, and frequently involve morality and ethics (Sadler & Zeidler, 2002). SSI scenarios have to be resolved through the interaction of multiple perspectives; in addition, a socioscientific issue is characterized by conflicting as well as fragile evidence (Sadler, 2007). Properly administered SSI curriculum requires the use of evidence-based reasoning and provides a context for understanding scientific information (Zeidler & Nichols, 2009). SSIs have been shown to be complex problems that science students analyze that have real world applications with moral and ethical components (Zeidler, Sadler, Applebaum, & Callahan, 2009; Zeidler, Sadler, Simmons, & Howes, 2005).

SSI argumentation – Proper argumentation is a critical component of SSI instruction. Dialectical arguments, also known as dialogical or multi-voiced (Driver et al., 2000), entail the contemplation of complex issues with multiple perspectives and no clear-cut solutions (Van Eemeren et al., 1996). Socioscientific argumentation relies on and can be identified by the existence of content knowledge. This content knowledge present in SSI argumentation in turn influences the argumentation practices of students (Dawson & Schibeci, 2003).

Prompting and explanation – Proper prompting and explanation will entail the classroom instructor reading or stating verbatim the instruction or testing prompts predetermined by the principle investigator and classroom instructor.

Classroom setting – General notes will be taken during each day of the investigation. Classroom setting notes will include but not be limited to: weather; community, national, or global events; attendance; time of year; and relevant school or community events.

Student engagement – Student engagement will be reported on as the level of participation students show in each, teacher – class, teacher – student, student – student, and student – class interactions.
Teacher attentiveness – Notes will be taken detailing the level of alertness, focus, and attention displayed by the classroom teacher on each day of the investigation.

Student attentiveness – Notes will be taken detailing the level of alertness, focus, and attention displayed by the students on each day of the investigation.

Student interactions and discourse – Noticeably vocal, boisterous, or contentious interactions and discourse will be noted, as well as patterns of unremarkable interaction or discourse during each day of the investigation.

Principle Investigator Notes: Date:

SSI instruction –

SSI argumentation –

Prompting and explanation –

Classroom setting –
Student engagement –

Teacher attentiveness –

Student attentiveness –

Student interactions and discourse –

Additional comments:
APPENDIX H. Student Background Profile

Prompt for Student Background Profiles:

Please fill in the "your response" section for each aspect on the student background profile sheets. The student identifier will be used in place of your name and should be three total letters. The first is for your gender (M for male and F for female). The second letter of the student identifier should be the first initial of your first name. Please use whatever name you most commonly use or what you will be able to remember. The third letter should be the first letter of your last name. If you prefer an alternative method of identifying yourself during this research you may do so, as long as you follow the three-letter format where your gender is the first letter. Please see the examples for further assistance. This identifier will have to be something that you will remember for future responses and feedback. If there is an aspect of the background profile that does not apply directly to you, please try and chose the answer choice that is closest to accurate for your situation. All responses will be anonymous and some of the data may not be used. There are no correct or incorrect answers and no values or scoring will be attributed to your responses.
<table>
<thead>
<tr>
<th>Profile Aspect</th>
<th>Your Response</th>
<th>Answer Format</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Identifier</td>
<td></td>
<td>Alphabetic response</td>
<td>M for male, F for female followed by initials</td>
<td>John Doe = MJD</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td>Numerical age in years</td>
<td>Your age in years</td>
<td>17</td>
</tr>
<tr>
<td>Grade</td>
<td></td>
<td>Numerical grade</td>
<td>Your grade in numeric years</td>
<td>11</td>
</tr>
</tbody>
</table>
| Housing                                            |               | Single family home = 1  
Apartment = 2  
Trailer = 3  
Other = 4 | What number best describes your living arrangements | 2                  |
| Smoker in immediate family?                        | Yes = 1  
No = 2 |                                        | Does anyone smoke in your immediate family (parents, guardians, or siblings)? | 1                  |
| Drug user in immediate family?                     | Yes = 1  
No = 2 |                                        | Does anyone use drugs for non-prescription purposes in your immediate family?  | 1                  |
| Do you regularly exercise (3 or more time per week)? | Yes = 1  
No = 2 |                                        | Do you undertake any type of exercise activity at least three times per week? | 1                  |
| Do you try and maintain a healthy diet?            | Yes = 1  
No = 2 |                                        | Do you make food choices that take into account the health consequences?        | 2                  |
| Do your or any member of your immediate family attend regular religious services? | Yes = 1  
No = 2 |                                        | Any religion or spiritual attendance on a regular basis would count as a yes.  | 1                  |
<table>
<thead>
<tr>
<th>Question</th>
<th>Type</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please list your number of siblings</td>
<td>Numeric</td>
<td>How many people do you count as brother or sister within your family unit?</td>
<td>3</td>
</tr>
</tbody>
</table>
| What is your parent or guardian composition at home?                    | Numeric | 1 = Two parents married  
2 = Two parents divorced / separated  
3 = Adoptive parents  
4 = Single parent  
5 = Other                                                               | 2     |
| If you have any siblings, where do you fall in the birth order?         | Numeric | 1 = Oldest  
2 = Middle  
3 = Youngest  
4 = No siblings                                                        | 3     |
### APPENDIX I. SSI Selection Pool

Potential SSI:

1. Birth defects / genetic testing
2. Terminal illness / euthanasia / end of life
3. Abortion
4. Stem cells
5. Drug testing
6. Forensic science
7. Obesity
8. Animal testing
9. Smoking
10. Fluoride

<table>
<thead>
<tr>
<th>Teaching objective</th>
<th>SSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genetics</td>
<td>Birth Defects / Genetic Testing</td>
</tr>
<tr>
<td>Body system, organ, or pathway</td>
<td>Terminal Illness / Euthanasia / End of Life</td>
</tr>
<tr>
<td>Development, cell bio, reproduction</td>
<td>Abortion</td>
</tr>
<tr>
<td>Development, cell bio, reproduction</td>
<td>Stem Cells</td>
</tr>
<tr>
<td>Organ systems, digestion</td>
<td>Drug Testing</td>
</tr>
<tr>
<td>Body fluids</td>
<td>Forensic Science</td>
</tr>
<tr>
<td>Diet, nutrition, organ systems</td>
<td>Obesity</td>
</tr>
<tr>
<td>Eye / vision, immune system</td>
<td>Animal Testing</td>
</tr>
<tr>
<td>Lungs, respiratory system</td>
<td>Smoking</td>
</tr>
</tbody>
</table>
APPENDIX J. Scott Applebaum CV

Scott M. Applebaum
604 Knollwood Drive
Largo, Florida
727-687-4606
scott.applebaum@gmail.com

Education:

Bachelor of Science, Physiology  Baylor University 1967-1971
Juris Doctor  University of Pennsylvania School of Law 1971-1973
Doctor of Dental Medicine  University of Louisville School of Dentistry 1973-1977

Doctoral Classes at the University of South Florida College of Education:

- Philosophy and Sociology of Science
- Socioscientific Issues in Science Education
- Epistemology, Reasoning and Cognition in Science Education
- Philosophy and Nature of Science
- Moral and Ethical Issues in Science and Society
- Qualitative Inquiry
- Advanced Research Seminar
- Current Trends in Secondary Science Education
- Writing for Professional Publication
- Secondary Science Methods

Training:
Advanced Placement in Biology: Florida State University
PreAdvanced Placement in Biology: University of South Florida

Conference Paper presentations:

Association of Science Teacher Educators (ASTE)
2004 Nashville, TN
2005 Colorado Springs, CO
2006 Portland, OR
2007 Clearwater Beach, FL
2008 St. Louis, MO
2009 Hartford, CT
2010 Sacramento, CA
2011 Minneapolis, MN

National Association of Research in Science Teaching (NARST)
2005 Vancouver
2007 Dallas, TX
2011 Orlando, FL
Workshops: American Medical Writers Conference in Jacksonville, Florida 10/2011
Statistics for medical writers
Regulatory documentation preparation for pharmacological studies
Clinical studies report preparation

Work Experience

Private practice, general dentistry, owner, managing partner 1975-1998
Legal consultant to requisite standard of practice for dentistry 1980-2001
Expert reports, preparation of interrogatory and deposition questions for negligent complaints
State of Florida, Agency for Health Care
Bock and Finkelman, Philadelphia, Pennsylvania
Shear, Newman and Hahn, Tampa, Florida
Teacher/Instruction of Human Anatomy and Physiology 2000-current
Pinellas County School Board
Palm Harbor University HS

PUBLICATIONS


SYMPOSIA PRESENTED TO PROFESSIONAL ORGANIZATIONS AND INSTITUTIONS

1. What does the respiratory system do? Please state the major function and describe the process involved using scientific or anatomical functions.

2. Diseases are usually caused by failure of one or more homeostatic mechanisms. Please describe the failure of the ____________ organ / system involved in the disease ____________. Please list as many affected organs, tissues, and cells as possible and list their function(s). Additionally, please provide a description of the failure involved in the affected organ / system.

   2A) List of organs, tissues, cells, and their function:
   
   2B) Description of the failure involved in ____________:

3. How does ____ (organ / system) ____ cause death in the disease ________________?
4. Why do some individuals who never smoke develop cancers of the respiratory system?

5. How is the anatomy of the nervous system related to its physiology?

6. What is an example of an external (environmental, diet, stimuli) factor that influences the functioning of the brain? How does this external factor affect the nervous system?

   Factor:

   Affect:

7. Name one thing that causes the nervous system to function better. Describe how your answer to part 7A improves or enhances functioning. Please use scientific evidence and terminology when possible.

   7A One thing that causes better functioning:

   7B Description:

8. Name one thing that causes the nervous system to function worse. Describe how your answer to part 8A interferes with or hinders functioning. Please use scientific evidence and terminology when possible.

   8A One thing that interferes with or hinders functioning:
9. Is there a difference between a scientific theory and a scientific law? Give a life science (biology, anatomy, physiology, ecology, etc.) example to illustrate your answer.

10. Is there a difference between scientific knowledge and opinion? Give an example to support your answer.

11. Some astronomers believe that the universe is expanding, while others believe that it is shrinking; still others believe that the universe is static without any expanding or shrinking. Similarly, scientists and medical experts differ in the manner and extent of treatment required in many neurological disorders such as Parkinson’s disease and cerebral palsy. How are these different conclusions possible if all of these scientists and medical experts are looking at the same experimental data?
Multiple Choice
Identify the choice that best completes the statement or answers the question.

