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Socioscientific Decision-Making in Undergraduate Students: The Role of Personal Epistemology

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This dissertation is dedicated to the two strongest women in my life: my grandmother who has taught me that from hard work, perseverance, love, and bravery, we can achieve anything we set our minds to. And to my mother who has taught me how to rock the boat without letting it rock me.

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ABSTRACT

Socioscientific issues (SSIs), or controversial scientific issues with social implications, influence members of society regardless of demographic. SSIs are contentious and ill-structured, meaning they do not have a definitive answer. To properly equip students with the tools needed to handle SSIs, undergraduate science curricula emphasize scientific literacy skills, such as the ability to search, recognize, and use accurate scientific information when handling science driven issues outside of the classroom. However, SSIs are influenced by political, social, economic, and cultural stakeholders. Therefore, students may not be basing their SSI decisions off of accurate information. An individual's personal epistemology is known to contribute toward how someone thinks, perceives, and behaves surrounding ill-structured problems. Personal epistemology is defined as an individual's personal theories surrounding knowledge and knowing. This dissertation examines how epistemological mechanisms contribute toward undergraduate students' SSI decision-making processes through qualitatively investigating how (1) students evaluate evidence during SSI decision-making, (2) how students justify their use of evidence when explaining their SSI decisions, and how (3) identity commitments from sociocultural in-groups relate toward students' ways of knowing during SSI decision-making. The results of this dissertation explain how students are utilizing information when handling SSIs. By furthering our understanding of these processes, instructors of science courses may tailor their coursework to acknowledge the various ways of knowing students are drawing upon when thinking through an SSI. By doing so, instructors can create learning environments that encourage objectivity when discussing SSIs within the classroom.

INTRODUCTION

As the world strives to disentangle socioscientific issues (SSIs) such as the COVID-19 pandemic, the importance of understanding SSI decision-making processes is critical. SSIs are controversial scientific issues that are influenced by political, economic, social, and cultural stakeholders (Herman *et al.,*2020; Sadler and Fowler, 2006; Sadler, 2004; Zeidler *et al.,* 2002; Zeidler *et al.,* 2009). Due to their complex nature, SSIs do not have a definitive answer making it increasingly difficult for communities to make informed decisions (Herman *et al.,*2020; Sadler and Fowler, 2006; Sadler, 2004; Zeidler *et al.,* 2002; Zeidler *et al.,* 2009. Furthermore, these issues influence all members of society; ranging in complexity depending on context and demographic (Herman *et al.,*2020; Sadler and Fowler, 2006; Sadler, 2004; Zeidler *et al.,* 2002; Zeidler *et al.,* 2009). In attempt to improve how society handles SSIs, many undergraduate institutions have adopted curricular changes to their science programs, requiring that all students regardless of major complete scientific requirements (American Association of Colleges and Universities, 2007; DeBoer, 2000; National Research Council, 2002). By doing so, students may increase their levels of scientific literacy which are indispensable skills that contribute toward handling SSIs outside of the classroom (American Association of Colleges and Universities, 2007; AAAS, 2011; DeBoer, 2000; National Research Council, 2002). However, due to the complicated nature of an SSI, science is just a small fraction of what decision-makers may consider. Therefore, it is paramount to understand how and why students are arriving at their SSI decisions.

Making an SSI decision is an inherently social process that is strongly influenced by the decision-maker's sociocultural group inclusions (Herman, 2018; Herman *et al.,* 2022). These

political, social, economic, and cultural in-groups have strong holds upon how the decision-maker perceives and acts upon the SSI (Alred & Dauer, 2020; Herman *et al.,* 2022; Sadler & Zeidler, 2005). An individual's sociocultural groups have a direct influence upon how they identify in a specific context and therefore, how they may behave during decision-making tasks (Herman, 2013; Herman, 2015; Herman, 2018; Sarimento *et al.,* 2019; Zeidler *et al.,* 2013;). These group inclusions play an even stronger role upon decision-making strategies when the SSI is contentious and threatens the well-being of the individual's life and social in-groups (Herman, 2013; Herman, 2015; Herman, *et al.,* 2022; Nadelson & Hardy, 2015; Zeidler *et al.,* 2013). Therefore, when evaluating a contentious SSI, the decision-maker may ignore essential scientific evidence and adhere toward the ideologies of their sociocultural groups in order to avoid tension and exclusion from the group (Alred & Dauer, 2020; Herman, 2015; Oulton *et al.,* 2004). These ideologies have epistemic consequences upon all who adopt them as they contribute toward someone's beliefs about knowledge and knowing (Herman, 2015; Packer & Goicoechea, 2000; Sinatra & Hofer, 2018). Therefore, by reflecting upon these ways of knowing, the decision-maker may be giving in toward misinformation about the SSI, basing their decision off of the controversy and fear from their in-groups (Herman, 2015; Herman *et al.,* 2022; Nichols, 2017). Therefore, it is necessary to investigate how students are making their SSI decisions. Current epistemological work explores how students are thinking, learning, and evaluating knowledge claims that are used to support SSI decisions. Contributing to this growing body of research, this dissertation investigates how students' personal epistemology contributes toward SSI decision-making processes.

Background

The term personal epistemology refers to "people's individual theories about the nature and limits of knowledge and knowing" (Greene *et al.,* 2016, p.2). In this dissertation, we refer to knowledge and knowing as an awareness and understanding of an individual's reality (Mater, 2000). Piaget broadly brought concepts of personal epistemology into the fields of education psychology (Burr & Hofer, 2002; Hofer, 2000; Piaget 1954;). Within this early work, Piaget discussed that an individual develops their own theories of knowing, where knowledge ebbs and flows through experiences and exposures (Burr & Hofer, 2002; Labbas, 2013; Piaget, 1954). Piaget's theory guided educational psychology researchers to pursue studies exploring how students know and learn, giving rise to the foundational research that motivates current epistemological studies across academic domains.

There are many ways to describe personal epistemology given its philosophical, psychological, and educational roots. Because of the scope and complexity of this phenomenon, it is essential to assign the definitions appropriate to the field of focus (Hofer and Bendixen, 2012). In the domain of science, personal epistemology encompasses two threads: the nature of science and epistemic cognition (Elby *et al.,* 2016). This dissertation focuses on epistemic cognition. We define epistemic cognition as a dynamic process of thinking that draws upon epistemic beliefs when making, arguing, or justifying decisions about an ill-structured problem (Chinn, *et al.,* 2014; Hofer, 2016; Kelly, 2016; Sinatra, 2016; Sinatra & Chinn, 2011; Mason, 2016). Epistemic beliefs are beliefs about the nature of knowledge and the nature of knowing (Ferguson *et al.,* 2013). We consider epistemic cognition to be the cognitive action that is built upon epistemic beliefs (Sinatra, 2016). Therefore, this dissertation dedicates one chapter entirely to the process

of epistemic cognition and then focusses on epistemic beliefs in the remaining two chapters. The following sections briefly introduce both constructs and how they are essential when evaluating SSI decision-making processes.

Epistemic Cognition

Epistemic cognition explains how people learn, reason, and use knowledge (Chinn *et al.,* 2014; Elby *et al,*2011; Hofer, 2016; Hofer & Bendixen, 2012; Sinatra, 2016;). This type of cognition is context specific, as different types of knowledge are accumulated through educational exposures as well as through experiences and from various authoritative sources (Hofer, 2016; Greene *et al.,* 2016). Essentially, epistemic cognition is how and why we know what we know and how we decide to use that knowledge when handling ill-structured problems (Hofer, 2016; Sinatra, 2016). As an educational construct, epistemic cognition has been studied in several academic domains. However, due to students being confronted with complex scientific information both inside and outside of the classroom, there needs to be an emphasis in studying students' epistemic cognition in the domain of science. By doing so, we may evaluate how students handle, use, and determine the validity of information about SSIs when constructing their decisions. This is essential to study as these decisions may have direct implications at both the individual and societal level (Herman, 2015; Herman *et al.,* 2018; Herman *et al.,* 2022).

To successfully evaluate epistemic cognition, it must be recognized as a cognitive process that has an activation and resolution based upon an individual's goals toward whatever problem they are reasoning through (Chinn *et al.,* 2011; Elby *et al,*2011; Hofer, 2016; Hofer & Bendixen, 2012; Kunda, 1990; Sinatra, 2016). Kunda (1990) discusses this by explaining that when faced

with a controversial issue, an individual may have preconceived decision-making goals and may select knowledge that aligns with these specific goals when reasoning through the issue. Furthermore, Chinn and colleagues (2011) emphasize these decision-making goals, by stating that they may be guiding the individual toward specific criteria for valid knowledge when working through specific contexts. However, it is a methodological challenge to recognize how decision-making goals influence the selection and utilization of knowledge when working through an SSI, especially when the field is predominantly comprised of quantitative models. Recent conversations surrounding effective ways to evaluate epistemic cognition discuss that these quantitative models may not be sensitive enough to provide the field with a robust description of the dynamicity of epistemic cognition (Greene *et al.*, 2016; Sinatra, 2016).

The AIR model (Barzilai & Chinn, 2020; Chinn *et al.*, 2011; Chinn *et al.*, 2014; Chinn *et al.*, 2021) provides a way to examine the dynamicity of epistemic cognition through explaining three universal decision-making components, epistemic Aims (the motivational goals for decision-making), Ideals (an individual's criterion for valid information), and Reliable Processes (the process dictating the validity of these ideals). Although not explicitly, the AIR model is unique in that it acknowledges the affective components that contribute to an individual's way of knowing and how they are utilizing that knowledge (Barzilai & Chinn, 2020; Chinn *et al.*, 2011; Chinn *et al.*, 2014; Chinn *et al.*, 2021; Muis *et al.*, 2015). Although this dissertation does not specifically ask about affective constructs such as emotions or engagement, the AIR model suggests that these constructs may be contributing to how an individual is cognitively constructing an SSI decision (Barzilai & Chinn, 2020; Chinn *et al.*, 2021). By qualitatively utilizing the AIR model to evaluate SSI decision-making, we may be able to uncover various

components that are contributing to an individual's SSI decision making process that have not been detected by other models.

Epistemic Beliefs

Perry's seminal phenomenological study pioneered how the field evaluates epistemic beliefs (Perry, 1970). In his study, Perry followed undergraduate male students throughout their collegiate careers (Perry, 1970), observing their views and assumptions of knowledge sources (Perry, 1970). This work discovered that students' beliefs about knowledge and knowing ranged on a continuum from having dualistic views of knowledge (knowledge is straightforward and not changing) to having multiplistic views of knowledge (knowledge is the same), to having relativistic views of knowledge (knowledge is contextual) (Perry, 1970). This continuum progresses over time (Perry, 1970). This work provided the field with the first empirical evidence that epistemic beliefs play a role in the development of knowledge (Hofer, 2000; Ladaas, 2013).

Influenced by Perry's (1970) seminal work, epistemic beliefs within educational psychology are often explained through a continuum (Greene *et al.,* 2008; Hofer and Pintrich, 1997; Perry 1970). Hofer and Pintrich (1997) developed a framework that describes how the continuums of epistemic beliefs are comprised of four dimensions. These dimensions are the source of knowledge, the simplicity of knowledge, the certainty of knowledge, and the justification for knowing (Figure 1; Hofer and Pintrich, 1997). This framework broke down the structure of epistemic beliefs, placing each dimension along a continuum that an individual may slide along throughout their academic careers. The beginning of each continuum can be considered dualistic, or novice, whereas the opposite end of the continuum can be considered as relativistic, or

advanced (Figure 1; Hofer and Pintrich, 1997). It is important to note that many students throughout their undergraduate career will seldomly reach advanced beliefs about knowledge (Hofer, 2000). These beliefs may be reached through maturation and academic exposures (Hofer, 2000).

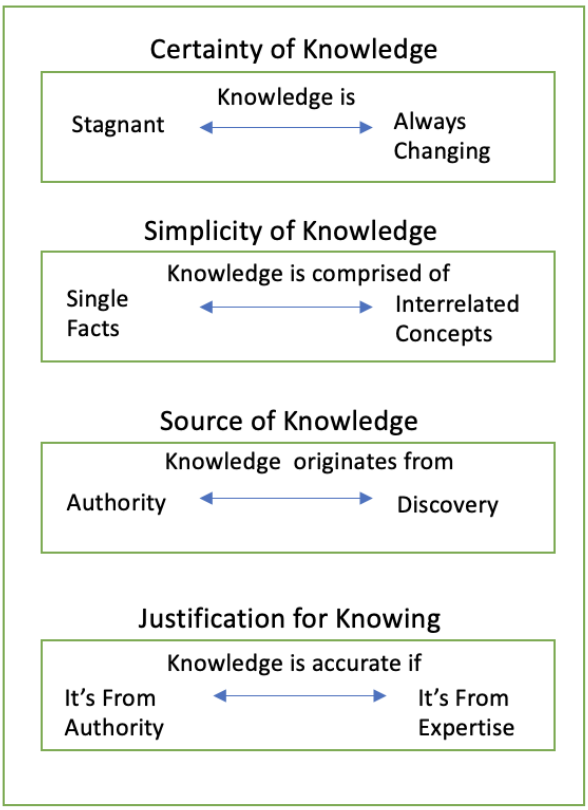

Figure 1: Hofer and Pintrich's 1997 epistemic belief framework

King and Kitchener (1994) suggest that in the classroom, domain specific academic tasks may elicit specific epistemic beliefs. Hofer (2000) further explored this phenomenon, stating that although students may have consistent epistemological beliefs about knowledge, there are strong differences in academic domain specific epistemic beliefs. Hofer (2000) found that students quantitatively reported more advanced beliefs about knowledge within the domain of science

than in the domain of social sciences. She also found the justification for knowing dimension suggested that students may favor their own experiences and opinions over figures with perceived expertise within each academic domain (Hofer, 2000). She states that this epistemic belief dimension needs to be further explored when thinking about epistemic belief domain specificity. However, little has been done with observing the differences in justification beliefs across different contexts or domains.

There has been an emphasis on further evaluating the justification for knowing within the last few years stating that individuals may be justifying knowledge claims through more than the unidimensional authoritative influence (Chinn *et al.,* 2011; Brandmo and Bråten, 2018; Greene *et al.,* 2008; Greene *et al.,* 2010; Ferguson *et al.,* 2013; Greene *et al.,* 2016; Strømsø and Krammerer, 2016). Greene and colleagues (2008) suggested that the justification for knowing should consider more than one dimension and may be influenced through personal views of knowledge. Further supporting this claim, Greene *et al.* (2010) then provided empirical evidence that the justification for knowing does contain two dimensions: justification by authority and justification by personal views. Additionally, this work also provided evidence that the justification for knowing varies across academic domains (e.g., math, history, science), encouraging further research on the topic (Greene *et al.,* 2010). Contributing to Greene and colleagues' work (2008, 2010), Ferguson, Bråten, and Strømsø (2012) discovered that when presented with multiple conflicting documents about an SSI, students justified knowledge claims through opinion, authoritative sources, and by comparing their knowledge across different academic domains and experiences. They also discovered that students would consistently check the given information sources, making sure that their justifications mirrored the information

which they deemed to be reliable (Ferguson *et al.,* 2012). Results from Ferguson and colleagues' (2012) work gave birth to a new framework in which the justification for knowing consists of three dimensions, instead of two.

Further validating this trichotomous framework, Ferguson and colleagues (2013) confirmed these dimensions through empirical evidence, stating that individuals may justify their opinions through justification from personal sources (JPS; justification for knowledge claims through personal views, opinions, and experiences), justification from authoritative sources (JAS; justification for knowledge claims through appealing to a reputable source), and by justification from multiple sources (JMS; justification for knowledge claims through the corroboration of reputable information sources) (Ferguson *et al.,* 2013) . This Justification for Knowing (JFK) framework has been used to explore the relationships between the justification for knowing, academic performance, interest, engagement, and SSI decision-making (Bråten and Ferguson, 2014; Brandmo and Bråten, 2018; Ferguson *et al.,* 2013; Strømsø *et al.,* 2016). However, this framework was designed to evaluate epistemic beliefs in the domain of the natural sciences. Therefore, the framework may not be as sensitive to detecting which beliefs an individual may reflect upon when justifying their SSI decisions as SSIs are influenced by more than scientific stakeholders.

Objectives & Significance

In summary, epistemic cognition is a dynamic process of thinking that draws upon epistemic beliefs (Sinatra, 2016). This process is involuntary and is constantly moving, making it difficult to quantitatively observe (Sinatra, 2016). However, epistemic beliefs are unlikely to change

unless the individual undergoes a transformative experience (Sinatra, 2016). Because epistemic beliefs are unlikely to change, epistemic beliefs have been quantitatively observed. However, there has been much discussion within the epistemology research community that quantitative measures do not recognize the involuntary reflection of epistemic beliefs during context specific tasks (Chinn *et al.,* 2014; Greene *et al.,* 2010; Hofer, 2004). Therefore, the three studies within this dissertation use a qualitative lens when investigating epistemic cognition and epistemic beliefs. These three studies address the following questions:

1. How does the process of epistemic cognition contribute toward the way students evaluate evidence during SSI decision-making?
2. How are students justifying their ways of knowing when supporting their SSI decisions? How do contextual SSI features contribute toward the reflection of these justifications for knowing?
3. How do identity commitments from sociocultural group inclusions relate toward students' justifications for knowing during SSI decision-making?

The objectives of this dissertation are to (1) describe how the process of epistemic cognition contributes toward the selection and utilization of evidence during SSI decision-making, (2) evaluate the role of justification beliefs when students are explaining SSI decisions, (3) investigate how SSI features, such as context, guide justification beliefs during SSI decision-making, and (4) explore how sociocultural group inclusions contribute toward students' justifications for knowing during SSI decision-making.

By addressing each objective, this dissertation aims to inform both researchers and practitioners in how epistemological factors are contributing toward how students work through an SSI decision. By furthering our understanding of how students are making SSI decisions, practitioners may be more effective in developing curricula and course work that recognizes the complex nature of SSI decision-making. This awareness may foster a learning environment that recognizes other stakeholders beyond science that may be contributing toward students' SSI decision-making. By doing so, students may feel supported and may not cognitively shut down during SSI decision-making activities. Furthermore, this dissertation aims to enrich the field by providing empirical evidence of personal epistemology in motion during SSI decision-making. This qualitative evidence may illuminate the various facets that are contributing toward SSI decision-making that are too subconscious to be quantitatively recognized.

CHAPTER 1: STUDENTS' EVALUATIVE PROCESSES WHEN USING EVIDENCE DURING SOCIOSCIENTIFIC DECISION-MAKING

ABSTRACT

Socioscientific issues (SSIs) are scientific issues with social implications and, therefore, affect all students. Students must think critically when formulating a decision through evaluating multiple forms of evidence. This first chapter is a preliminary investigation exploring how epistemic cognition contributes toward how undergraduate students are evaluating evidence when handling an SSI. Although it is challenging to measure epistemic cognition, the AIR model provides a framework for examining how individuals use evidence when formulating a decision through describing their Aims (knowledge goals), Ideals (standards for accuracy), and Reliable processes (processes that meet those standards). Through 30-minute semi-structured interviews, this study probes undergraduate students' (N=26) SSI information searching processes, using the AIR model as an analytic lens. We found that students have the epistemic aim to look for the most accurate information through both scientific and social domains of knowledge. Students' epistemic ideals are information that has a specific internal structure, information developed by believing in the testimony of others, and information that is connects to their other ways of knowing. These ideals are informed by students' emotions, intuition, through consulting experts, peer review, and by corroborating between information sources. These results may help instructors of science courses understand why students are relying on non-scientific sources of information when making an SSI decision despite regularly exercising their scientific literacy skills within the classroom.

Introduction

Within today's sociopolitical climate, controversial scientific issues, or socioscientific issues (SSIs) are strongly influencing the functioning of society (Herman *et al.*,2018; Sadler, 2004; Sadler and Fowler, 2006; Zeidler *et al.*, 2002; Zeidler *et al.*, 2009). SSIs such as climate change, the vaccination controversy, and the COVID-19 pandemic contain a variety of participatory stakeholders, all who express their conflicting opinions through multiple forms of media that are readily available to the public (Barzilai & Chinn, 2020; Bråten, *et al.*, 2019). Therefore, the ability to identify inaccurate information is necessary when information searching about an SSI. In an effort to foster this skill in undergraduate students, calls for increasing levels of scientific literacy have been prevalent within the last decade (AAAS, 2011; The National Academies of Sciences, Engineering, Medicine, 2016). However, despite these efforts, many students are still relying on misinformation when formulating an SSI decision with little consideration of the scientific knowledge that is foundational in understanding the SSI (Brandmo & Bråten, 2018; Greene *et al.*, 2016; Herman *et al.*, 2022; Stenseth *et al.*, 2016). In attempts to understand this, studies have investigated students' SSI decision making processes by evaluating their levels of scientific literacy (Ke *et al.*, 2021; Sadler & Zeidler, 2009; Romine *et al.*, 2017) and their SSI reasoning and argumentation patterns (Sadler & Zeidler, 2005; Sadler, 2007; Zeidler *et al.*, 2017). However, the field has recently turned its focus toward the cognitive and affective components of SSI decision-making in order to gauge how students are tacitly evaluating evidence when handling an SSI (Zeidler *et al.*, 2017).

One of these cognitive and affective components is a process called epistemic cognition (Barzilai & Chinn, 2020; Chinn *et al.,* 2014; Sinatra, 2016). Epistemic cognition is an involuntary and dynamic process of thinking that draws upon epistemic beliefs (beliefs about the nature of knowledge and the nature of knowing) when formulating opinions, justifying an argument, or making a decision about an ill-structured problem (Chinn *et al.,* 2014; Ferguson *et al.,* 2013; Greene *et al.,* 2016; Sinatra, 2016). Like SSIs, ill-structured problems are problems that do not have a definitive answer (Herman et al.,2018; Sadler, 2004; Sadler and Fowler, 2006; Zeidler *et al.,* 2003; Zeidler *et al.,* 2009). Epistemic cognition has been known to play an essential role in information processing (Brandmo & Bråten, 2018; Ferguson *et al.,* 2013), information searching during an academic task (Barzilai & Chinn, 2020), and in determining the validity of information sources when handling an SSI (Ferguson *et al.,* 2013; Greene *et al.,* 2016; Sinatra, 2016; Sinatra & Hofer, 2016). However, epistemic cognition is notoriously difficult to observe quantitatively due to its contextual and complex nature. Therefore, studies have stressed that small-scale qualitative work is needed to observe how students' epistemic cognition is functioning when they work through an SSI (Barzilai & Chinn, 2020; Chinn *et al.,* 2014; Hofer, 2000; Hofer, 2004; Greene *et al.,* 2016; Sinatra, 2016). Therefore, this study qualitatively investigates the role of epistemic cognition in how students evaluate and use evidence during an SSI decision-making process

Theoretical Framework

SSI decision-making outside of the classroom is a complex process that requires the decision-maker to assess information that may surpass their contextual knowledge (Herman, 2015; Herman *et al.,* 2018; Barzilai & Chinn, 2020; Herman *et al.,*2022). In addition to evaluating

these information sources, the decision maker has to contend with their ethics, emotions, values, and morality when formulating a decision (Herman et al.,2017; Sadler and Fowler, 2006; Sadler & Zeidler, 2005; Zeidler *et al.,* 2009). Moreover, the decision-maker may wrestle with the beliefs of their sociocultural in-groups, feeling socially pressured to adhere toward these beliefs and ignore other forms of information (Alred & Dauer, 2020; Herman *et al.,* 2022). Over the last several years as society has grappled with major SSIs such as the COVID-19 pandemic, there has been a focus upon evaluating students' epistemic cognition in order to gauge how they are thinking, behaving, and determining the validity of evidence when handling SSIs (Bang & Medin, 2010; Barzilai & Chinn, 2020; Sinatra & Hofer, 2016). By doing so, researchers are able to assess how students uniquely determine the validity of information sources when dealing with an SSI.

When working through an SSI, an individual's epistemic cognition provides a selection process where they may choose from a variety of context-specific beliefs, resources, and conceptual knowledge when making a decision, forming an opinion, or creating an argument (Barzilai & Chinn, 2020; Chinn *et al.*, 2014; Sinatra, 2016). Epistemic cognition also has been found to influence how an individual understands, interprets, and usess information when engaging with scientific topics (Barzilai & Chinn, 2020; Sinatra *et al.,* 2014; Sinatra & Hofer, 2016). Furthermore, epistemic cognition influences how well individuals can decipher between conflicting sources of information and how they can integrate knowledge from across academic domains when thinking about a topic (Bråten *et al.,* 2011; Barzilai & Chinn,2020; Ferguson *et al.,* 2013; Greene *et al.,* 2010; King & Kitchener, 1994). Epistemic cognition is contextual and domain specific, meaning that students have specific ways of thinking when engaging with

different academic subjects or when engaging with certain SSI contexts (Hofer, 2004; Sinatra, 2016; Zeidler *et al.*,2017).

Although epistemic cognition is a core contributor toward how an individual uses information when constructing their SSI decision, it is dependent upon how an individual perceives what is accurate in relation to the SSI (Bråten *et al.,* 2011; Barzilai & Chinn, 2020; Chinn *et al.*, 2014; Ferguson *et al.,* 2013). This is concerning as today's world is flooded with a sea of misinformation, especially about SSIs. Given that an individual's epistemic cognition cannot be willfully activated, it is challenging to predict and measure how an individual determines accuracy of the information they encounter. However, the AIR model (Chinn *et al.,* 2014) provides a way to examine how an individual's epistemic cognition determines the accuracy of information and how they use that information when making a decision (Chinn *et al.,* 2014). The AIR model is comprised of three variables: Aims, epistemic Ideals, and Reliable processes, all of which interact to influence the decision, justification, or argument that an individual makes regarding an ill-structured problem (Chinn *et al.*, 2014).

