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Epistemological framing in statistics courses for psychology students

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EPISTEMOLOGICAL FRAMING IN STATISTICS COURSES FOR PSYCHOLOGY STUDENTS

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As an undergraduate student I had an opportunity to present an Honor's thesis 13 years ago, and by the end of this presentation I went home and checked my email, and a professor from the Psychology department emailed me saying that he found the presentation very interesting, and that he looked forward to meeting me if I studied a Master's degree, that was Dr. Osvaldo Morera. After 2 graduate school courses I asked him to be part of my Master's thesis committee, to which he graciously accepted, then almost 10 years later I approached him again now seeking his support as a member of my dissertation committee, and he again accepted. For your continuous support, I thank you Dr. Morera. Then 5 years ago I began this PhD journey enrolling on a summer course, and little did I know that the course would have such a strong impact on my academic and professional career as I received a wonderful introduction to the field of Education and the Learning Sciences, and by the end of the course our last assignment was an interview with the instructor, and in there I met a young faculty member who evidenced all the professional qualities that I desired: passion, dedication and care. That was Dr. Song An. For your continuous support, I thank you Dr. Song An. Finally, as I enrolled on this new program and did my research on our

faculty, I was immediately drawn to the academic work of one professor who introduced principles of cognitive psychology in his research. As I had the chance to meet him, I was impressed by the number of projects he had going, and I still remember how confidently he pointed at a pile of documents on his book stand and told me that those were projects waiting on the future. I right away understood that no task is impossible, and as I had the chance to meet him through the years, I met a great mentor that took the time to know me not only as a student, but as a person. We talked through the years about research, education, politics, sports, and life in general; that was Dr. Mourat Tchoshanov. For your continuous support, I thank you Dr. Tchoshanov.

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ABSTRACT

As psychology grows in popularity, most students select professions related to therapy, which constantly deem statistics courses as irrelevant and accentuate negative attitudes. This study explores perspectives of knowledge, also known as epistemological frames, that students enrolled in a psychology-based course in statistics generate and the extent to which these relate to attitudes. Research evidence the existence of productive and unproductive epistemological frames; the former involves automatic thought processes that require minimal effort or sense of voluntary control, while the latter prompts conscious learning efforts. This study follows an explanatory sequential design as it begins with a quantitative phase analyzing the range of attitudes that students generate and the extent to which these change among psychology instructors, for the follow up qualitative phase, students of different attitude ranges were chosen to explore their epistemological frames. The quantitative results evidence similarity across attitude levels, regardless of the professor teaching the course. The qualitative and integrated analysis evidenced patterns of unproductive frames among low and medium attitude students differing from high attitude students on perspectives of knowledge and course content knowledge. This study should encourage every statistics professor to question not only if the delivery of material is effective to generate knowledge, but if this knowledge transitions to the construction of productive epistemological frames that can foster positive attitudes as this course is useful for every psychology student, regardless of the specialization area.

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CHAPTER I: INTRODUCTION

Background of the Problem

As of 2017, nearly 3.5 million people in the United States held a Bachelor's degree in psychology (Conroy et al., 2019), out of which almost 1 million have received degrees over the last decade (Landrum, 2018), and data as recent as 2020 evidence a career growth of 3.46% as 183,794 degrees were awarded that year (Bureau of Labor Statistics, 2020). These numbers evidence the growing popularity that this discipline embraces, and it spans across dozens of specialty areas leading to a wide array of careers, such as health psychology, sports psychology, consumer psychology, experimental psychology, industrial-organizational psychology and engineering psychology, among others (Cherry, 2020). However, despite the broad range of occupations available in the field, most students select areas related to therapy as school psychologists, clinical psychologists, counselors, or family therapists, among other similar professions (Bureau of Labor Statistics, 2020). The latest data available from the U.S. Census Bureau validates this assumption as the following figures visualize the most common occupations among psychology graduates in our nation over the last years with professions related to therapy becoming the overwhelming majority.