_____ 1. Air is warmed, filtered, and moistened by
   a. lungs
   b. alveoli
   c. bronchioles
   d. nasal cavities
   e. all of the above

_____ 2. Functions of the nasal cavity do not include
   a. filtering air
   b. creating turbulence
   c. the cartilage rings
   d. moistening air
   e. providing a storage area for mucus

_____ 3. The elastic cartilage that protects the larynx is
   a. the thyroid cartilage
   b. the cricoid cartilage
   c. the cartilage rings
   d. the epiglottis
   e. hyaline cartilage

_____ 4. The nasal cavity is separated from the oral cavity by
   a. the pharynx
   b. the nasal conchae
   c. the nasal septum
   d. epiglottis
   e. the hard palate

_____ 5. Which of the following is a function of surfactant?
   a. control sighing
   b. initiate yawning
   c. prevent lungs from collapsing
   d. prevent alveoli squamous cells from sticking together
   e. increase surface area of alveoli

_____ 6. When the diaphragm and intercostal muscles contract
   a. the size of the thoracic cavity increases
   b. the size of the thoracic cavity stays the same but not affected by diaphragm contraction decreases
   c. the size of the thoracic cavity is not affected by diaphragm contraction
   d. the sizes of the thoracic cavity and lungs never change

_____ 7. Which of the following describes difficulty in breathing?
   a. eupnea
   b. hyperpnea
   c. apnea
   d. dyspnea
   e. hypopnea

_____ 8. When does the epiglottis cover the larynx?
   a. during inspiration
   b. during expiration
   c. while talking
   d. while swallowing
   e. while yawning
Appendix L: Content Knowledge Exam POST INSTRUCTION, Marijuana Safety

Student Identifier _____________________
Class period _____________________

Human Anatomy and Physiology Content Assessment Instrument

Please answer the following questions to the best of your ability using examples, evidence, and explanations your rationale wherever possible. This exam is intended to be similar to the version taken at the beginning of the respiratory unit. You may chose to use previous answers, modify them, or improve them as you wish.

1. What does the respiratory system do? Please state the major function and describe the process involved using scientific or anatomical functions.

2. Diseases are usually caused by failure of one or more homeostatic mechanisms. Please describe the failure of the respiratory system involved in the disease emphysema. Please list as many affected organs, tissues, and cells as possible and list their function(s). Additionally, please provide a description of the failure involved in the respiratory system.

   2A) List of organs, tissues, cells, and their function:

   2B) Description of the failure of the respiratory system involved in the disease emphysema:

3. Why do some individuals who never smoke develop cancers of the respiratory system?

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. Air is warmed, filtered, and moistened by
   a. lungs
   b. alveoli
   c. bronchioles
   d. nasal cavities
   e. all of the above

____ 2. Functions of the nasal cavity do not include
   a. filtering air
   b. creating turbulence
   c. the cartilage rings
   d. moistening air
   e. providing a storage area for mucus

____ 3. The elastic cartilage that protects the larynx is
   a. the thyroid cartilage
   b. the cricoid cartilage
   c. the cartilage rings
   d. the epiglottis
   e. hyaline cartilage

____ 4. The nasal cavity is separated from the oral cavity by
   a. the pharynx
   b. the nasal conchae
   c. the nasal septum
   d. epiglottis
   e. the hard palate

____ 5. Which of the following is a function of surfactant?
   a. control sighing
   b. initiate yawning
   c. prevent lungs from collapsing
   d. prevent alveoli squamous cells from sticking together
   e. increase surface area of alveoli

____ 6. When the diaphragm and intercostal muscles contract
   a. the size of the thoracic cavity increases
   b. the size of the thoracic cavity stays the same but decreases
   c. the size of the thoracic cavity is not affected by diaphragm contraction
   d. the sizes of the thoracic cavity and lungs never change

____ 7. Which of the following describes difficulty in breathing?
   a. eupnea
   b. hyperpnea
   c. apnea
   d. dyspnea
   e. hypopnea

____ 8. When does the epiglottis cover the larynx?
   a. during inspiration
   b. during expiration
   c. while talking
   d. while swallowing
   e. while yawning

Appendix M: Digestive System, Fast Food Safety

Pre Instruction Content Knowledge Exam

Student Identifier ___________________________
Human Anatomy and Physiology Content Assessment Instrument
Digestive System PRE

Please answer the following questions to the best of your ability using examples, evidence, and explanations for your rationale wherever possible or beneficial. If you need more space for writing answers, please use the provided scratch paper.

1. What does the digestive system do? Please state the major function and describe the process involved using scientific or anatomical functions.

2. Diseases are usually caused by failure of one or more homeostatic mechanisms. Please describe the failure of the digestive system involved in inflammatory bowel disease. Please list as many affected organs, tissues, and cells as possible and list their function(s). Additionally, please provide a description of the failure involved in the affected organ / system.

   2A) List of organs, tissues, cells, and their function:

   2B) Description of the failure involved in inflammatory bowel disease:

3. Colorectal cancer is cancer of the colon or rectum. Most colorectal cancers are due to lifestyle, diet, and age-related factors. Why do some individuals who do not fall into the category of common lifestyle, diet, or age-related factors still develop colorectal cancer?
5. How is the anatomy of the digestive system related to its physiology?

6. What is an example of an external (environmental, diet, stimuli) factor that influences the functioning of the digestive system? How does this external factor affect the digestive system?

Factor:

Affect:

7. Name one thing that causes the digestive system to function better. Describe how your answer to part 7A improves or enhances functioning. Please use scientific evidence and terminology when possible.

7A One thing that causes better functioning:

7B Description:

8. Name one thing that causes the digestive system to function worse. Describe how your answer to part 8A interferes with or hinders functioning. Please use scientific evidence and terminology when possible.

8A One thing that interferes with or hinders functioning:

8B Description:

Multiple Choice
Identify the choice that best completes the statement or answers the question.

1. Our throat divides into two separate tubes: the windpipe (respiratory) and the gullet (digestive). What prevents food from entering the windpipe?
   a. The tongue  
   d. The uvula
b. The trachea
e. All of the above
c. The epiglottis

_____ 2. What happens when food reaches the stomach during normal digestion?
  a. Nothing. No digestion occurs in the stomach.
  b. The food moves quickly into the small intestines.
  c. Juices mix with the food and stomach muscles squeeze it.
  d. None of the above.

_____ 3. How does food finally reach the bloodstream?
  a. It passes through the esophagus into the blood.
  b. It is absorbed into the blood through blood vessels.
  c. It is absorbed into the blood through the walls of the lungs.
  d. It passes through the small intestine into the large intestine, then into the blood.
  e. It mixes with blood in the stomach during digestion.

_____ 4. The digestive system processes food into usable and unusable materials. The usable materials are sent to the body’s cells as food. What happens to the unusable material immediately prior to disposal?
  a. It goes into the pancreas to await disposal.
  b. It goes to the right ventricle to await disposal.
  c. It goes into the large intestine to await disposal.
  d. It goes into the small intestine to await disposal.

_____ 5. Solid waste leaves the body through the rectum then the anus. Liquid waste leaves the body after passing through the?
  a. Kidney and bladder
  b. Blood vessels and lungs.
  c. Large intestine and bowel.
  d. Small intestine and large intestine.

_____ 6. Which of the following does NOT manufacture digestive juices or fluids involved in digestion?
  a. The liver
  b. The kidneys
  c. The stomach
  d. The pancreas
Appendix N: Digestive System, Fast Food Safety Post Instruction Content Knowledge Exam

Human Anatomy and Physiology Content Assessment Instrument
Digestive System POST

Please answer the following questions to the best of your ability using examples, evidence, and explanations for your rationale wherever possible or beneficial. If you need more space for writing answers, please use the provided scratch paper.

1. What does the digestive system do? Please state the major function and describe the process involved using scientific or anatomical functions.

2. Diseases are usually caused by failure of one or more homeostatic mechanisms. Please describe the failure of the digestive system involved in inflammatory bowel disease. Please list as many affected organs, tissues, and cells as possible and list their function(s). Additionally, please provide a description of the failure involved in the affected organ / system.

   2A) List of organs, tissues, cells, and their function:

   2B) Description of the failure involved in inflammatory bowel disease:
3. Colorectal cancer is cancer of the colon or rectum. Most colorectal cancers are due to lifestyle, diet, and age-related factors. Why do some individuals who do not fall into the category of common lifestyle, diet, or age-related factors still develop colorectal cancer?

5. How is the anatomy of the digestive system related to its physiology?

6. What is an example of an external (environmental, diet, stimuli) factor that influences the functioning of the digestive system? How does this external factor affect the digestive system?

    Factor:

    Affect:

7. Name one thing that causes the digestive system to function better. Describe how your answer to part 7A improves or enhances functioning. Please use scientific evidence and terminology when possible.

    7A One thing that causes better functioning:

    7B Description:

8. Name one thing that causes the digestive system to function worse. Describe how your answer to part 8A interferes with or hinders functioning. Please use scientific evidence and terminology when possible.

    8A One thing that interferes with or hinders functioning:

    8B Description:

Multiple Choice
Identify the choice that best completes the statement or answers the question.

1. Our throat divides into two separate tubes: the windpipe (respiratory) and the gullet (digestive). What prevents food from entering the windpipe?
   a. The tongue
e. The uvula
   b. The trachea
   c. The epiglottis
   d. All of the above

2. What happens when food reaches the stomach during normal digestion?
   e. Nothing. No digestion occurs in the stomach.
   f. The food moves quickly into the small intestines.
   g. Juices mix with the food and stomach muscles squeeze it.
   h. None of the above.

3. How does food finally reach the bloodstream?
   f. It passes through the esophagus into the blood.
   g. It is absorbed into the blood through blood vessels.
   h. It is absorbed into the blood through the walls of the lungs.
   i. It passes through the small intestine into the large intestine, then into the blood.
   j. It mixes with blood in the stomach during digestions.

4. The digestive system processes food into usable and unusable materials. The usable materials are sent to the body’s cells as food. What happens to the unusable material immediately prior to disposal?
   e. It goes into the pancreas to await disposal.
   f. It goes to the right ventricle to await disposal.
   g. It goes into the large intestine to await disposal.
   h. It goes into the small intestine to await disposal.