Epistemic aims are the knowledge-driven goals a person adopts when constructing an argument, making a stance upon an issue, or making a decision when confronted with an ill-structured problem (Barzilai & Chinn, 2020; Chinn *et al.*, 2014). These knowledge goals influence how people choose to interpret and interact with information depending upon what they are searching for (Barzilai & Chinn, 2020; Chinn *et al.,* 2014). Examples of epistemic aims are searching for accuracy, looking for truth, developing wisdom, or avoiding false information (Chinn *et al.*, 2014).

Epistemic ideals are the standards or criterion used by an individual to determine if an information source will meet their epistemic aims (Chinn *et al.,* 2014). There are five broad epistemic ideal categories. These five categories are (1) internal structure of a knowledge source, (2) connections to other knowledge, (3) connections to empirical evidence, (4) testimony of others, and (5) good communication (Chinn *et al.,* 2014). 'Internal structure of a knowledge source' is defined as knowledge that is complex, internally consistent, and that describes causal relationships (Chinn *et al.,* 2014). People can describe this ideal by discussing the information source's characteristics, such as what it looks like and how it is presented to the reader (Chinn *et al.,* 2014; Wei *et al.,* 2021). 'Connections to other knowledge' is defined as knowledge that aligns with the knowledge of the individual, such as a personal experience or information learned in school (Chinn *et al.,* 2014). 'Empirical evidence' is defined as information that is not contradicted and can be used to predict outcomes of the same phenomena (Chinn *et al.,* 2014). 'Believing in the testimony of others' is defined as when the decision-maker believes an information source due to the belief that whoever produces the information deeply knows about the topic given their position or title (Chinn *et al.,* 2014). Lastly, 'good communication', is defined as information that an individual perceives to be easily understood and interpretable (Chinn *et al.,* 2014). An individual can have multiple epistemic ideals when information searching.

Reliable processes are beliefs about the processes of how knowledge is developed (Chinn *et al.,* 2014). Like ideals, an individual can have multiple reliable processes when information searching. Reliable processes are unique to the decision-maker, as this component of epistemic

cognition consists of broad epistemic beliefs about the specific context. Examples of reliable processes are using one's senses to assess information (e.g., smelling, hearing, tasting, seeing), feeling an emotional response about information, or physically asking professionals for advice (Chinn *et al.*,2014).

Consider the following as an example of how epistemic aims, ideals, and reliable processes are used in the decision-making process. A student is deciding to get vaccinated for COVID-19. When information searching about the vaccine, they have the knowledge goal to seek the most accurate sources of information; accurate information is, therefore, their epistemic aim. This student deems information sources that corroborate with their personal experiences about vaccines and with information that they have learned within their classes to be accurate sources of information. Their standard for accuracy, or epistemic ideal, is connections to knowledge. So, before deciding to get vaccinated, they cross-check and corroborate between their personal experiences and their course content for information consistency. Their reliable process that makes these information sources accurate is to personally cross-check and corroborate between the information sources to check for consistency (Chinn *et al.*, 2014).

The AIR model is the only current model that recognizes the contextuality and individualistic nature of epistemic cognition (Chinn *et al.*, 2014; Chinn *et al.*, 2021; Greene *et al.*, 2016; Sinatra, 2016). Furthermore, it is often used to qualitatively investigate how students think through decision making tasks through evaluating student discussions about academic topics (Herrenkohl & Cornelius, 2013; Wei *et al.*, 2021). Therefore, this study broadly uses the AIR model as an analytic lens to explore how undergraduate students are evaluating evidence when discussing an

SSI in the context of the vaccination controversy. The objective for this preliminary investigation is to describe how epistemic cognition informs students' use of evidence. Furthermore, this study sets the precedent for the next two chapters of this dissertation through providing a foundational view of how students epistemically handle information when working through an SSI.

Methods

Setting and Participants

Participating individuals were interviewed about their opinions and decisions about vaccinations during the 2018-2019 Academic year. The vaccination controversy is a long-standing SSI that has been consistently in the media since the 1800s when the first vaccination was publicly criticized (Porter and Porter, 1988). Because this study examines both science majors and non-science majors, vaccination is an appropriate SSI because it does not require an intensive scientific background to discuss (Zeidler *et al.,* 2009). Participants of this study (N=26, 50% science majors, 50% non-science majors) were recruited from multiple mixed-major science courses at a high research-intensive (R1) public institution in the northeastern United States. This institution is comprised of primarily white students. Although we are not interested in academic year, we wanted participants to have already determined their academic majors. Therefore, we recruited students within their sophomore, junior, or senior year. Students were recruited from each course through an in-person introduction during the beginning of each course's lecture, followed by an email reviewing the expectations and procedures of participation. As an incentive to participate, students were offered a university mug. This study was approved by the University's Human Subjects Institutional Review Board (#7009). The IRB approval letter is located within Appendix B.

Interview Protocol

We conducted 30-minute semi-structured interviews. These interviews were in person and audio recorded. The recordings were then transcribed through a transcription service and checked for accuracy. The development of the interview protocol was informed by the AIR model (Chinn *et al.*, 2014). The beginning of the interview consisted of several questions about how the participants feel about vaccinations. These initial questions were meant to uncover the participants' opinions about vaccinations and how they would go about looking for information sources regarding vaccinations. They were then asked what processes make these sources reliable pieces of information. These questions uncovered the participant's goals for participating in the interviews (epistemic aims: e.g., What would some of your goals be when seeking information?) and assessed their criterion for accurate information (epistemic ideals: e.g., How would you learn more about vaccines? Where would you look specifically?) and how accurate information is produced (reliable processes: e.g., what makes these information sources good sources of information?). The interview protocol also had participants read an article about the pros and cons of vaccines (Pros&Cons.org) with follow-up questions regarding the reliability of the article. However, we decided to remove this section from our analysis due to the questions mirroring a reading comprehension-type activity, which was inappropriate for this study. The final questions of the interview asked participants if they would vaccinate their future or (if applicable) current children. Participants were also asked about vaccinations which they thought to be important or not important and why. This part of the interview explored the decision-making process by asking them to walk through how they arrived at a decision (Appendix A).

Data Analysis

Due to the nature of the research question, data analysis must be cognizant of the complexity and contextuality of both the AIR model and epistemic cognition. Therefore, the data is informed by functional pattern analysis (Rogoff & Gauvain, 1986). This type of analysis examines phenomena within individual cases as a guide for aggregation across the entire data corpus, preserving the ethnographic veracity of each individual case (Rogoff & Gauvain, 1986; Rogoff *et al.,* 1993). Functional pattern analysis involves writing ethnographic memos for each participant and then organizing the data into tables per emerging theme (Rogoff & Gauvain, 1986; Rogoff *et al.,* 1993). The primary aim of the memos is to inductively root codes that are essential to the process of epistemic cognition (Rogoff & Gauvain, 1986; Rogoff *et al.,* 1993). This idiographic approach, or a case-by-case view, stays true to the individualistic nature of epistemic cognition. During functional pattern analysis, a first round of coding is conducted through these memos followed by a second round that is conducted through the actual interview transcript, with the goal of organizing the data into tables. The tables allow the researcher to notice unexpected patterns within the data that may have been overlooked (Rogoff & Gauvain, 1986; Rogoff *et al.,* 1993; Tukey, 1977). The physical tables are not presented within this chapter as they were used as an analytic tool.

Coding Procedure

First, the corresponding author randomly split the data into two sets of thirteen interviews. Using the first set of thirteen interviews, the corresponding author wrote an ethnographic memo for each participant. These memos were thematically coded to find broad emerging themes. We used these themes to create a codebook. These broad themes were the AIR model variables (Aims,

Ideals, and Reliable Processes). The corresponding author then used the codes created from the memos to inductively code each transcript of the first thirteen interviews, adding to the codebook when new patterns or themes were found. We used each AIR model variable to categorize students' information searching processes. Furthermore, we categorized the information sources students were referencing as either scientific or social information sources. After the first thirteen interviews were fully coded, the corresponding author repeated the process with the second set of thirteen interviews. New codes from this set of interviews were added to the codebook. The new themes found within this phase centered around the ideal categories described within Chinn and colleagues' AIR model (2014). Once the remaining thirteen interviews were fully coded, all of the first thirteen interviews were re-coded to account for the new codes found in the second half of the interviews. This methodology is similar to the constant comparative method which is used when doing grounded theory (Charmaz, 2006). Lastly, the codes were categorized into tables where our codes were then organized. These tables are for analytic purposes and are not included within the manuscript. Each theme is discussed in the results and discussion section.

Results and Discussion

We found that students use various forms of evidence from both scientific and social knowledge sources of information when formulating an SSI decision. The process in which students evaluate evidence is based upon their knowledge-driven goals (epistemic aims), their standards for identifying reliable information (epistemic ideals), and their beliefs in how reliable information is produced (reliable processes). In the context of the vaccination controversy, students have the knowledge goals, or epistemic aims, of finding accurate information and avoiding inaccurate information. However, we found variation in their standards for accurate

information, or epistemic ideals, due to students' differing experiences with vaccinations. Additionally, we found that students have a variety of reliable processes. Some of these processes are based upon scientific literacy skills such as cross-checking and corroborating between information sources for consistency (DeBoer, 2000). However, students applied these skills across all sources of knowledge, not just scientific information. We discuss these results below using Chinn and colleagues' (2014) AIR model as an interpretive lens. When describing our results, we rely upon direct quotes from the participants. The participants are given pseudonyms for confidentiality and any identifiable information or clarifying language has been changed and noted with brackets.

Students use evidence from both scientific and social sources of information when formulating an SSI decision

We found that students reflected upon various forms of evidence that fell within two information source categories, scientific sources of information and social sources of information. We believe that both categories encompass the variety of evidence referred to by our participants when describing what they are looking for when information searching about vaccines. Across all interviews, students used both information source categories. This is consistent with previous studies that have demonstrated that students rely upon more than science when constructing their SSI decisions (Herman, 2015; Herman *et al.*, 2022; Zeidler *et al.*, 2017).

We define the scientific information source category as information that includes any reference to medical institutions (e.g., medical professional, medical procedures, medical institutions) or

academic domains (e.g., a professor, a classroom, research articles) or a combination of both. For example, “My mom has a bunch of medical books. So, I would probably just scroll through that just because I know that’s accurate information and stuff.” These scientific resources were predominantly discussed at the beginning of the interview, where students describe how they would look for information about vaccines. When asked how she would learn more about vaccines, Molly describes that she would find information from researchers in research facilities, books about vaccines, and from medical professionals.

> I would speak to someone directly if I knew like where they were. If I actually typed into Google and tried to find any research facilities regarding vaccinations or maybe even talk to a doctor themselves, go straight to a hospital and get it directly from the horse's mouth…I would visit different research facilities and try to like look at, maybe, talk about some of your common vaccines that you may receive, like maybe from MRSA... I would want to go to the people who know the information first. I'm a big fan of books too. Like I'll crack open a book any day and learn more.

Like Molly, Hellen also draws upon scientific sources when information searching about vaccines. Here, she discusses how she would look at information from medical professionals.

> I know doctor's offices and stuff, specifically if you go on their websites. So I could go to my doctor's website. I'd go to [a hospital website] and actually look at all the vaccines, because all of that's available online.

Aside from scientific sources of evidence, participants also referenced social sources of evidence. We define social sources of evidence as when students referred to the government, their social ingroups (e.g., family and peers, social media), and their personal experiences when describing the information they reflect upon regarding the vaccination controversy. When thinking through an SSI, the decision-maker may be motivated to draw information that aligns with their context-specific beliefs about the SSI, which may fall within these social categories of knowledge (Kølsto *et al.,* 2006; Sadler, 2004; Sadler & Zeidler, 2004). These beliefs encompass the decision-maker's values and ethics and can direct the trajectory of an SSI decision, regardless of scientific evidence (Alred & Dauer, 2020; Kølsto *et al.,* 2006). Therefore, when evaluating SSI decision-making, it is essential to understand how students are utilizing these social information sources.

Due to the recent political climate, we defined any information source that involves the government, politics, or government officials as a social source. This was reflected by the way our participants discussed this information category during decision-making. Although government resources such as the FDA inform scientific practices, some of our participants stated that the validity of the information coming from a government-driven organization would be based upon who is currently in power. For example, "I think with vaccines, government websites are fluctuating based on administration." Students also stated that they would have to see the political affiliations of an information source to determine its accuracy. The participant below states that she would like to see what type of degree the medical professional has and where they earned it from, suggesting that science and the products of science can be influenced by political affiliations.

> I'd have to see what kind of medical degree they've gone through and what school they've got it from. If it was like LA Liberal School, maybe they have a different degree, or if it's really conservative or religious school they would have different viewpoints on vaccines.

Political affiliations and trust in the government have been known to interact with SSI decision-making (Herman *et al.,* 2022; Lee *et al.,* 2012). For example, although Molly predominantly relies upon scientific sources of information, she also considers information coming from government resources, such as the Food and Drug Administration (FDA) when information searching about vaccines. Her reference toward the government as a "higher power" suggests that she believes information from the government is meant to inform and protect.

> But mostly I would turn to anything that's been recommended by the government, like in nutrition we use, 'myplate.gov' or 'living plate'. Reputable source that had been promoted to us. Look at Food and Drug Administration, dietary guidelines. Things that have been promoted to us by a source of a higher power that is actually operating the system.

In addition to referencing government information sources, students referenced information they have learned within their social in-groups. This social knowledge source includes any reference toward information heard or read within social spaces (e.g., in public or on social media), or knowledge developed from their family and peers. For example, Bonnie, a pre-med major does not get the flu vaccine due to her father's experience. Because of her father's experience, she

believes that the flu vaccine gives the recipient the flu. Despite the knowledge from her academic major, this belief, motivated by her family in-group, has implications on her decision to get the flu vaccine.

> I don't know. I just feel like they make you sick. They make you more sick than it's worth protecting you against…My dad got it actually a few years back, and I guess he was the one who influenced me to not get it. When I can make the choice to not get it. He got it, and it was the first time he had gotten it too, the flu vaccine. Then he got really, sick afterwards. Not just like I have a runny nose. He got the actual flu from getting the vaccine, instead of the other way around. You know what I mean? Then, I don't know? I got brainwashed I guess.

Medically-focused SSIs, such as the vaccination controversy, concern the lives and well-being of people and their group-inclusions (Herman *et al.*, 2022). Therefore, it is not surprising that one's social circle, such as family in-groups, have such a strong influence on the direction of an SSI decision. As demonstrated with Bonnie, social in-groups may contribute toward how people perceive, think, and act upon an SSI. However, because someone can belong to multiple in-groups, beliefs from one may conflict with the other. When this happens, the decision-maker may feel torn between these beliefs, influencing them to rely upon heuristics instead of thinking critically through the problem (Alred & Dauer, 2020). By doing so, the decision-maker avoids conflict and maintains their in-group status. However, by choosing to believe evidence from their social in-group, they may choose to ignore the evidence supported by academic in-groups, such as an academic major (Herman *et al.*, 2022).

Social media and other social information platforms (e.g. magazines) were referenced as viable sources of information by several of our participants. Social media platforms provide a space for social in-groups to express their beliefs about SSIs regardless of the available scientific evidence (Herman *et al*., 2022). This poses a broad threat toward society as decision-makers may be persuaded to adhere toward these beliefs that are often subjective and emotionally-based (Herman *et al*., 2022). Discussions on social platforms influence how an individual perceives information, especially in the digital world (Bråten *et al.,* 2019). We see this with Dylan. For example:

> I probably saw the conversation permeate into Facebook, or this person who thinks this posted this article, and this person who thinks this posted a Reddit thread. So it moves from news to discussion in a community. And then I think if I truly didn't know what was going on, or someone said something that seemed way out of left field, I think that's the point where I would research it.

Information from various online platforms such as social media spaces interfere with people's ability to think critically about SSIs (Barzilai & Chinn, 2020). This digital world has given all social in-groups the opportunity to publicly voice their beliefs about controversial topics regardless of the available empirical evidence from trusted scientific models (Bråten *et al.,* 2019; Chinn *et al.,* 2020; Herman *et al.,* 2022). Although scientific models are not solitary in informing SSI decisions, scientific models have contributed toward the well-being and longevity of societal functioning (Herman *et al.,* 2022; Sinatra & Hofer, 2021). Beliefs from social in-groups can

create an air of distrust with the process of science and therefore with recent scientific models that are being used to inform current SSI behavior (Herman *et al.,* 2022; Latour, 2004; Sinatra & Hofer, 2016). Although people may be comfortable with scientific models in the classroom, when science is "in the making" during a global crisis, people become uncomfortable and turn toward other authoritative players of knowledge, such as parents, or politicians (Latour, 2004). Therefore, it is not surprising that our participants reference information from their social in-groups.

Another social source of evidence that we found was personal experiences. We define this social category as when a participant references something that they have personally gone through without the influence of others. For example, "I've stepped on a lot of rusty nails, so I'm really glad for my tetanus shot…so it is a good idea to get that one I think" and "I've got it [the flu vaccine] every year and I am fine". Additionally, when asked to describe why she believes vaccines are important Eden discusses how she has received the rabies vaccine series due to her involvement with wildlife. She believes that all vaccines are important if there is a clinical need for them.

> For me, personally, I got my triple-series rabies [vaccines] because [I am involved with], wildlife and vet technology…I think they're all equally important if there's a need. If it's that common that we made vaccine for it, you should probably get it.

Raul also reflects upon his personal experiences as a medic in the military when explaining what he thinks about vaccines. He describes his role as a medic and how he administered several

vaccines, including the ‘peanut butter shot.’ His reference toward his personal experience of both administering and receiving the peanut butter shot has contributed toward his knowledge about that vaccine. He indicates that these experiences have a strong effect on how he thinks about vaccines as a whole.

> I spent four years as a medic in the army. They don’t go that deep into what a vaccination is, believe it or not. As a medic, I was trained more for battlefield medicine. I did give flu shots. I gave some vaccinations. Not many. I gave what we call the peanut butter shot... it feels like peanut butter going into your butt muscle, which is-why they call it the peanut butter shot. It’s very entertaining to give to someone. I’ve received it myself so I know exactly what it’s like…it had a strong effect on what I thought.

By allowing students to draw upon both scientific and social sources of information during SSI decision-making activities within a classroom, we may be able to reduce cognitive shut-down in students who may not initially consider the scientific component of the SSI. Although scientific knowledge may not be how all students ground their SSI decisions, the ability to critically evaluate all forms of information is needed to make an informed SSI decision (Sinatra & Hofer, 2021).

Students want to find the most accurate information when evaluating evidence about the vaccination controversy

We found that when information searching about the vaccination controversy, students have the knowledge goals, or epistemic aims, to find and use the most accurate sources of information to inform their decisions. For example, “I'm just trying to find out the most real information, [information that] cannot be easily turned into something” or “They are [information sources] getting me the right knowledge” and “When I'm looking for information, I want to make sure that it's accurate.” We also found that students were trying to avoid false information through searching for evidence that does not support a specific bias. For example, “I'm looking for kind of like avoiding my own bias. Looking at facts or evidence as like its own thing instead of putting myself, my own ideas into it...I can always be wrong.”

Although this study does not focus on students’ epistemic aims, through identifying them we can understand how students are developing their standards for accuracy and how they are determining the processes used to produce accurate information (Barzilai & Chinn, 2018; Chinn *et al.,* 2014; Chinn *et al.,* 2021). Through knowing that our participants are trying to find accurate information, we can see how they define what constitutes accurate information, how that accurate information is produced, and how they may use the information when formulating their SSI decision. These standards and beliefs about accurate information, or epistemic ideals and reliable processes, illuminate why students are drawn toward the various forms of evidence that we found during their SSI decision-making processes.

Students’ standards for accurate information (ideals) determine their use of scientific or social information sources

Epistemic ideals are the standards that an individual uses to explain why an information source is accurate (Chinn *et al.,* 2014). Students described their epistemic ideals when explaining how they know if an information source is accurate or inaccurate. Like the entire process of epistemic cognition, epistemic ideals may change within a context. We found that students' ideals broadly fell within four of Chinn and colleagues' (2014) five broad epistemic ideal categories: (1) internal structure of a knowledge source, (2) connections to other knowledge, (3) connections to empirical evidence, and (4) testimony of others (Chinn *et al.,* 2014). Our participants did not give us sufficient data supporting that they reflect upon good communication as an ideal. In this section, we define and describe how our students fell within each ideal category.

Epistemic Ideal: Internal Structure

Within this ideal category, we found that students described that accurate information reports numbers and structurally will look 'professional'. Although these characteristics do not fully meet Chinn and colleagues' (2014) definition of this epistemic ideal category (knowledge that is complex, internally consistent, and that describes casual relationships), we believe that numbers and the physical traits of the information source are how students determine the accuracy of evidence about the vaccination controversy. This may be due to students' level of education and level of maturation as undergraduate students often believe in information based upon how it may look regardless of the content (Hofer, 2004; Sinatra & Hofer, 2016).

We predominantly found this ideal when students referenced science sources of information. For example, when describing why she thinks scientific journals are accurate forms of knowledge, Sage states, "I think numbers really are one of those things that just make you feel like... Makes

it [evidence] feel real." Similarly, Zoey states "I think numbers mean proof. Numbers are proof, or likely to be. So while nothing's 100 percent provable, it shows that there's a large set of data behind what you believe." Students also referred to the structure of scientific articles, stating that they were taught that these types of knowledge sources are accurate.

> Scientific articles have a lot of citations and parentheses in them. So that makes me think it's believable because we've always been taught that citations are important and scientific articles are serious.

We believe that students may be drawn to these characteristics of information sources during uncertain SSIs due to a distrust in their own knowledge and their reliance upon context-specific scientific players, such as professors or medical professionals (Herman, 2022; Køstlo *et al.*, 2006;). Køstlo and colleagues (2006) qualitatively found that students were more likely to depend upon information sources that looked presentable, complete, and empirically adequate (e.g., meets students' beliefs about scientific evidence) when evaluating evidence about several SSIs. This may have been influenced by students' science-focused course work. Like Køstlo *et al.* (2006), we believe that students' course work may have contributed toward this ideal for information accuracy. For example, when asked why she believes that medical books are accurate sources of information, Tanya states, "I know the books and stuff, they're primary sources. And we talked about that in bio class."

Epistemic Ideal: Connections to Other Knowledge

Students also have the epistemic ideal of looking for knowledge that is consistent with what they have heard, learned, or already know. Chinn *et al.* (2014) defines this ideal as connections to 'other knowledge'. Due to our findings mirroring their definition, we coded this ideal similarly. Students applied this epistemic ideal to both scientific sources of information (e.g. "The doctors told me to get a vaccine."). They also applied this ideal to social sources of information, "I guess my own personal experiences would make me biased towards one or the other [information source] depending on which way it's going." This ideal was also applied without describing a specific source of evidence, just their personal ways of knowing such as their personal biases. We believe that students' personal biases fall within the epistemic ideal of connections to knowledge given how students connected information that they have read about vaccines to their personal biases about vaccines. For example, in the quote below, this participant states that their preconceived notions about vaccines have set a standard for their knowledge about vaccines. They suggest that if the information does not align with their biases about vaccines, they will believe that the information is not credible.

> I think definitely having the preconceived notions that vaccines are good and that's how I was brought up has been like if I read something [against vaccines] I'm like, oh that's not credible, or like that person is not educated, or this is like a hippy person that lives in the middle of nowhere. Like I have kind of biases that go against a lot of the other side.

We define personal biases as when a participant references their ways of knowing as a moral or personal belief (Mclean *et al.*, 2017). For example, Molly states that when information searching if she is biased toward a subject it will be difficult for her to look at different viewpoints.

> If I'm already biased towards one particular subject it may be hard for me to look at information disproving that, which may be where I mess up at.

Connections to other knowledge may influence students to feel a sense of familiarity with the SSI (Garecht *et al.,* 2021). However, in regard to SSI decision-making, familiarity can be both beneficial and detrimental depending on how students are perceiving the SSI. For example, beneficial familiarity may motivate students to reflect upon information that aligns with their academic backgrounds or academic groups (e.g., an academic major) (Garecht *et al.,* 2021; Herman *et al.,* 2022; Sinatra & Hofer, 2018). By doing so, they may be determining the accuracy of information by connecting it toward well-established theories that may have informed SSI decision-making in the past (Chinn *et al.,* 2020; Herman *et al.,* 2022; Sinatra & Hofer, 2016). In contrast, students may determine the accuracy of information by connecting it toward their personal biases that may have been developed through their sociocultural group-inclusions, such as their political, religious, or social groups. Although this is not always a detriment during SSI decision-making, students may formulate their decisions by adhering toward these in-groups, ignoring evidence that may be critical toward making an informed decision (Garecht *et al.,* 2021; Herman *et al.,* 2022; Sinatra & Hofer, 2018).

Epistemic Ideal: Empirical Evidence

Students described this ideal similar to Chinn *et al.*'s (2014) definition. Students applied this ideal with scientific sources of information. Students expressed this ideal by stating that they know vaccines are useful because they have eradicated diseases. For example,

> I think that vaccinations are a wonderful thing. I really do. Because, it's basically herd immunity. So if a bunch of people are immune to a disease then the few that aren't vaccinated which hopefully are very, very few and far between are protected from the virus from the one person that may get a case, like polio. Polio's been eradicated almost completely from the United States for years. And that's incredible, and it's all because of the Salk vaccine in the '50s, or '40s.