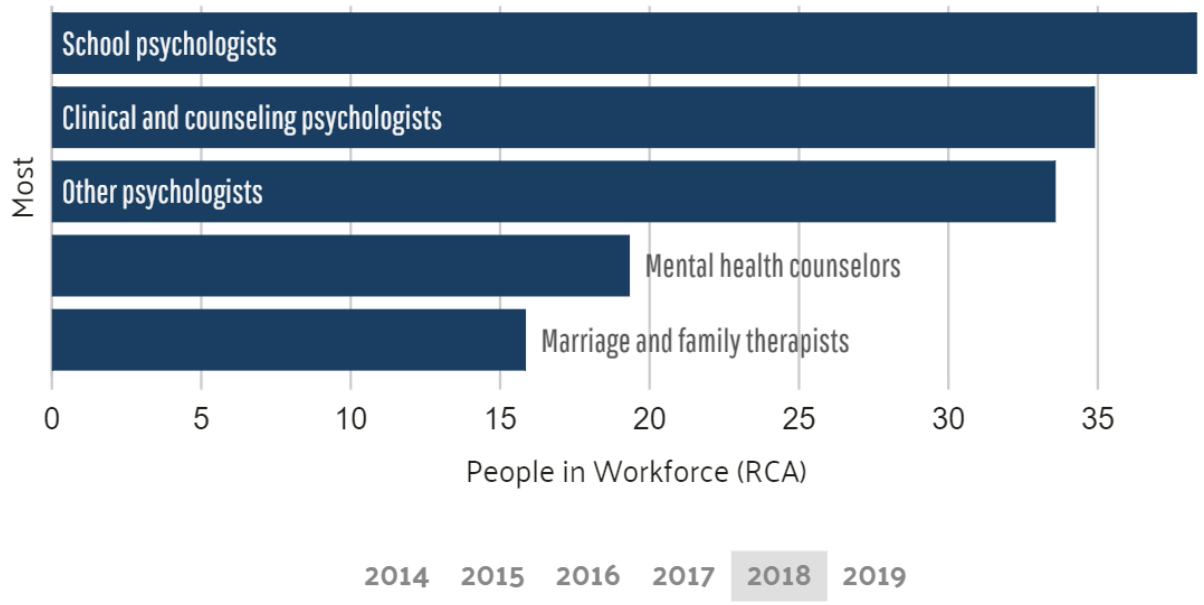

Figure 1. Most common occupations among psychology majors in 2018

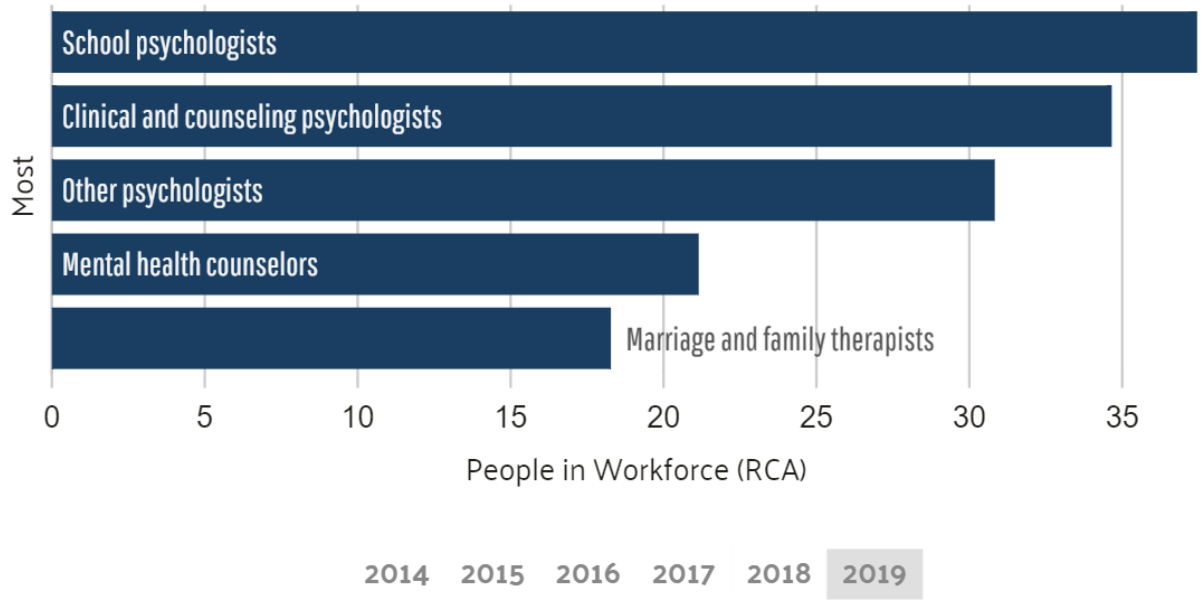

Figure 2. Most common occupations among psychology majors in 2019

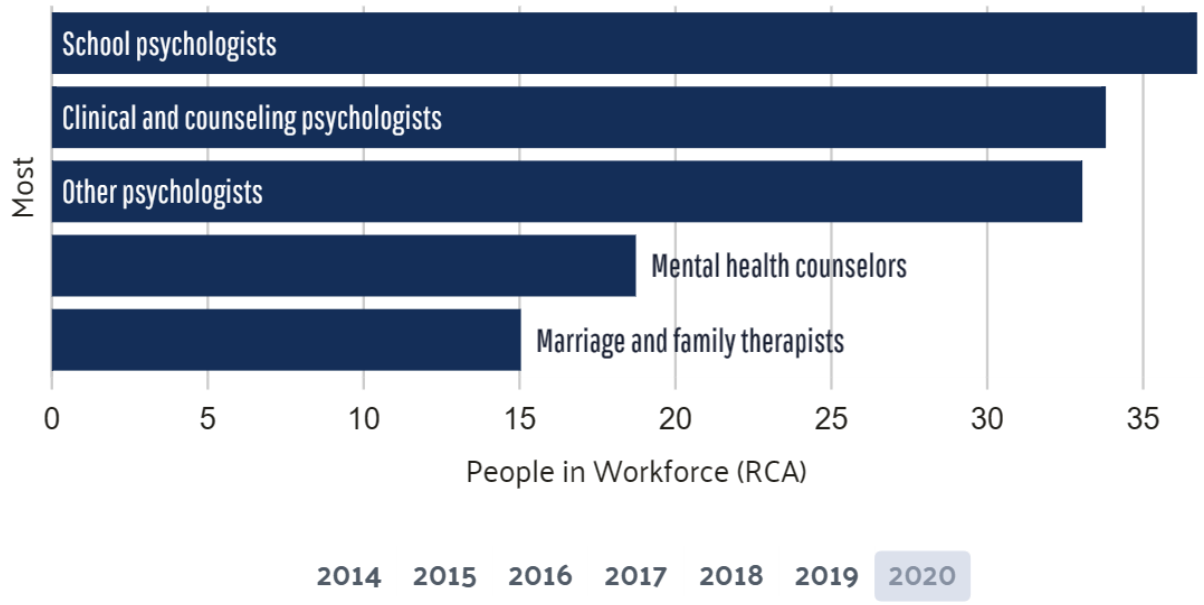

Figure 3. Most common occupations among psychology majors in 2020

As suggested by this data, most college students selecting psychology as a major eventually plan a career as therapists, which leaves them frequently surprised when encountering math requirements on their degree plan, more specifically in statistics courses (Rajecki et al., 2005) which reduces motivation to enroll in these courses in comparison to more popular content classes such as abnormal, social or personality psychology. Consequently, psychology students frequently frown on the reality of enrolling in at least an introductory course on statistics during their undergraduate education (Prayoga & Abraham, 2017), and often dread on the possibility of encountering more statistics courses through graduate programs (Counsell & Cribbie, 2020). This is unfortunate as courses in statistics can help us analyze and interpret data, identify relationships between variables and predict future outcomes related to our study in behavior and cognition (Ollson-Collentine et al., 2019), which lends further credibility to psychology research. Furthermore, learning statistical methods empowers a person to cut the middle source providing information of scientific findings, such as news outlets or social media, as much evidence exists

on the distortion of data or misinformation when the source is biased (e.g., Fenn et al., 2014). Instead, knowledge from a course in statistics and research design allows a person to read an article directly from the source, the researcher that conducted the study, and through the data reach a conclusion without interference from other intermediary sources. In essence, learning statistical methods allow us to become wiser consumers of information, and that is useful regardless of any area of specialization (including therapy).