5. Solid waste leaves the body through the rectum then the anus. Liquid waste leaves the body after passing through the?
   e. Kidney and bladder.
   f. Blood vessels and lungs.
   g. Large intestine and bowel.
   h. Small intestine and large intestine.

6. Which of the following does NOT manufacture digestive juices or fluids involved in digestion?
   e. The liver
   f. The kidneys
   g. The stomach
   h. The pancreas
Appendix O: Short Answer Follow-Up Questions FAST FOOD SAFETY PRE INSTRUCTION

Student Identifier _______________________
Class Period _________________________

Directions – Please write the most complete and detailed response possible that best identifies your thoughts, opinions, and rationale regarding FAST FOOD AGE LIMITS as they relate to the digestive system and digestive health concerns.

Q1) Please list what your top influence would be in forming an opinion and framing your argument on the SSI issue of FAST FOOD AGE LIMITS. In other words, what would be most influential to you in making decisions about this issue?

Top influence =

Q1a) Please describe the types of evidence, data, or input that this influence provided for you.

Q2) What is one scientific question that you would like answered to better support or confirm your opinion, hypothesis, or understanding of this issue?

Q3) Please describe 3 additional pieces of scientific data that would help you further investigate this issue.

Q4) Describe what type of evidence or data would be required for you to change your stance on this issue. If it is impossible for you to change your stance, please state why.
Appendix P: Short Answer Follow-Up Questions FAST FOOD SAFETY POST

INSTRUCTION

Directions –You have now had the opportunity to learn about and discuss the digestive system, digestive health, and anatomy and physiology as it relates to the safety and legality of fast food. Please use any and all sources of information that you feel are relevant during the completion of this questionnaire. Please write the most complete and detailed response possible that best identifies your thoughts, opinions, and rationale regarding FAST FOOD AGE LIMITS as they relate to the digestive system and digestive health concerns.

Q1) Please list your top influence in forming your opinion and framing your argument on the SSI issue of FAST FOOD AGE LIMITS. In other words, what was the most influential to you in making your final decisions about this issue?

Top influence =

Q1a) Please describe the types of evidence, data, or input that this influence provided for you.

Q2) What is one scientific question that you would like answered to better support or further confirm your opinion of this issue?

Q3) Please describe 3 additional pieces of scientific data that would help you further investigate this issue.

Q4) Describe what type of evidence or data would be required for you to change your stance on this issue. If it is impossible for you to change your stance, please state why.
Appendix Q: Appendix O & P Short Answer Follow-Up Questions Scoring Rubric

15 Points Possible

Q1) Please list your top influence in forming your opinion and framing your argument on the SSI issue of ____________________.

Top influence =
0 pts = non-science answer and no justification or support below
1 pt = non-science answer with justification or support below
2 pts = quasi-scientific source or response
3 pts = scientific source

Q1a) Please describe the types of evidence, data, or input that this influence provided for you.
0 pts = no answer
1 pt = sources are non-scientific and non-justified
2 pts = sources are scientific and non-justified or lack consistent logic
3 pts = sources are scientific and justified with consistent logic exhibited
4 pts = conflicting sources are recognized and/or represented

Q2) What is one scientific question that you would like answered to better support or confirm your opinion, hypothesis, or understanding of this issue?

0 pts = non-scientific or no question asked
1 pt = scientific question
2 pts = scientific question that exhibits consistent logic
3 pts = plausible and appropriate scientific question with consistent logic exhibited

Q3) Please describe 3 additional pieces of scientific data that would help you further investigate this issue.

1 pt. One scientific data example
2 pts. Two scientific data examples
3 pts. Three scientific data examples

Q4) Describe what type of evidence or data would be required for you to change your stance on this issue. If it is impossible for you to change your stance, please state why.

1 pt. Ability to change mind
2 pts. Scientific evidence cited
Appendix R: Marijuana Safety Unit Activity Outline

Marijuana Activity Outline

Overview: The focus of this activity is student negotiation of the controversy surrounding the physiological effects of marijuana. The activity challenges students to consider data representative of multiple perspectives relative to the issue of physiological effects of marijuana. Students will review five articles from a variety of sources presenting disparate lines of evidence supporting and refuting significant medical impacts resulting from the use of marijuana. The students will then work in small groups to prioritize pieces of evidence drawn from the articles reviewed. In the final phase, each small group will evaluate how a peer group prioritized the data. The sections which follow provide detailed descriptions for each step of the activity.

Phase I:
Goal: Students become familiar with five articles representing various perspectives relative to the issue of the physiological effects of marijuana use. Students will isolate pieces of evidence used to support positions presented in the articles.

Materials: Articles (contained in 1 packet); Phase I Activity Sheets (1/student)

Grouping: Students work on this phase *individually*.

Procedure: Each student reads all five articles. For each article, the student must 1) Summarize the main argument or position of the article; 2) Identify all lines of evidence (relative to the physiological effects of marijuana use) presented in the article; 3) Identify the source of the article.

   After completing these tasks for all five articles, students are asked to answer two questions based on the whole set: 1) Which article do you find most convincing? Please explain; 2) Which article has the most scientific merit? Please explain.

Student Product(s): Phase I Activity sheets, from each student, which will provide written documentation of the evidence they have identified for each article.

Phase II:
Goal: Students evaluate and prioritize the evidence presented in the five articles.

Materials: Each student should use his/her completed Phase I Activity Sheet; Phase II Activity Sheet (1/student)

Grouping: Small groups of 3-4 students

Procedure: Small groups of students will come together and must collectively determine the six most important pieces of evidence presented across the five articles. This process should involve group negotiation, prioritization of all the evidence, and justification of their final ranking.

   When a group reaches consensus on the most important lines of evidence, each student must write a justification for their group’s final ranking.

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When all members of the group complete their written justifications, they should select a single justification which best represents their negotiations.

**Student Product(s):** Phase II Activity Sheets, from each student, which will provide the group ranking of evidence and a written justification (a paragraph or two) for why his/her group chose to prioritize its chosen lines of evidence over others.

**Phase III:**
**Goal:** Students will critically evaluate how another group prioritized evidence from the five articles.

**Materials:** Each group will receive the evidence rankings and “best justification” from another group; Phase III Activity Sheet (1/group); *Palm Harbor Journal of Scientific Research* review letter (1/group)

**Grouping:** Students should work in the same groups formed for Phase II.

**Procedure:** The premise of this phase is that the students are serving as reviewers for the *Palm Harbor Journal of Scientific Research (PHJSR).* *PHJSR* seeks to publish brief summaries of evidence relative to the physiological effects of marijuana use. The group must review the six pieces of evidence chosen by their peer group as the most important and the accompanying justification. The group must then accept or reject this work for inclusion in the PHJSR. As in all journal reviews, the reviewers must explain their decision in writing (one or two paragraphs).

**Student Product(s):** Each group will complete the PHJSR review letter, which will record its decision (accept/reject) and provide a written explanation for its decision.
Appendix S: Marijuana Safety Unit Reading Articles

Article 1.

HEAVY MARIJUANA USE LINKED TO BRAIN DAMAGE
News Article

Researchers report that chronic users of marijuana suffer memory loss and attention problems that can affect their work, their life, and their ability to learn. However, a medical expert not involved in the study questioned the findings and whether the alleged adverse impact of marijuana is really there, which is indicative of the controversy surrounding the drug.

The findings are published in the current Journal of the American Medical Association. The study was based on patients seeking help for marijuana dependence at clinics in Seattle, Farmington, Connecticut, and Miami, between 2000 and 2003.

Fifty-one people were examined who had been using marijuana regularly for an average of 24 years. Also, 51 short-term users and 33 nonusers were included as controls for comparison purposes in the research. "Long-term users ... performed significantly less well on tests of memory and attention than nonuser control groups and shorter-term users with an average of 10 years' use," the study said.

On a verbal learning test "long-term users recalled significantly fewer words than either shorter-term users or control groups; there was no difference between shorter-term users and controls. Long-term users showed impaired learning, retention and recall compared with controls," the study said.

The study's authors, including Dr. Nadia Solowij at the University of New South Wales, Sydney, Australia, and colleagues with the Marijuana Treatment Project Research Group said the findings confirmed and expanded upon previous findings of cognitive (thinking) impairments among constant users. "For addicted users, the kinds of impairments observed in this study have the potential to impact academic achievements, occupational proficiency, interpersonal relationships and daily functioning," said the study.

However, in an editorial in the same issue, Harrison Pope of Harvard Medical School said "a recent analysis of many neuropsychological studies of long-term marijuana users found no significant evidence for deficits in seven of eight ... neuropsychological ability areas and only a small effect for the remaining area of learning."

He said in a separate statement that the study does not explore whether the heavy users may have been taking other drugs that could have accounted for the deficits uncovered, or whether they might have been suffering from anxiety or depression that could cause the problems noted.

"Another recent study from our laboratory ... found virtually no significant differences between 108 heavy cannabis users and 72 control subjects -- screened to exclude those with current psychiatric disorders, medication use, or any history of significant use of other drugs or alcohol -
- on a battery of ten neuropsychological tests after 28 days of supervised abstinence from the drug," he said.

Pope, the director of the Biological Psychiatry Laboratory at McLean Hospital in Belmont, Massachusetts, added: "The safest thing to say at this point is that the jury is still out on the question of whether long-term marijuana use causes lasting impairment in brain function."

Article 2.

NO BRAIN DAMAGE SEEN IN MARIJUANA-EXPOSED MONKEYS
California NORML (*National Association for the Reform of Marijuana Laws)

Two new scientific studies have failed to find evidence of brain damage in monkeys exposed to marijuana, undercutting claims that marijuana causes brain damage in humans.

The studies were conducted by two independent research groups. The first, conducted by Dr. William Slikker, Jr. and others at the National Center for Toxicological Research in Arkansas examined some 64 rhesus monkeys, half of which were exposed to daily or weekly doses of marijuana smoke for a year. The other, by Gordon T. Pryor and Charles Rebert at SRI International in Menlo Park, California, which is still unpublished, looked at over 30 rhesus monkeys that had inhaled marijuana one to three times a day over periods of 6 to 12 months. Neither study found evidence of structural or neurochemical changes in the brains of the monkeys when examined a few months after cessation (stopping) of smoking.