Students also referenced how vaccines prevent the spread of diseases that were once rampant in society. For example,

> I think diseases that are things like the measles or polio or DTaP, I think they're so outdated and preventable. They're things we haven't seen in so long, so that's a good thing, and it's very directly linked to vaccinations. So I think those are important.

Students also used this ideal when describing what they would have to see to change their beliefs about vaccines. Norine states that she would have to see a study that shows there is something wrong with vaccines. She wants to see the success rate of the vaccines. This type of information would influence her to start changing how she feels about vaccines.

> If I saw from a reputable source or a recent study that maybe had been conducted with all the right demographics represented, that there actually was something wrong with the

> vaccines and there had been a decrease in the amount of vaccines, well, the success rate of certain vaccines, then I would maybe start changing my opinion and looking into it.

This category of ideals essentially means that if a student sees empirical evidence of causal relationships, they will deem that evidence as accurate. As students reflect upon the use of vaccines and how they have eradicated diseases, they may understand that vaccines allow communities to be free of communicable diseases. However, despite the overwhelming evidence supporting the benefits of vaccines, many undergraduate student populations are hesitant in receiving the COVID-19 vaccine (Herman *et al.*, 2022). This may be due to people being uncomfortable with science as a dynamic process instead of a finished product (Packer, 2018; Latour, 2004). Science as an ongoing process may violate people's trust with science due to scientific players not having answers in how to fix contentious SSIs, such as the COVID-19 pandemic (Herman *et al.,* 2022). This concept of trust brings us to the fourth category of epistemic ideals.

Epistemic Ideal: Testimony of Others

Our participants described this ideal through stating that they have trust in their information sources due to their profession or relationship to the information source. Therefore, we summarize this ideal by calling it trust. Although trust can be defined in several ways, we define trust as when a participant believes in the integrity of knowledge that is produced by the information source (e.g., medical doctors producing medical information) (Roduta-Roberts *et al.,* 2011). The knowledge coming from these information sources are meant to direct people in navigating the uncertain nature of SSIs. Students referenced trust across both scientific (e.g.,

doctors, and professors) and social sources of information (e.g., media and parents). For example, Lucy trusts that her doctors would provide her with correct information about vaccines "I would say my doctors... I trust in their degree, I guess. They are getting me the right knowledge." Similarly, Mika believes that doctors and professors would tell her accurate information about vaccines,

> I believe what doctors are telling me about it. So I trust it… [I would] ask your doctor if you're not in college. And then if you're in college, I think specific courses…I don't think professors are able to just tell you lies.

We found that during SSI decision-making, people are more inclined to reflect upon trustworthy sources of information for people or processes that produce knowledge meant to protect and inform during uncertain situations. However, we believe that this trust may have been developed through students' social in-groups, such as their family or academic major. For example, Lexi describes how she trusts the same media outlets that her parents trust.

> I would probably most trust the New York Times or the BBC. FOX or MSNBC I think are just for show, they glorify things. So I would think FOX or MSNBC would be less about the science and more about glorifying the issue to get click bait. You can pull the easy, "Oh, they're objective. They have good reporting." But I think my parents just have always trusted those sources, so I think I really absorbed that.

Trust is developed between individuals when both parties share similar values, ethics, and goals during decision-making (Herman *et al.,* 2022; Roduta-Roberts *et al.,* 2011). However, in SSIs, the role of trust may exceed interpersonal relationships. When handling SSIs, people are interacting with multiple domains of knowledge that they may trust implicitly, such as the domain of science (Roduta-Roberts, *et al.,* 2013). People put their trust in abstract knowledge-generating systems despite not regularly interacting with them, or at least not consciously (Giddeons, 1990). This subconscious faith in knowledge-producing processes is the foundation of public trust with science when they are working through an SSI (Giddens, 1990). Furthermore, trusting in the science domain requires the individual to be vulnerable and patient, which may be non-negotiable for various sociocultural groups (Herman *et al.,* 2022; Roduta-Roberts *et al.,*2013). This is especially prevalent during controversial SSIs, where people are required to remain patient in times of uncertainty. This may threaten the trust people have with science and may direct them toward other knowledge domains that have been built upon fear or anger as opposed to empirical evidence. Although our study limits us from exploring this phenomenon, we call upon others to close this knowledge gap as it is a pressing issue within today's political climate.

In summary, students have several epistemic ideals, or standards, that tell them if information sources meet their epistemic aims. These ideals dictate how people react toward inaccurate and accurate information (Chinn *et al.,* 2014). In the case of this study, our participants' epistemic ideals provided them with information standards that ensure the information sources they reflect upon are accurate. Although students' epistemic ideals are a quintessential component of epistemic cognition during information searching, students' beliefs about the processes used to

produce accurate information determine why they ultimately choose to use specific sources of information.

Students' reliable processes describe how accurate information is produced

In this section, we describe students' reliable processes for producing accurate information and show how they work with students' epistemic ideals. Reliable processes can be people's beliefs about how accurate knowledge is produced (e.g., the process of peer review) and what people physically do to determine the accuracy of information (e.g., cross-check and corroborate between information) (Chinn *et al.*,2014; Chinn & Rinehart, 2016). We found that students' emotions, intuitions, beliefs about experts, and beliefs about peer-reviewed information sources are their reliable processes for producing accurate information. Furthermore, we also found that students described cross-checking and corroborating between information sources as a reliable process for producing accurate information.

Emotion

As a reliable process, negative emotions such as anger have been shown to influence how an individual interprets and processes information as certain emotions may trigger the individual to perceive information in a specific way (Chinn *et al.,* 2014). Negative emotions such as fear, anger, and confusion affect one's ability to identify accurate information when dealing with an SSI (Brosch, 2021; Fallon *et al.*, 2014; Stanley *et al.,* 2021; Tiedens & Linton, 2001). These negative emotions have direct implications upon decision-making behavior depending upon their personal experiences with the issue, what they have heard about the issue, and their attempts to avoid coming face-to-face with the specific issue (Brosch, 2021; Fallon *et al.,* 2014; Stanley *et*

al., 2021; Tiedens & Linton, 2001). We found that students were utilizing their negative emotional responses as their processes to producing accuracy when evaluating information about vaccines. Specifically, students reported their anger and fear. For example, Monica expressed fear through describing a personal experience. Monica reflected upon a swine flu outbreak within her school when she was younger.

> You're seeing outbreak, like this one. So, the outbreak was a huge thing, I remember. And it was terrifying…The whole school had to shut down and turn into a facility where you could all get vaccinated and like-it makes you wonder, it's like, "Well, did everyone get the flu shot?" I know it was a different strand that wasn't necessarily protected against, but it was so scary….It was like you were waiting to hear somebody in your school got the swine flu, and it was very scary. I remember my parents talking about it and everyone was watching for symptoms…

When dealing with a contentious and dangerous issue, people are more inclined to believe information that elicits emotional responses such as a personal anecdote as they want to avoid experiencing the negative situation that is being described (Freling *et al.,*2020). This is especially prevalent when an individual is dealing with a medically focused issue, as anecdotal evidence is more relatable and easily understood compared to empirical evidence that may spark feelings of uncertainty and ambiguity (Freling *et al.,*2020; Herman *et al.* 2022). Additionally, emotional responses are unique to the individual and may implicitly bias them to be against or for certain behavior (e.g., electing to get a vaccine) (Hakamata *et al.,* 2022). We believe this is why students

referenced their emotional personal experiences or the experiences of others (e.g., Monica's quote above) to determine how accurate knowledge is produced.

When presented with an SSI, emotions are elicited when the decision-maker's values, sense of self, and way of life are threatened (Gao *et al.,* 2019). Moreover, we believe that students referred to their emotions due to their lack of deep knowledge about the SSI as emotions are often the processes relied upon when the decision-maker does not have deep conceptual knowledge about the issue (Tiedens & Linton, 2001; Chinn *et al.,* 2014; Muis, 2007; Herman, 2022). Although our interview protocol was not designed to assess emotions, a few participants referred to their emotional responses as a reliable process of producing accurate knowledge. For example, Whitney firmly believes in vaccines and states that vaccines protect others. "I support vaccines entirely. If you don't vaccinate your child, if you don't have vaccinations, you're hurting everyone." However, despite this statement she will not get the flu vaccine. She describes her reasoning behind this belief through her experiences with her mother. Because of this experience, she expresses an emotional response of fear.

> She [my mom] had gotten the flu shot because it's really dangerous for people who are going through cancer to get sick. And so she got it to be preventative, and then she ended up getting the flu, and it was really bad. So, I am scared of getting the flu shot, because of that experience with my mom.

Emotions can be elicited in multiple ways, triggered from all academic activities (Muis, 2007). However, they are not often considered when evaluating students' SSI decision-making

processes during in-class activities. SSIs elicit an emotional response for the decision-maker given the moral and ethical implications of the SSI (Sadler, 2009). However, we believe that emotions specifically from personal experiences may play an integral part in how the decision-maker perceives the SSI and how they may act upon it. Additionally, when observing how an individual navigates the world, their personal interpretations of how the world works interferes with their abilities to critically evaluate problems that they may encounter (Fredrickson, 2000). She states that people's choices are based upon their previous emotional experiences (Fredrickson, 2000). These emotional experiences can be both negative and positive (Fredrickson, 2000). However, the role of negative emotional experiences have deep implications for how the individual chooses to engage with similar issues (Lievonen *et al.*, 2018). Although this study did not explicitly aim to explore emotions, we call upon the field to further investigate how emotions direct students' information searching processes during SSI decision-making.

Intuition

Previous studies have found that people may search for evidence that aligns with their personal biases (Chinn *et al.,* 2014; Herman, 2018, 2022). Although we discuss the role of personal biases as an epistemic ideal within the connections to knowledge category, we believe that an individual's gut feeling, or intuition, is a reliable process for making this ideal accurate. An individual's intuition is often drawn upon when they need to solve a problem in an area which they lack expertise or which they feel unsteady with (Westcott, 1968). Therefore, it is not surprising that students referred to their intuitions as a reliable process for producing accurate information. We define intuition as when a participant states that their criterion for knowing is

what feels right to them (e.g., a gut feeling). This reliable process was primarily found within the connections to knowledge ideal. For example, when asked how she determines the validity of information, May reflects upon her intuition. She describes how her gut feeling acts as a decision-making guide, pointing her to what kind of evidence feels right.

> I think it would come down to what I feel in my gut. I think I'd be more inclined to believe information that I already thought that I believed before I started researching. So if it was something that sounded right, I think I'd just be like, "Yeah, that sounds right," and go with it.

Like May, Leigh also relies on her gut feeling when describing how she can tell if an information source is correct. “It's sort of with anything. You kind of just go off gut. You can tell when things aren't true.”

Because intuitions are a major part of one’s sense of self (Mclean & Syed, 2015), we believe that the reliance upon one’s intuition during SSI decision-making cannot be mitigated. Intuition is elicited when someone is put in an unknown situation, such as high-stakes decision-making, and influences a person’s ability to interpret information when they need to preserve their sense of self (Nichols & Bruno, 2010). This is not surprising given that the vaccination controversy has major implications upon health and well-being. Furthermore, during SSI decision-making, the reflection upon one’s intuition is a surface approach for decision-making (Garrecht *et al.*,2020). This type of approach is taken when the decision-maker does not thoroughly understand the issue (Garrecht *et al.*, 2020). Given that our participants are early in their academic careers, they are

not extremely knowledgeable about vaccines. However, this may be broadly representative of undergraduate student populations when they are confronted with an SSI. Therefore, we urge researchers to explore how students use their intuitions during SSI decision-making so we can understand how to work with them when teaching SSI decision-making strategies in the classroom.

Consulting in Experts

The third reliable process for producing accurate information we found is consulting experts in the field for information regarding the SSI. This reliable process was applied across both science and social sources of information within the epistemic ideal of testimony of others (i.e., trust). Consulting experts is a reliable process because the individual believes that the expert's knowledge produces accurate information, and it may be why students are turning to professionals in the field about a topic that they may not know enough about (Chinn & Reinhart, 2016). These experts can be a parent, scientist, or medical professional. For example, Lena discusses how she would talk to her doctors and other professionals in the field because she trusts in their expertise. She refers to academic professionals (e.g., doctors and scientists) and news articles or other means of news forms because she believes them to be experts.

> If I see the person who was talking about the vaccines in the article is, or in any other news form, is, has a PhD in things related to vaccines, or they're a practicing doctor, I am more likely to trust them because they dedicated a large part of their lives to study the area.

Similarly, Julia consults her mother, who is a registered nurse. We consider Julia's mother both a scientific and social source of information given how she describes her as both a caretaker and a medical professional. In this quote, we see Julia reflect upon two epistemic ideals: connections to knowledge and trust.

> I feel like everybody should get them [vaccinations]. Just because my mom was a nurse, she always told us, "Take care of your body. Be safe." And she got us every single vaccination and everything like that... And my mom, she just told me it's for your benefit. My whole life telling me that…[she is a] trusted professional…my mom's an RN, so she got taught all this. She knows it first-hand.

This reliable process suggests that students believe information coming from people who are experts in the field such as a doctor, university, or scientist. Students described this reliable process by stating that the information sources are known for having specific types of information. For example, "Universities are known for studies." Another example of this reliable process is:

> I think probably back to their [doctors] credentials. This is their field of study, this is what they're doing with their lives. Clearly there's a reason for it if they're recommending it.

Peer-Reviewed Information

Several students described looking for peer-reviewed information sources as they believe that the process of peer review produces accurate information. Believing that the process of peer-review produces accurate forms of information is commonly found when people are engaging with a science driven issue (Chinn *et al.*, 2014). Broadly, academic domains use this process before presenting their new ideas and findings to the world. It is a quintessential part of academic discovery and is discussed within most academic settings. Students referred to this process when describing how they know that an information source is accurate. For example, Gordan states that she believes journals and experts in the field are accurate sources of information about vaccines.

> They've been peer reviewed and they've been tested a lot, the authors underwent the scientific process in order to collect the data and such on all of it… Like, it's been looked at by other scientists, other experts in relevant fields and make sure it's not falsified or inaccurate.

Similarly to Gordan, Hannah believes that information coming from magazines or other forms of media are not accurate due to the lack of peer-review. In this quote, she describes how she believes reliable medical information must be peer-reviewed, edited, and posted by professionals in the field.

> It [information from magazines] is not something which is peer-reviewed. It is not something which is edited, and it does not have to be posted by medical doctors. It does

not have to be posted by even people with a degree. And I think that those things are required to make certain judgments on medical information.

During SSI decision-making, various group inclusions, such as political or religious groups may ignore peer-reviewed evidence, replacing the evidence with their context-specific beliefs when constructing an SSI decision (Herman *et al.*, 2022; Sadler & Zeidler, 2005; Zeidler *et al.*, 2019). This is dangerous for society as many decision-makers are resorting to this type of behavior (Herman *et al.*, 2022). We believe that this may be due to people's thresholds for ambiguity, or their ability (or lack of) to handle levels of uncertainty when handling controversial issues (Fensham, 2012; Lederman *et al.*, 2014; Sadler, 2004). When an individual surpasses their thresholds for ambiguity, they will cognitively shut down and will do whatever they can to solve the issue quickly (Fensham, 2012; Lederman *et al.*, 2014). Unfortunately, SSIs are unavoidable. As the world contends with SSIs that are starting to be severe in nature, such as the pandemic or global climate change, it is paramount that all people regardless of demographic learn how to critically evaluate evidence during these times of uncertainty. This way, people may be able to make a more informed SSI decision when their thresholds for ambiguity are passed.

Cross checking and Corroborating

Many students considered the process of cross-checking and corroborating between multiple domains of knowledge to be a reliable process for determining accuracy. Cross-checking and corroborating is a personal evidence-gathering processes where the individual will evaluate, synthesize, and compare evidence across multiple sources of knowledge when determining the accuracy of information (Chinn *et al.*, 2014; Chinn & Reinhart, 2016). For example, Dev

explains that when information searching about vaccines, he would frequent various websites to look for consistent information.

> I'll tend to Google it, scroll through and look for something that looks like it's not an advertisement for something and just click on that and see what they have to say. Then I'll do that a couple different sites and then the ones that are most often agreeing with each other. Those are the ones I start to look at as most likely to be accurate… part of it is the popularity, how often it comes up.

Additionally, Jonathan describes how science produces consistent evidence across multiple sources and that consistency is what makes the information reliable.

> When I'm looking for information, I want to make sure that it's accurate, so I'll look at a few different things, see where they, if they conflict or if they all say the same thing.

The ability to evaluate evidence through utilizing scientific procedures such as cross-checking and corroborating sources are quintessential scientific literacy skills needed to handle SSIs (DeBoer, 2000; National Research Council, 2002; National Academies, 2016). However, students applied these scientific skills across both science and social sources of information. This suggest that when navigating the epistemic climate during SSI decision-making, students may determine accuracy from other information sources outside of scientific domains.

The reliable process of corroborating between information sources suggest that the courses aimed toward increasing scientific literacy skills for all students are working. However aside from students' scientific literacy skills, students may also use their emotions, intuition, and personal experiences when evaluating evidence. Therefore, when improving efforts toward increasing scientific literacy for undergraduate students, these affective components should be considered when designing course work through including classroom discussions about how they may contribute toward SSI decision-making (Fowler and Zeidler, 2016; Sadler and Fowler, 2006). Additionally, these discussions can center around how to navigate students' emotions, biases, and intuitions when they are trying to work through an SSI. By doing so, instructors can start to implement functional scientific literacy skills instead of the traditional scientific literacy skills that only emphasize scientific ways of knowing. Functional scientific literacy skills provide students with the skills to recognize their affective components and use them in conjunction with their information searching techniques without compromising their abilities to evaluate evidence (Herman, 2018; Karisan & Zeidler, 2017; Sadler & Zeidler, 2005; Zeidler & Sadler, 2011).

Limitations

There are several limitations to this study. First, because the process of epistemic cognition is so implicit, there may have been undetected influences contributing towards our results. Therefore, in future studies we recommend doing a think-aloud qualitative study where students have to evaluate multiple forms of evidence and describe how they are determining the validity of that evidence. By doing so, the researchers may be able to better gauge how students'

epistemological mechanisms are contributing toward how they are actually handling information during SSI decision-making instead of hypothetically discussing it.

Another limitation is that all participants were eager to participate, and they all had strong opinions about the vaccination controversy. We acknowledge that this is not reflective of an undergraduate student population. Furthermore, the university used to recruit participants is not culturally diverse. Therefore, our data may be reflective of a small and specific population of students. Lastly, because we were discussing a controversial issue, students may have tailored their responses to adhere toward what they believed that the researcher wanted to know (Packer, 2018). This asymmetry of power has negative implications on the interviewees' responses and can damage the validity of the data by pulling away from the interviewees' lived experiences (Packer, 2018). This is problematic because it distracts from the individual's constitution in regard to the phenomenon and forces their responses to take the shape of the researcher's *own* take upon that phenomenon (Packer, 2018).

Conclusion and Implications

In this preliminary investigation, we used the AIR model as an analytic lens to explore how students evaluate evidence when forming an SSI decision. We found that when discussing the vaccination controversy, students referred to both scientific and social sources of information. All students have the epistemic aims of stating that they wanted to search for the most accurate information. Their standards for accuracy, or their epistemic ideals, included information that contained specific characteristics such as numbers (internal structure of a knowledge source), information that connected to their other sources of knowledge (connections to other

knowledge), information that showed causal evidence (connections to empirical evidence), and information that they trust (testimony of others) (Chinn *et al.,* 2014). Students used their reliable processes such as: emotions, intuitions, consulting with experts, searching for peer-review, and cross-checking and corroborating between information sources to determine their standards for accuracy. Lastly, we found that students were suggesting that they use their scientific literacy skills when discussing cross-checking and corroborating between information sources. Students were applying these skills across both scientific and social sources of information, suggesting that scientific literacy skills are being used outside of scientific domains.

Primarily, through the lens of the AIR model, the results of this study provide future researchers with evidence of how students' epistemic cognition contributes towards how they determine the accuracy of knowledge, how they use knowledge, and how they choose to interact with knowledge when describing how they information search about an SSI. There are little to no studies that use the AIR model as an analytic lens when exploring this phenomenon. Therefore, this study is illuminating. However, we call upon researchers to further investigate these phenomena through in-depth think-aloud studies with a more diverse audience. By doing so, we may be informed of how epistemic cognition operates when students belong to specific cultural groups. This may be beneficial for instructors of undergraduate science courses who have a diverse student body. The results of this study may also inform instructors of undergraduate science courses by showing them how scientific literacy skills are being used outside of the classroom. Through recognizing that students are using their scientific literacy skills across all knowledge sources, instructors can strive to make course content applicable and relevant for students' lives outside of the classroom. Although this is difficult to do, especially in large

introductory lectures, instructors can use course-specific terminology and concepts as a lens to evaluate current SSIs such as the COVID-19 pandemic. Furthermore, we recommend that instructors broadly discuss the presence of emotions and students' social ways of knowing when evaluating information about SSIs within the classroom. By doing so, instructors can normalize that student rely upon these social ways of knowing and guide their students in how to use them in conjunction with their scientific ways of knowing.

In conclusion this study explored how students evaluate evidence during SSI decision making through investigating the process of epistemic cognition. We used Chinn *et al.'s* (2014) AIR model to evaluate students' epistemic cognition. This study provides evidence of how students are handling knowledge when handling SSIs. We encourage future researchers to expand upon this work through utilizing a more interactive qualitative methodology such as a think-aloud study or through evaluating small groups of students when discussing the validity of information. By doing so, the field may discover other nuances of epistemic cognition that may be interfering with students' SSI decision-making processes.

CHAPTER TWO: THE DECISION IS IN THE DETAILS: JUSTIFYING DECISIONS ABOUT SOCIOSCIENTIFIC ISSUES

ABSTRACT

Controversial scientific issues, or socioscientific issues (SSIs), demand the consideration of more than scientific content when constructing decisions. Because undergraduate students are participants of democracy, it is critical to understand how students are weighing information

sources during SSI decision making. The Justification for Knowing framework (JFK) was developed to categorize the information sources drawn upon when making SSI decisions within the academic domain of natural sciences. These information sources stem from personal sources (JPS), authoritative sources (JAS), or multiple sources (JMS). However, these sources may not explain the array of knowledge claims reflected upon during SSI decision making. Furthermore, the selection of these information sources may be dependent upon context. This qualitative study aims to explore each JFK belief dimension across two SSIs and asks how contextual features are contributing toward the selection of these beliefs. Students (N=199) recruited from an R1 public institution responded to a modified Decision-Making Questionnaire. The questionnaire consisted of two SSI context scenarios. After each scenario, participants responded to open-ended prompts asking them if they support the proposed SSI decision and to explain their decision. Through two rounds of thematic coding, we found several subdimensions of JAS and found how students are utilizing JPS. Although the frequency of these broad sources did not differ between contexts, we saw differences within the types of sources reflected upon within each context. We also found that SSI context may ignite specific identity commitments that operate as a vehicle toward the selection of knowledge sources when an individual is supporting their SSI decisions. The results of this study provide insight on specific information sources students rely upon when justifying their knowledge. Furthermore, this work emphasizes how identity commitments may be contributing toward the selection of these information sources during SSI decision making tasks.

Introduction

Regardless of demographic, all global citizens contend with socioscientific issues. Socioscientific issues, or SSIs, are controversial scientific issues with social implications

(Herman *et al.*,2020; Sadler, 2004; Sadler and Fowler, 2006; Zeidler *et al.,* 2002; Zeidler *et al.,* 2009). Examples of SSIs include global warming, vaccinations, and the COVID-19 pandemic. SSIs are ill-structured problems, meaning that they do not have a definitive answer (Herman *et al.*,2020; Sadler, 2004; Sadler and Fowler, 2006; Zeidler *et al.,* 2002; Zeidler *et al.,* 2009). This is due to the multiple participatory stakeholders involved within each SSI. These stakeholders stem from various entities, such as science, policy, economy, and culture (e.g., religious practices) (Herman *et al.*,2020; Sadler, 2004; Sadler and Fowler, 2006; Zeidler *et al.,* 2002; Zeidler *et al.,* 2009). Each stakeholder can have a strong influence upon SSI decision-making action by presenting the public with large volumes of information that are readily available through multiple information platforms (Greene, 2016; Muis *et al.,* 2015). However, these information sources are often conflicting, forcing the decision-maker to decipher each information source by implicitly drawing upon their epistemic beliefs, or beliefs about knowledge and knowing (Barzilai & Chinn, 2020; Hofer, 2000; Sinatra, 2016). Therefore, it is critical to understand how epistemic beliefs are contributing toward how an individual uses information when formulating an SSI decision. This is especially needed within the undergraduate student population, as these emerging adults are beginning to participate in democratic activities such as voting for policymakers (Barzilai & Chinn, 2020).

Epistemic beliefs are domain specific and contextual, where an individual will subconsciously draw upon specific epistemic beliefs when engaging with a specific context (Brandmo and Bråten, 2018; Chinn, *et al.,* 2014; Hofer, 2006; Sinatra, *et al.,* 2014). Therefore, context may influence how an individual uses information when formulating their SSI decisions (Herman, 2015; Herman *et al.,* 2018). However, epistemic beliefs are often evaluated from the lens of a

specific academic domain, which may limit our understanding of how they operate during SSI decision-making as SSIs often include multiple contexts (Herman *et al.,* 2022). Additionally, these studies have mostly been quantitative, which further limits our understanding of the role of context and how it may contribute toward the way students use information when handling SSIs (Brandmo & Bråten, 2018; Chang *et al.,* 2020; Ferguson *et al.,* 2013). Although quantitative methods provide us with an empirical understanding of a phenomenon, they may not be sensitive enough to illustrate how students are implicitly reflecting upon their epistemic beliefs when engaging within a specific context. Therefore, this study qualitatively investigates how undergraduate students' epistemic beliefs contribute to how they use information when explaining their SSI decisions.