Statement of the problem

Research methods courses can be perceived as difficult and dull by social and behavioral science students (Murtonen, 2005), and statistics courses are often among the most problematic for psychology students (Gal et al., 1997). There are multiple reasons for this, among them inadequate teaching methods, difficulties linking theory with practice, complexities with statistical concepts and negative attitudes toward quantitative method studies (Murtonen & Lehtinen, 2003). Aligned with the last point, two decades worth of academic literature suggest that psychology students continuously hold negative attitudes toward statistics, or neutral at best (e.g. Conners et al., Hogg, 1992; Ruggeri et al., 2008), and a majority of psychology majors will settle only for the required statistics modules while postponing them as much as possible (Onwuegbuzie, 2004).

Traditionally, negative attitudes toward statistics are explained by adverse experiences with mathematics through primary education, which can trigger negative emotions toward any related topic such as statistics (Onwuegbuzie, 2000). However, these dreadful attitudes are especially relevant among psychology students due to the misconceived connection of the discipline with qualitative oriented methods when associating the field with careers in therapy (Murtonen et al., 2008) and ignorance about the usefulness of quantitative courses with this area

of study (Griffith et al., 2012). Addressing the concept of attitudes and perspectives of knowledge in statistics courses, a research gap exists in tracing a potential link among these two variables; possibly the perspectives of knowledge that students generate in statistics courses can mediate attitudes toward the course. Therefore, an essential goal starts by understanding the perspectives of knowledge (epistemological frames) that psychology students enrolled in statistics courses generate, as well as the extent to which these frames can affect attitudes. If statistics educators understand these frames, they can modify them to maximize proficiency in these courses, ultimately aiming to lower the negative perspectives that psychology majors hold with this subject. In the end, learning statistics give us an opportunity to make logical decisions when solving problems and understanding its content is critical to establish credibility in research methods and results for our field (Prayoga & Abraham, 2017).

Purpose of the Study

The present study will explain epistemological framing and review academic literature on this topic across different disciplines such as biology (Ross & Luna, 2013), engineering (Shim & Kim, 2018; Wendell et al., 2019) and mathematics (Van de Sande & Greeno, 2012) to name a few. Interestingly though, despite the availability of research on this topic since Redish (2004) published an influential literature review almost 20 years ago, there is a notable gap about research on epistemological frames in psychology courses, even though the interest in frame theory emerged through the social sciences. Furthermore, this study will explain the distinction of epistemological framing to epistemological beliefs and its role in moderating attitudes, which establishes a link to explain how frames can control attitudes. Understanding epistemological framing will allow psychology professors to recognize the perspectives of knowledge that their students evoke and their impact in altering these frames through teaching strategies to shift

neutral or negative attitudes; this project holds the potential to improve the education system in our discipline if the awareness of unproductive frames halts student success and the existence of productive frames can enhance achievement.

Research Questions and Hypothesis

An essential goal starts by understanding the epistemological frames that psychology students enrolled in statistics courses generate, as well as the extent to which teaching strategies can alter these frames. This interest leads to the following research questions:

- Q1: What are the range of attitudes from students enrolled in a psychology-based course in statistics and would such range of attitudes significantly vary among instructors?
- Q2: What type of epistemological frames do students enrolled in a psychology-based statistics course generate?
- Q3: How do epistemological frames generated by these students relate to course attitudes?

The first question is quantitively oriented as it attempts to replicate findings from multiple studies testing preconceived attitudes that psychology students generate through a statistics course while also exploring the degree to which these attitudes change across instructors. As the data will be collected from multiple courses taught by different instructors with different years of experience and teaching techniques, there could be a variability among attitudes held in distinct classes. To test these student attitudes the scale used is the *Survey on Attitudes toward Statistics* (*STATS*; Schau, 2003). The second question is qualitatively oriented as the outcome of the first question will lead to the selection of students with varying attitudes who were interviewed to assess the epistemological frames generated through this course. The third and last question explored a connection between epistemological frames and student attitudes. The hypothesis for this study states that despite the range of attitudes generated through the course, there will be a

significant difference from the course of at least one professor, and epistemological frames evoked by students will follow different patterns among students with low (negative), medium (neutral) and high (positive) attitudes.

Outline of Chapters

The first chapter introduces the main theme and describes the background of the problem, along with information pertaining to the statement problem, in this case the concern about negative preconceived notions with statistics courses which gains relevance when acknowledging that psychology is growing popularity as an area of study. Lastly, the chapter concludes with a discussion of the research questions and general direction of the study. The second chapter explains the literature review on the variables of interest for this study, first explaining the theoretical framework by introducing the main thesis behind cognitive theory and one of its main contributions, the two systems of thought, also known as the duplex mind. This chapter emphasizes how the duplex mind helps to understand the vulnerabilities of automatic thought processes, yielding into processes such as framing. This topic has already been explored across different disciplines, including education, where it is best understood as epistemological framing. Furthermore, the chapter explains how framing can alter class lessons and its impact on academic achievement. The chapter concludes describing the connection between epistemological framing and epistemological beliefs, which establishes a theoretical connection to student attitudes. This connection supports the hypothesis by linking epistemological frames with student attitudes generated in statistics courses.

The third chapter describes the research methods for this study, which is a mixed methods approach as it combines quantitative data through the assessment of student attitudes toward statistics and is followed by the selection of students with varying attitudes to study

patterns of their epistemological frames and analyze the degree to which these can alter such different attitudes to the course. The chapter also provides data from an exploratory study ran over the summer of 2021 to test the methods proposed in the construction of this dissertation.

The fourth chapter provides an ample overview of the results collected through this study as it divides in three areas: quantitative findings, qualitative findings and an integrative approach combining data from both approaches. The quantitative findings provide an answer to the first research question and the first part of the hypothesis as it analyzes the quantitative data gathered by the *STATS* to explain the range of attitudes held by students enrolled in a statistics and research design course and compares the variability in these values across different courses to explore if there are significant differences. The qualitative findings analyze excerpts of the interviews collected to trace the existence of trends, some of which are immediately evident. Nonetheless, the integrative analysis allows for a better understanding of these patterns when the qualitative data is coded and the analysis breaks down into themes of productive and unproductive epistemological frames, which then evidence its impact in student attitudes toward this course.

The fifth chapter reiterates the results by discussing the implications of these findings while connecting them to research carried over epistemological framing and student attitudes toward statistics courses. The chapter then describes limitations and future directions from this study and concludes with a discussion on the importance of these findings. This study contributes to the literature on epistemological framing and its relationship to student attitudes in statistics courses.