The new results cast doubt on earlier studies claiming to show brain damage in animals. The most famous of these was a study by Dr. Robert Heath, who claimed to find brain damage in three monkeys heavily exposed to cannabis. Heath's results failed to win general acceptance in the scientific community because of the small number of monkeys used, questionable controls, and heavy doses.

More recent rat experiments by Dr. Slikker and others reported persistent structural changes in the brain cells of rats chronically exposed to THC. The studies did not show that pot kills brain cells, as alleged by some pot critics, but they did show degeneration of the nerve connections between brain cells in the hippocampus, where THC is known to be active. Although scientists have regarded the animal evidence as inconclusive, some critics have cited it as proof that pot causes brain damage in humans. Thus, Andrew Mecca, the director of California Department of Alcohol and Drug Abuse, recently stated on the John Stewart talk show (Sep. 2, 2004) that marijuana "leaves a black protein substance in the synaptic cleft" of brain cells, a claim apparently based on Heath's monkeys. When asked by a member from the group NORML (National Organization for the Reform of Marijuana Laws) for his evidence, Mecca sent a list of three references, none of which turned out to have anything to do with brain damage.
Although the new monkey studies found no physical brain damage, they did observe behavioral changes from marijuana. Slikker's group found that monkeys exposed once a day to the human equivalent of four or five joints showed persistent effects throughout the day. Slikker says that the effects faded gradually after they were taken off marijuana, and were not detectable seven months later, when the monkeys were sacrificed. Autopsies did reveal lingering chemical changes in the immune cells in the lungs of monkeys that had inhaled THC. However, Slikker's group concluded that experimental exposure to marijuana smoke "does not compromise the general health of the rhesus monkey."

**Article 3.**

*News release issued by University Of California, Los Angeles Health Sciences*

**RESEARCHERS AT UCLA'S JONSSON CANCER CENTER REPORT SMOKING MARIJUANA MAY INCREASE RISK OF HEAD AND NECK CANCERS**

Researchers at UCLA's Jonsson Cancer Center are reporting, for the first time, that smoking marijuana may increase the risk of head and neck cancers.

Results of an epidemiological study of more than 340 people are outlined in an article published in today's (Dec. 17) edition of the peer-reviewed journal Cancer Epidemiology Biomarker and Prevention.

Previous laboratory and clinical studies have indicated that marijuana use may be related to molecular changes in the respiratory tract, changes that may lead to cancer. This is the first study to examine whether smoking marijuana increases risk of head and neck cancers, said Dr. Zuo-Feng Zhang of UCLA's Jonsson Cancer Center, a professor in the Department of Epidemiology in the UCLA School of Public Health and director of the cancer epidemiology training program at UCLA.

"Most people don't think about marijuana in relationship to cancer," said Zhang, lead author of the journal article. "The carcinogens in marijuana are much stronger than those in tobacco. The big message here is that marijuana, like tobacco, can cause cancer."

Zhang studied the relationship between marijuana use and head and neck cancers in 173 patients diagnosed with those diseases. He compared those findings to 176 cancer-free control patients, and found that those who habitually (very often) smoked marijuana were at higher risk for head and neck cancers.

The epidemiological data were collected using a standard questionnaire, which asked patients about their histories of tobacco smoking, marijuana smoking and alcohol use. Zhang said researchers were able to evaluate the data on marijuana smoking independently from data on tobacco smoking and alcohol use, which also increase the risk of certain cancers.
The results of the study are particularly important now, Zhang said, as habitual marijuana smokers from the 1960s reach older ages. Because head and neck cancers -- cancers of the mouth, tongue, larynx and pharynx -- take many years to develop, people who smoked large amounts of marijuana in the 1960s may just now be contracting head and neck cancers, Zhang said.

"In the '60s, we had very high numbers of people in their 20s smoking marijuana," Zhang said. "These people are just now getting to the ages at which they will get head and neck cancers. This is the time to study a risk like this."

The more times per day a person smokes marijuana, the greater his or her risk of head and neck cancers, according to the study. Additionally, people who use marijuana habitually for many years also increase their risk of head and neck cancers, Zhang said.

"If you smoke a little, your risk increases a little," Zhang said. "If you smoke a lot, your risk increases a lot."

Marijuana is the most commonly used illegal drug in the United States, Zhang said. It is estimated that about 31 percent of the U.S. population 12 years or older has used marijuana, according to the journal article.

Zhang's research builds on previous studies of marijuana and cancer risk. An article by UCLA cancer researchers published in the Aug. 19, 2001, issue of the Journal of the National Cancer Institute stated that habitual smoking of marijuana and crack cocaine causes the same kinds of molecular changes that precede the development of lung cancer in cigarette smokers.

"Now we have evidence that may link marijuana smoking to head and neck cancers," Zhang said. "Many people may think marijuana is harmless, but it's not."

In addition, the epidemiological study and the subsequent journal article also touch on the connection between marijuana smoking and the genetic defect that prevents DNA from repairing itself. Some marijuana smokers with this genetic defect might not have the ability to repair DNA damage prompted by the habit. Zhang said these people are about 16 times more likely to develop head and neck cancers than non-marijuana smokers whose DNA repair function is operating normally.

Zhang said larger epidemiological studies are needed to replicate the results obtained by UCLA cancer researchers. One such study, funded by the National Institutes of Health, is being conducted now at UCLA.

**Article 4.**

**MARIJUANA: A SCIENTIFIC CONTROVERSY**

Much of the debate surrounding the use of marijuana as medicine stems from conflicting claims
over its medical benefits. Although medical marijuana has a documented history, dating back to 2737 B.C. when Chinese Emperor Shen purportedly urged its use for various ailments, modern society has generally shunned the substance. In fact, the federal government classifies marijuana as a Schedule I drug, considered to have high potential for abuse and no known medical benefits. Yet many Arkansans claim to have received significant benefits from marijuana used to relieve pain, nausea and stimulate the appetite, among others.

Despite the evidence proponents use to prove marijuana is a beneficial medicine, federal officials continue to say marijuana has no medical benefits. Barry McCaffrey, director of the Office of National Drug Control Policy, wrote in a March 1998 letter to then speaker of the house Newt Gingrich, "...marijuana is a dangerous and addictive drug, and should not be legalized for medicinal use. State ballot initiatives that define marijuana as a 'medicine' fail to address the negative impact such legislation would have on the health of our youth and the nation's scientific process of approving medications."

Adding to the scientific confusion, the Arkansas Department of Health (ADH) issued a press release Feb. 3 revealing the department's negative stance toward the use of marijuana as medicine. "Scientific research has shown marijuana to be harmful to a person's brain, heart, lungs, immune system, memory, perception, judgment and motivation. Use of marijuana as a beneficial medicine projects a false and fraudulent message contradicting current scientific knowledge and research."

Yet, some believe, the Health Department press release seems to run contrary to current scientific knowledge and research. Retired Fayetteville physician John Day, former director of the University of Arkansas Health Clinic, as well as doctor of internal medicine at the Veterans Administration Medical Center, said scientific evidence is too often used as political ammunition to support continued marijuana prohibition.

As a supporter of the Alliance for Reform of Drug Policy in Arkansas, an organization working to place an initiative on the ballot for November's general election legalizing marijuana for medical use, Day said scientific literature clearly shows marijuana does alleviate nausea and vomiting, chronic pain and stimulates the appetite better than many prescription drugs.

And, when comparing side effects of marijuana to those of popular prescription painkillers, Day said, evidence shows the herb is far safer than most legal drugs. "The science just doesn't back up Boozeman’s (Director of Arkansas Department of Health) negative stance," he concluded.

To help end the debate about marijuana's medical benefits, in January 1997, armed with $1 million for research, the Office of National Drug Control Policy requested the National Academy of Sciences' Institute of Medicine (NASIM) to conduct a thorough review of the scientific evidence for both the benefits and risks associated with marijuana.

According to the executive summary from that study (NASIM) released in March 1999, "The accumulated data indicate a potential therapeutic value for cannabinoid [marijuana derived] drugs, particularly for symptoms such as pain relief, control of nausea and vomiting, and appetite stimulation." However, the report also warned, smoking marijuana is a crude delivery system
that also delivers harmful substances.

As a result, to mitigate the harm from smoking marijuana, the report urged further clinical studies to develop a non-smoked, rapid onset form of marijuana.

Far from being a report signaling the demise of the medical marijuana issue, the NASIM report has stirred growing debate among the medical community over the need for additional study.

Asked if this new NASIM study seemed to contradict the ADH position on medical marijuana, Boozman said, the new study should not be interpreted as an open door to legalization of marijuana. However, he conceded there may be patients who would benefit from the drug. Boozeman added that while the IOM study revealed marijuana has potential therapeutic benefits, more research under strictly controlled guidelines is needed before a final assessment can be offered.

Furthermore, Dr. Joe Bates, deputy state health officer at ADH and professor of internal medicine and microbiology at the University of Arkansas for Medical Sciences, said any future studies of marijuana for medicine should concentrate on isolating the individual compounds known as cannabinoids, then develop a safer delivery mechanism for those chemicals than smoked marijuana provides.

*The Stepping-Stone Effect Controversy*

Every negative report released about medical marijuana inevitably carries with it the accusation that smoking the drug will cause a person to experiment with more dangerous drugs like methamphetamine or heroin, thus escalating the social ills resulting from drug abuse. However, as with all information about marijuana, opponents and proponents of its use offer conflicting evidence.

Federal law enforcement officials have warned the public of marijuana's stepping-stone effect for decades. In a 1998 letter from the drug-czar McCaffrey to Gingrich, he wrote, "Marijuana is also associated with behavior leading to more extensive drug use." The website for the National Institute on Drug Abuse also claims marijuana has been known to lead people to use harder drugs.

Local law enforcement officials agree. Asked about medical marijuana use, Washington County Sheriff Kenneth McKee said he believes the drug is definitely a stepping stone to other, more harmful substances, and legalization for medical use should not be considered without scientific evidence of its benefit.

Yet evidence for marijuana as a stepping-stone to crime or harder drugs are not so clear for area drug abuse counselors or the district prosecutor.

Larry Counts, director of Decision Point, a Springdale based substance abuse treatment facility,
said empirical evidence shows literally thousands of addicts first used marijuana before trying other drugs. However, he also acknowledged there is no direct evidence that using marijuana causes a person to experiment with hard drugs.