Theoretical Framework

Research exploring epistemic beliefs is diverse with various definitions and models (Hofer & Bendixen, 2012; Sinatra, 2016). Perry's foundational phenomenological study has set the stage for how epistemic beliefs are evaluated within the field of educational psychology (Perry, 1970). In summary, his work discovered that in undergraduate students, there is a continuum of beliefs about knowledge and knowing, ranging from novice to advanced beliefs, that develops throughout their academic career (Perry, 1970). Influenced by Perry's (1970) work, epistemic belief research is currently explored within continuums split between two epistemic belief categories: beliefs about the nature of knowledge, or how an individual defines knowledge, and beliefs about the nature of knowing, or how an individual knows knowledge (Hofer & Pintrich, 1997; King & Kitchener, 1994). Each belief category has been empirically expanded and refined into several dimensions. (Ferguson *et al.,* 2013; Greene *et al.,* 2008; Greene *et al.,* 2010; Hofer,

2004; Hofer & Pintrich, 1997). The nature of knowledge epistemic belief category focuses on the certainty of knowledge and the simplicity of knowledge (Hofer & Pintrich, 1997; King & Kitchener, 1994). The nature of knowing epistemic belief category focuses on the source of knowledge and the justifications for knowing (Hofer & Pintrich, 1997). Due to current pressing SSIs such as the COVID-19 pandemic, there has been emphasis on further exploring the justifications for knowing dimension as this may explain how people are evaluating evidence when arriving toward their SSI decisions (Brandmo & Bråten, 2018; Hofer & Bendixen, 2012).

Justifications for knowing (JFK) concern how an individual determines the validity of information when handling an ill-structured problem (Brandmo & Bråten, 2018; Hofer & Bendixen, 2012). Building off of Perry's work (1970) Hofer and Pintrich (1997) defined the JFK as an independent continuum, where an individual will justify their ways of knowing from their personal beliefs about knowledge to accepting the beliefs and opinions of external authorities throughout their academic career. However, by drawing from philosophical epistemology, this unidimensional definition was challenged by Greene and colleagues (2008), where they discussed how internal personal ways of knowing (e.g., opinions and feelings) and authoritative ways of knowing (e.g., knowledge from experts in the field) should be considered as two separate dimensions instead of one continuum. Further supporting this claim, Greene *et al.* (2010) provided evidence that the justification for knowing contains two dimensions: justification by authority and justification by personal sources of knowledge. Encouraging further research on the topic, this work also provided evidence that the JFK beliefs may vary across academic domains (e.g., math, history, science), a concept that derived from the broader epistemic belief literature, where academic domain has been found to elicit specific epistemic

beliefs when students are engaged within domain specific tasks (Hofer, 2000; King and Kitchener, 1994).

Following Greene and colleagues' (2010) research, Ferguson, and colleagues (2012, 2013) expanded upon the JFK framework by evaluating JFK beliefs when students are presented with multiple conflicting texts about an SSI. However, they evaluated JFK beliefs from the academic domain of natural sciences as the SSI was presented as a predominantly scientific issue (Ferguson *et al.,* 2012). Ferguson, Bråten, and Strømsø (2012) found that students justified knowledge claims by comparing and contrasting information from the texts with their own personal knowledge and knowledge from external authorities such as other academic domains. They also discovered that students would consistently check the given information sources, making sure that their justifications mirrored the information which they deemed to be reliable (Ferguson *et al.,* 2012). In a follow-up study, Ferguson and colleagues (2013) expanded the two-dimensional JFK framework, stating that when thinking about SSIs, students may justify their decisions through justification from personal sources (JPS; justification for knowledge claims through personal views, opinions, and experiences), justification from authoritative sources (JAS; justification for knowledge claims through appealing to an external reputable source), and justification from multiple sources (JMS; justification for knowledge claims through the corroboration of reputable information sources) (Ferguson *et al.,* 2013). This new trichotomous framework has been used to explore the relationships between the JFK and academic performance (Brandmo and Bråten, 2018; Bråten and Ferguson, 2014; Strømsø *et al.,* 2016), SSI reasoning (Chang *et al.,* 2020), and motivational constructs such as personal interest and

engagement when individuals are handling SSIs (Brandmo and Bråten, 2018; Ferguson *et al.*, 2013).

Ferguson and colleagues' (2013) framework was specifically developed within the domain of natural sciences. Therefore, the three JFK dimensions, especially JAS, have been broadly thought about from an academic perspective. For example, a JAS belief could be a scientific text or professor in the field. However, when making a decision about an SSI, students may not simply be reflecting upon academic authoritative sources, but rather a variety of authoritative sources that are elicited by the sociocultural aspect of the SSI (Sadler & Zeidler, 2004). Moreover, the knowledge sources reflected upon by the decision-maker may vary with the context of the SSI. For example, when constructing a decision about the vaccine controversy, one may reflect upon medical knowledge, ethical knowledge, or religious knowledge. Whereas, when constructing a decision about hunting, one may reflect upon scientific knowledge, economic knowledge, and cultural knowledge. Furthermore, each SSI scenario may elicit specific decision-making strategies, depending upon how the decision-maker reacts while interacting with the SSI (Herman *et al.,* 2018; Herman *et al.,* 2020; Herman, 2022; Sadler & Zeidler, 2004). Therefore, understanding SSI decision-making broadly may require investigating how additional domains of knowledge, including people's sociocultural ways of knowing, contribute toward the selection of JFK beliefs when individuals make SSI decisions.

People's sociocultural ingroups may determine how an individual chooses to engage with SSIs, including how they choose to evaluate information about the SSI and therefore, how they use their JFK beliefs (Herman *et al.,*2022; Kahan, 2015). This poses an issue, as people's ingroups

may claim to have all the correct answers in how to handle an SSI. By adhering toward the ideologies of their in-groups, the decision-maker may ignore essential information needed to make an informed SSI decision (Chinn & Barzilai, 2020; Herman *et al.,* 2022). It has been found that students ground their SSI decision-making from their political and sociocultural identities, irrespective of their level of scientific knowledge (Herman *et al.,* 2022). Although there are multiple ways of knowing when constructing an SSI decision, sociocultural group inclusions may guide the decision-maker away from peer-reviewed scientific evidence when handling novel SSIs (Herman *et al.,* 2022). This makes SSI decision-making complicated for society as well-established scientific evidence is often accepted, but new scientific evidence may be perceived as a threat by specific sociocultural groups and replaced with misconceptions about science (Barzilai & Chinn, 2020; Herman *et al.,* 2022; Herman *et al.,* 2018). When this occurs, people are no longer referring to well-established scientific knowledge during SSI decision-making, but to the beliefs developed from their group inclusions (Herman *et al.,* 2022). To mitigate this issue, it is critical to include sociocultural ways of knowing in the JFK framework. By doing so, we may be able to further understand how and why decision-makers favor some knowledge sources and reject other knowledge sources.

A different methodological approach toward evaluating the JFK framework must be taken to recognize the sociocultural ways of knowing people may draw upon during SSI decision-making. Predominantly, the JFK dimensions have been evaluated through the Justification for Knowing Questionnaire (JFK-Q), an 18-item instrument that provides a quantitative lens of the JFK dimensions within the domain of natural sciences (Bråten *et al.,* 2013; Brandmo & Bråten, 2018; Ferguson *et al.,* 2013). Although surveys may be appropriate when exploring epistemic

beliefs about specific academic domains (Ferguson *et al.,* 2013; Greene *et al.,* 2008), quantitative methodologies may be insufficient for fully understanding how the JKF framework is relevant in SSI decision-making processes. In contrast, a qualitative lens would allow us to observe the nuances of students' lived experiences, cultures, and ways of knowing that are not always detected through a likert-style survey during SSI decision-making (Packer, 2018). Therefore, this study qualitatively investigates the JFK belief dimensions when undergraduate students support SSI decisions. By doing so, we aim to discover other ways of knowing that students may be drawing upon that are not currently included in instruments that measure JFK beliefs. We ask the following research questions:

(1) What JFK beliefs dimensions do students use during SSI decision-making?
(2) How does SSI context relate to students' JFK when supporting their SSI decisions?

Methods

Setting and Participants

Participants of this study were recruited from two sections of a mixed majors science course at the University of New Hampshire, a high research-intensive (R1) public institution in the northeastern United States. This institution is comprised of predominately white students (80%), with a small population of black, indigenous, and persons of color (10%), and a small population of international students (4%) (UNH Data & Reporting, 2020). Students were recruited from each section through an in-person introduction during the course's lecture followed by an email reviewing the expectations and procedures of participation and a link to an online survey. As an incentive to participate, students were offered five points of extra-credit toward their cumulative

exam score within the course. The course had approximately 357 students per academic year, with a response rate of 66%. Participating students (N=199) were primarily science majors (57%), with the remainder identifying as either a non-science major (36%) or undeclared (8%). Of these students, 81% were first-years or sophomores (underclassmen) and the remaining 19% of students were juniors or seniors (upperclassmen). We removed one participant from the data set given that their responses were 'uncodable', bringing our total number of participants to 198. This study was approved by the University's Institutional Review Board (#8035).

Materials and Procedure

Students completed a modified version of the Decision-Making Questionnaire (DMQ; Bell & Lederman, 1999; Bell, 2003). The original DMQ was designed to assess the role of people's nature of science beliefs during decision-making (Bell, 2003; Bell & Lederman, 1999). The DMQ consists of four SSI scenarios: climate change, fetal tissue use in medical research, cigarette use, and obesity (Bell, 2003; Bell & Lederman, 1999). Each SSI scenario introduces a character or entity and discusses the issue from a third person narrative. After each SSI scenario, participants are asked several open-ended questions regarding their opinions about the specifics within each scenario (Bell, 2003; Bell & Lederman, 1999).

Due to the length of the DMQ, we decided to use only two SSI case studies to prevent participant fatigue: fetal tissue use in medical research and climate change. We decided to use these two scenarios due to their current relevance within today's social climate. The fetal tissue SSI describes a scenario in which a woman with a relative suffering from Parkinson's Disease has an unexpected pregnancy. The woman considers aborting the fetus and donating the fetal tissue to a

doctor who is experimentally utilizing fetal tissue as a viable treatment for Parkinson's Disease. The climate change SSI discusses how climate change poses severe ecological consequences toward the global community. The scenario states that there needs to be some sort of policy passed that will help mitigate the effects of climate change. The solution presented is to tax vehicle owners and put those taxes toward the reduction of greenhouse gas emissions.

Given that the DMQ was not constructed to specifically examine the JFK framework, we piloted these two scenarios with the original questions from the DMQ in spring 2019 (Table 1). To ensure we could elicit the JFK dimensions in students' responses, we added the question "what helped you form this opinion" to both SSI scenarios. Participants for this pilot (N= 114; response rate = 72%) came from the same science course used in our present study. However, we noticed that students' answers were vague, some not even answering the questions and just responding with a yes or no. Therefore, when finalizing the modification of the DMQ, we split the pilot questions into separate questions, such that students first answered whether or not they agreed with a proposition, and then expanded on their decision by answering "why or why not?"

Table 1. The Pilot and Modified DMQ Questions.

SSI Scenario	***Pilot DMQ Questions***	***Modified DMQ Questions***
Fetal Tissue Use in Medical Research	• Should Dr. Harrison be allowed to continue his work on fetal brain tissue transplantation as a treatment for Parkinson's disease? Why or why not? What helped you form this opinion?	• Should Dr. Harrison be allowed to continue his work on fetal brain tissue transplantation as a treatment for Parkinson's disease? • Why or why not? • In your life, which experiences formed this opinion? • How have your beliefs helped form this opinion?

Climate Change	• Should the U.S. impose special taxes on carbon dioxide emission to encourage energy conservation, even if this increased monthly electricity and heating bills by $25 per month? Why or why not? What helped you form this opinion?	• Should the U.S. impose special taxes on carbon dioxide emission to encourage energy conservation, even if this increased monthly electricity and heating bills by $25 per month? • Why or why not? • In your life, which experiences formed this opinion? • How have your beliefs helped form this opinion?

Additionally, we created two questions to better understand students' justifications for knowing when supporting their decisions: "In your life, which experiences formed this opinion?" and "How have your beliefs helped form this opinion?" (Table 1). We specifically asked about experiences and beliefs because an individual will justify how they know about an issue through reflecting upon their unique ways knowing that may have been influenced by their personal experiences or a personal feeling, authoritative influences (e.g., knowledge from an academic domain, experts in field, parents, policy makers), or a combination of both (Ferguson *et al.*, 2013; Hofer 2004; King & Kitchener; 1994). Furthermore, we decided to ask the experiences question given that epistemic beliefs are developed through various experiences in both academic and non-academic settings (Kahan, 2015; Muis *et al.,* 2006; Tabak, 2008). The beliefs question was meant to elicit students' authentic beliefs about the SSI scenario without targeting specific JFK dimensions such as the JFK-Q or other quantitative instruments. By doing so, students had the freedom to describe their unique beliefs without being restricted by a likert-style instrument or by the researcher. Moreover, this question attempted to reduce the threats toward the validity of our findings by allowing the students to authentically interpret the question and draw from their ways of knowing that they felt would appropriately answer the question. we

asked these as two separate questions to avoid getting the one-word answers that we found within our pilot.

Because students' ways of knowing are generated by experiences and beliefs about specific phenomena (Hofer, 2004; Hofer & Pintrich, 1997) we used both the experience and belief questions together to categorize which JFK dimensions students were referencing when explaining their answers to the first 'yes or no' question. Similar to how Bell and Lederman (1999) developed the DMQ, we reviewed each question and the selected SSI scenarios with a panel of experts before using the modified DMQ to collect data. The fully modified DMQ is located within the Appendix.

Data Analysis

The data was analyzed by myself and three undergraduate research assistants. Before coding began, the undergraduate research assistants were introduced to the theory and analytical techniques of qualitative coding along with the relevant epistemology literature. Once they had become familiar with the terminology, theory, and details of the project, we thematically coded the data in two phases. Phase one consisted of deductively coding the responses from both the experiences and beliefs questions together using Ferguson and colleagues' (2013) JFK framework. Phase two consisted of inductive coding, exploring patterns in the data not described by the original JFK framework. Within this analytic phase, we unpacked each JFK dimension by identifying the specific sources of information the participants referenced. Each phase consisted of coding subsets of data in individual pairs and then coming together once a week to compare codes through a consensus coding session. As a guiding tool for the head researcher, a percent

agreement was calculated to ensure that there was a range of 90%-99% coder agreement between both coding pairs (McAlister *et al.,*2017; Miles & Huberman, 1994). This was reflected upon as a means of informal inter-rater reliability (IRR) to ensure that all researchers were understanding the codebooks. Once all subsets were completed per phase, a Cohen's Kappa was calculated for official IRR purposes. Details of each analytic phase are discussed below.

Phase One: Deductive Coding

For both SSI case studies, the data was subsetted into manageable portions with the goal of decreasing analytic fatigue (MacQueen *et al.,* 1998; Saldaña, 2015). For each portion, we alternated coding partners, where each pair coded together throughout the week. The entire coding team met once a week, coming to consensus on our coding choices. The alternating coding partners helps mitigate biases by providing an additional lens of interpretation per data portion (Belur *et al.,* 2021; Cornish *et al.,* 2013; MacQueen *et al.,* 1998). By doing so, both partners contribute toward preventing the other from obscuring the ethnographic fidelity of each participant's response (Cornish *et al.,* 2013). The codebook for phase one, developed by the first author, consisted of the three JFK dimensions and their definitions from the literature (Table 2; Brandmo & Bråten, 2018; Ferguson *et al.,* 2013). Our broad frequency counts of each JFK dimension are based upon this phase of coding (Table 3).

Table 2. Phase 1 codebook

Code	**Definition***
Justification from Authoritative Sources (JAS)	Evaluation of knowledge claims by appealing to a reputable external source
Justification from Personal Sources (JPS)	Evaluation of knowledge claims in relation to one's own views or opinions

Justification from Multiple Sources (JMS)	Evaluation of knowledge claims from corroborating between personal and authoritative ways of knowing

***Definitions from Ferguson *et al.*, 2013**

Our percent agreement scores ranged from 80%-99% per coding section, where the lower percent scores were within the first few rounds. Percent agreement began to improve after taking a few weeks to review the codebook (Table 2) as well as the epistemic belief literature. As an official means of IRR, a Cohen's Kappa was calculated for the entire data through the 'irr' package in R (Gamer *et al.,* 2012) and resulted in $\kappa = 0.855$. A kappa value above 0.8 is considered a very high level of agreement between coders (Hartman, 1997).

Phase 2: Inductive Coding

Within the second analytic phase, we inductively coded the data, identifying specific authoritative or personal sources that were reflected upon between both the experiences and beliefs questions. This allowed us to interpret the JFK belief dimensions we found through our deductive coding in ways that were broader than the definitions from the original JFK framework. By expanding each definition, we acknowledge more specific sources of information that may be contributing toward the selection of each justification belief when supporting an SSI decision. We considered each JFK dimension to be a "parent code." Within each parent code, we developed several subcodes. The phase 2 codebook (discussed within the results section) was developed through analyzing 20% of the completed phase 1 data. We coded these responses as a group, discussing the nature of each JFK dimension as well as the nature of epistemic beliefs. For this second round of coding, we primarily focused on the two questions that asked participants how their beliefs and experiences shaped their decision. As stated before, these

questions exposed the participants' criteria for which information source they relied upon when justifying their knowledge claims.

Once the codebook was developed, 50% of the data (approximately half from the fetal tissue SSI context and half from the climate change SSI context) was coded for IRR purposes (Hartman, 1997). We followed the same coding protocol as the first phase of analysis. During our analysis, we deemed two participant responses as 'uncodable' for the subcode. Although we were unable to subcode, we kept these two participants within the data analysis for their parent codes. Several responses coded within the first phase of analysis were unanimously changed between all researchers. These changes were strictly between the JPS and JMS dimension because our reflections led us to consider multiple personal sources of information to be a JPS response, not a JMS response. Similarly, to the first phase of analysis, percent agreement was calculated for an informal sense of IRR. Percent agreements within this phase ranged from 90-99%. Once the data portions were analyzed, IRR was calculated by a Cohens Kappa through the 'irr' package in R ($\kappa = 0.911$) (Gamer *et al.*, 2012). I independently coded the remaining portion of the data. The frequency counts of the specific information sources reflected upon within the JFK dimensions are based upon this analytic phase.

Results

Among the three JFK dimensions, we found that students predominantly relied upon multiple sources (JMS) when justifying their knowledge claims, with personal sources (JPS) medially,

and authoritative sources (JAS) as the least reflected upon as a singular dimension (Table 3). This was consistent across both SSI scenarios.

Table 3. Overall JFK Patterns

JFK Dimension	Frequency in fetal tissue SSI scenario	Frequency in climate change SSI scenario	Total frequency
JAS	8%	4%	6%
JPS	34%	40%	37%
JMS	57%	56%	57%

These broad results suggest that students often cross-check and compare knowledge sources when arriving at an SSI decision, and this does not vary with SSI context. Because JMS responses are a corroboration between multiple ways of knowing (Ferguson *et al.,* 2013), they include a combination of authoritative and/or personal sources of information. Meaning, for a response to be coded as JMS, participants must refer to multiple authoritative sources or a combination of personal and authoritative sources. Therefore, we disaggregated JMS responses into authoritative and personal ways of knowing. Within this dimension, 56% of participants reported more than one authoritative knowledge source and 44% of participants reported a personal knowledge source combined with an authoritative source when justifying their SSI decisions. Similar results were seen across both SSI contexts. These results suggest that authoritative sources of knowledge are important sources of information for students as they make SSI decisions. However, these results also suggest that despite content knowledge about the specific topic, some individuals may ultimately rely upon their personal knowledge sources during SSI decision-making.

Although we were able to determine whether students were justifying their ways of knowing from authoritative sources, personal sources, or multiple sources, the current JFK dimensions did not provide insight into the types of authoritative or sources that may be important for students in the context of SSI decision-making. Through inductive coding, we found five subdimensions of authoritative sources that represent the context-specific authoritative sources students used. We also found that students used JPS through reflecting upon their personal experiences when explaining their SSI decisions. However, there may be other personal ways of knowing that were not detected within our study due to the nature of our methodology. We further discuss this within our limitation section. Both the JAS and JPS dimensions were reflected upon individually or combined with other knowledge claims (coded as JMS). Our findings within the JAS and JPS dimensions are discussed below.

Authoritative Sources Subdimensions

Ferguson and colleagues (2013) define the JAS dimension as an evaluation of knowledge claims by appealing to a reputable external source. Therefore, we coded any information sources that were described as a reputable external source of knowing in the context of each SSI as a JAS subdimension. Students reported these JAS subdimensions by describing them as their ways of knowing within the context of each SSI. In total we found five subdimensions: religion/dogmatic practices, media, politics, social circle, and academic influences (Table 4).

Table 4. Subdimensions of JAS

Authoritative subdimension	***Definition of subdimension***	***Representative quote from fetal tissue SSI scenario***	***Representative quote from climate change SSI scenario***

Religion / Dogmatic Practices	Reference to religious upbringing, religious leaders, religious views, identity derivative of an authoritative practice (e.g., veganism)	"My parents have raised my brother and I Catholic. This had influenced me to, initially, be against abortion. This made it difficult for me to become more open-minded on the subject."	"I grew up vegan, always reduced, reused, and recycled, and refuse to kill bugs that wander into my room."
Media	Any sort of media outlet; can be digital (e.g., the news) or more traditional (e.g., research article)	"I have not had any personal experiences that have helped me form this opinion other than reading articles and trying to become educated on these topics."	"Watching the news and seeing the companies that refuse to change because of money."
Politics	Reference to political views, political affiliation, or political action	"I grew up with a liberal background, so I am very liberal."	"I was always exposed to liberal and progressive views. This has influenced me to be more interested in preserving the environment."
Social Circle	Reference to members of a broad social circle (e.g., guardian figure, peers, family members, culture)	"My parent's beliefs and opinions have definitely helped sharpen mine."	"My friends and their concern with the environment have made me care more about it. "
Academic Influences	Reference toward academic influences (e.g., power of science, textbooks, professors, academic institutions, academic domains)	"I just believe that if it is safe and within the power of science then it should be allowed."	"Being educated on the effects of climate change."

It is important to note that within the quotes of Table 4, several students reference their upbringing. Although this may suggest that they are describing their personal experiences (which would be coded as the JPS dimension), they use reputable external authoritative sources to

explain their ways of knowing in the context of each SSI. The reputability of these authoritative sources may be based upon the role they play within our participants' knowledge of the specific SSI context. For example, within Table 4, we use a quote from the fetal tissue SSI scenario to portray the religious/dogma JAS subdimension. In this quote, the student describes being raised as Catholic. They then state that because of their Catholicism, they were initially against abortion. Furthermore, the influence of their Catholicism made it difficult for them to change how they view the SSI. The quote suggests that for this participant, religion acts as a reputable external authoritative way of knowing when handling the specific context of fetal tissue use in medical research.

As another example, consider the quote used in Table 4 for the politics JAS subdimension within the climate change SSI scenario. In this quote, the participant states that they have always been exposed to liberal and progressive political views, suggesting that they have had multiple experiences engaging with these political ideologies. However, the participant states that the role of the liberal and progressive views have contributed toward their interest in preserving the environment. Therefore, these political ideologies are behaving as a reputable external source of authority that is being reflected upon as the participant's ways of knowing about the climate change SSI scenario.

In the following section, we describe each JAS subdimension by heavily relying upon our participants' responses. These quotes have been lightly edited for grammatical purposes and explanatory language has been placed within brackets.

JAS Subdimension: Religion and Dogmatic Practices

For SSIs that focus on women's reproductive issues, such as subjects centering around abortion (Oulton *et al.,* 2004), lay-people will often reference religious beliefs or religious group inclusions (Oulton *et al.,*2004; Sadler & Zeidler, 2005). Although our study does not specifically use abortion as an SSI topic, the fetal tissue in medical research scenario suggests that one of the decision-making players opts to abort her fetus for medical research. Therefore, we have found that several students justified their ways of knowing by reflecting upon the JAS subdimension of religion mostly in the fetal tissue SSI scenario. For example, in the two quotes shown below, these students justify their ways of knowing through reflecting upon their religious beliefs.

> My views have greatly influenced my decision…[like] my Christian beliefs and desire to preserve life.

> My religious upraising [influenced my decision]. It [Dr. Harrison's research] sounds very inhumane and unethical. The aborted fetus should be something that is buried not used in science. It sounds like something out of Frankenstein.

Furthermore, this student refers to their religious upbringing as their justification for knowing in the context of the fetal tissue SSI scenario. "I grew up somewhat religious so I just think a life should be taken very seriously regardless of if it's born or not."

Within the climate change scenario we had one student broadly reference religion by stating that they believe God has tasked humanity with taking care of the planet, "God gave us this planet

and tasked us with taking care of it." However, several students referenced having a spiritual connection with the earth and used that connection to justify their ways of knowing when explaining their SSI decision. For example,

> I feel a spiritual instinct to connect with the environment. I think we have to be responsible for our impacts, and we do a lot to negatively harm the ecosystem we are a part of.

Like the quote above, this student uses their spiritual connection with the earth as a justification for knowing when explaining their SSI decision.

> I have always been connected with Nature and have been interested in helping the world. My connection with nature has helped me form this opinion. I believe in environmental stewardship and this has influenced my opinion.