Summary

Data from the Bureau of Labor Statistics evidence the irrefutable reality that psychology is growing in popularity over the last decade (Landrum, 2018) and despite the broad range of available occupations within this field, most college students plan careers in qualitative-oriented professions, such as therapy. This leaves students often surprised when encountering quantitative-oriented courses, such as statistics, as part of their degree plan and exacerbate negative, or at best neutral, attitudes toward them (Prayoga & Abraham, 2017). This dissertation explores epistemological frames that psychology students generate and the extent to which they affect their attitudes, since they can affect even the willingness to enroll in statistics courses (Hilton et al., 2004). The following chapters will carefully explain the theoretical framework, literature review, research methods, results and implications of these findings laying the foundation for this dissertation, which contributes to the literature on psychology education as a noticeable gap exists in the understanding of a relationship among epistemological frames and statistics courses.

CHAPTER II: LITERATURE REVIEW

Theoretical Framework

A theoretical framework is an important aspect of the research process as it serves as a foundation upon which knowledge will be constructed (Osanloo & Grant, 2016), as such it originates from established theories in our discipline that are validated to be used in scholarly literature. The field of psychology traditionally builds from two contrasting theories: psychoanalytic theory, which focused primarily on the mind, and behaviorism, which brought scientific methodology and an interest on observable behavior (Myers & Dewall, 2019). Hence the current definition of psychology as the scientific study of behavior and mental processes. However, contemporary psychology evolved since the 1960s as an outcome of a cognitive revolution leading to a third major branch labeled cognitive theory; the theoretical framework for this study is primarily situated on principles of cognitive theory.

Cognitive Theory

Cognitive psychology explores mental processes related to how we perceive, process and remember information; in essence how we think. Therefore, cognitive theory is an approach to understand human behavior by exploring thought processes (VandenBos, 2007). This theory explains basic principles of thought, one of its most recognized being dual processing, which refers to the principle of information simultaneously processed on separate levels. These two systems of thought consist of an automatic (often implicit or intuitive) process and a deliberate (often explicit or deliberate) process (Lizardo et al., 2016). This principle is held under different names on the field, some the most common ones being dual processing, dual track mind, two track mind, or my personal favorite, the duplex mind.

The Duplex Mind

A basic principle of psychology notes that humans engage in two ways of thinking, despite the disagreement in names, the principle remains the same: Humans operate on two levels of thought, which we can call System 1 and System 2 (Stanovich & West, 2000). Kahneman (2011, p.21) offer the following descriptions for them:

- *System 1 operates automatically and quickly, with little or no effort and no sense of voluntary control (mostly unconscious intuitions).*
- *System 2 allocates attention to the effortful mental activities that demand it. The operations of System 2 are often associated with the subjective experience of agency, choice, and concentration (mostly a conscious thoughts).*

Psychologists have explored the functions and distinctions among each and overall agree that a division of labor in these two systems allows our brain to remain efficient (Myers & Dewall, 2019). While System 1 operates automatically over our daily actions, System 2 remains below to conserve low-effort and save mental energy. Ideally, if System 1 ran into unexpected or difficult tasks, then System 2 would support by offering deliberate and analytical thought processes that would address a problem with its backup of previously saved mental energy. Most often, the division of labor among these systems minimizes effort and optimizes performance. Numerous examples can help us envision these systems of thought, a common one being the act of driving. If we are used to drive the same route on a continuous basis we tend to turn on the car and start driving along the same route as an unconscious act of habituation, sometimes we may even start driving and realize once we reach our destination that we spent time driving and did not had our mind on the road, but rather on external stimuli like background music or conversations with other passengers. However, if we are driving to a new location and we get lost, or if traffic gets

heavy, we immediately reduce the number of distractions by lowering the music or stopping the conversation with the passengers as we intuitively attempt to focus. The automatic habit of driving through the same route is run through System 1 as it keeps us in low-effort while saving mental energy, however, if we encounter unexpected or difficult tasks such as driving through a new road or navigating through rough traffic, we shift to system 2 as an effortful mental activity now demands it to take control over our actions; this is an example of the wonderful capabilities of our duplex mind. As visualized through Figure 2, researchers corroborate the existence of these two modes of thinking even from a biological standpoint.

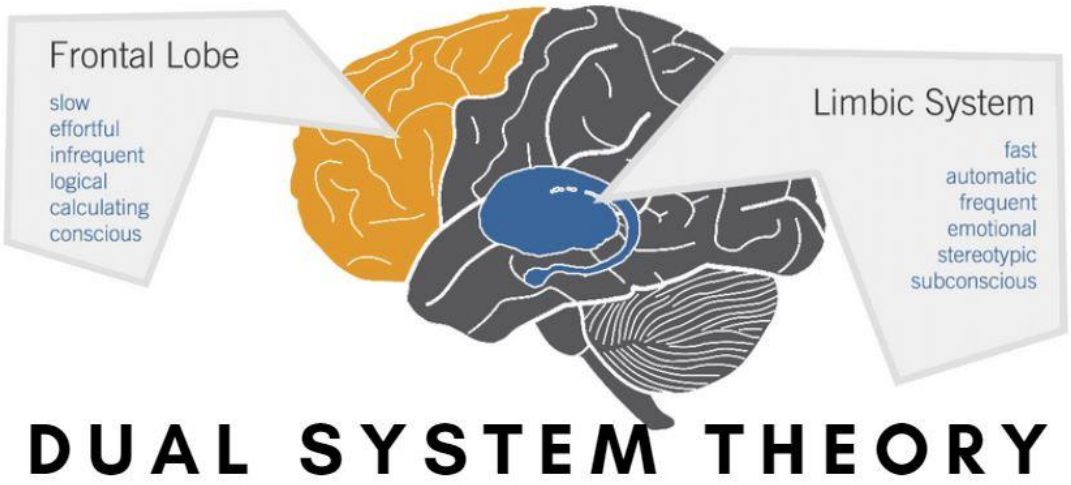

Figure 4. The two modes of thinking generally involve even different pathways as evidenced by neuroscience studies (Gerrard et al., 2008).