As far as crime resulting from marijuana use, Terry Jones, 4th Judicial District Prosecuting Attorney, said his office is not overly concerned about marijuana, as the herb is benign compared to the threat methamphetamine has become to Arkansans. "As far as marijuana causing crime," Jones said, "That would be zero." The prosecutor's office does not encounter cases where people break into homes searching for money to buy marijuana, he said. "On a list of drugs I'd like to see removed from the earth forever," Jones said, "Marijuana would be about 200 yards behind meth."

Even the NASIM study released in March seems to debunk the stepping-stone argument. "There is no conclusive evidence that the drug effects of marijuana are causally linked to the subsequent abuse of other illicit drugs," the report says.

Furthermore, the report adds, the suggestion that medical marijuana would increase drug abuse should not be a factor in the medical marijuana debate at all.

According to Denele Campbell, president of the Alliance for Reform of Drug Policy in Arkansas and a firm believer in the medical benefits of marijuana, there is no credible scientific study demonstrating marijuana causes increased drug use.

In fact, she said, the NASIM study found most drug abusers begin with alcohol and nicotine - both legal drugs - and if society is truly concerned about removing genuine stepping-stones to addiction, they should focus on the real culprits.

Perhaps the best argument against the stepping-stone effect, Campbell said, are the examples set by hundreds of successful Americans who have used marijuana and not become hard drug users.

"If marijuana is a stepping stone, former President Bill Clinton, Vice President Al Gore and Senator Newt Gingrich [all admitted marijuana experimenters] wouldn't have been so successful," she concluded.

Article 5.

NEW SCIENTIST

FOCUS

TURN ON, TUNE IN, GET WELL

Marijuana as medicine? Tough-on-drugs America is finally coming round to the idea that the evil weed might do some patients a power of good. —Kurt Kleiner, Washington DC
IF you're old enough to remember peace and love and bell-bottoms, then America's latest debate on marijuana will have a familiar ring to it. What's new is that the government might be coming—somewhat reluctantly—to the conclusion that marijuana could make good medicine.

Last month, at the request of the US National Institutes of Health, a group of experts spent two days reviewing all the evidence. After analyzing the few scientific studies that have been done, and listening to doctors and their patients who say they have benefited from the drug, the panel concluded that marijuana could be useful for treating glaucoma, nausea brought on by chemotherapy, AIDS-related wasting, and the symptoms of other diseases.

The debate about the healthy and harmful effects of marijuana has rumbled on for years, but in the US it intensified in November when voters in Arizona and California approved controversial measures that would allow people to smoke marijuana legally on their doctor's orders. The federal government's response was to remind doctors that prescribing pot was still illegal under federal law and that any who do risk losing their medical license and perhaps a spell in prison.

Anecdotal (Sketchy) Evidence

Faced with the controversy, Harold Varmus, head of the National Institute of Health (NIH) called for a workshop to examine the evidence. While the expert panel's conclusions have no official force, they are a victory for advocates of the drug, who see them as ammunition against the official government line that marijuana has no medicinal uses. On the other hand, the panel did not explicitly endorse the drug. Instead, it recommended that more research should be carried out.

"The major problem here is getting good scientific data," says William Beaver, a pharmacologist at Georgetown University in Washington DC and chairman of the workshop panel. "You can argue policy and politics all you want, but if you haven't got the data then the politics make no sense. For at least some of the potential indications, the data are good enough to recommend that new controlled studies be done."

There is no shortage of anecdotal evidence for the weed's therapeutic powers. The panel heard from people who said marijuana had helped their glaucoma, prevented nausea and eased painful muscle spasms associated with multiple sclerosis. But properly controlled studies to confirm any of these claims are rare. There was a brief flurry of research in the 1970s, when society seemed to be growing more tolerant towards the drug, but that ended with the election of President Reagan in 1980 and the return to a get-tough policy on drugs of all kinds.

One of marijuana's better-known side effects—as an appetite booster—has increased the pressure to legalize the drug for medical use. Many AIDS patients battling the deadly wasting that can be caused by the disease smoke marijuana to stimulate their appetites. This has made the drug a key issue for America's powerful and well-organized AIDS activists.

"There is a clear consensus that marijuana has a positive effect on appetite," says Richard Mattes, professor of nutrition at Purdue University in Indiana. But it is uncertain whether a healthier appetite actually leads to weight gain: after a sudden increase in food intake, the body may
simply compensate by dulling the appetite when the drug's effects wear off. Studies of small groups of patients have shown that they do gain some weight but they do not specify whether it was useful weight in the form of lean body mass such as muscle.

There are also question marks over how helpful marijuana is at preventing nausea. Studies in the 1970s showed that the drug clearly does have anti-nausea effects say Richard Gralla director of the Ochsner Cancer Institute in New Orleans. But the effect seems to be weak compared with recently developed drugs, which work well for most chemotherapy patients.

Even with these drugs, there may still be a place for marijuana. However good a drug there are always some people who do not respond to it and for them smoking marijuana might help. The same argument applies for patients with glaucoma -- a blinding disease caused by too much pressure inside the eye.

The original enthusiasm for marijuana as a glaucoma treatment dates back to the 1970s before a number of effective drugs came onto the market says Paul Kaufman professor of ophthalmology at the University of Wisconsin. But in this case he says those few studies that have been done suggest that marijuana might be just as effective as the newer drugs and again could help those for whom these new treatments don’t work.

Marijuana might also bring relief to patients suffering muscle spasms associated with multiple sclerosis Huntington's disease and Tourette's syndrome. In one small study five patients with MS showed mild to moderate improvement says Paul Consroe a pharmacologist at the University of Arizona.

Conducting the necessary trials of marijuana is likely to prove difficult for both political and medical reasons. Simply setting up a trial that tests marijuana against a placebo is a challenge. Patients are not supposed to know whether they are receiving the drug or a placebo and it will be hard to produce a dummy drug that fools anyone who has ever tried marijuana.

Testing a drug that is smoked also causes problems. Therapeutically administering the drug this way has advantages: the drug reaches the bloodstream almost immediately. Smoking also allows patients to regulate their dose themselves by controlling the size of each puff and how long they hold it in the lungs. But this is not accurate enough for a controlled study that aims to find out the precise effect of a specific dose.

On the other hand, efforts to deliver the drug in the form of a pill have not always been satisfactory. The main psychoactive ingredient in marijuana is delta-9-tetrahydrocannabinol (THC), which is legally available in capsule form. But THC given this way takes longer to reach the bloodstream and with fixed amounts in a capsule, it doesn't allow the patient to adjust the dose so precisely. Some patients prefer the smoked version because they can stop as soon as they begin to feel its benefits but before they feel stoned something that is often impossible with capsules.
It is also possible that delta-9-THC is not the only chemical in marijuana that contributes to the medicinal effect. Although THC is the major psychoactive compound in marijuana, the plant contains some 460 other compounds including 60 other chemically related cannabinoids.

But the real problem marijuana researchers face is a political one. The pro-marijuana lobby claims that the National Institute on Drug Abuse has been unwilling to fund studies into the therapeutic effects of marijuana because it undermines its message that pot is bad for you.

The NIDA is also the only legal source of marijuana for medical studies and anyone wanting supplies must have the agency's approval. Donald Abrams of the University of California San Francisco has tried for almost five years to win approval to study the drug’s effect on AIDS wasting.

Abrams's university review committee and the Food and Drug Administration approved his study. But when he tried to acquire the drug the NIDA turned him down. Abrams says that the NIDA judged the study by harsher standards than normal. I just think everybody has a political agenda. It’s hard to retain scientific objectivity he says.

As its name suggests the NIDA sees marijuana mostly in terms of its potential for abuse and many observers claim this colors its judgment on which studies should be done. The NIDA will only fund research that tries to show the harmful effects of the drug says Rick Doblin a spokesman for the Multidisciplinary Association for Psychedelic Studies a pressure group in North Carolina.

In 1993, the agency redoubled its efforts to educate the public about the perils of pot when figures showed that more young people were taking it up after a long period when it seemed to have fallen out of favor. In a single year from 1994 to 1995, the proportion of teenagers smoking marijuana rose from 6 per cent to 8-2 per cent. And the average age at which people first try the drug has fallen from 18.8 in 1987 to 16.3 today.

"Our teenage drug problem is for the most part a marijuana problem—and we have a generation of children who are using marijuana earlier and earlier and are more and more likely to be armed with the dangerous misconception that it will do them no harm," says Donna Shalala the US Secretary of Health.

According to the NIDA, a number of animal and human studies show that smoking marijuana can have a range of ill effects including impairment of memory brain damage lung cancer and damage to the immune system and can lead to harder drugs.

The NIDA also disapproves of the idea of dispensing a drug in a cigarette. The panel suggested that a smokeless inhaler that heated the drug and vaporized its ingredients without creating smoke might solve this problem.
Political problems aside John Morgan medical professor at the City University of New York believes there is so much evidence that the drug is safe that it could take as little as three months to approve marijuana as a prescription drug. With so much existing research showing the relative safety of pot it is time to move straight to trials of the drug's effectiveness he says.

As far as the FDA is concerned any drug—and that includes marijuana—only has to be shown to be safe and effective says Robert Temple, the agency's associate director for medical policy. It does not have to be shown to be better than existing drugs. But realistically for marijuana to make it onto the market its proponents are going to have to show it is not only as good as existing drugs but better says Temple. Smoked marijuana will need to show it has advantages to overcome the opposition of the skeptics. Showing superiority is not normally a requirement. It's hard to prove.
Appendix T: Fast Food Legality Activity and Articles

Fast Food Age Limits Activity 1

Overview: Individually read through the following 9 articles and summarize the main points in a one-paragraph summary. During activity 2, as a group, use the following articles and information you have learned during the digestive system unit to create an informed opinion regarding establishment of a fast food age limit. Use any external sources or influences that may also provide you with information or insight regarding establishment of a fast food age limit. During Activity 3 you will present your recommendations and defend your age limit.

Assignment: First read and summarize the articles in the spaces provided below. Then come to a consensus as a group regarding the age / age range at which fast food will now be prohibited. You must be specific with your ages and restrictions. Restrictions may include minimum and maximum ages, gender, health conditions, or any other relevant measure that is based on your understanding of the issue with specific regard for the anatomy and physiology of the digestive system, digestive diseases, and diet-related health concerns. You may also choose to prohibit based on gender, health conditions, behavior types, and any other circumstance that you feel appropriate to include.