Within the climate change scenario, we found that several students referred to their dogmatic practices, such as veganism, as their ways of knowing (Table 4). Dogma must be recognized when it comes to SSI decision-making as these practices may be deeply rooted, contributing toward the development of epistemic beliefs (Bendixen & Rule, 2004). Because students described these practices as an authoritative way to live their lives, such as religious practices (Oulton *et al.,* 2004), we combined these practices with the JAS subdimension of religion. For example, the quote below illustrates how a dogmatic practice such as altering a food choice can be similar to someone's religious beliefs. The student states that they are passionate about the

earth and will “give back” to the earth, referring to the planet as a mother who needs protecting. They use their dogmatic practice of being a vegetarian to explain their ways of knowing about the environment.

> 5 years ago I decided to become a vegetarian so this [climate change] is something I am very passionate about… I believe in a love for Mother Earth. The earth gives to us and so we must give back to her. I believe in the value of all living things.

Similarly, the student below references how saving the earth is a priority to them. They describe their dogmatic practices such as using reusable bags or walking instead of driving as their justifications for knowing when supporting their SSI decisions.

> Saving the earth is a priority. Whether it be reusable bags, metal straws, or walking instead of driving, I always make conscious decisions to better the environment

We believe that we see these dogmatic practices within the climate change scenario due to the familiarity of the issue. Because of this familiarity, students may feel a sense of control and adhere toward personal practices to reduce their impact on the planet (Jones & Song, 2014).

JAS subdimension: Media

We deemed media as an authoritative source subdimension given how media may be functioning authoritatively during SSI decision-making tasks. In the context of this study, media was reflected upon to confirm participants’ epistemic beliefs about both SSIs. For example, the

quotes below show how students reference media outlets as their justifications for knowing when supporting their SSI decisions.

> Watching different shows on TV and watching debates or seeing women have to march for the rights of their own bodies.

> I have heard stories from women that have been harassed or judged for their choice which I believe is wrong. That is what made me form my opinion on this situation.

The influence of social media has been insurmountable upon how people think about SSIs (Barzilai & Chinn, 2020; Bråten *et al.,* 2018; Herman *et al.,* 2022; Sadler *et al.,* 2017). We found that several students justified their ways of knowing through reflecting upon social media and from what they have head within the news. For example,

> The social media always advertises global warming and climate change and it does influence my beliefs on our planet and how we need to take care of it.

> Hearing things from other people and the news, it makes me think we really need to save the planet.

JAS subdimension: Politics

We found that both political beliefs and political affiliations also contributed toward students' ways of knowing regarding each SSI. This was particularly evident within the fetal tissue SSI

case study. The role of policy as an authoritative source may have been elicited due to the nature of both SSI scenarios. This could have also been due to the current political climate within the US, where both SSI scenarios are at the forefront of political conversation. As members of society participate in the formulation of policy through actions such as voting, the role of policy will certainly dictate the decision-maker's stance upon SSIs. Within the fetal tissue SSI scenario, we see this through the multiple references of identifying as a feminist or being pro-choice. For example, this participant refers to their identity as a feminist and how that political stance has directed her beliefs upon the matter.

> I consider myself a feminist. I met many women travelling who did not have any say in the choices that were made about their bodies. I think everyone deserves to make their own decisions.

Similarly, these participants reference their pro-choice political stance as their ways of knowing when supporting their SSI decision.

> I am pro-choice and believe women have the right to do what they want with their bodies, including having an abortion (or in this case, donating a fetus for a greater cause).

> My beliefs are pro-choice. I am pro-choice and I think that people have the right to do what they want with their bodies, so if someone wants to give their fetus to science or give their bodies to science after they die, who are we to tell them not to.

Within the climate change scenario we see students using the political subdimension differently. Students refer to their political affiliations instead of adopting a politically affiliated stance that we see within the fetal tissue SSI scenario. For example, the two quotes below show students reflecting upon their political affiliations as their ways of knowing when explaining their SSI decisions.

> My beliefs have typically leaned more on the Republican side. This has made me less concerned about preserving the environment for the future and more concerned about preserving the ways of the past.

> I am a democrat. I believe in government policy that will help to reduce climate change. Climate change does not just affect humans, it affects all living and non-living things on earth. It is destroying ecosystems across the world. And since we are the ones that are causing it, we need to find a way to stop it.

The role of political influences as authoritative ways of knowing is strong in shaping SSI decisions (Herman *et al.,* 2022). However, as seen between both SSI scenarios, people refer to this domain differently. This may be due to the influences of people's sociocultural group inclusions such as their academic, religious, and social groups (Sadler, 2004; Sadler & Zeidler, 2005). However, the role of policy will likely be constantly changing as society progresses, making this authoritative sources subdimension invaluable to how we observe JFK beliefs.

JAS subdimension: Social Circle

Consistent with the literature, we found that students' social circle had an authoritative hold on their JFK beliefs (Bendixen *et al.,* 1998; Muis & Franco, 2009; Muis & Sinatra, 2008). "Social Circle" was coded for when a participant reflected upon knowledge claims that were generated from their social influences, such as their parents or peers. The reflection upon students' peers, guardian figures, and cultures when justifying knowledge claims suggests that social influences may be contributing toward their ways of knowing. Within this JAS subdimension, students also referenced their social circles. These responses differ from when students refer to their religious or political upbringings as the JAS subdimensions of religion and policy are described as authoritative means of knowing not the social figures who have raised them. For example, in the quotes below we see how students justify their ways of knowing through reflecting upon knowledge generated from their parents and peers.

> My mother has always made sure that I always had the right to do whatever I so chose with my body. Nobody should be able to tell me what I can and cannot do with my body. It comes down to supporting Sally's right to her body. She may do whatever she wants with her body as long as it's not hurting anyone.

> My father is a huge advocate for cleaner energy [so] I simply believe we need to shift our views of using oil and focus on cleaner ways to create energy to reduce the amount greenhouse gases produced in the atmosphere.

Students interact with their social circles every day. These interactions have implications upon how they view and behave around socially constructed issues, such as SSIs (Albe, 2008; Barzilai

& Chinn, 2020; Herman *et al.,* 2022) For example, these two quotes highlight how students' social circles contribute toward their ways of knowing about both SSI contexts.

> My mother raised me to be supportive of women's rights. As well as, my sister works in an emergency room and helped with a needed abortion since the fetus was in the fallopian tube. She described the aborted fetus as a larger period. I believe people have the right to their own bodies. Also, I believe we should optimize the use of things we have access to.

> My parents always told me to turn off any appliances right after using them, and to turn off all the lights when I'm done using them (anywhere I went, not just our house). So I got into the habit of turning everything off after using it, and now I remind my friends to do it.

These quotes portray how students' social circle deeply influence their epistemic beliefs about the SSIs. Therefore, we believe that it is important to include this subdimension within the JFK framework when evaluating SSI decision-making.

JAS subdimension: Academic Sources

Similar to Ferguson *et al.'s* (2013) JFK framework, we found academic sources to be an authoritative means of knowing. However, the academic sources we found between both SSI scenarios included more than professors or textbooks. Within this subdimension, we found that students were also referring to entire academic institutions, along with academic majors, and

even academic techniques, such as information searching that they have learned from their courses. For example, the participant below reflects upon how their high school influenced their beliefs.

> My entire high school was always very concerned with the environment. This has influenced me to be more interested in preserving the environment.

Similarly, the participant below reflects upon how their academic major influenced their decision.

> I suppose the biggest influence on my opinion is the fact that I'm a Biomedical Science major, so I have at least some insights into the processes of medical research/procedures.

These quotes demonstrate how various academic sources infiltrate an individual's decision-making process. Furthermore, the quotes portray that this subdimension may also refer to students' academic sociocultural in-group, such as an academic major.

We found 181 authoritative ways of knowing reflected upon within the JAS and JMS dimensions within the fetal tissue SSI scenario and 162 authoritative ways of knowing within the climate change SSI scenario (JMS responses may contain more than one authoritative source). Although we found all subdimensions in both SSI scenarios, the frequencies of the subdimensions differ by SSI (Table 5). In particular, there were more political sources being reflected upon in the fetal tissue SSI scenario compared to the climate change SSI scenario, whereas there were more

academic ways of knowing being reflected upon within the climate change SSI scenario than in the fetal tissue SSI scenario. Therefore, the subdimensions allow us to see how authoritative ways of knowing may differ across different SSI contexts. It is important to mention that JAS subdimensions such as religion and politics may vary in type depending on SSI context. For example, political knowledge sources range from liberalism to republican to democrat depending on the specific participant.

Table 5. Frequencies of JAS subdimensions for each SSI scenario

Authoritative subdimensions	***Frequency in fetal tissue SSI scenario***	***Frequency in climate change SSI scenario***
Religion / Dogmatic Practices	17%	9%
Media	8%	16%
Politics	38%	21%
Social Circle	14%	10%
Academic Influences	23%	44%

Personal Sources Dimension

Within the JPS dimension, we found that students reflected upon their personal experiences alone or in conjunction with having a specific feeling about an issue or referencing an emotion. This was consistent with Ferguson and colleagues' (2013) definition (e.g. justifying knowledge claims from personal experiences or other personal means of knowing). In this section we broadly describe our findings within JPS between both SSI scenarios.

We define students' reflection of their personal experiences as when the participant justified their ways of knowing through reflecting upon solely personal experiences (e.g., "I practice safe sex", "I grew up being a nature lover"). For example, in the climate change SSI scenario this student

reflects upon their experience of coming from a wealthy family when supporting their SSI decision.

> I personally come from a family that is well off financially and I can assure you money will not change my electrical use.

Similarly, this participant refers to personally experiencing the results of climate change as their way of knowing when supporting their SSI decision.

> Being born in 2001, and with technology advancing at exponential rates since my birth, the only thing I have experienced regarding the health of the planet is negative. Oil spills, deforestation, etc.

Like the climate change SSI scenario, students reflected upon their personal experiences as their ways of knowing within the fetal tissue SSI scenario. For example, this participant reflects upon their experiences with seeing patients who have Parkinson's disease as their ways of knowing when supporting their SSI decision.

> I have seen Parkinson patients and their families. Neurological degenerative diseases are pretty tough on the family and an aborted fetus will not be used for anything else so it may as well be used to help someone.

We suspect that there are many facets of knowing behind JPS that were not fully supported within the short responses. However, students' personal experiences may be used to express other ways of personal knowing such as a personal feeling or an emotion. For example, this participant reflects upon their financial personal experiences and personal belief that living without heat would be miserable in New England as their ways of knowing when supporting their SSI decision.

> While I am fortunate enough to have never struggled financially, I know people who have and those who are living from paycheck to paycheck would be stretched even more thin than they already are. I know there are also people that would be very deterred from using their heat in the winter due to this, and especially coming from New England I know that it would make life a miserable existence during winter.

Additionally, the participant below discusses their personal experience with a family member and other members of their social circle. They then discuss how their beliefs differ depending on the situation. We coded that as JPS due to how the participant describes their personal beliefs. Similarly, in the second quote, the participant reflects upon their experiences seeing the environment changing. They then reflect upon the emotion that the experiences cause.

> I have had close family with Parkinson's [disease] that is awful to see and have also had close people in my life undergo abortion, so I see both sides of it and would not judge at a decision. My beliefs differ, so I believe that whatever decision one makes would be the right in their situation.

> I see the oceans getting warmer, air temperatures are getting warmer, more storms are happening, species are dying, the reefs are deteriorating, and it is scaring me.

People scaffold their ways of knowing and will subconsciously draw upon them when needed (Sterelny, 2004; Sterely, 2010). These scaffoldings have cognitive boundaries based upon the context of decision-making (Sterelny, 2010). Therefore, although reflecting upon more than one knowledge claim, we considered the corroboration between personal sources of knowing as JPS and not as the JMS dimension. Our reasoning behind this was that both personal experiences and other personal ways of knowing came from the same 'epistemic container', a term we coin to help visualize the subconscious organization of context-specific epistemic beliefs reflected upon when justifying a knowledge claim. This term stems from the theory of epistemic organization, where individuals subconsciously organize their ways of thinking when undergoing daily tasks (Heritage, 2012). In contrast to the JPS dimension, multiple authoritative sources come from different epistemic containers, where an academic source of knowledge is generated from an academic influence and a political source of knowledge is generated from a political influence. Therefore, we believe that the term 'epistemic container' is appropriate when describing JFK belief subdimensions in the context of SSI decision-making.

In total, there were 449 reflections upon JPS between JPS as a singular dimension and within JMS across both SSIs. Within the fetal tissue SSI scenario, there were 203 JPS responses and within the climate change SSI there were 246 JPS responses.

SSI Context Triggers Students to Commit to an Identity Which May Relate To Students' JFK Beliefs

We found that SSI context may trigger students to commit toward a specific identity when explaining their SSI decisions. These identity commitments are a major emerging theme within the data. We define identity commitment as when an individual commits to a specific SSI stance or ideology from their sociocultural group inclusions when working through an SSI (Table 6). Examples of identity commitment include political identities, gender identities, religious identities, and generational identities. In total, 60% of participants reflected upon their identity commitments when explaining their SSI decisions. These identities may have been triggered by the nature of the SSI context, resulting in students using specific identity commitments when supporting their SSI decision.

Table 6. Identity Commitment Examples from Data

SSI Context	Representative Quote
Fetal tissue SSI scenario	"I am a woman who believes in pro-choice, Woman should be able to do what they think is best for themselves… I believe in science, and fundamental human rights."
Climate change SSI scenario	"By growing up in the 21st century, the issues regarding climate change and global warming have been heavily talked about and taught to my generation, making me not only more informed on the subject, but more aware of the actions we need to take worldwide."

We see identity commitment play a different role within the fetal tissue SSI scenario compared to the climate change SSI scenario. Within the fetal tissue scenario, we saw personal identities, such as religion, gender, and politics (Table 6). Identity commitments within the climate change scenario consisted of generational identities along with dogmatic practices such as veganism or environmental stewardship (Table 6). However, it's important to note that identity commitment codes are different than a JAS response as responses were coded as JAS when the participant

uses JAS as their ways of knowing, not their way of thinking. For an example, consider the quote for the fetal tissue SSI scenario within Table 6: the participant uses their gender identity to explain their way of thinking within the context of the SSI. They then bring up the JAS subdimensions of politics (pro-choice and human rights) and academic sources (science) as their ways of knowing in the context of the SSI.

Although we cannot make any causal claims due to the qualitative nature of the data, identity commitment may be reflected upon as a narrative guide toward the selection of JFK beliefs. We can visualize this by imagining an SSI context triggering specific identity commitments in the decision-maker. The identity commitments serve as a funnel for the decision-maker's thinking process to flow through, picking up context-specific JFK beliefs when arriving toward the SSI decision. For example, one student's non-religious identity served as a funnel of thinking for them to reflect upon JPS with the JAS subdimension of religion.

> I am not religious, and I do not believe that life begins at conception. I believe that an abortion involves removing a fetus, not a baby. Therefore, I do not really feel an ethical dilemma about using tissues from an aborted fetus.

Similarly, the participant below reflects upon their generational identity which may be guiding them to draw upon the JPS and the JAS subdimension of politics when supporting their decision.

> Seeing our leaders completely ignore our generation's plea for fossil fuel executives to stop knowingly contributing to climate change and threatening biodiversity on earth has

> influenced me. So has being a climate activist. Most of our politicians work for the ruling class and don't listen to the people that voted for them. The movement I am apart of helped elect a leader [in our state] and now he will not listen to our cries for action. They don't care about us. Seeing hurricanes and floods and droughts and wildfires has helped me form this opinion. There is a crisis around us and everybody needs to wake up and do something about it.

Participants reflected upon different identity commitments in the different SSI scenarios. Within the climate change SSI scenario, students were often drawing upon a broader generational identity (Table 6). Within the last decade, many companies have "greenwashed" their products, advertising that they may reduce their consumer's effect upon the planet (Nyilasy *et al.,* 2012; Self *et al.,* 2010). Additionally, many social platforms have preached the importance of reducing carbon footprints along with altering lifestyles to help mitigate the climate crisis (Pearce *et al.,* 2019). Lastly, climate change is spoken about frequently within the classroom, often implemented within many scientific curricula (AAAS, 2011). These frequent public discussions may have set an epistemic norm for these students, guiding them to reflect upon a generational identity when thinking about climate change. For example:

> The intense sense of hopelessness in regards to the environment that every educated person of my generation feels. The look on my little sister's face when she realized the deadline is within her lifetime.

In contrast, the fetal tissue SSI scenario seems to engender different identity commitments than the climate change SSI scenario. Predominantly, we found that students reflected upon their political, gender, and religious identities within this SSI. Students stated that they have a right to what happens to their bodies and that their political stances, such as pro-choice or pro-life, dictate the way that they formulated their SSI decision. For example, gender identity and social identity as a feminist informed this student's decision:

> I am a woman and a feminist and I believe in bodily autonomy for all and that fetuses aren't persons.

We also found that students reflected upon religious identities, stating that because of their religious beliefs, they feel that Dr. Harrison's research is unethical. For example:

> Donating cells from a new baby symbolizes killing a human being. I am a Christian, so from my perspective, killing a baby is not allowed to happen here.

We found that identity commitments were closely connected with JAS subdimensions, such as religion. This could be due to authoritative influences potentially contributing to how individuals develop their epistemic beliefs and how they may behave within specific decision-making contexts (Hofer, 2008)

Discussion

The justification for knowing framework (Ferguson *et al.,* 2013) provides a criterion of information sources an individual may draw upon when justifying knowledge claims within the domain of natural sciences. These information sources are the justification from authoritative sources (JAS), the justification from personal sources (JPS), and the justification from multiple sources (JMS). These justification belief dimensions are known to contribute toward SSI decision-making. However, they have predominantly been studied through a quantitative lens and from the domain of natural sciences. This is problematic when evaluating SSI decision-making as SSIs warrant multiple ways of knowing that are not recognized within the current quantitative instruments to evaluate the JFK (Herman *et al.,*2020; Sadler, 2004; Sadler and Fowler, 2006; Zeidler *et al.,* 2002; Zeidler *et al.,* 2009). For example, SSIs consist of multiple perspectives that often reside outside of scientific domains (e.g., political, religious, personal, and cultural perspectives). Therefore, it is unclear how the JFK dimensions are operating during SSI decision-making.

This study qualitatively investigates the JFK framework by applying Ferguson and colleague's framework (2013) to two SSI scenarios, fetal tissue uses in medical research and climate change. Furthermore, this study explores how SSI features drive the selection of the justification beliefs in the context of SSI decision-making. Between the two SSIs, we found that the proportion of the JAS, JPS, and JMS core dimensions are similar between both SSI scenarios, with most students using JMS to support their SSI decisions. However, we see differences between the SSIs in the specific authoritative sources that students are reflecting on, both alone in the JAS dimension and as part of the JMS dimension. This may be due to the contextual nature of the SSI scenarios. Furthermore, identity commitments may also be invoked by the nature of the SSI context and

may be contributing toward the selection of justification beliefs when formulating an SSI decision.

Authoritative ways of knowing are often established within an individual at a young age (Conley *et al.,* 2004; Ricco *et al.,* 2010). Specifically, an individual will turn to an authoritative knowledge source when handling SSIs, especially if they do not understand the scientific evidence surrounding the issue (Bråten *et al.,* 2019; Herman *et al.,* 2022). In this study, we found that students reflected upon religious and dogmatic, social (e.g., from the media and social circles), political, and academic ways of knowing (Table 4). These authoritative knowledge domains were used to ground students' SSI decisions between both SSI scenarios. We consider each authoritative subdimension to be students' sociocultural ways of knowing based upon how they were described. Moreover, these authoritative groups have their own ideologies, consisting of values, ethics, morals, and philosophies (Cebesoy & Rundren, 2021; Herman *et al.,* 2022; Oulton *et al.,* 2004). For example, students referred to their political affiliations as their justifications for knowing, stating that because of their specific political group, they think a certain way. Therefore, the ways in which we evaluate students' SSI decisions must surpass exploring their academic ways of knowing and delve into other external authoritative sources that dictate how students may evaluate information.

In the last several years, SSI decision-making research has described how students are drawing upon various sociocultural perspectives and their moral and ethical ways of knowing when handling SSIs (Herman *et al.,* 2018; Herman *et al.,* 2022; Newton & Zeidler, 2020). Like political affiliations, religious practices are often deeply rooted within an individual's culture and

social circles (Cebesoy & Rundgren, 2021). This may set an epistemic precedent of behavior and decision-making, especially from a young age (Cebesoy & Rundgren, 2021). Because epistemic beliefs are developed through experiences and various exposures to different knowledge sources, the authoritative presence of sociocultural groups need to be further studied, especially in the context of how students are evaluating information during SSI decision-making.

The JAS subdimensions we found allow us to see which sources of information students are relying upon when arriving at their SSI decision. These diverse array of subdimensions can be drawn upon differently depending on the context of the SSI. For the climate change SSI, the authoritative subdimension of academic influences was the most reflected upon. Within the fetal tissue SSI, the political sources subdimension was the most reflected upon (Table 5). This may be due to climate change being often included within science curriculum compared to fetal tissue use in medical research. In contrast, fetal tissue use in medical research may be spoken about in a more public arena, such as in political discussions or within societal conversations. Furthermore, SSIs involving fetal tissue use or women's reproductive topics elicit decision-makers' religious beliefs (Cebesoy & Rundren, 2021; Oulton *et al.,* 2004). These authoritative sources have not been discussed within the original JFK framework. Therefore, the subdimensions expand our understanding of how SSI decisions are being developed.

Epistemic belief models have always included the influence of personal ways of knowing (Chinn *et al.,*2011; Ferguson *et al.,* 2013; Greene *et al.,* 2010; Hofer & Pintrich, 1997; Hofer, 2004; Sinatra, 2016). Therefore, it was not surprising that our findings within the JPS dimension included references to personal experiences and other personal ways of knowing (e.g., an

emotion). Although we have sufficient evidence supporting that student may draw upon their personal experiences as their ways of knowing, the structure of our study did not let us further probe students' responses. Therefore, we believe that the JPS dimension may have nuances that must be recognized so that we can broaden our understandings of the role of personal knowledge upon SSI decision-making. We urge researchers to explore the JPS dimension through semi-structured interviews so that researchers can ask follow-up questions when students describe their personal ways of knowing.

Students were predominantly justifying their ways of knowing through corroborating between multiple JAS subdimensions and the JPS dimension when explaining their SSI decisions (JMS) (Table 3). Cross-checking and corroborating between information sources when evaluating evidence is a scientific literacy skill taught within most undergraduate science courses (American Association of Colleges and Universities, 2007; DeBoer, 2000; National Research Council, 2002). Because most science courses only emphasize academic ways of knowing when discussing SSI decision-making (Fowler and Zeidler, 2016; Sadler and Fowler, 2006), there has been a call to make scientific literacy functional for handling SSIs (Herman *et al.*, 2018; Karisan & Zeidler, 2017; Sadler & Zeidler, 2005; Zeidler & Sadler, 2011). This type of scientific literacy entails the use of traditional scientific literacy skills (e.g., ability to recognize valid information, corroborate between information sources, and to use this information to draw conclusions) along with emotions, personal experiences, cultural beliefs, ethics, morals, and empathy (Herman *et al.*, 2018; Karisan & Zeidler, 2017; Sadler & Zeidler, 2005; Zeidler & Sadler, 2011).We encourage researchers to further investigate functional scientific literacy as we noticed that students were not only emphasizing academic ways of knowing between both SSIs but drawing

upon their diverse sociocultural perspectives (i.e., personal experiences, and the political, religious, and social JAS subdimensions), their emotions, and their personal beliefs (Herman, 2018; Karisan and Zeidler, 2017; Sadler and Zeidler, 2005; Zeidler and Sadler, 2011). Consequently, functional scientific literacy may already be in practice with students outside of the classroom. However, we do not have the data to investigate this phenomenon. Therefore, we recommend that researchers further explore how functional scientific literacy is being used so they can inform the development of science curricula for undergraduate students.

Lastly, we found that SSI context may trigger students to commit toward an identity that may stem from their sociocultural group inclusions, such as their religious, political, social, and academic groups. Our results suggest that these identity commitments may be a way of thinking that guides the decision-maker to their way of knowing. This phenomenon may be provoked when an individual must make an SSI decision that has a definitive answer according to their specific sociocultural group inclusions, such as a religious practice or political affiliation. These in-groups may be contributing toward decision-making behavior that will have both universal and individualistic implications. In the literature, sociocultural group inclusions have been shown to lead toward decision-making action, especially when the decision-maker is handling a controversial scientific issue such as climate change (Adger *et al.,* 2011; Clayton, 2003; Herman *et al.,* 2022; Stets & Biga, 2003; Stapleton, 2015). Although this study was limited in that we were unable to ask follow-up questions, we believe that the finding of identity commitment should be considered a component of SSI decision-making that elicits students' context-specific epistemic beliefs. Therefore, it is imperative that further research is conducted to explore the influence of identity commitment upon epistemic beliefs and SSI decision-making behavior.

Limitations

The results of this study were limited by the study design. We opted to collect short, open-ended responses as opposed to conducting semi-structured interviews where we could have asked follow-up questions regarding SSI decision-making processes. Although open-ended responses allowed us to collect a larger sample size, the data derived from these responses is not as rich as data from semi-structured interviews. This wound up hindering our ability to fully understand how students were interpreting the modified DMQ questions, including how they differentiated between their experiences and beliefs. However, because all participants have unique ways of thinking and interpreting questions, this is a common issue with qualitative research (Packer, 2018). Furthermore, because we were unable to ask follow-up questions regarding their experiences and beliefs, our ability to make inferences about how students were weighing specific JFK beliefs was also hindered. We recognize that this is a threat toward the validity of our findings and recommend that researchers use semi-structured interviews to fill the knowledge gaps of this study, especially within the JPS dimension. Additionally, we recommend that using semi-structured interviews may detect any underlying themes that have not been explored when investigating the selection of knowledge claims when justifying SSI decisions.