According to Kahneman (2011), this dual thought is effective as System 1 is generally capable in its tasks, such as "models of familiar situations are accurate, its short-term predictions are usually accurate and its initial reactions to challenges are swift and generally appropriate" (p. 25). For most of our day-to-day actions we can run on an automatic mindset as it is supported by characteristics that ease for us its ongoing use: intention, control, effort, and efficiency (Baumeister & Bushman, 2020). Automatic thoughts can often happen outside of our awareness,

as noted by the previous example related to driving, they are not ruled by intention, nor are they controlled by deliberate effort. Most importantly though, thoughts from System 1 are efficient as they can allow us to retrieve, encode and provide information faster than the slow and burdensome thought processes from System 2. However, principles in psychology address the limitation of System 1 as its ongoing use leads our thought process to rely on it more than needed, ultimately leaving us as "cognitive misers" (Fiske & Taylor, 1991), which is a term used to describe our refusal to engage in analytical thought, even if the situation demands it. A common example highlighting the use of different systems of thought comes from the Stroop test (Stroop, 1935), which is illustrated in Figure 3.

Figure 5. Stroop task.

Within the strengths of System 1 also lies its weakness as we spend most of our time on 7automatic thoughts that do not require intention, control or effort while sustaining a considerable amount of efficiency; yet a problem arises when we encounter situations that demand our deliberate thoughts from System 2, as highlighted by the incongruent list from the Stroop test. The problem is that we get used to System 1 and may refuse the use of analytical thinking when prompted to do so. In other words, the over-reliance in automatic thoughts from System 1 makes us reluctant to engage in the conscious thoughts of System 2, since it requires effort. Interestingly, this concept even carries its own name as a *principle of least effort*, which applies to any information-seeking activity as an organism tends to choose a course of action requiring the smallest amount of effort or use of energy (Fisher et al., 2005) and echoes on similar concepts such as the principle of least action in mechanics or the path of least resistance in physics. This informally called *Law of least effort* asserts that when different options exist to achieve a goal, we tend to gravitate toward the least demanding course of action; as noted by Kahneman (2011) "In the economy of action, effort is a cost, and the acquisition of skill is driven by the balance of benefits and costs. Laziness is built deep into our nature."

Consequently, the over-reliance on System 1 leads us to become lazy thinkers (a term popular with my students). What is the problem with lazy thinking? The reluctance to engage in System 2 can lead System 1 to systematic errors in specific circumstances, such as the misinterpretation of data when our brain attempts to simplify information. As will be explained over the next section, these self-imposed cognitive limitations, such as *unproductive frames,* are not always in our best interest, yet they are natural and addressing them can be beneficial on multiple aspects of life, including education.

Framing

Framing is an interpretation to a situation, also described as an answer to the question "What is going on here?" (Goffman, 1974). To properly understand it, we first need to explain a concept in cognitive theory labeled *schema*. In psychology, a schema refers to a concept or framework that organizes categories of information and the relationships between them (Myers, 2014), this concept was originally coined by Jean Piaget to explain the foundation of cognitive development through our childhood life stages, and as we collect experiences through life, we build more schemas to organize information to simplify our understanding of new information. Our schemas prompt us to notice primarily information that fits in it, and schemas can often remain resistant to change, even when encountering contradictory information as we are prone to organize new information into our schemas as an attempt to minimize our cognitive effort (Georgeon & Ritter, 2011). An example of a schema is a stereotype, to reduce the complexity of understanding each person we meet, which would overwhelm our mind, we tend to sort people in categories based on a salient characteristic, like a physical trait. This is an automatic reaction of our System 1 to reduce effort. However, as mentioned above, our schemas lead us to continuously notice information that fits in it, so we may carry a bias toward a person based on our stereotype, which would facilitate our perception of information that confirms our beliefs. Furthermore, when encountering contradictory information, we are prone to organize it into our schema to avoid the deliberate efforts required by System 2. For example, if a person holds a stereotype, it will be easier to notice information that validates the stereotype (*believing that all women are bad drivers and while driving only noticing mistakes done by women while driving*). If that person encounters contrary information to the stereotype (*a woman driving without flaws*), there will be two options: confront the previously held beliefs by reasoning with deliberate

thoughts (*maybe not all women are bad drivers*) or find an easier solution such as holding the contrary information as an exception, while still maintaining the stereotype (*this woman knows how to drive, but the rest are still bad drivers*). Following the law of least effort, the second option is more likely; this is the reason why stereotypes are so hard to change, they require effortful thoughts, but we are lazy thinkers.

How do schemas relate to framing? Through schemas, we predispose our mind to generate specific frames based on our life experiences (Baumeister & Bushman, 2020). Just as schemas are a natural occurrence to facilitate our interactions with the world, framing help us navigate the world by narrowing our perception to account for small bits of information that we consider relevant, acting as an interpretation to a situation (Myers & Twenge, 2019). For example, humans can absorb 11,000,000 bits of information of which we consciously process only 40 (Wilson, 2002), it makes sense why we would need to create schemas that groups information and further narrow our perception by asking ourselves "What is going on here?" to consciously process only the information that we deem relevant.

Framing is predisposed by schemas, which are created by life experience; thus, two individuals with different life experiences can perceive the same situation differently. Russ and Luna (2013) provide an everyday example when describing the case of an informal conversation with a colleague before the start of a meeting can alter frames if the colleague opens a laptop, leading to an altered frame from "casual conversation with a friend" to "meeting about work," even if the colleague did not intend to switch frames when opening the laptop. In the same way, a professor may unknowingly prompt students to shift frames from "free time" to "class time" by remaining silent and establishing eye contact, which may change the behavior of students from speaking with each other to remaining quiet as they expect lecture to begin. An interesting point

to consider here is that a source generating frames, in this case the professor, may not be aware of how simple verbal and non-verbal behaviors can modify the interpretation of a situation. Therefore, the way in which a situation is framed can alter the interpretation of a message, which gives the messenger enormous influence (Entman, 1993). As frames are an outcome of System 1, even slight changes to an activity or context can alter frames (MacLachlan & Reid, 1994).

Frames act as a quick way to process information when we remain on an automatic level of thought (System 1); this can leave us vulnerable as the way a subject is presented can influence our decisions and judgements if this is misinterpreted (Myers & Twenge, 2019); therefore, framing can be a powerful tool to exert change in thought. For example, a framing effect exists when positive or negative connotations about a situation generally persuade different perspectives as the different ways in which information is presented evoke diverse emotions (Kahneman, 2011). A classic study on the framing effect was conducted by Tversky and Kahneman (1981) when participants were asked to choose between two treatments that would be used on a group of 600 people to battle a deadly disease. This scenario was proposed either on a positive or negative frame.