Summary Paragraph Article 1:

Summary Paragraph Article 2:

Summary Paragraph Article 3:
Summary Paragraph Article 4:

Summary Paragraph Article 5:

Summary Paragraph Article 6:

Summary Paragraph Article 7:

Summary Paragraph Article 8:

Summary Paragraph Article 9:
Fast Food Age Limits Activity 2

Class Period
Student Identifiers

As a group, please fill in the following items with as much detail as possible. Use your individual summaries to select the 8 most important pieces of evidence from the reading. You may also choose to include references from lecture, class, or other scientific sources. Please be as specific and detailed as possible in your references.

Article or other reference 1-

Article or other reference 2 –

Article or other reference 3 –

Article or other reference 4 –

Article or other reference 5 –

Article or other reference 6 –

Article or other reference 7 –

Article or other reference 8 –
Assignment: As a group, determine the specific age limit and restrictions that you will place on fast food. Please initially state the age limit and then write 2 – 3 paragraphs outlining your position and citing evidence as needed to support your position. You should include any background information, details, or supporting evidence that may be needed to defend your position in a debate.

Fast Food Age Limit(s) ______________________________

Justifications for fast food age limit: Please write a 2 – 3 paragraph statement outlining your group’s age limit recommendation and rationale for determining your fast food age limit.
Article 1: University of Washington: Youth, Digestion and Nutrition Review

Growth
In the first few years of life, children grow rapidly and need a variety of foods to help them grown. From birth to age one, a child's body weight increases by an average of three-fold. During this period of rapid growth, children rely on the calories and nutrition from breast milk or baby formula, as well as some solid foods. Throughout the rest of early childhood, children continue to grow, though not as rapidly, and they need calories, protein, iron, calcium, vitamin A, vitamin D, vitamin C and other nutrients to support their growth.

Brain Development
Early childhood is a time when the brain is developing rapidly, and nutrition is an important part of healthy brain development. During infancy, the amino acids and fatty acids in breast milk are ideal for optimal brain development. The brain continues to grow throughout early childhood, and children who do not consume a balanced diet that provides the vitamins and nutrients their brain needs are at risk of developing mental retardation and behavioral problems.

Bone Building
During early childhood, it is essential for children to consume the calcium they need to build strong bones and teeth. As children's bones grow bigger and stronger, they need calcium, and this calcium must come from the diet. In addition to calcium, children also need plenty of vitamin D and phosphorus to support the growth of their bones. Children who eat 2 to 3 servings of dairy products, such as low-fat milk, low-fat yogurt or natural cheese, can support the growth of strong bones and decrease their risk of developing osteoporosis later in life.

Muscle Growth
As children grow bigger and stronger, their muscle mass also increases. A balanced diet is necessary for the increases in muscle mass that occur during children's growth spurts. One nutrient in particular, iron, is especially important for muscle development. That's why children need plenty of healthful iron-rich foods, including lean meats, fish, beans, green vegetables, nuts and iron-fortified grains to support their muscle development.

Eating Habits
A balanced diet in early childhood doesn't just support the physical development of children, it also influences their psychosocial development, including the eating patterns they will adopt for a lifetime. It is important for young children to learn to eat a variety of healthful foods in pleasant and relaxed environments. Parents who support their children by exposing them to a healthful diet and acting as good-eating role models can help them develop a lifetime of healthy eating patterns and attitudes.

Article 2: The Mayo Clinic Council in Healthy Eating and Nutrition:

Question: How do you track dietary fat

Answer: Dietary guidelines suggest that healthy adults generally limit dietary fat to no more than 20 to 35 percent of total daily calories. To figure out how many fat grams or calories that means for you, start with the number of calories you normally eat or want to eat a day. Multiply that number by the recommended percentages to get the range of fat calories you can eat each day.
Here's an example based on a 2,000-calorie-a-day diet.

1. Multiply 2,000 by 0.20 (20 percent) to get 400 calories
2. Multiply 2,000 by 0.35 (35 percent) to get 700 calories

How many fat grams is that? There are 9 calories in a gram of fat, so you divide the number of calories by 9.

1. Divide 400 calories by 9 (calories a gram) to get about 44 grams of fat
2. Divide 700 calories by 9 (calories a gram) to get about 78 grams of fat

So if you're on a 2,000-calorie-a-day diet, 400 to 700 calories can come from dietary fat, which translates to between 44 and 78 fat grams a day.

Use the Nutrition Facts label to find out how much fat is in the foods you eat. The Nutrition Facts label shows the amount of total fat, saturated fat and trans fat in one serving. The label also shows how many calories come from fat.

To monitor the fat in your diet, simply add up the fat grams from all the food you ate during the day and compare the total to your target range. Knowing how much fat is in the foods you eat can help you control the fat and calories in your diet, which can help you, meet your health and nutrition goals.

The French paradox is the catchphrase frequently used to summarize the observation that French people have a relatively low incidence of coronary heart disease (CHD), despite having a diet relatively rich in saturated fats, in apparent contradiction to the widely-held belief that the high consumption of such fats is a risk factor for CHD. The paradox is that if the thesis linking saturated fats to CHD is valid, the French ought to have a higher rate of CHD than comparable countries where the per capita consumption of such fats is lower.

The French paradox implies two important possibilities. The first is that the hypothesis linking saturated fats to CHD is not completely valid. The second possibility is that the link between saturated fats and CHD is valid, but that some additional factor in the French diet or lifestyle mitigates this risk—presumably with the implication that if this factor can be identified, it can be incorporated into the diet and lifestyle of other countries, with the same lifesaving implications observed in France. Both possibilities have generated considerable media interest, as well as some scientific research.

It has also been suggested that the French paradox is an illusion, created in part by differences in the way that French authorities collect health statistics, as compared to other countries, and in part by the long-term effects, in the coronary health of French citizens, of changes in dietary patterns, which were adopted years earlier.

The overall impact of the popular perception, in the English-speaking world, that the French paradox is a real phenomenon, has been to give added credibility to health claims associated with specific French dietary practices.

This was seen most dramatically when, in 1991, an early account of the then-novel concept of the French paradox was aired in the United States on 60 Minutes. The broadcast left the impression that France's high levels of red wine consumption accounted for much of the country's lower incidence of cardiac disease. Within a year, the consumption of red wine in the United States had increased 44% and some wine sellers began promoting their products as "health food."

The cultural impact of the French paradox can be seen in the large number of book titles in the diet-and-health field which purport to give the reader access to the secrets behind the paradox:

3. The Fat Fallacy: The French Diet Secrets to Permanent Weight Loss (William Clower, 2003);
5. French Women Don't Get Fat (Mirielle Guiliano, 2004, which became a #1 best-seller in 2006)

The existence of the French paradox has caused some researchers to speculate that the link between diet, saturated fats and coronary heart disease might not be as strong as had previously been imagined.

Article 4: Journal Of Digestive Health: Dietary Health; Gallstones

Gallstones form when elements in bile harden into small, pebble-like pieces in the gallbladder. Most gallstones are made mainly of hardened cholesterol. If liquid bile contains too much cholesterol, or the gallbladder doesn’t empty completely or often enough, gallstones can form.
Women are twice as likely as men to have gallstones. Estrogen, a female hormone, raises cholesterol levels in the bile and slows gallbladder movement. The effect is even greater in pregnancy as estrogen levels rise. This helps explain why many women develop gallstones when pregnant or after having a baby. Like-wise, if you take birth control pills or menopausal hormone therapy, you have a greater chance of developing gallstones.

You are also more likely to have gallstones if you:

- have a family history of gallstones
- are overweight
- eat a high-fat, high-cholesterol diet
- have lost a lot of weight quickly
- are older than 60
- are American Indian or Mexican American

**Warning Signs of a Blocked Bile Duct**

If you have any of these symptoms of a blocked bile duct, see your doctor right away:

- pain lasting more than 5 hours
- nausea and vomiting
- fever
- yellowish skin or eyes
- clay-colored stool

Here are some steps you can take to help prevent gallstones:

- Maintain a healthy weight.
- If you need to lose weight, do it slowly—no more than 1/2 to 2 pounds a week.
- Eat a low-fat, low-cholesterol diet.
Healthy Eating  Goal: Promote the consumption of a variety of nutritious foods.

**Recommendation 4-1:** To ensure that child care facilities provide a variety of healthy foods and age-appropriate portion sizes in an environment that encourages children and staff to consume a healthy diet, child care regulatory agencies should require that all meals, snacks, and beverages served by early childhood programs be consistent with the Child and Adult Care Food Program meal patterns and safe drinking water be available and accessible to the children.

**Recommendation 4-2:** The Department of Health and Human Services and the U.S. Department of Agriculture should establish dietary guidelines for children from birth to age two years in future releases of the *Dietary Guidelines for Americans.*

Goal: Create a healthful eating environment that is responsive to children’s hunger and fullness cues.

**Recommendation 4-3:** State childcare regulatory agencies should require that child care providers and early childhood educators practice responsive feeding.

Potential actions include:

3. For toddlers/preschoolers—providing meals and snacks as part of a daily routine; requiring adults to sit with and eat the same foods as the children; when serving children from common bowls (family-style service) allowing them to serve themselves; when offering foods that are served in units (e.g., sandwiches) providing age-appropriate portions and allowing children to determine how much they eat; and reinforcing children’s internal cues of hunger and fullness.  

**Goal: Ensure access to affordable healthy foods for all children.**

**Recommendation 4-4:** Government agencies should promote access to affordable healthy foods for infants and young children from birth to age five in all neighborhoods, including those in low-income areas, by maximizing participation in federal nutrition assistance programs and increasing access to healthy foods at the community level. Potential actions include:

- The federal government assists state and local governments in increasing access to healthy foods.  

**Goal: Help adults increase children’s healthy eating.**

**Recommendation 4-5:** Health and education professionals providing guidance to parents of young children and those working with young children should be trained and educated and have the right tools to increase children’s healthy eating and counsel parents about their children’s diet.

**Article 6: Harvard Journal Of Healthy Living: Effects of Poor Diet in Children**

Nutrition certainly affects a child's physical health, but did you know that it could also affect
your child's behavior as well? Studies show that a poor diet may be associated with Attention-Deficit/Hyperactivity Disorder (ADHD), due to the preservatives, sugars and lack of thiamine found in many junk foods. Lack of proper nutrients can also affect a child in the opposite way. Without enough carbohydrates, proteins and good fats, a child may become lethargic and irritable.