Qualitative research often creates an asymmetry of power between participant and researcher, where the researcher elicits an air of authoritative power over the participant as the participant responds to the researcher's prompts (Packer, 2018). This asymmetry has negative implications

upon the participants' responses and can threaten the ecological validity of the data by pulling away from the participants' lived experiences and adhering toward what they believe the researcher wants to hear (Packer, 2018; Schmuckler, 2001). When exploring a deeply rich cognitive phenomenon such as epistemology in the context of SSI decision-making, the researcher needs to account for these issues when analyzing the data. Given that the materials of this study were distributed as an extra-credit assignment for a course, we must account for this asymmetry through acknowledging that students may have tailored their responses based upon a fear of being judged or scrutinized for their beliefs (Packer, 2018). However, further qualitative research through a deeper methodology, such as semi-structured interviews, may provide the constitutions needed to suggest new hypotheses about the JFK dimensions.

Implications for Teaching

When a student sits down on the first day of class, they are bringing a variety of identities that have been developed through multiple experiences, academic domains, and social and cultural spaces (Chin *et al.*,2014; Hofer, 2004; Muis, 2007). Being a "student" is only a fraction of how someone may describe themselves. The remaining defining pieces of who they are deeply contribute toward how they are thinking about the course topic as well as how they think about various SSIs (Darner, 2019). Because we are contending with more than a "learner" identity, it is important to understand how students are justifying their knowledge claims when SSIs are integrated within the classroom. The results presented in this study suggest that the nature of the SSI context may elicit specific identity commitments which may act as a vehicle toward the selection of knowledge sources during SSI decision-making. These knowledge sources are diverse, nested within the JFK belief dimensions.

Dissonance in students during SSI decision-making activities may occur when a student is presented with information that conflicts with their identity commitments and ways of knowing (Darner, 2019; Muis *et al.,* 2015). Understanding students' identity commitments may reduce student cognitive shutdown during in-class SSI decision-making activities and help mitigate any negative learning outcomes, such as low information retention, or beliefs about the class's academic domain that may stem from negative experiences (Muis *et al.,* 2015; Pekrun *et al.,* 2017). Perhaps to mitigate this issue, instructors can increase their awareness of both the variety of identity commitments that may be elicited during SSI decision-making tasks and how those commitments are guiding students toward the selection of knowledge claims when arriving toward their decisions. By acknowledging these identity commitments, instructors may be able to develop a stronger understanding of their students' information selection processes so that when designing SSI activities, these information sources can be represented and integrated into classroom discussion.

As instructors, we can attempt to prepare our students with the skills needed to handle SSIs through teaching them how analyze various information sources (Bråten & Strømsø, 2006; Bråten *et al.,* 2011; Deboer, 2000; Greene *et al,* 2016). More importantly, we can teach them how to recognize their emotional, social, and cultural SSI concerns while not singularly relying on them when developing an SSI decision. Instructors can include multiple domains of knowledge when approaching the SSI, emphasizing the importance of the multidisciplinary nature of the problem. Having students practice SSI decision-making within the classroom may help them feel more comfortable with various information sources and help them sift through

various points of view when thinking about SSIs in the 'real world'. Making SSI decisions within the classroom is a lower-risk activity compared to making an SSI decision in a public arena where decisions shape the world's future. Therefore, instructors of science courses should strive to integrate SSIs within their curriculum to develop informed members of society.

Conclusions

This study applied the original JFK framework to SSI decision-making. Through investigating these beliefs outside of the domain of natural sciences, we found that there are several subdimensions that are nested within the JAS belief dimension within the context of SSI decision-making. This provides the evidence needed to expand how the current JFK framework is being evaluated during SSI decision-making. We also found how SSI context may dictate how students are thinking through the SSI by invoking specific identity commitments from sociocultural group inclusions that are idiographic to the decision-maker. These identity commitments may be acting as a vehicle toward the selection of JFK dimensions when developing an SSI decision. Moving forward, we recommend that the refined JFK framework should be explored through deeper qualitative methodologies, such as through semi-structured interviews. Finally, we recommend that questions regarding identity commitments and their contribution to epistemic belief selection and development be further explored when asking questions about SSI decision-making processes.

CHAPTER 3: RELATIONSHIPS BETWEEN IDENTITY COMMITMENTS AND JUSTIFICATION BELIEFS DURING SOCIOSCIENTIFIC ISSUE DECISION-MAKING

ABSTRACT

Socioscientific issues (SSIs) or controversial scientific issues with social implications, present the public with various information sources that are often conflicting. The SSI context may trigger an individual to adhere toward the ideologies of their sociocultural group inclusions which may contribute toward how they evaluate information. The Justification for Knowing framework (JFK) explains how an individual determines the validity of information when handling controversial issues. An individual justifies their knowledge about something through evaluating knowledge from personal sources (JPS), authoritative sources (JAS), or by corroborating across multiple sources of information (JMS). However, little is known about how identity from sociocultural group inclusions contributes toward an individual's justifications for knowing during SSI decision-making. This qualitative study aims to explore these relationships. Participating students (N=26) recruited from an R1 public institution participated in a 30-minute semi-structured interview about the vaccination controversy. Through thematic coding, we found that SSI context triggers students to commit toward an identity from their sociocultural in-groups or from their state of being. We found that students' various identity commitments intersect when information searching about vaccines, guiding students to justify their knowledge about the vaccines through JMS. However, when making an SSI decision, students relied upon their personal identities and justified their knowledge through JPS. The results of this study illuminate

the interconnectedness between SSI decision-making, identity, and the JFK. Moreover, this study proposes a model that can be used to evaluate this phenomenon in future studies.

Introduction

Controversial scientific issues, or socioscientific issues (SSIs), have direct implications upon the functioning and well-being of society (Sadler & Zeidler, 2005). These implications range from threatening people's health to influencing the voting of policymakers (Herman *et al.*, 2022; Sadler & Zeidler, 2005). SSIs are ill-structured and do not have a definitive answer. They involve multiple participatory stakeholders, such as political, economic, cultural, and academic stakeholders, who often present the public with conflicting information (Brandmo & Bråten, 2018; Herman, 2015). One goal for undergraduate science curricula is to train students with effective information searching strategies so that they can navigate these information sources. However, students belong to various sociocultural ingroups that have instilled deeply rooted beliefs about knowledge (AAAS, 2011: Sinatra & Hofer, 2016). Therefore, when students are confronted with conflicting information sources about an SSI, they may adhere toward the beliefs from their sociocultural group inclusions and deviate from scientific information when making an SSI decision (Herman *et al.*, 2022; Kahan 2015; Nadelson & Hardy, 2015: Nichols, 2017). Although making an informed SSI decision requires the consideration of sociocultural beliefs in addition to scientific knowledge, sociocultural groups may distill misinformation about well-supported scientific claims that are foundational to societal functioning (Herman *et al.*, 2022; Kahan 2015; Nadelson & Hardy, 2015). Therefore, it is critical to investigate how undergraduate students' sociocultural group inclusions relate to how they determine the validity

of information when handling an SSI.

Over the last several years as the public has contended with misinformation about pressing SSIs, there has been a focus upon evaluating people's beliefs about knowledge and knowing, or their epistemic beliefs (Hofer, 2004). Epistemic beliefs do not change and are developed from personal experiences and are deeply influenced by an individual's sociocultural group inclusions (Herman, 2015; Hofer & Pintrich, 1997; Hofer, 2004; Kuhn & Park, 2005; Sinatra, 2016; Tabak & Weinstock, 2008). They are an important component of SSI decision-making, as they often concern how individuals determine the validity of information sources (Hofer, 2004; Ferguson *et al.,* 2013). However, studies have not explored how sociocultural group inclusions may elicit an individual's epistemic beliefs when handling an SSI. Therefore, this study investigates how undergraduate students' commitments to their sociocultural group inclusions relate toward their epistemic beliefs during SSI decision-making.

Theoretical Framework

Epistemic beliefs have been described through four dimensions: the simplicity of knowledge, the certainty of knowledge, the source of knowledge, and the justifications for knowing (Hofer & Pintrich, 1997; Hofer, 2004). An individual's justifications for knowing, or their JFK, explains how they determine the validity of information when justifying their knowledge about a specific topic (Ferguson *et al.,* 2013; Greene *et al.,* 2010; Hofer & Pintrich, 1997; Hofer, 2004). Therefore, these epistemic beliefs have been predominantly focused upon within the SSI decision-making literature, especially when investigating how students are evaluating evidence (Brandmo & Bråten, 2018; Brandmo *et al.,* 2019; Ferguson *et al.,* 2013).

Justification for Knowing (JFK) beliefs were originally thought to contain one dimension, where an individual's JFK slides along a continuum of justifying their ways of knowing through a personal information source (e.g., what feels correct) to an external authoritative information source (e.g., a professor) depending upon their level of knowledge about the subject (Greene *et al.,* 2008; Hofer & Pintrich, 1997; Hofer, 2004; Hofer & Bendixen, 2012). However, Greene and colleagues (2008) challenged this unidimensional definition of JFK beliefs, stating that authoritative sources of knowing and personal sources of knowing should be considered two separate belief dimensions. They later found quantitative evidence of this claim, proposing a new model to evaluate students' ways of knowing (Greene *et al.,* 2010). This model is based upon the concept that epistemic beliefs are specific for each academic domain (e.g., science, history, math) (Greene *et al.,* 2010; Hofer, 2000; King & Kitchener, 1994).

Building upon Greene and colleagues' (2010) model, Ferguson and colleagues (2012, 2013) believed that students may be combining both personal and authoritative information sources when determining the validity of multiple conflicting texts about an SSI. Through this study, they found that students justified their ways of knowing through cross-checking and corroborating between information sources in addition to justifying their ways of knowing by a singular authoritative or personal information source (Ferguson *et al.,*2013). From their study, they proposed a new framework to evaluate the JFK by stating that students draw from three dimensions of JFK beliefs instead of two. These dimensions are justification from authoritative sources (JAS), justification from personal sources (JPS), and justification from multiple sources (JMS) (Table 7).

Table 7: JFK dimensions and definitions

JFK Dimension	Definition*
Justification from Authoritative Sources (JAS)	Evaluation of knowledge claims by appealing to a reputable external source (e.g., textbook, professor, medical doctor)
Justification from Personal Sources (JPS)	Evaluation of knowledge claims in relation to one's own views, personal experiences, or opinions
Justification from Multiple Sources (JMS)	Evaluation of knowledge claims by corroborating between two or more sources
***Definitions from Ferguson *et al.*, 2013**	

JFK beliefs through the JFK framework (Ferguson *et al.,* 2013) have been quantitatively investigated alongside constructs such as academic performance (Brandmo & Bråten, 2018; Bråten & Ferguson, 2014; Strømsø *et al.,* 2016), interest and engagement (Brandmo & Bråten, 2018), and how students evaluate information when handling SSIs (Bråten *et al.,* 2019). These beliefs are most commonly assessed through the Justification for Knowing Questionnaire (JFK-Q), an instrument that quantitively assesses students' JFK from the domain of natural sciences (Brandmo & Bråten, 2018). Therefore Ferguson *et al.'s* (2013) model is limited when assessing SSI decision-making because SSIs consist of information that goes beyond scientific domains. Moreover, the quantitative methods used to evaluate JFK beliefs during SSI decision-making do not account for the contextual and subconscious nature of epistemic beliefs and, therefore, do not explain how students may be justifying their knowledge when explaining their SSI decisions.

In Chapter two, we qualitatively used Ferguson *et al.*'s (2013) JFK framework to see how students' JFK operated during SSI decision-making across two SSI contexts, fetal tissue use in medical research and climate change. In our study we found several subdimensions of JAS that surpassed Ferguson and colleagues' definition. In addition to the academic domains that

Ferguson and colleagues (2013) found within their JAS dimension, we found that students referred to religion, dogmatic practices, politics, media, and social circle as subdimensions of authoritative ways of knowing when explaining their SSI decisions. Within the JPS dimension we found that students justified their ways of knowing through reflecting upon personal ways of knowing, which is consistent with the Ferguson *et al.,* (2013) framework. Within JPS, we found that students reflected upon their personal experiences or other personal ways of knowing such as an emotion or a gut-feeling. However, our findings within this dimension were limited due to our inability to ask follow-up questions with the participants. This new view of the JFK framework allows us to more comprehensively assess how students may be justifying their ways of knowing when constructing their SSI decisions. By doing so, we are able to see how students are determining the validity of information and how they are grounding their ways of knowing when handling an SSI.

The most notable finding from Chapter Two, and the impetus for this third chapter, is that in both SSI contexts, students committed to a context-specific identity (e.g., being pro-choice, being a vegan) from their sociocultural group inclusions when supporting their SSI decisions. We found that students' context-specific identity may guide students' JFK beliefs when explaining their SSI decisions. Identity commitments are defined as the commitment and individual makes to an ideology or SSI stance based upon their sociocultural group inclusions. Because SSIs are so controversial, they may affect sociocultural ingroups differently depending on the group's beliefs (Herman *et al.,* 2022). For example, a religious group may take offense toward fetal tissue use in medical research because they believe it is morally wrong. Because of this belief, they may vote, rally, or even riot against those who are in opposition of their beliefs

(Oulton *et al.,* 2004). Whereas, a political group, such as people who identify as being pro-choice, may feel the opposite and may do what they can to prevent other group inclusions from influencing policy about fetal tissue use in medical research. Therefore, we believe that the triggering of students' identity commitments may be due to the nature of the SSI.

An individual may have various identities that change overtime through their involvement of their sociocultural groups (Kitchell *et al.,* 2000). Specifically, these identities are influenced when individuals participate in collective decision-making about an SSI through protesting or through voting (Kitchell *et al.,* 2000). When participating in collective decision-making, the individual may develop strong beliefs about the topic that centers around the beliefs from their sociocultural groups (Kitchell *et al.,* 2000). These beliefs may be foundational for how the individual knows how to behave when dealing with the specific issue (Kitchell *et al.,* 2000). Additionally, an individual's various identities act as a subconscious guide in how to understand controversial issues (Holland *et al.,* 2008). When working through something controversial, these identities guide the individual's sense-making and shapes how they move through the issue (Holland *et al.,* 2008). This phenomenon has been mostly detected when groups of individuals handle culturally relevant issues that are personally relevant, such as women's reproductive rights, indigenous rights, and global issues surrounding equity and justice (Holland *et al.,* 2008). We saw something similar in Chapter two, where students committed to their identities that were relevant to the SSI topics (e.g., gender identities within the fetal tissue SSI scenario and academic identities within the climate change SSI scenario).

Sociocultural groups provide a framework for decision-making action that group members will adhere to when presented with the specific issue that threatens their beliefs or ways of life (Holland *et al.,* 2008). Therefore, an individual's sociocultural groups provide the individual with a specific dialogue and viewpoints that are meant to influence the individual's actions when dealing with the issue (Holland *et al.,* 2008). When this happens, the individual may subconsciously commit to the identity that is specific to the affected sociocultural group and may use their group specific beliefs when decision-making. Similar to the domain specificity of epistemic beliefs, where students may hold different beliefs about knowledge from the perspective of history compared to the perspective of math (Hofer, 2004), SSI context may evoke specific beliefs about the SSI for both the individual and their sociocultural group inclusions. For example, the COVID-19 pandemic poses a diverse set of challenges that influence all members of society. However, individuals who do not interact with science or medical research on a regular basis may struggle when evaluating information about the pandemic as new mandates and procedures may be communicated from authoritative influences that go against the beliefs of various sociocultural groups (Chinn *et al.,* 2020; Herman *et al.,* 2022; Sinatra & Hofer, 2016). People may reject this information as it may go against their ethics, values, and ways of life. This rejection may be due to their inability to understand the situation and their level of fear while determining how to behave in regard to the SSI (Herman *et al.,* 2022). Therefore, an individual may commit to the ideologies of their sociocultural groups in order to feel a sense of security in their decisions. When this occurs, the individual may favor their epistemic beliefs about the topic and in-group identities over scientific facts (Herman, 2015; Herman *et al.,* 2018; Herman *et al.,* 2022; Sinatra & Hofer, 2016).

Students' identities may cloud their ability to make informed SSI decisions based upon the influences of their sociocultural group inclusions (Simonneaux & Simonneaux, 2009). In-group identities, such as political, religious, cultural, and academic, may influence the specific types of evidence that someone may deem reliable as well as which specific sources of information someone may trust (Herman *et al.*,2022; Kahan, 2015; Simonneaux & Simonneaux, 2009). This poses an issue as whatever in-group someone belongs to may claim to have all the correct answers in how to handle an SSI (Herman *et al.,* 2022; Nadelson & Hardy, 2015). For example, Nadelson & Hardy's work (2015) states that undergraduate students with lower levels of evolution acceptance showed higher levels of religious beliefs and a greater distrust in science. Moreover, Herman and colleagues found that students grounded their SSI decision-making in their political and cultural ideologies, irrespective of their level of scientific knowledge (Herman *et al.,* 2022). Therefore, it is critical to further investigate the role of students' sociocultural group inclusions on how they determine the validity of information during SSI decision-making as these ideologies may be influencing in-group members to ignore essential information needed to construct an informed decision (Chinn *et al.,* 2020; Herman *et al.*,2022; Sinatra & Hofer, 2016).

Addressing this critical issue, in this study we ask the following question: how do students' identity commitments, informed from their sociocultural in-groups, relate to students' JFK during SSI decision-making? The objective of this study is to increase our understanding of students' SSI decision-making process by disentangling the relationships between identity commitments and justification beliefs.

Methods

Setting and Participants

For this chapter, we used the same interviews we conducted in Chapter One. However, we applied a different theoretical and analytical lens. Participating individuals were interviewed about their opinions and decisions about vaccinations. The vaccination controversy is a long-standing SSI that has been consistently in the media since the 1800s when the first vaccination was publicly criticized (Porter and Porter, 1988). Because this study examines both science majors and non-science majors, vaccination is an appropriate SSI because it does not require an intensive scientific background to discuss (Zeidler *et al.*, 2009). Participants in this study (N=26, 50% science majors, 50% non-science majors) were recruited from multiple mixed-major science courses at a high research-intensive (R1) public institution in the northeastern United States. This institution is comprised of primarily white students. Although we are not interested in academic year, we wanted participants to have already determined their academic majors. Therefore, we recruited students within their sophomore, junior, or senior year. Students were recruited from each course through an in-person introduction during the beginning of each course's lecture, followed by an email reviewing the expectations and procedures of participation. As an incentive to participate, students were offered a university mug. This study was approved by the University's Human Subjects Institutional Review Board (#7009) (Appendix B).

Interview Protocol

The development of the interview protocol was centered around the process of epistemic cognition. However, many interview questions were designed to specifically target justification

of knowing beliefs. The beginning of the interview consisted of several questions about how the participants feel about vaccinations. These initial questions were meant to uncover the participants' stances about the SSI and prompted them to explain why they hold these stances regarding vaccinations. They were then asked how they would information search for vaccines, where they would look specifically for information and how they would determine the validity of these information sources. The interview protocol also had participants read an article about the pros and cons of vaccines (Pros&Cons.org) with follow-up questions regarding the reliability of the article. However, we decided to remove this section from our analysis due to the questions mirroring a reading comprehension-type activity, which was inappropriate for this study. The final questions of the interview asked participants if they would vaccinate their future or (if applicable) current children and why or why not. This part of the interview had students justify their ways of knowing when explaining their SSI decisions.

Each interview was approximately 30 minutes long and was conducted in the University's library, which represents an academically neutral location. This was done in attempts to reduce the asymmetry of power between researcher and participant (Packer, 2018). By doing so, we aimed to increase the ecological validity of the findings through promoting a conversation that is not influenced by a domain-specific location such as a lab or lecture hall (Packer, 2018; Schmuckler, 2001). Interviews are part of a social reality that is unique to the population of individuals (Packer, 2018; Wortham *et al.,* 2011). Generally, each of the participant's responses describe their lived worlds and explains the social weight of the phenomenon in question (Wortham *et al.,* 2011). Therefore, because SSIs are so controversial, we wanted to create a space that was conducive to elicit these social weights and that did not adhere toward a specific

academic way of thinking. We wanted students' responses to be representative of how they would organically handle an SSI.

Analysis

For this chapter, we organized the interviews into two main sections. The first section asks students to describe how they feel about vaccines and how they would information search about vaccines. We summarize the first section as "Information searching strategies." The second section asks students to make and explain a hypothetical SSI decision. We summarize the second section as "Making a hypothetical SSI decision" (Table 8). We use these interview sections to illustrate our results within the following section. However, we coded the whole interview in its entirety and not by separate sections. Our coding consensus sessions and IRR is based upon the entire interview, not the separate sections.

For each interview, we first deductively coded the data using the updated JFK framework and codebook developed from Chapter two of this dissertation. This codebook consisted of Ferguson and colleagues' original JFK dimensions (JAS, JMS, & JPS) (Table 7) with the addition of the several subdimensions we found within the JAS dimension. These subdimensions are religion and dogmatic practices, political influences, media, social circle (e.g., parents and peers), and academic influences (e.g., textbooks). We also coded for identity commitment, which we define as the commitment an individual makes to an ideology or SSI stance based upon their sociocultural group inclusions. Responses were coded for identity commitment when a participant committed to a specific group or stance when explaining their answers. Meaning, when a participant stated that they are a specific identity and that is why they believe in a

specific thing, we coded it as identity commitment. For example, "I am a science major, so I am pro-vaccine". After we deductively analyzed the interview, we then inductively coded the data by recognizing the emerging themes within each code, specifically within the identity commitment code. During this analytic phase, we determined which identities students were committing to, which sociocultural groups these identity commitments may be coming from, and how their identity commitments may have been contributing toward their JFK. These codes are described within the results section.

IRR was conducted on 50% of the interviews. Myself and my research assistant individually coded an interview and then came together once a week for consensus coding. Once we coded 50% of the interviews, a Cohen's Kappa was calculated through the 'irr' package in R ($k = 0.84$) (Gamer *et al.*, 2012). Our kappa value suggests that our codes are reliable and not due to chance. I coded the remainder of the interviews independently.

Results

We found that SSI context triggers students to commit toward an identity that adheres toward the ideologies from their sociocultural in-groups or from their personal ways of knowing. Students use their identity commitments to explain their stance on the SSI, such as being pro-vaccine (e.g., *"I'm a science major, so I am pro-vaccine"*). Throughout the interview, students committed to several different identities. When discussing their information searching techniques, we found that students primarily relied on cross-checking and corroborating information sources (JMS) (Table 8). When doing so, we found that students' identity commitments intersect, guiding them to evaluate multiple sources of information that are specific

to their sociocultural in-groups (i.e., a political identity commitment may evaluate political information). However, when students were asked to make a hypothetical SSI decision, their personal identity trumped their previously mentioned identity commitments, resulting in them evaluating mostly personal sources of information (JPS) (Table 8).

These results are discussed in detail within the paragraphs below. First, we describe the different identity commitments that emerged from our data. Then, we discuss how these identity commitments inform the use of different JFK dimensions when information searching compared to when making a hypothetical SSI decision. When describing our results, we heavily rely upon quotes from our participants. These quotes are lightly edited for grammar and any clarifying language has been placed within brackets.

Table 8. Frequencies of JFK belief dimensions for each SSI decision-making prompt

Interview Section	Justification from Authoritative Sources (JAS)	Justification from Multiple Sources (JMS)	Justification from Personal Sources (JPS)
Information Searching Strategies	14%	64%	22%
Making a hypothetical SSI decision about the vaccination controversy	16%	33%	51%

Identity Commitments Used to Explain SSI Stance

Consistent with Chapter Two's findings, we found that the context of the SSI triggers students to commit to the ideologies of their sociocultural group inclusions through stating a specific identity. Students used these identity commitments to explain their SSI stances, such as being pro-vaccine. Within the interviews, we found six identity commitments: family identities, political identities, religious identities, and academic identities, and personal identities. Students

also committed to their context-specific personal identities, such as being immunocompromised or referencing their state of being, which we define as an individual's personal orientation based upon how they view themselves and their perceived role within the specific context (Mclean & Syed, 2015). In this section, we describe each identity commitment from students' sociocultural in-groups and their personal identities reflected upon within the interviews.

Family Identity Commitments

We found that family identity emerged when students described their family in-groups when explaining their beliefs about vaccines. This is not surprising, as family dynamics teach group members with how to respond to various situations that one may face throughout their lifetime (Bornstein & Lansford, 2019). Participants referenced their family in-groups when describing how they feel about vaccines. For example, Talia discusses how she believes that everyone should get vaccines due to being raised by a mother who is a nurse.

> I feel like everybody should get them. Just because my mom was a nurse, she always told us, "Take care of your body. Be safe." And she got us every single vaccination and everything like that. So it's just kind of like ... And my mom, she just told me it's for your benefit. My whole life telling me that… it's [a vaccine] gonna help you not get sick in future with like crazy diseases and stuff like that.

Within Talia's quote, family identity commitments emerged as she describes the role of her mother and how her mother has instilled Talia's beliefs about vaccines. Similar to Talia, Leigh's father has a strong hold on her beliefs about vaccines, especially the flu vaccine. Despite saying

that she is pro-vaccine and believes that they are an important thing for society, Leigh will not get the flu vaccine. She believes that the flu vaccine is ineffective because of a personal experience with her father getting sick with the flu after receiving the flu vaccine.