- Positive frame: Treatment A saves 200 lives, while Treatment B holds a 33% chance of saving all 600 people and a 66% possibility that no one will survive.
- Negative frame: Treatment A will have 400 people die, while Treatment B holds a 33% chance that no one will die and a 66% probability that all 600 will die.

While 72% of participants chose Treatment A presented with a positive frame, only 22% chose it when the option was introduced with a negative frame. Other studies have replicated this result, for example 93% of PhD students registered early when a penalty fee for late registration was emphasized, unlike 67% that did so when a discount for earlier registration was accentuated

(Gachter et al., 2009). Kahneman (2011) also notes that statements such as “the odds of survival one month after surgery are 90%” is more reassuring than an equivalent statement suggesting that “mortality within one month of surgery is 10%.” Or to keep it even more simple, food that is “90% fat free” is more appealing to the regular costumer than something described as “10% fat.”

As framing refers to an interpretation about a situation, these examples evidence how unawareness of its existence can dramatically alter thoughts or choices, especially when a person over relies on an automatic mindset and falls for misguided, or unproductive, frames when it condones decisions or thoughts without properly analyzing information (Kahneman, 2011). However, recent research suggests that framing is pervasive and dynamic (Tannen & Wallat, 2018) thus an adequate prompt by external factors can promote effortful/analytic thoughts that can ultimately shift to productive frames (Bryant et al., 2012). This leads to our interest of frames in education, which is primarily focused on the study of epistemological framing.

Literature Review

A theoretical framework builds a foundation for a scholarly review, which then explains the problem statement, the purpose, significance, and research questions (Osanloo & Grant, 2016). Cognitive theory led to our understanding of the duplex mind, and by exploring this concept we understand how humans are prone to engage in automatic thoughts to simplify the world, hence why framing occurs. However, the prevalent effects of framing can undermine our perception of information, hence why it is a critical concept in education. As this second chapter shifts from the theoretical framework to the literature review, it will explain how framing is understood in the field of education and understand its importance across a range of different disciplines, excluding psychology where a significant gap exists in research related to statistics courses.

Epistemological Framing

As previously discussed, framing acts as an interpretation to a situation, or an answer to the question "What is going on here?" (Goffman, 1974). Research in learning sciences evidence the existence of frames in education within a context of knowledge, which can be answers to questions such as "What do I expect to learn?" and "By what standards will my intellectual contributions be judged?" (Redish, 2004). By the time a student steps into a new classroom there are many years of experience that already built a schema for what is the situation: where to sit, what to do, how to act. Past this point, class begins, and students generate frames to develop expectations about what they are supposed to do, such as selecting portions of information to decide what is relevant to succeed in a course (Scherr & Hammer, 2009); this notion of students' framing emphasizing knowledge and learning is known as epistemological framing. Sometimes students and teacher match on their epistemological frames and the expectations of both are met, other times the student expectations do not match those of the teacher, leaving both dissatisfied.

An interest on epistemological framing began with an influential scholarly review by Redish (2004) who discussed multiple learning processes that were addressed by research on cognitive psychology and neuroscience. The author initially addresses that a general concern exists for student knowledge and how it is constructed, which is referred to as epistemology, is of primary importance to educators (p. 29), yet there is often omission of the distinction among declarative and functional epistemology; the first referring to statements about the nature of knowledge and the latter as the method to construct knowledge. While much research abounds regarding declarative epistemology, there was a need to study functional epistemology, thus the author concludes that academics "need a finer grained analysis of the resources associated with

knowledge construction and with the control and activation of these resources" (p. 30) and considered epistemological framing one of these important resources.

Redish (2004) describes framing as a process in the cognition of individuals yet hypothesized that such individuals ultimately choose an input from prompts of the external world, and this selection is influenced by the physical world, by culture and by social interaction. Indeed, by the time that a college student steps into a classroom there are years of experience that lay out expectations for what to do in class or how to succeed in a course, and if these thoughts are aligned with those of the teacher there is success, if there is incoherence though both may feel disappointment. A combined analysis of epistemological framing, available resources and an actual message can provide "a very rich and revealing analysis of student knowledge construction" (p. 30). The author described framing from its roots by citing theories of Bateson (1972) and Goffman (1974), the founders on the study of framing, and described framing as the way in which individuals select, organize, and respond to situations. Even though framing is part of cognition, the following characteristics explains it in depth (p. 33):

- *Framing is carried out by the individual in response to social and physical experience.*
- *Framing responds strongly to social cues.*
- *When interacting individuals frame a situation differently, it can cause serious communication problems.*

Regarding epistemological framing, Redish (2004) explains that students frame situations when they enter a classroom. This framing process contains the following characteristics:

- *A social component (Who will I interact with and how?)*
- *A physical component (What materials will I be using?),*

- *A skills component (What will I actually be doing?)*
- *An affect component (How will I feel about what I'm going to be doing?)*
- *An epistemological component (How will I learn / build new knowledge here? What counts as knowledge here?)*

At last, the author explains that epistemological frames can be rigid or fluid, depending on the situation and invites educators to analyze not only the epistemological resources available to teach, but also the epistemological frames that students create. Sometimes the difficulty to grasp a lesson might not relate to student knowledge about a topic, but to how the student framed the situation. An everyday example for any teacher happens when we ask students a question related to class material, the situation prompts students to seek out an answer through their notes or textbook instead of thinking about the question to offer a response based on their knowledge; the student and teacher framed the situation differently (p. 34). The author further exemplifies epistemological framing with an observation based on a tutorial run by Mcdermott and Shaffer (2001) where a group of students collaborate on a physics activity, yet two students, Jan and Veronica, frame the lesson different. The following excerpt provides details of this interaction (p.35):

Claire: But what's the normal direction of the light? Cause that's what I'm asking.

Veronica: It spans out, and whatever passes through that circle is the part we're going to see.

Jan: So the light is like that [drawing], and these are the rays, and the vector that points that way is going to go through the hole.

Claire: Ok, so then if you move it up then it's going to be…?

Claude: … [unintelligible] …the light…

Jan: Right. So like it has…[pause]

Veronica: Really, it's just normal.