**Intelligence**
The link between nutrition and intelligence has been studied since the 1980s. In 1984, one study found that children who took a micronutrient supplement had increased IQ scores, and other studies later confirmed these findings. In terms of cognitive ability, children who eat a healthy diet will be better able to concentrate during school, which means that they can take full advantage of their intelligence potential.

**Dental**
Children with poor diets typically have poor dental health when compared to children who eat healthy diets. The main problem with a poor diet in regards to teeth is the amount of refined sugar in junk food. Sugars feed the bacteria in the mouth that cause cavities. In addition, processed foods and soft drinks usually have a lot of dyes in them, which can lead to staining.

**Vitamin Deficiency Problems**
Vitamin deficiency can especially be a problem in children, as lack of specific nutrients could cause serious and irreversible health problems in children. Remember, children are affected more quickly than adults because their bodies are smaller and they are still growing. Lack of B vitamins can cause health problems like leg pains, ulcers, nausea, breathing problems and weakness. Vitamin C is another important nutrient for children, though most can get the Vitamin C they need pretty easily through foods and exposure to sunlight. Vitamin D deficiency is extremely dangerous for children, because it can cause bowed legs, spine deformities and other growth problems. With a picky eater, parents can use a multi-vitamin made for kids as a supplement to prevent problems.

**Obesity**
Most parents know that obesity is not a good thing in children. With a poor diet, weight can be a problem, even if your child is fairly active. The key here is to replace bad fats and sugars, such as those found in soda, chips, sweets and other junk foods with good fats, such as those found in olive oil, fruit and potatoes. Obesity can cause diabetes, trouble sleeping, high blood pressure and breathing problems, as well as problems that last into adulthood.
Article 7: Science Daily

Most people know that fast food is not the best choice for a healthy diet. Most will also say that exercising moderation is the key. “Everything in moderation” is a common mantra these days. We are often criticized for saying that moderation is just an excuse to eat anything you want. However, a new study from the University of Minnesota seems to back us up.

According to researchers there, “people who consume fast food even once a week increase their risk of dying from coronary heart disease by 20 percent in comparison to people who avoid fast food. For people eating fast food two-three times each week, the risk increases by 50 percent, and the risk climbs to nearly 80 percent for people who consume fast food items four or more times each week. Eating fast food two or more times a week was also found to increase the risk of developing Type 2 diabetes by 27 percent.”

So what do you have to say about the idea of moderation now? There are plenty of folks that eat fast food four or more times every week. In fact, if we took a poll, many parents would admit to buying their children fast food that often (or more).

The researchers looked at 52,000 Chinese residents in Singapore over a period of 16 years starting in 1993. This was a period where there was a recent and rapid transition from their traditional diet to Western-style fast food. What was more interesting was that the study participants tended to be younger, better educated, smoked less and were more physically active. They would normally be the folks expected to have lower risk for these conditions.

Because fast food is now so common here in the West and over 70% of us are overweight and have various health problems, we can’t see the forest through the trees. Fast food is not harmless. Fast food is dangerous and even moderation in eating it is a big mistake. The people eating it are getting sick and dying more frequently and earlier too.

If you care about your health and the health of your family, you need to start making healthier choices. You need to take responsibility for your diet and lifestyle. Your healthcare is your responsibility. Only you can help yourself and the sooner you start, the lower your risk.
Alzheimer’s, dementia, and other diseases that impair cognitive function have been getting more and more attention as our baby boomer generation reaches old age. Today, it’s estimated that a third of adults will experience a gradual decline in their cognitive abilities, characterized by slower thinking, reduced ability to learn, and impairment in memory. Many people, including conventional doctors, view this slowing down of cognitive functions as inevitable, but new research has begun to uncover possible reasons for these impairments and has identified some ways to combat them.

The Importance of Vitamin B to an Aging Mind

What we refer to as “Vitamin B” is actually an array of vitamins, which support several systems in your body, and they are especially important to your brain and neurological functions. For many years, doctors and medical professionals maintained that vitamin B deficiencies are rare because of the wide array of foods that these vitamins can be found in. However, a large scale study published in 2008 may have opened some eyes. The study conducted by researchers at Tufts University found that vitamin B6 deficiency is more common than thought, even when participants reported consuming more than the Recommended Daily Allowance of B6. The problem is that the Standard American Diet (S.A.D.) being consumed these days is so loaded with sugar, preservatives, and processed foods that the vitamins and minerals are no longer viable.

What’s worse, a diet high in nutrient-poor processed foods weakens digestion and destroys the micro flora (friendly bacteria and yeast) that should be living inside your inner ecosystem. You must have an inner ecosystem teeming with beneficial micro flora in order to properly absorb nutrients, have strong immunity, and stay healthy and strong.

Simply put, the typical American diet does not provide enough of the essential nutrients needed to maintain good health, and most people have poor digestive systems so that even when they do eat healthy, they are unable to efficiently absorb these vital nutrients. The older you get, the worse it becomes.

There are a number of reasons for this, but it’s often because their digestion is worse than it was in their youth. So while you age, you become more and more vitamin and nutrient deficient, which further hastens the aging process. It’s a vicious cycle: Poor digestion = fast aging = worsening digestion = increased age-related health declines.
Benefits of Healthy Eating
6. Proper nutrition promotes the optimal growth and development of children.
7. Healthy eating helps prevent high cholesterol and high blood pressure and helps reduce the risk of developing chronic diseases such as cardiovascular disease, cancer, and diabetes.
8. Healthy eating helps reduce one’s risk for developing obesity, osteoporosis, iron deficiency, and dental caries (cavities).

Consequences of a Poor Diet
4. A poor diet can lead to energy imbalance (e.g., eating more calories than one expends through physical activity) and can increase one’s risk for overweight and obesity.
5. A poor diet can increase the risk for lung, esophageal, stomach, colorectal, and prostate cancers.
6. Individuals who eat fast food one or more times per week are at increased risk for weight gain, overweight, and obesity.
7. Drinking sugar-sweetened beverages can result in weight gain, overweight, and obesity.

Eating Behaviors of Young People
• Most U.S. youth
  Do not meet the recommendations for eating 2½ cups to 6½ cups* of fruits and vegetables each day
  Do not eat the minimum recommended amounts of whole grains (2–3 ounces* each day)
  Eat more than the recommended maximum daily intake of sodium (1,500–2,300 mg* each day).
  • Empty calories from added sugars and solid fats contribute to 40% of daily calories for children and adolescents aged 2–18 years. Adolescents drink more full-calorie soda per day than milk.

Diet and Academic Performance
Eating a healthy breakfast is associated with improved cognitive function (especially memory), reduced absenteeism, and improved mood.
Benefits of Healthy Eating
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Appendix U. Short Answer Taxonomic classifications

Personal, Egocentric:

*Description = Characterized by logic or rationale centered on consequences, effects or experiences that are personally relevant and or self-focused.*

Example: “… an illegal substance like marijuana would be equally harmful and as an athlete I take respiratory health very seriously and would not do anything to harm my respiratory system.”

Example: “Loss of personal identity. You’re not yourself anymore. You’re neutral or like everyone else. There isn’t something to make you different. This was more of a personal reason” FRB1

Example: “It causes dandruff, hemorrhoids, obesity, asthma, leprosy, red eye, dry mouth, vomiting and high blood pressure. I don’t want any of those – yuck.” FCJC31a

Example: In response to a prompt for justification…”Personal experience of a cousin’s long cancer caused by marijuana usage for many years” FRD31b

Example: “It doesn’t affect me. I don’t care if its legal or not because I could care less, if it doesn’t bother me which it doesn’t if its illegal than I’m neutral. I do not use marijuana and I never will so it doesn’t affect me.” MARC4Q1a,b

Example: “It doesn’t matter. I know I don’t do it and it doesn’t affect me.” MPS4Q1

Example: “I have had a second hand experience with someone ruining their life because of marijuana. It’s just not worth it.” FSO2Q1bPRE

Medical / Health:

Scientific:

*Description = logic and rationale present is centered around scientific, medical or health related themes.*

Example: “I like to know that the information I find is true and supported by evidence and not just rumors. Scientific information research provides proof of the safety or dangers of marijuana use. With accurate information I can formulate my opinion more accurately” FAG1

Example: “Scientific data is my main factor. If the data shows that there is an effect from a cause with no outside disturbances (influences), than one must cause the other.” MRY1

Example: “One study used a large number of users and controls, but there was no psychological backgrounds taken to influence choice of subjects, and concluded that marijuana caused a
learning deficiency. Another study with an equally large group, but a much stricter selection of subjects concluded there was little difference between users and non users”. FAL2 1b

Example: “Heavy users performed less well on tests of memory and learning, and in an experiment with rats evidence of the degeneration of connections between the cells in the hippocampus was found.” FMK2 1b

Example: “Scientific findings that provide / defend / reject marijuana safety influenced the majority of my decisions. FES2 1a

Example: “My health is my most important factor. When reading the articles and during discussion the risks stated scare me. I don’t think marijuana should be legal.” FKN4Q1a

Example: “What specifically can be done for medical marijuana to be safe to use? In what circumstances would marijuana be prescribed? What specific conditions? FES2Q3

Family, Familial or Family History:

Description = justifications and or logic use family members or aspects of family history.

Example: “My dad does drug busts and arrests the person that is growing marijuana. Knowing that you can get arrested for even possessing marijuana it has always made me very anti marijuana”. FJL1

Example: “My parents both tell me the bad effects that marijuana has. They say it kills brain cells and my mom even told me one time she heard about this girl that smoked it and then suffered from really bad brain damage or something”. FJL1

Example: “My uncle is mentally different after many years of use. Slurred speech, little teeth left, socially insensitive and unaware, lowered total brain power.” MRCM2 1a

Example: “The study I read from a news article states that chronic users of marijuana perform less well than those who don’t and this directly supports most of the symptoms observed in my uncle.” MRCM2 1bEX2

Example: “At the dinner table we’ve talked about the reality of drugs and the damages they can cause. As a result, this has influenced me to believe that marijuana use is not safe.” FSG3Q1a

Example: “My oldest step sister habitually uses marijuana and has no motivation. She had aspirations but she’s depressed all the time, she’s aggressive. Its done her no favors.” FMR4Q1a

Example: “My family is my most important factor on the issue of marijuana safety. They have always told me not to do it. I have always been shown the problems that arise from them (family). It can cause more trouble that it is worth.” MJM4Q1a,b
**Emotive / Empathetic:**

*Descriptions* = emotive or empathetic characteristics are present in responses and justifications or rationale express emotional or empathetic tones.