> I know it's really important, so I have all my vaccinations. The only one I don't get is the flu shot...I just feel like they make you sick. They make you more sick than it's worth protecting you against…My dad got it actually a few years back, and I guess he was the one who influenced me to not get it. When I can make the choice to not get it. He got it, and it was the first time he had gotten it too, the flu vaccine. Then he got really, really sick afterwards. Not just like I have a runny nose. He got the actual flu from getting the vaccine, instead of the other way around. You know what I mean? Then, I don't know? I got brainwashed, I guess.

When participants describe their family group inclusions, they are often referencing their personal experiences of being with their family group members, such as Leigh and her father. In addition, students also describe their family groups when they adhere toward political and religious identity commitments. Although both political and religious identities are discussed in the next paragraphs, we acknowledge that the influence of one's family can drive an individual's political and religious ideologies (Morek, 2015; Oulton et al., 2004). This is seen within the examples we use to demonstrate how students are committing to political and religious identities.

Political Identity Commitments

Unsurprisingly, we found that several students referenced their political identity commitments from political group inclusions when describing their beliefs about the vaccination controversy. For example, “My political stance I think influences [my beliefs about vaccines] a lot.” Students committed to their political identities from various political groups when describing why they wanted to discuss the vaccination controversy. For example, “I run a libertarian group on campus so I try and get involved with politics and things that are going on in the current day.” Students also stated that they would check the political identities of people before talking with them to assess if they conflict with their own political identities. For example, Tilly describes that when information searching she would look on social media to see if she can figure out the political identity of whomever she is searching for. She states that you can make assumptions about how that person may think based upon a political identity.

> So it's very easy to know what someone thinks right off the bat, rather than figure it out over time. So before you meet someone, if you stalk them on Facebook, you're like, "Oh, she's Republican," that's your basis going into it. It's not like something you find out over time… I would say [I’m] left, very progressive…I think in the world of identity politics, it's so easy to be like, "Okay, Person X doesn't have the same political beliefs as me, and therefore I think they uphold the system that can oppress my friends.”

Religious Identity Commitments

We did not have many students commit to a religious identity. However, the students who did reflected upon their religious ways of thinking and used them to explain how they feel about vaccines. For example, Becky, a non-science major, explains that although she is a religious

person, she still believes in medical advances. She describes how her religious views of doing things to help people influences how she feels about vaccines.

> Science, especially hard sciences, don't make sense in my brain to me.... I'm an extremely religious person, but every religion has that baseline ideology that if it's going to help people, then everything else is irrelevant….I mean, Orthodox Jews don't believe in modern medicine either, but they still get vaccines because they recognize the importance of medical discovery. It [vaccines] will help save a life.

Academic Identity Commitments

The last identity commitments we found that stem from a sociocultural ingroup are the academic identity commitments. Academic group inclusions promote the growth of academic-based identity commitments that are specific to an academic domain (Baker & Lattuca, 2010; Frick & Brodin, 2020). Students reflect upon their academic group inclusions when they reference their academic majors (e.g., "I classify myself as a science major"), if they are a student (e.g., "I think as a student right now I think it's important to know what a vaccination is"), or if they are a science/non-science person (e.g., "I'm not a science person because my mind physically doesn't understand those concepts."). In our study, students committed to an academic identity when explaining why they are interested in vaccines. For example, "I'm a social worker, so it [the vaccination controversy] like really piqued my interest." And "I am a neuroscience science major, so [the vaccination controversy is] very interesting."

Students also reflected upon this identity when explaining why they believe that it is important to learn about vaccines. For example,

> I'm a nutrition and wellness major with a dual major in gastronomy … the field of nutrition has to do with health and vaccinations also have to do with health. So I feel like knowing a little bit about vaccinations is important, at least for my major

Additionally, students referred to their science identity when explaining how they would information search about vaccines. We define science identity as when a participant references their involvement in science and their utilization of scientific processes such as the scientific method (Stets *et al.,* 2017). Students referenced their science identities throughout the interview. For example, Barbara states that because she identifies as a science person, she is looking for clear facts.

> I wanna know the facts and everything, because I do have kind of a science brain, so I wanna know [that] this happens when this happens…I'm very clean and clear kind of thing.

Personal Identity Commitments from Sense of Being

Personal identity commitments are the most notable identity that has emerged from the data as students reflect upon this identity without referencing the influence of social groups. We define personal identity commitments as when a participant refers to a context-specific state of being that has been built upon personal knowledge without the influence of external groups

(Drummond, 2021; Mclean & Syed, 2015; Mclean *et al.,* 2017). A context state of being refers to an individual's personal orientation based upon how they view themselves and their perceived role within the specific context (Mclean & Syed, 2015). For example, Ash refers to her personal identity of being immunocompromised when explaining her SSI stance.

> I'm definitely pro-vaccines. Coming from I have a really weakened immune system. I was born with pneumonia, so my body in general... Thankfully, I can be vaccinated.

Like Ash, Layla describes how she is immunocompromised and how that personal identity contributes toward how she elects to receive vaccines.

> I have like a compromised immune system, so there are some vaccines that I shouldn't get because ... like the Prevnar 13 vaccine. While it's generally only given to people over the age of 55 or people who are immunocompromised, they don't want me to get it because I have such upper respiratory like issues.

We also consider personal identity to be when a participant refers to themselves as an internal state of knowing such as an emotion or an intuition without the influence of external pressures (Drummond, 2021). For example, "I'm more likely to believe in my first gut opinion and not super influenced by the people around me." As well as:

> I think it would come down to what I feel in my gut. I think I'd be more inclined to believe information that I already thought that I believed before I started researching.

Within the data, personal identity also emerged when students referenced themselves as their reasonings for thinking a specific way. For example, Matilda expresses that that she does not believe any information that goes against vaccines. She states that she especially does not believe that vaccines are linked to autism. We coded this quote as personal identity because Matilda is referencing herself (e.g. '*I just feel like'* and '*I just think that'*) and because she does not support her reasoning about her statement with information from an external group.

> Whenever anybody says anything that's against vaccinations I tend to not believe it… I just feel like the biggest thing is people saying that it causes autism… I think that the argument that vaccines cause autism is super dumb. [Because] So what if someone has autism? You know?

However, within these responses such as Matilda's quote above, students may be referring to an external information source that may have not been detected by our interviews. Therefore, we recognize that this is a limitation of our study. We address this limitation in detail within our discussion section.

Identity commitments intersect, guiding students' JFK; however, personal identity ultimately guides SSI decisions

Identity commitments may dictate how students evaluate information when handling an SSI. We found that students were drawing upon information sources that stem from their context-specific

identity commitments when describing how they would information search about vaccines. For example, Hera describes how she would information search from two different identities. She states that if she was looking for information about vaccines as a student (an academic identity), she would look for academic articles. However, if she was looking for information about vaccines for herself (her personal identity), she would simply look up information on the internet and would then personally decide if the information sounds credible.

> I mean, if I was looking for vaccination for a class I would use a database and find actual scholarly articles that are peer-reviewed… but I [personally] would click on the top search of vaccinations and whatever I wanted ... Like I would type in a question and literally just hit the first response… I would look at the website and try to determine if that felt like it was credible, if they were talking in a way that seemed credible…It's sort of with anything. You kind of just go off gut.

When explaining how they would information search, students' identity commitments intersect, guiding them to evaluate knowledge claims by cross-checking and corroborating between identity-specific information sources (JMS). However, when asked to make a hypothetical SSI decision, students' personal identities trump their previously mentioned identity commitments, guiding them to justify their ways of knowing through personal sources. Below, we show these results through an in-depth view of several participants' responses.

Payton

Payton introduced herself as a science major and uses this identity to explain that she is constantly trying to improve ‘things’ and give back to what nature and people have taught her. She suggests that her academic major is a way for her to do so. She then discusses how her academic identity was cultivated through her personal experiences within natural spaces and with her father. She discusses how she grew up in a small community that centers around nature, suggesting that her childhood experiences have also cultivated this want to ‘give back.’ The notion of giving back and improving society is consistent throughout her entire interview.

> I am a wildlife and conservation biology major, so expanding and making sure that things constantly get improved is my thing...I was always a really hands-on kid but was never good at building things, so I was like, "Might as well put this to work somehow." And I grew up in a very nature-oriented community, really small town surrounded by the woods. Always went hiking, fishing, doing stuff like that with my dad. So integrating that in the continuation of my life so I can give back to what people and nature taught me has always been really important

Payton is also religious. She describes this identity when discussing her beliefs about vaccines. Similar to her academic identity, we see how she is referencing this notion of improving a community.

> I went to a church when I was younger, just because my family did, but it wasn't really topic then that we talked about. I, personally, would like to think that, yes, there's something up there that might be in control or just sitting down watching us kill ourselves

> with our stupid decisions…I think vaccines are an important part, and I think that if there were something up there, that they would like us to use things that we've created to better ourselves.

We see both Payton's religious and academic identities start to intersect when she is asked how she would information search about vaccines. Initially, she justifies her ways of knowing through corroborating between multiple authoritative sources (e.g., books, internet, professional), which we coded as JMS. In this quote she is drawing from her academic identity.

> I probably do research first ... books, internet, and then if I didn't feel fulfilled, I think I'd go straight to the horse, per se, and go talk to a professional… they're coming from people that are in the field that have firsthand experienced it.

When Payton is asked to explain why she would choose these information sources, she discusses the process, meaning, and effort that developed the information source. She then references that the people who developed the information also dedicated their time to save lives. Based upon her previous responses where she describes the notion of giving back and improving society when explaining both her academic and religious identities, these beliefs about knowledge may have been developed through the ideologies of both her religious and academic group inclusions. For example:

> Just knowing the amount of effort that people put into. It's not just, "Oh, we've always had this." Knowing the process and all the trial and error and all the effort, it makes it a

> little more meaningful. It's not just, "Oh, you're just doing this because you have to". We're doing this because other people took the time and the expenses and did this so they could, potentially, save lives.

However, when asked if she would vaccinate her future children, Payton's personal identity trumps her previously mentioned identity commitments, guiding her to evaluate her knowledge through personal sources (JPS) (e.g., '*I feel…..I care…I'm gonna love them either way'.)*. For example,

> Yes…[Because] I feel that vaccines are important and if I can give someone that I care about that chance with a minute possibility that they might have a serious reaction [to vaccines], I think that's worth the risk, because I'm gonna love them either way.

Students often reference their personal identity in conjunction with personal sources (JPS). We see this when students reference their state of being or when they justify their knowledge through evaluating an opinion, emotion, or personal experience, such as Payton's quote above. When students reference that they believe something because of who they are without the reference of an external knowledge source, we implicitly believe that they are referring to their personal identities.

Ross

Ross's academic and personal identity commitments intersect when describing how he would information search about vaccines. This intersection may be guiding him to justify his

knowledge by cross-checking and corroborating between multiple sources of information (JMS) that are specific to his identity commitment. For example, when asked how Ross would information search about vaccines, he describes his academic identity and how he would use the scientific method.

> I definitely consider myself a science person...research is just really implementing the scientific method. So you have a hypothesis, you have a thought like, maybe this does this and then you continue to find different methods that ... So like a certain test and you know that this test will give you a positive result for this outcome. Now does this affect this? Do the test, it doesn't. Okay go back to the drawing board. Okay maybe this affects this and go back and maybe not rewrite the whole hypothesis but adjust it until you find a conclusive answer

As a follow up to this statement, we asked how he would learn more about vaccines. He states that he would reflect upon the knowledge he has gained as a science student in college, which we coded as an academic identity. We also believe that Ross is referencing his personal identity due to how he is describing himself separate from academic identities (‘*with the knowledge I’ve gained being a science student…I honestly have no idea…for me, it’s finding out what is in these vaccines.’).*

> Probably with the knowledge that I've gained being a science student in college. That would probably be actually understanding like what is this vaccine, what is in the vaccine? That's probably what I would find out because I honestly have no idea what a

> lot of vaccines contain. For all I know there could be carcinogens in some vaccines. I know that, that's another argument that a lot of anti-vaxxers make. So, for all I know there could be. I think it's really about, for me, it's finding out what is in these vaccines.

Ross's personal and academic identities start to intersect with each other when discussing what he is specifically looking for when information searching about vaccines. He states that he wants to find the truth regardless of his personal biases. He then brings up his SSI stance to show support of his personal beliefs about vaccines. However, Ross winds up relying upon his academic identity, stating that if evidence points to vaccines being harmful, he would change his beliefs. He believes that the process of science and the academic domain of biology produces true knowledge and that is how he chooses to perceive the world. We coded this response as JMS given him corroborating between personal beliefs (JPS) and academic domains/processes (JAS).

> When looking at things that are so controversial such as vaccines, I think it's important to find the truth, whether or not it supports my opinion or not. I'm obviously a big proponent of vaccines and I think everyone should get their scheduled vaccines as said by your doctor. But, if there is evidence that's been proven to me, that I have seen to be true that proves something else, I have to accept the fact that this evidence has been found through a scientific method and is true and correct…I think finding the truth helps cure that sense of ignorance. With biology, something I love about biology is that now I know. I know how everything works. And finding out how everything works makes me feel like there's a sense of completion. So I feel like finding the truth is important for me to find that conclusion and whatever that conclusion may be, is just to bring closure to that event.

When asked what has influenced him to feel this way, Ross brings up the authoritative influence of his family. He also references the authoritative influence of his school. Because he corroborates between multiple sources of information, we coded this response as JMS.

> A lot of them have been from my family, 'cause I know my family's very in medicine. My grandfather's an orthodontist so he's taught me a lot about vaccines and medicine of that nature. I've learned a lot through the university, a lot about bacteria, medicine, different infections, things of that nature.

However, despite Ross's strong academic identity commitments, his personal identity winds up guiding his SSI decision to vaccinate his future children. In this response, he explains his decision through evaluating his personal sources of information (JPS). We see his personal identity when he states that he wants to keep his family safe.

> Absolutely…Because I believe it is for their own health as well as for the health of everyone around them… my beliefs are that I wish for my family to be safe, and I know that to keep them safe, that [getting vaccinated] is a method to keep my family and my loved ones safe.

Karly

Unlike Payton and Ross, Karly's multiple identity commitments pose a challenge when information searching for vaccines. Karly has very strong personal beliefs about vaccines,

discussing how people who do not vaccinate on the premise that their children may become autistic enrages her. Emotions such as anger contribute toward the development of one's personal identity as well as their stances about specific issues (Holland, 2007). Therefore, we believe that Karly is referencing her personal identity surrounding vaccinations. In this response Karly also references her academic identity of being a social worker. She states that despite her anger, as a social worker she believes that people should not demonize autism. We coded this response as JMS given how she references both personal sources of information (JPS) and references her knowledge as a social worker (JAS).

> …People [who] don't want vaccinations really enrages me…personally, I don't wanna get the measles or polio, which I think is a good enough start. But also, as a social worker, even if ... And I know it doesn't lead to it, but even if it... had some cause in ... I'm forgetting the word right now…Autism. I kept thinking Alzheimer's, which it's not. Even if for some reason it did [cause Autism], you would rather your child dies of measles or something than have Autism? That's very ableist and gross to me.

Students' academic identities often determine how they view the world and handle specific situations (Hegarty, 2008). However, Karly's beliefs developed by her personal identity about vaccines are rooted in emotion, specifically in anger toward those who do not vaccinate. One's personal identity may interact with group commitments, such as Karly's academic group commitment as a social work major (Doeselaar *et al.,* 2018). This interaction between identities may contribute toward inner turmoil when discussing what she thinks about people who do not vaccinate their children during the first section of the interview (Doeselaar *et al.,* 2018). We

describe her information searching process with several quotes. Initially, she states that she would investigate the reasonings behind why people choose to believe that vaccines are connected to autism. She exclaims that because people are not vaccinating, they are a danger to society.

> I would look into the validity and the background of why people think it's connected to autism. But again, if it was, that enrages me on its own… I think especially with the measles outbreak in, I think it's Washington right now… it just makes it even more important [getting vaccinated] because these people's choices on not vaccinating their kids is affecting the general population.

When asked to explain why she would look for this type of information, she discusses how her biases play a role in how she considers information. When an individual becomes aware that they are relying upon a personal bias, it puts tension between their various identity commitments, specifically with their professional identity commitments (Sukhera *et al.*, 2018). We see this with Karly.

> I guess I'm very biased because of it against people that don't vaccinate. And that's an unfortunate thing that I really shouldn't automatically assume they're dumb because some of them do have religious reasons and things like that, which I should have no opinion in that, that's their own values.

We can see tension between Karly's personal and professional identity commitments when she

discusses in the following quote that despite her biases, the social worker identity binds her to protecting others regardless of how others behave. This quote portrays the inner-turmoil Karly feels about people who do not vaccinate. We coded this response as JMS given that Karly references her social worker knowledge (JAS) and her personal biases (JPS).

> As a social worker, we're supposed to respect the dignity and beliefs of all people. So people should have self-determination. But at the same time, their children don't have that right to self-determination yet, so what they're doing is affecting their children by it. So that sets a bad thing in my stomach for that. So it's hard for me to try to put away that bias. But I have to as a social worker to try to help all people.

However, when asked to make the hypothetical SSI decision to vaccinate her future children, Karly reflects upon her personal identity, again stating that she would elect to have them vaccinated due to her personal experiences with vaccines and desire to avoid communicable diseases (JPS).

> If I had children, then yes…Well I don't really want the measles to come back again or polio. And I've stepped on a lot of rusty nails, so I'm really glad for my tetanus shot, so I want them to have that same freedom.

Discussion

This study qualitatively evaluates how students' identity commitments from sociocultural in-groups relate to their JFK when working through an SSI. We found that SSI context triggers

students to commit to specific ideologies from their family, political, religious, and academic group inclusions. Students expressed these commitments through adhering to an identity when working through the SSI. Aside from these identities, students also committed to their personal ideologies or, their states of being. When information searching, we found that students' identity commitments intersect, leading them to justify their knowledge by corroborating across multiple sources (JMS). Lastly, we found that students' personal identities trump their previously mentioned identity commitments, leading them to justify their knowledge through personal sources when explaining their SSI decisions.

Although we cannot make causal claims given the qualitative nature of this study, we discuss our findings through a model (Figure 2). It is important to note that this model does not include the specific JFK dimensions as we do not have the quantitative evidence to support directional relationships between them. Relationships between JFK dimensions have been presented within various studies that quantitatively investigate the JFK framework (Anmarkrud *et al.,* 2014; Brandmo & Bråten, 2018; Bråten *et al.,* 2019). Therefore, we use this proposed model as a means to broadly discuss our results and to suggest directions for future research. We believe that this study may provide the ecological validity needed for future researchers to quantitatively explore the directional relationships between identity commitments and JFK belief dimensions.

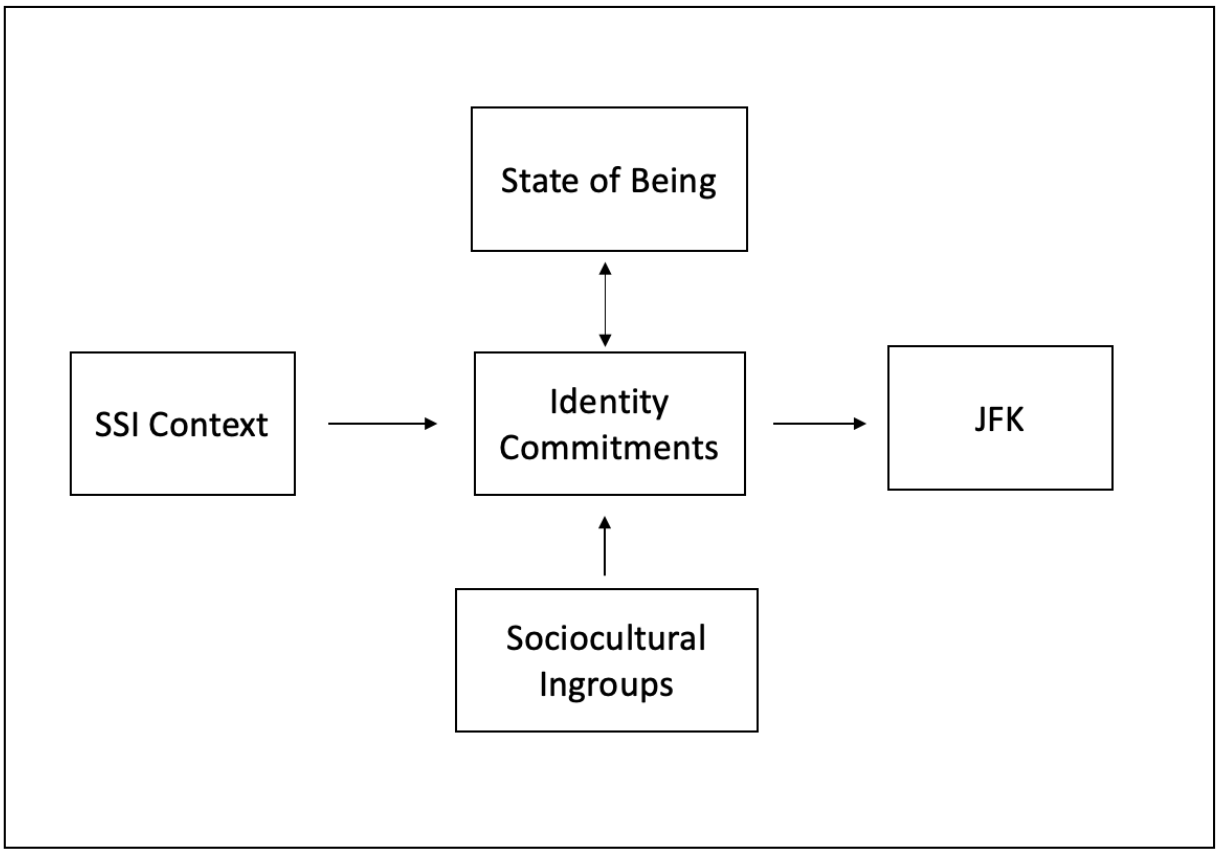

Figure 2. Model of the suggested relationships between SSI topic, identity commitments, and JFK beliefs.

SSI Topic and Identity Commitments

An arrow is shown connecting SSI context to students' identity commitments. In this study, we found that identity commitments may be influenced by both students' sociocultural group inclusions and their state of being. A directional arrow illustrates how these group inclusions contribute toward students' identity commitments as students have multiple epistemologies from these influences that contribute toward how they may perceive the SSI (Bang & Medin, 2010). Furthermore, a double-sided arrow illustrates how students' personal identity feeds into their other identity commitments as students' state of being can contribute toward the development of

students' identities and may be acting as a narrative guide in how students reflect upon the ideologies from their sociocultural in-groups (Mclean & Syed, 2015). In this section, we first discuss students' identity commitments from their sociocultural in-groups and then discuss our finding of personal identity commitments from their state of being.

The nature of an SSI has unique implications for the individual, communities, and for sociocultural groups such as political, economic, religious, and social groups (Herman, 2018; Herman *et al.,* 2022; Nichols, 2017; Sadler & Zeidler, 2005; Zeidler *et al.,* 2017). Specifically, medically focused SSIs, such as the vaccination controversy, present the decision-maker with information that surpasses their knowledge and creates feelings of uncertainty, confusion, and fear (Herman *et al.,* 2022; Muis *et al.,* 2007). To assuage these feelings, people may seek guidance from their non-academic groups when they struggle with what to do in the context of the SSI (Herman *et al.,* 2022; Nichols, 2017; Oulton, *et al,* 2014). By referring to these groups, the decision-maker may relieve their sense of ambiguity by replacing complex scientific information with the well-established knowledge of their in-groups (Herman *et al.,* 2022; Oulton et al., 2004). These groups encompass belief systems that have been used as explanations for centuries (Bang & Medin, 2010; Oulton et al., 2004). Therefore, it is not surprising that students drew upon the ideologies of their sociocultural groups when explaining their knowledge about the vaccination controversy. Within this study, students reflected upon the ideologies of their cultural, political, religious, and academic groups.

We found that family group inclusions emerged as students discussed the influences of their families. People's families are foundational in their ways of knowing (Bang & Medin, 2010).

Additionally, family in-groups are foundational to how someone learns about language, health, and taking care of living beings (Bornstein & Lansford, 2019; Ross *et al.,* 2018). They also play a strong role in how someone behaves when having to make medical decisions (Pharr *et al.,* 2014; Ross *et al.,* 2018). Beliefs from our students' family groups were used to explain student's knowledge about vaccines and their stances about vaccines (e.g., Ross and Talia). Furthermore, they behaved as a baseline that connected students with political, religious, and academic ways of knowing. We see this when they would mention that their experiences or influences with their families contribute toward how they think about an issue. Through investigating role of family in-groups upon students' ways of knowing, we may understand what is guiding students toward adopting specific identities. However, this goes beyond the scope of our study. Therefore, we call upon other researchers to explore this phenomenon in the future.