Jan: All the rays are going like this. So, it's kind of like polarized.

Veronica: [pause] Mmmm. Not really. [long pause] It's just, well, it's just, guys, you're making it, you're trying to make it too difficult. It's just, the light goes out. It only goes through that one circle. So, obviously, if it's down here [pointing to the screen], and I'm looking [back towards the light] through that circle… Look. You're sitting down here [pointing to the screen]. You're looking up through that little circle [pointing to the mask]. All you're going to see is what's up there. It's a direct line.

Jan: [overlapping] Look, I see what you're saying, right? But I'm just trying to make it like physics – physics-oriented. [laughs]

Veronica: [decisively] It is physics-oriented. That's just the way it is.

Jan: [in a low voice] Okay

While Veronica continuously frames the activity as an opportunity to make common sense (noted by comments such as "you're trying to make it too difficult"), Jan frames it as an opportunity to apply formal knowledge (noted by comments such as "I'm just trying to make it physics-oriented"). Furthermore, the authors assert that follow-up interviews and written assignments evidence this pattern in Jan as she often relies on technical vocabulary and does not attempt to make sense of the lesson. Although interestingly, another analysis of discourse evidence how Jan can conduct tutorials where she demonstrates an ability to engage in common sense reasoning yet chooses to not to do so in situations that she does not consider appropriate. This observation exemplifies how students' difficulties in doing physics the way their teachers want is not due to conceptual difficulties or misconceptions, but due to inappropriate

epistemological frames to a learning situation. Jan can engage in common sense reasoning like Veronica, but she may need a prompt to do so in situations unrelated to tutoring.

The author closes this literature review by explaining that different elements can alter the epistemological frames that students create. For example, an instructor might say "It's really important for you to learn the concepts and to make sense of the science you are learning" but if the homework only requires plugging numbers to find an answer to an equation, then incoherence exist as the explicit message contradicts the activity at hand, furthermore an instructor may follow up with testing such limited skills and the message gets lost (p. 40). Despite the plead to make sense of the science being taught the message may translate to "what matters is knowing the equation, not make sense of the science." Thus, awareness of predominant epistemological frames evoked not only by the instructor, but about teaching techniques is essential for a coherent, and thus more consistent, class lesson. Along the same route, instructors should realize the different types of frames that can activate even by the structure of a classroom. A good example exists on the distinction of traditional classrooms and SCALE-up classrooms (Burke, 2015) as illustrated in Figure 4.

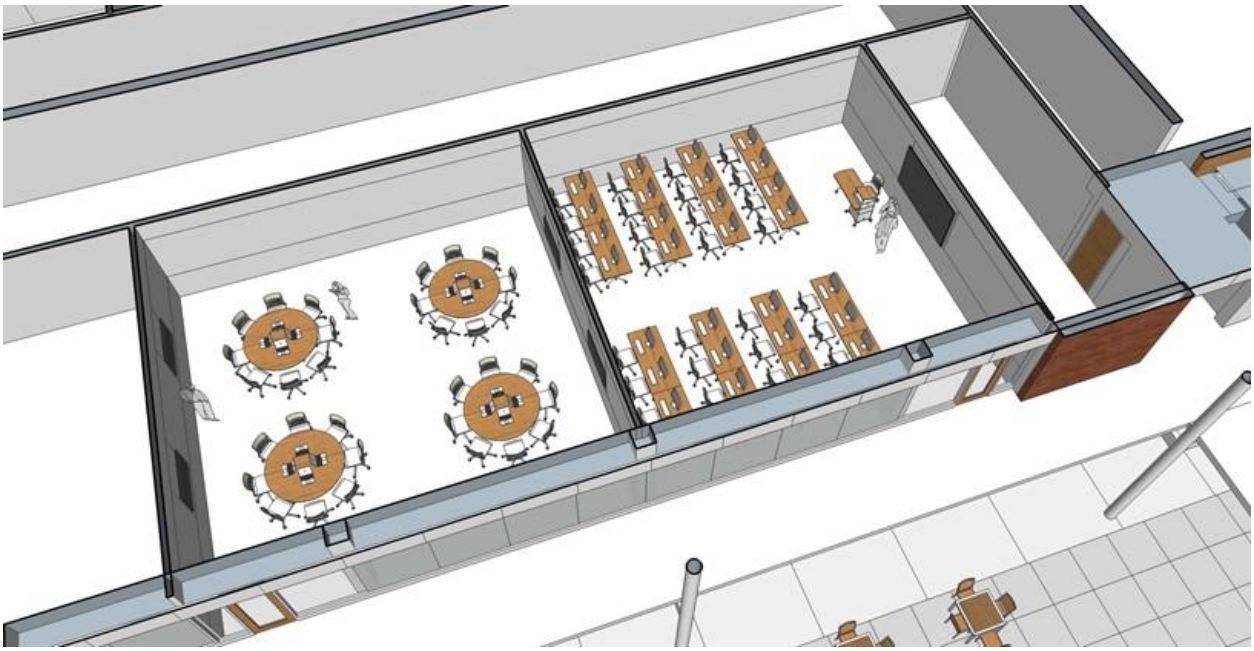

Figure 6. On the right side is a traditional classroom where students do not expect an interaction with classmates or the instructor, activating frames related to note taking and listening to understand the lessons from the lecturer. On the left side is a SCALE-UP classroom that immediately prompts students to recognize an unusual course format, which prompts epistemological frames related to group learning as they are less expectant of a traditional lecture.

Redish (2004) concludes that epistemological frames can be controlled by teachers as the way in which a situation is framed by the message, in this case the class lesson, can alter its interpretation giving the messenger, in this case the instructor, great influence over how receivers interpret a message (Entman, 1993). The influence of this scholarly review impacted academia as research over epistemological framing gained prominence on the learning sciences. An early contribution by Engle (2006) explained framing as the implicit communication used by participants to understand expectations on their action and participation in the classroom; therefore, framing is not focused on the way that a source (in this case a professor) presents the information, but rather on how a student understands this information. Echoing early perspectives that shifted the interest from the professor to the student, Greeno (2009) built on the same concept to explain that every student in a classroom can have a framing that may or may

not be aligned with framings of other students. Recent studies confirm this hypothesis as evidence suggests that students with diverse epistemological frames can even understand the same lesson differently since the interpretation of a lecture is not directly tied to the lecture itself, but to the perspective that a student creates about the subject (Krupnik et al., 2018). Therefore, a productive epistemological frame of the student coherent with the frame of an instructor can influence whether class instruction will achieve successful or unsuccessful goals (Hammer et al., 2005). Then a question gains relevance, what differentiates an unproductive from a productive frame? The answer may lie on the duplex mind.