Example: “I believe the effects of marijuana are negative, and even if they don’t necessarily hurt you, you could do something stupid while using it and hurt someone and that would be not only sad but as bad or worse than hurting yourself.” FBR1

Example: “Legalization of tobacco and alcohol vs. marijuana. It doesn’t make sense that more harmful substances are accepted. Tobacco and alcohol are 100% confirmed to be harmful and addictive. MACB3Q1a

Example: “The side effects of using marijuana are destroying peoples lives. People can get addicted to it and soon it will consume their lives.” MPL4Q1PRE

Example: “I believe marijuana is not safe and it leaves damages on the brain and respiratory system.” FMK2Q1aPRE

Example: “You only get one brain. Why would you want to do something that can potentially ruin / harm your brain. It is plain stupid.” FSO21aPRE

Example: “It’s scary to see all of the long term effects marijuana has. It swayed my opinion to believe 100% how dangerous and bad marijuana is.” FEAF2Q1b2PRE

**Apathetic / Defeatist:**

*Description* = responses display patterns of apathy, defeatism or a general sense that the problem, issue or topic is beyond the scope of what is scientific, personally or academically approachable. There is a sense of apathetic detachment from the issue in a manner that suggests there is no use concerning oneself with its discussion or resolution.

Example: “People are going to use this drug anyway so know how much they can have in one use might stop abuse” MBM1

Example: “People will smoke marijuana regardless of if it is legal or illegal. People smoke cigarettes despite the harmful factors that can lead to cancer and cigarettes are perfectly legal. FKA3Q1

Example: “How can the government make something natural illegal? It grows naturally and isn’t chemically altered so how bad can it be vs. genetically modified food readily available at practically every intersection?” FMA4Q3PRE
**Friends / Personal Influences:**

*Description = Examples or logical decisions are based on at least a portion of personal influences that include friends or non-familial acquaintances.*

Example: “Everyone that I know smokes it says it isn’t (addictive) so I would want to know the scientific answer” FAL1

Example: “I know people who smoke on a daily basis and run cross country and get low times on 5K’s.” MJMY2Q3

Example: When asked what other info they would like to know about marijuana safety…“I have a friend who smokes marijuana and takes anti anxiety medication. When combined does it produce an adverse effect?” FED3Q2

Example: “My most important factor was friends and peers. Most of my friends experiment with and smoke marijuana.” MJT4Q1a

Example: “Friends and peers were my main source in influence. Smoking marijuana isn’t horrible if you practice self control. Plenty of my friends smoke and they are not brain dead.” FEJ4Q1

**Broad Generalization or Over Non Evidenced Statement, S.W.A.G.:**

*Description = Scientific or quasi-scientific statements are made with little or no justification, evidence or supporting follow up. Statements tend to contain scientific terminology, units or verbiage but little supporting data or evidence.*

Example: “It lowers IQ and negatively affects ALL OF THE BODY SYSTEMS” FLL1

Example: “The amygdala, a region of the brain responsible for emotional control is directly influenced by cannabinoids – making marijuana more effective for treating all emotional disorders than any other drugs” MJP1

Example: “The overwhelming evidence that marijuana has no definite negative effect. Besides being a carcinogen, marijuana has little to no proven negative effects on the brain. The evidence is just not there to prove marijuana is unsafe.” MJC2 1a

Example: “The most important factor is that marijuana isn’t harmful enough to your body to be illegal.” MJDB 1a

Example: “Why is the government tricking us as to why weed is so bad? Cuz its not.” FKF3Q3
Example: “I do not agree with marijuana usage no matter what its recent legalization in multiple states. Marijuana is a distant form of some plant that is no longer natural and should not be consumed by anyone.” FRD31a

Example: “If I don’t agree with the experiment then I don’t agree with the results.” MRB3Q1a

Example: “The use of marijuana has little to no long term effects that damage the body’s function.” FDR4Q1aPRE

Example: “Although the drug is used to help some cancer patients it has been proven in most cases that marijuana can lead to brain damage. Smoking in early years can cause impairments on memory, cognition, increase developing risk of schizophrenia and restriction of arteries in the brain which can lead to stroke.” FJG2Q1bPRE

Example: “Even though marijuana has very few benefits to the medical field, it hasn’t been tested enough to declare that it’s benefits outweigh its negatives. So, for right now, marijuana is unsafe.” FMH2Q1aPRE

Example: “There have been many studies that have declared marijuana as a natural and excellent medication for many patients, that have problems with prescription drugs that got off due to marijuana. Studies show that marijuana can have benefits to your health in various ways.” MJMY2Q1abPRE

Example: “Certain chemicals will damage the way the systems are run and can cause diseases that can lead to death.” FAW2Q1aPRE

**Religion:**

*Description = Theology or religious ethics, morals or dogmas are presented as an influence factor in negotiating the issue.*

Example: “My largest influence is religion. My religion says that it is important to have a healthy body and mind and that marijuana goes against that.” MKG4Q1

**Exhibits or recognizes multiple scientific points of view:**

*Description = The student acknowledges that there are more than one side to the issue and identifies points, evidence or scientific arguments that could both support or refute a stance on the issue. Evidence may be presented that both supports their or any position on the issue while both or either agreeing with or disagreeing with evidence in a scientific manner.*

Example: “…There is a general lack of confirmation in the studies. Most studies contradicted each other, Ex. One concluded that marijuana causes learning deficiencies, while another says there was little difference between users and non users.” FAL2 1a
Example: “Are researchers unbiased when performing experiments? Are the studies fair? All controls and things have to be fair because different researches may conflict with the results.

Example: “The contradictions of research studies of pot being a carcinogen but also preventing cancer is not very assuring” FRD31a

Example: “Although people (including scientists) argue that marijuana provides some benefits, the negative effects, such as memory loss and brain damage, outweigh the benefits.” FKN3Q1aPost

Example: “…does it (marijuana) really cause any brain damage? Some articles claim it does some claim it doesn’t. Similarly, one article claimed it increased the risk of cancer… is that really true? MTH3Q3

Example: “Marijuana can be used to relieve nausea and vomiting, chronic pain and stimulates appetite. Even though marijuana can have some downsides it has been said by many people and researchers to help with nausea.” MAG3Q1a

Example: “A good deal of the evidence presented sounded reliable from both sides of the argument, so the contradiction of the evidence was confusing and frustrating at times. Eventually I formed my own opinion pertaining to marijuana usage based on my interpretation.” FRD31a

Example: “Some people (researchers / doctors) say marijuana doesn’t affect your health while others say it will cause cancer and brain damage. Science shows it has helped with glaucoma, muscle spasms and nausea, however, science has shown that long term users performed less well on tests of memory and attention than non smokers. MPL4Q1a,b

Example: “Scientific studies show that it (marijuana) changes your behavior and causes brain damage. Other studies show it helps with glaucoma and MS. Marijuana’s benefits or detrimental affects are what makes it healthy or unhealthy in the opinion of the user or researcher. Scientific studies prove it or disprove it depending on what benefit or detriment is being looked for.” MMD4Q1a,b

Example: “There are both positive and negative sides to why marijuana should or should not be legalized. In the packet of reading there were some studies that talk about the positive and some about the negative. Many studies disprove other studies.” MAS4Q1a,b

Example: “Patients have found marijuana to release their pain and it helps them with nausea. Scientists have done studies where there have been negative affects on the brain. Scientists are still not sure if the use of marijuana is beneficial medically or if it is a major harm to the brain.” FVJU4Q1a,b

Example: “Many articles said that the studies were inconclusive, unreliable or inconsistent. Several studies or researchers use vague terms like “long term”, “short term” and “heavy user”. One article compared groups where users are not necessarily using the same amount. Both sides
argue benefits or risks, but results of studies are to unclear to for sure prove either side.”
FAB4Q1a,b

Example: “Why are marijuana research results so different from one another? One article would say it is safe, while another would say it isn’t. Why are the results so contrasting.”FKTN4Q3PRE
This demonstrates awareness of multiple viewpoints without any acknowledgment for the NOS principles behind data, research and experimentation.

Example: “Bias of researchers is why articles are double sided and why hasn’t there been one established fact or on its effects.” MPR4Q4PRE shows recognition of bias and scientific debate or influence. May not show total recognition of multiple points of view and their impact on the process of knowledge but this is emergence at least of the concept of multiple scientific points of view.
### Appendix V. Figure 4.6 – 4.11 Raw Data

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# Appendix W. Interview Protocol

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<th><strong>Probe Question</strong></th>
<th><strong>Purpose</strong></th>
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<td><strong>1.</strong> What do you think about the previous statement? (If no thoughts or point of view are offered, ask:) Could you ever say which was the better position? How? Why not? How would you go about making a decision regarding this issue? Will we ever know for sure which is the better position? How / Why not?</td>
<td>To allow participant to share an initial reaction to the problem presented. Most state which point of view is closer to their own.</td>
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<td><strong>2.</strong> How did you come to this point of view?</td>
<td>To find out how the respondent arrived at the point of view, and whether/how it has evolved from other positions on the issue.</td>
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<tr>
<td><strong>3.</strong> On what did you base that point of view?</td>
<td>To find out about the basis of the respondent’s point of view, such as personal evaluation of the data, consistency with an expert’s point of view, or a specific experience. This provides information about the respondent’s concepts of justification.</td>
</tr>
<tr>
<td><strong>4.</strong> Can you ever know for sure that your position is correct? How or why not?</td>
<td>To find out about assumptions concerning the certainty of knowledge.</td>
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<td><strong>5.</strong> When two people differ about matters such as this, is it the case that one opinion is right and one is wrong? If yes, what do you mean by “right”? If no, can you say that one opinion is in some way better than the other? What do you mean by better?</td>
<td>Assesses the adequacy of alternative interpretations; to see if dichotomous either / or view of the issues held; to allow the participant to give criteria by which she or he evaluates the adequacy of arguments.</td>
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<td><strong>6.</strong> How is it possible that people have such differing points of view about this subject?</td>
<td>To elicit comments about the respondent’s understanding of differences in perspectives and opinions.</td>
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<td>7. How is it possible that experts in the field disagree about this subject?</td>
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