SSI decision-making usually involves political stakeholders such as government officials, laws, and political affiliated groups (e.g., identifying as a Republican) (Chinn *et al.,* 2020; Herman, 2022; Herman, 2015; Nichols, 2017; Sadler & Zeidler, 2005). Therefore, we expected to find references to students' political ways of knowing within the interviews. We found that students committed to their political identities when discussing why they wanted to participate within the study, their beliefs about vaccines, and how they assess information sources (e.g., "My political stance I think influences [my beliefs about vaccines] a lot."). It has been found that undergraduate students' political affiliations contribute toward how they evaluate SSIs, especially when the SSI is new and controversial (Herman, *et al.,* 2022; Nichols, 2017). Similarly, we found that students would investigate if someone belonged to a specific political party when consulting them for information because their political affiliations may be perceived

as threatening (e.g., Tilly). Due to the threatening nature of the SSI, students turn to their political leaders when determining their decision-making behavior and SSI stances (Herman, *et al.,* 2022; Nichols, 2017). SSI stances, such as being pro-vaccine, encompass a body of values and ethics that are typically imparted through political affiliations (Herman *et al.,* 2022; Gottipati *et al.,* 2013). Given today's political climate, there needs to be an emphasis on evaluating students' political affiliations and how they are determining their SSI stances, especially because conflicting political beliefs have been known to elicit hate crimes or violence toward those with opposite beliefs (Gottopati *et al.,* 2013; Mirra & Garcia, 2022). By doing so, researchers can inform instructors in how to navigate their classrooms when SSI stances interfere with student behavior.

Religious ideologies from religious group inclusions provide an individual with explanations of physical phenomena such as natural disasters, outbreaks of diseases, and even with extinction (Khishfe *et al.,* 2017; Ladachart & Ladachart, 2021; Sadler & Zeidler, 2005;). Although not as heavily referenced as other sociocultural group inclusions, we found a few students referenced their religious identities when discussing their beliefs about vaccines (e.g., Becky and Payton). However, this may have been due to our sample size and therefore may not be as representative of our undergraduate student population. Religious ways of knowing are often used to support decisions of medically focused SSIs due to people's uncertainty of medical procedures and fear of negative side-effects, such as fetal tissue research or newly developed medical advances (Oulton et al., 2004). However, our entire research population adopted the stance of being pro-vaccine, therefore we did not have any students use their religious identities as a reasoning for being against the SSI. Although we are currently amid a global pandemic where the notion of

receiving newly developed vaccines is distressing to several religious and political in-groups (Herman, *et al.,* 2022), our study was conducted before the pandemic was declared. Therefore, we may have found different information if conducting this study when the vaccines were being introduced to society. Given that we are still dealing with the pandemic, we encourage researchers to investigate students' religious identities and how they may be playing a role in how students are handling a current and contentious SSI.

The growth of academic identity is influenced by positive experiences with the topic, exposures to the topic, and feeling a sense of belonging when engaging with the topic (Frick & Brodin, 2020; O'Sullivan *et al.,* 2019). All students reflected upon an academic identity when referring to their academic group inclusions. However, this may have been due to the setting of the interview. Additionally, a question about academic major was asked in the beginning of the interview as means to understand the participant. Therefore, students may have been influenced to use their academic identities as a lens to evaluate the vaccination controversy. However, unsolicited, several students referenced their academic identity commitments before we asked about their academic majors. We believe that this was due to the nature of the vaccination controversy. For example, students referred to their social work major or to their neuroscience major when explaining why they wanted to participate (e.g., "I'm a social worker, so it [the vaccination controversy] like really piqued my interest." And "I am a neuroscience science major, so [the vaccination controversy is] very interesting.").

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When an individual refers to their academic identity, they are not just describing their content expertise (Frick & Brodin, 2020). Rather, they are describing their values, analytic skills, and their social behavior from the respective academic domain (Frick & Brodin, 2020). Furthermore, we found that students' information searching behavior may have been informed by their academic group inclusions, as the university emphasizes scientific literacy skills throughout their course requirements. However, the majority of SSI research involves evaluating decision-making in an academic space. Therefore, we recommend that researchers investigate how academic in-groups contribute toward how students evaluate and behave during SSI decision-making outside of the classroom.

Our most notable finding is students' reflection of their personal identities when describing their beliefs about vaccines, how they would information search about vaccines, and when they made a hypothetical decision about vaccines. In our study, we believe that our participants' personal identity may be acting as a master narrative (Mclean *et al.,* 2017). We illustrate this within our model with a double-sided arrow (Figure 2). A master narrative refers to an identity that dictates how someone behaves, thinks, and perceives information (Mclean *et al.,* 2017). It is an integral part of who someone is and contributes toward how they think through contentious situations (Mclean *et al.,* 2017). Students use these master narratives by referring to themselves within the interview without referencing an external influence such as an academic domain. Moreover, we see these master narratives when students oscillate between their other identity commitments but then ultimately rely upon their personal identities during SSI decision-making. As this result is emergent within the data, we propose that researchers further investigate how students' personal identities are operating when explaining their ways of knowing during SSI decision-making.

We found that students' personal identity may stem from their state of being, suggesting that students' epistemologies about the SSI may be influenced by their ontology, or their nature of being. People's ontological meanings of objects, scenarios, phenomena, and entities, such as family or religion, may shape their epistemological stances when handling contentious issues (Wells, 2008). However, the interconnectedness of ontology and epistemology has been argued within the field. Several researchers claim that epistemological products such as epistemic beliefs only include the nature of knowing, where ontology concerns one's nature of being, and therefore the two should be considered separate constructs (Greene *et al.,* 2016). However, we argue that when explaining epistemic beliefs, especially justification beliefs, ontology may illuminate how people are developing their ways of knowing and how they may use them when handling ill-structured problems.

Identity Commitments and JFK beliefs

The proposed hypothetical model shows a directional arrow connecting identity commitment to JFK beliefs. It is known that sociocultural group inclusions can influence someone to adopt a bias toward a specific belief system or domain of knowledge (e.g., such as political groups demonizing scientific stakeholders) (Clough & Herman, 2017; Herman, 2015; Herman, *et al.,* 2022). When this happens, the individual may choose to disregard information when evaluating evidence and rely upon heuristics when formulating an SSI decision (Clough & Herman, 2017; Herman, 2015; Herman, *et al.,* 2022). The decision-maker may also deem identity-specific information sources to be valid, simply because the information is generated by their group inclusions (Barzilai & Chinn, 2020; Chinn *et al.,* 2021; Herman *et al.,* 2022). We found this

within our interviews when students would commit to an identity and then justify their knowledge by referencing an identity-specific authoritative source. For example, Ross, who commits to his academic identify, justifies his knowledge through referencing academic information sources (JAS). Additionally, Karly commits to her social-worker identity, justifies her knowledge through reflecting upon the information she has learned as a social work major (JAS).

However, we found that students' identity commitments intersect when describing how they would information search about vaccines. Because of this intersection, students justified their knowledge through JMS, cross-checking and corroborating between identity-specific authoritative sources or a combination of authoritative and personal sources. Although we did not have students physically evaluate evidence during the interview, these results illustrate how students may be using their identity commitments as a tool in determining the validity of information. Therefore, we believe that the context of an SSI may trigger students' identity commitments, which may then drive their JFK when information searching. Specifically, students' multiple identity commitments may drive them toward identity-specific authoritative sources, thus leading them to cross-check and corroborate between them. However, when making a hypothetical decision, students' personal identities acted as a master narrative, guiding them toward justifying their knowledge through referencing personal sources of information.

Although our data supports the proposed model (Figure 2), there are several limitations to our study which threaten the validity of our findings. Therefore, we emphasize and encourage other researchers to further investigate these relationships. Our major limitation of this study is how

we evaluated personal identity and the JPS dimension. Personal identity may be a foundational component to the JPS belief dimension as when someone justifies their knowledge through evaluating a personal source of information (e.g., gut-feeling or intuition), they are reflecting upon their state of being without the influence of authoritative knowledge sources (e.g., political leader) or corroborating between multiple knowledge sources. However, JPS may be influenced by the ideologies of other sociocultural groups, as personal identity is developed through exposures to belief systems throughout an individual's lifetime (Mclean & Syed, 2015). Given our project's design, we were unable to detect this from our study. Therefore, more research needs to be conducted in this area as there are many nuances within personal identity that may be contributing toward how students are utilizing personal sources of information when justifying their ways of knowing. Lastly, because we were discussing a controversial issue, students may have answered specifically to adhere toward their perceived beliefs of the researcher (Packer, 2018). By doing so, students may not have answered the questions honestly, which damages the validity of the data by pulling away from the interviewees actual lived experiences (Packer, 2018).

Implications and Conclusion

The role of science in undergraduate curricula centers around the goal of "Science for all Americans" (AAAS, 1989). In achieving this goal, students need to develop skills and strategies to handle SSIs outside of the classroom (AAAS, 1989; AAAS, 2011; Deboer, 2000). However, the results of this study suggest that there needs to be a change in narrative in how these skills are being implemented within the classroom, as we found that students do not solely rely upon their academic ways of knowing when evaluating an SSI. Instead, we found that the context of

an SSI elicits students to commit to the ideologies of their effected sociocultural group inclusions regardless of academic major. Moreover, we found that when exercising their information searching skills, students intersect the knowledge from their group inclusions with their academic groups, addressing the SSI ideographically. Therefore, we encourage instructors of undergraduate science courses to emphasize sociocultural knowledge with scientific information when teaching SSI decision-making strategies to their students. We recommend implementing conversations surrounding personal experiences, gut-feelings, and the role of intuition when discussing SSI decision-making, as it is inevitable that students will prioritize them when making an SSI decision. By doing so, instructors may create a learning space that encourages diverse ways of thinking that combines scientific information with students' ways of knowing.

The nature of learning and using knowledge is a cultural process that is unique to the individual (Bang & Medin, 2010; Rogoff, 2003). Although there are many conversations surrounding diversity and inclusion within the STEM fields, there needs to be an emphasis on how to promote the representation of these ways of knowing within SSI focused curricula. We argue that a core focus of undergraduate science curricula should stress diversifying the ways in which instructors represent knowledge. Therefore, we recommend that instructors of science courses stress the importance of representation when discussing SSIs. For example, when presenting an SSI to the class, instructors can represent various cultures through providing an SSI narrative from multiple perspectives (Darner, 2018). By doing so, the instructor diversifies how they are representing knowledge and may foster a sense of belonging for students who may identify with those narratives (Darner, 2018). Moreover, we encourage instructors to recognize that the standard ways in how science is communicated may cause their students to feel disconnected

with the material (Bang & Medin, 2010; Darner, 2018; Rogoff, 2003). This is essential to prevent, as fostering a sense of belonging within the classroom contributes toward how someone may perceive and use science outside of the classroom (Bang & Medin, 2010; Darner, 2018; Rogoff, 2003).

In conclusion, we found that SSI context elicits students' identity commitments from relevant sociocultural ingroups, guiding students' justification beliefs during SSI decision-making. This is consistent with Chapter two's findings. However, through our interviews we were able to further investigate the role of identity upon the JFK beliefs. We found that students' beliefs from their various identity commitments may contribute toward students' SSI stances, such as being pro-vaccine. Furthermore, we found that the beliefs from students' identity commitments intersect when information searching about vaccines, guiding them to reflect upon multiple sources. Particularly, the authoritative sources within JMS were driven by identity (e.g., Ross and Biology and Karly and Social Work). We believe that these results describe the complicated nature of SSIs, especially how they involve multiple social stakeholders. However, students do not reflect upon these identity commitments when making a hypothetical SSI decision. Instead, their personal identities act as a master narrative, guiding them to justify knowledge through the JPS dimension. Using the model we illustrated when discussing these results, we call upon researchers to continue investigating the relationships between identity commitment and JFK beliefs during SSI decision-making. By doing so, we may gain a deeper understanding of these relationships and how it may contribute toward SSI decision-making.

CONCLUSION

Hurd (1998) states, "a valid interpretation of scientific literacy must be consistent with the prevailing image of science and the revolutionary changes taking place in our society" (Hurd, 1998, p.409). My dissertation supports this statement by providing evidence that when handling controversial SSIs, the decision-maker relies upon diverse ways of knowing that surpass scientific knowledge. This work starts a conversation about the role of scientific literacy and how students are applying these skills outside of academic domains of knowing. Furthermore, my dissertation proposes a new framework to evaluate epistemic beliefs in the context of SSI decision-making that describes the influence of SSI context upon students' ways of knowing. Lastly, this body of research begins to disentangle the relationships between identity and the justifications for knowing during SSI decision-making.

My first chapter explored how undergraduate students' epistemic cognition plays a role in evaluating evidence when discussing the vaccination controversy. This qualitative study used Chinn and colleagues' AIR model (2014) as an evaluative lens through 26 semi-structured interviews where participants described their opinions about vaccines, how they would information search for vaccines, and the hypothetical SSI decisions they would make about vaccines. We found that students want to look for the most accurate information when information searching about vaccines. However, accuracy is determined by the individual based upon how they trust or feel about the information source. These information sources stem from both scientific (e.g., medical doctors) or social (e.g., peers and parents) sources of evidence. When discussing how they would information search, students described cross-checking and corroborating these information sources, which is a scientific literacy skill they have learned

through their academic careers. We found that students were applying this scientific literacy skill to all sources of information, providing evidence that scientific literacy skills are being used outside of academic spaces. However, this chapter mentions the need for functional scientific literacy, a set of skills that merge trust, values, empathy, and ethics with foundational scientific literacy skills (Herman *et al.*,2020; Sadler and Fowler, 2006; Sadler, 2004; Zeidler *et al.,* 2002; Zeidler *et al.,* 2009). By implementing functional scientific literacy skills within the classroom, instructors are able to recognize students' multiple ways of knowing and use them to better inform SSI decision-making strategies.

My second dissertation chapter evaluates the justifications for knowing (JFK) framework during SSI decision-making. The JFK beliefs concerns how people determine the validity of knowledge claims when making ill-structured decisions (Ferguson *et al.*, 2013). the JFK framework consists of three dimensions of justification beliefs: justification from personal sources (JPS), authoritative sources (JAS), or multiple sources (JMS). Similar to other frameworks of epistemic beliefs, the JFK is contextual. The JFK framework is predominantly evaluated through a quantitative lens and through the domain of natural sciences. However, because SSI decision-making involves the evaluation of more than scientific knowledge, observing JFK beliefs this way restricts our understanding of how they may be operating during SSI decision-making. Therefore, this chapter investigates JFK beliefs during SSI decision-making across two SSI contexts. We found that students justified their ways of knowing by drawing upon several authoritative knowledge sources that were not recognized within the original JFK framework. Furthermore, we found that SSI context triggered students to commit toward specific identities from their sociocultural group inclusions which may direct them toward reflecting upon specific

JFK beliefs. However, deeper qualitative research needs to be conducted to explore this relationship further.

The third and final chapter of this dissertation qualitatively disentangles the relationships between identity commitments and the JFK framework during SSI decision-making. In this study, we found that students referenced multiple identities through reflecting upon their political, religious, academic, and cultural group inclusions. When information searching about vaccines, these several identity commitments intersect, guiding them to justify their ways of knowing through cross-checking and corroborating between group-specific knowledge claims (JMS). However, when supporting their SSI decisions, students may abandon these identity commitments and reflect upon their personal identities, referencing their personal ways of knowing when explaining their decisions (JPS). The results of this study illuminate how although students may reflect upon various domains of knowledge during SSI decision-making tasks, such as information searching, their sense of self trumps these other ways of knowing when making an SSI decision. However, more research needs to be done in this area to explore the nuances of one's personal ways of knowing during SSI decision-making.

In conclusion, the results of this dissertation illuminate how epistemological mechanisms are influencing undergraduate students' SSI decision-making, specifically how they evaluate evidence and how they use evidence when formulating their decisions. These results have implications for instructors of science courses. For instructors, these studies provide insight in how students are both using their scientific literacy skills and how students are thinking about science driven issues outside of academic contexts. By furthering our understanding of these

phenomena, instructors will increase their awareness about the diverse ways of knowing students may draw upon during SSI decision-making coursework. Instructors can use this awareness to promote objectivity when teaching information searching strategies about SSIs. Furthermore, these results inform instructors of the influence of sociocultural group inclusions upon how students perceive and act upon SSIs. By recognizing these group inclusions, instructors can provide a learning environment that supports diversity and encourages students to voice their preconceived beliefs about science and scientific knowledge. This is critical for students, as instructors can address these beliefs and direct them toward accurate scientific models without causing students to cognitively shut down (Darner, 2018).

In sum, this work presents the field with the relationships between personal epistemology and SSI decision-making. In future studies, I recommend that more qualitative research is conducted to provide the field with the ecological validity needed to design quantitative measures to evaluate epistemological processes across many participants. These quantitative measures may provide the field with an easier way to target epistemological processes so that researchers and instructors of undergraduate science courses can better understand how students are drawing upon knowledge. By doing so, we may be able to generalize how young adults are utilizing knowledge generated from various influences to support their SSI decisions. Although I acknowledge that epistemic cognition and epistemic beliefs are context specific and individualistic, these constructs play a critical role in how people perceive and use knowledge when handling science driven issues.

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SUPPLEMENTARY MATERIALS

CHAPTER ONE SUPPLEMENTARY MATERIAL:

Appendix A: Semi-structured Interview Protocol

Interview preamble:

Thank you so much for taking the time to be here today! Please have a seat. Before we get started, I just want to reiterate that your participation today is completely voluntary. I have a consent form for you to read and sign. Please read through the entire consent form before signing.

Questions before participant reads the vaccination article

1. What brought you here today?

2. What is your major?

3. Have you ever taken a science course before?
    a. Do you consider yourself a science person? Why or why not

4. How do you personally feel about vaccinations and why?
    a. Would you want to learn more about them? Why?
    b. Do you think that learning about them is important? Why?

5. How would you learn more about vaccinations?
    a. Where would you look for information specifically?

b. What makes these sources good sources of information?
    i. How can you tell if the information given by these sources are real?
    ii. Define Peer review…only use if participant brings this up
c. If two of these sources have conflicting information, how would you know which source is right?

6. So, when you are looking for information about vaccinations, or something like it, what would some of your goals be when seeking additional information?
    a. What makes these goals valuable to you?
    b. How does/do these values/this value influence the way you read and think about information?

Questions after article is read

7. What are your thoughts about what you just read?
    a. Was there anything that you do not believe in this article?
    b. What makes it not believable?
    c. What makes it believable?
    d. Would you like to see the works cited?

8. Did your past experiences or past knowledge about vaccinations influence the way you are thinking about this article? How so?

9. Can you remember a time where you read or heard something that you did not believe about vaccinations?
    a. Tell me about this situation
    b. What characteristics made that source not credible/credible?

10. Would you vaccinate your children? Why?
    a. What strategies are you using to make this decision?
    b. Should individuals who choose not to vaccinate their children be able to enroll those children in public schools? Why or why not?
    c. How have your beliefs influenced this opinion?

11. Are there specific vaccinations that are important and are not important?
    a. What experiences are you using to help make this opinion?

12. If your peers, family, or others that have a deep influence within your life were to think differently about your opinion about vaccinations would you change your mind? Why?
    a. What are things that would make you change your mind?

13. Did our discussion today motivate you to want to learn more about any aspect of vaccinations? Why?

a. Do you think it is important for instructors to include these aspects within your science classes? Why?

Closing statement:
Thank you so much for your time! Have a great day. Please let me know if you have any questions.

Appendix B: IRB Approval Letter Chapter One and Three

IRB #: 7009
Study: The Influence of Epistemic Cognition on Socioscientific Decision Making in Undergraduate Students
Approval Date: 27-Sep-2018

The Institutional Review Board for the Protection of Human Subjects in Research (IRB) has reviewed and approved the protocol for your study as Exempt as described in Title 45, Code of Federal Regulations (CFR), Part 46, Subsection 101(b). Approval is granted to conduct your study as described in your protocol.

Researchers who conduct studies involving human subjects have responsibilities as outlined in the attached document, *Responsibilities of Directors of Research Studies Involving Human Subjects.* (This document is also available at http://unh.edu/research/irb-application-resources.) Please read this document carefully before commencing your work involving human subjects.

Note: IRB approval is separate from UNH Purchasing approval of any proposed methods of paying study participants. Before making any payments to study participants, researchers should consult with their BSC or UNH Purchasing to ensure they are complying with institutional requirements. If such institutional requirements are not consistent with the confidentiality or anonymity assurances in the IRB-approved protocol and consent documents, the researcher may need to request a modification from the IRB.

Upon completion of your study, please complete the enclosed Exempt Study Final Report form and return it to this office along with a report of your findings.

If you have questions or concerns about your study or this approval, please feel free to contact Melissa McGee at 603-862-2005 or melissa.mcgee@unh.edu. Please refer to the IRB # above in all correspondence related to this study. The IRB wishes you success with your research.

For the IRB,

Julie F. Simpson
Director

CHAPTER TWO SUPPLEMENTARY MATERIAL:

Appendix C. Modified Decision-Making Questionnaire [1]

Instructions:

Answer the following questions. Please note that there are no "right" or "wrong" answers to these questions. I am simply interested in your views on a number of issues about science.

Scenario 1

In the past decade, research has opened the doors to fetal tissue transplantation, a procedure that typically involves transferring tissue from an aborted fetus to another human. The procedure could potentially provide therapy for victims of a variety of debilitating diseases, including diabetes, Parkinson's disease, and Alzheimer's disease. As in many areas biotechnology, the development of this technique has outpaced the development of ethical policy. Please read the following scenario and thoughtfully answer the questions that follow.

Bill and Sally are a happily married couple in their late 30s. They enjoy a comfortable life style and a stable home life with their two teenaged children. Recently, Sally's elderly father was diagnosed as having Parkinson's disease, a slowly progressive disabling ailment marked by tremor and increasing muscular stiffness. His symptoms are mild but his physician has explained that he will become more and more incapacitated with time.

[1] Adapted from Bell, 1999

Close to the time that she learns about her father, Sally reads an article in the local newspaper about a research project being run at a local university. A team of researchers, led by Dr. Harrison, have applied to the federal and state governments for permission to do a study with Parkinson's victims. She visits with Dr. Harrison to learn more about the disease. During the course of their discussions, she finds out that the progression of Parkinson's can be slowed and possibly reversed by implanting fetal brain cells in the brain of the patient.

Two months later Sally is surprised to learn that she has become pregnant. Due to the unexpected nature of the pregnancy, Sally considers aborting the fetus. Furthermore, as her father's condition begins to deteriorate, she and Bill consider some therapeutic options for him. Recalling her discussions with Dr. Harrison, Sally, and Bill begin to discuss the option of using tissue from the fetus in her womb to donate the cells to cure her father.

Questions:

1. Given the experimental nature of fetal tissue transplant treatments, are Sally and bill justified in considering the procedure for her father? Why or why not? What helped you form this opinion?

2. Should Sally be allowed to have the abortion if her primary reason for wanting it is to provide a source of tissue for transplantation into her father? Why or why not? What helped you form this opinion?

3. Should Dr. Harrison be allowed to continue his work on fetal brain tissue transplantation as a treatment for Parkinson's disease? Why or why not? What helped you form this opinion?

Scenario 2.

Today, global climate change is a major environmental issue facing the United States and the international community. According to one side, the prospect of human induced global warming is a near certainty, and failure to address the problem will have catastrophic ecological consequences. According to the other side, global warming is a hypothesis lacking scientific validation, and reducing greenhouse gas emissions will have serious negative economic consequences.

In 1992, the United States, along with roughly 150 other nations, signed the United Nations Framework Convention on Climate Change (FCCC) at the Earth Summit in Rio Janerio. The FCCC was ratified by the US Senate in 1992 and has now been ratified by a total of 166 nations. The ultimate objective of this treaty is to "achieve…..stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. "In line with this objective, the most industrialized nations, including the U.S., agreed to the voluntarily aim of returning their greenhouse gas emissions back to 1990 levels by the year 2000. However, the U.S. and most other industrialized nations

are not on course to meet this target. In fact, emissions in the U.S. are projected to be 13 percent higher in the year 2000 than they were in 1990.

Because these voluntary targets have proven inadequate in curbing emissions growth, there is now widespread agreement that legally-binding measures are necessary. The upcoming climate conference in Kyoto, Japan, is based on the premise that the participating nations should agree, for the first time, upon a legally-binding limit on emissions.

Questions

1. Should the U.S. agree to legally-binding limits on greenhouse gas emissions? Why or why not? What helped you form this opinion?

2. Should the U.S. impose special taxes on carbon dioxide emission to encourage energy conservation, even if this increased monthly electricity and heating bills by $25 per month? Why or why not? What helped you form this opinion?

3. Would you be willing to pay increased taxes in order to provide funding for research on alternative energy resources, such as solar power and fusion reactors? Why or why not? What helped you form this opinion?

Appendix D: IRB Approval Letter Chapter Two

Approval Date**:** 01-Mar-2019

The Institutional Review Board for the Protection of Human Subjects in Research (IRB) has reviewed and approved the protocol for your study as Exempt as described in Title 45, Code ofFederal Regulations (CFR), Part 46, Subsection 104(d). Approval is granted to conduct your study as described in your protocol.

Researchers who conduct studies involving human subjects have responsibilities as outlined in the attached document, Responsibilities of Directors of Research Studies Involving Human Subjects. (This document is also available at http://unh.edu/research/irb-application-resources.) Please read this document carefully before commencing your work involving humansubjects.

Note: IRB approval is separate from UNH Purchasing approval of any proposed methods of paying study participants. Before making any payments to study participants, researchers should consult with their BSC or UNH Purchasing to ensure they are complying with institutionalrequirements. If such institutional requirements are not consistent with the confidentiality or anonymity assurances in the IRB-approved protocol and consent documents, the researcher may need to request a modification from the IRB.

Upon completion of your study, please complete the enclosed Exempt Study Final Report formand return it to this office along with a report of your findings.

If you have questions or concerns about your study or this approval, please feel free to contact Melissa McGee at 603-862-2005 or melissa.mcgee@unh.edu. Please refer to the IRB # above in all correspondence related to this study. The IRB wishes you success with your research.

For the IRB,

Julie F.
Simpson
Director