Productive and unproductive epistemological frames

On a similar note as the duplex mind, much research on epistemological framing focused on the existence of productive and unproductive epistemological frames. As noted on the following examples, unproductive frames often involve automatic thought processes that require little to no effort or no sense of voluntary control (System 1), while productive frames require conscious efforts and prompts the student to take ownership of education (System 2). Hutchinson and Hammer (2010) provide an example through a case study comparing a productive and unproductive epistemological framing in a science classroom. Under an unproductive frame, the student relegated knowledge to the authority figure, the teacher, and perceived his role as a static source limited to receive and repeat the knowledge (Jimenez-Aleixandre et al., 2000), furthermore exerting efforts solely to follow a procedure rather than attempting to interpret the content of scientific information. This approach contrasts to the productive frame leading students to recognize their role in producing knowledge and exert the effort to establish logical sequences of information to "do science." However, it is important to remember that as we are prone to use an automatic mindset due to our nature as cognitive misers, the authors note that

"the case study demonstrates how some student activity commonly seen as undesirable may be evidence of productive framing, and activity commonly viewed as desirable may be seen as evidence of unproductive framing" (p. 506). The student might not be willing to exert effort to establish a productive frame, thus deeming it undesirable and instead shift to an unproductive frame, which is perceived as desirable.

Examples of unproductive frames include group work strategies solely devoted to find answers without deliberation or consultation with each other, often evoked by comments such as "one less thing for us to find" and a trend of "this is the right answer for the question" without inquiring each other (Scherr & Hammer, 2009), this "cut and paste" mentality can also be prominent in group work when a high achieving student earns a reputation as an unquestioned authority of knowledge and classmates rely on individual contributions from this student without assessing the value of other contributions (Shim & Kim, 2018). These last authors conducted a study testing shifts in frames in group work and noticed a pattern of unproductive frames when students considered the highest achieving student in the group as the sole source of knowledge, which limited the amount of discussion and instead relied on epistemological resources such as "accumulation" of information relied by the highest achieving student and "acceptance of information without doubt" (p. 137). A follow-up interview confirmed these epistemological frames as students did not feel a need to construct knowledge as a group as they held two more epistemological resources by holding "trust in authority" and maintained "knowledge as propagated from authority," which resulted in unquestioned acceptance of information even if they could not understand the logical sequences from the lesson. Under this assumption, the perception of a high achieving student as the sole source of knowledge mimics the perspectives held with unproductive frames when the teacher is perceived instead as the authority figure in a

traditional classroom setting and students cannot envision their role in the construction of knowledge.

A pattern of unproductive frames in traditional classroom settings echoes on the misconception of lecture as an attempt to hoard facts without relevance or a classroom strategy of accumulating facts without considering their connection to real life (Hutchinson & Hammer, 2010). The authors from this last study explain that students in science classes often believe that activities solely require the production of an answer for a teacher or a test, rather than an attempt to make sense of the real world, and this can often be reinforced by a teacher that asks a question and considers a single word or short phrase as a correct response without encouraging for discourse. The following excerpt further emphasize this point by the authors:

While educators are justifiably dismayed that this is how the students do homework, it is important to recognize that from a student's perspective it is reasonable behavior. We presume the students in this episode have a history of academic success, and what we see them do is simply what has served them well in school science in the past. A number of accounts in the literature tell a similar story.

For the most part [students] were asked to accumulate facts that seemed to have little relevance to their lives and to complete tasks accurately and efficiently without delving deeply into subject. An A grade, therefore, did not necessarily mean that the students learned and retained content area knowledge and skills or that they understood important concepts or theories; rather, the grades proved that the students were adept at providing the teachers with the information required on tests and quizzes, and that they memorized these facts and figures just long enough to "ace" the exams and move on to the next set of tasks. (p. 156)

Even though teachers may feel discouraged by these frames, their own actions can retain or strengthen such misconceived strategies to generate knowledge. For example, studies analyzing classroom discourse identify teacher-student interactions where a teacher can ask a question to which a student responds with a single word or short phrase and the teacher evaluates as correct or incorrect without delving into dialogue to encourage them to rationalize the question or to generate their own knowledge (Lemke, 1990), thus leading students to be part of this "classroom game." A similar example is explained by Redish (2004) when explaining how a visit to the lecture of a fellow physics professor prompted introspection and an eventual realization that interactions among students and teachers led to a unique opportunity to maintain unproductive frames or foster productive frames:

At one point, he projected a diagram of electric field lines from three charges. The figure was quite complex with lines looping and curving everywhere. After he had finished, he called for questions. A student asked him to explain why the diagram looked like that. He treated the question as a technical one and spent a few minutes explaining why field lines never crossed. He asked if the student was satisfied and got a mumbled "Yes" in response.

I found this event quite thought provoking. Watching the student from behind and trying to read the hesitation in his voice and his body language, I felt the student was asking a much simpler question: "What's an electric field and what do those lines mean?" I was convinced that my colleague's technical answer left the student even more confused than he was at first. I was interested in the fact that I did not know which of us had interpreted the student's question correctly and I realized that often in my own response to questions I usually assumed that I understood what the student was really asking without confirming my interpretation. Since then, I have been careful to make it my common practice to respond to a student's question with

another question, one designed to clarify for me what the student is really thinking and what question the student is really asking. Often I find that a student has "technified" the question in order to make it seem he is more knowledgeable about the subject than he actually is. I often have to start any explanation I am offering at a lower level than I first expect. As I have become more experienced in questioning students, I find that questions carefully posed are often better than an explanation. If the student generates the explanation himself, he feels better about the physics and is more likely to feel that he can possibly answer some questions by himself. (p. 43)

Again, it is important to remember that students step into a classroom with years of education lending information that create expectations for how to succeed (Elby, 1999), and a teacher emphasizing the use of technical terms or short phrases as correct answers could continue to prompt such unproductive frames (Scherr & Hammer, 2009), or students may perceive inconsistent frames when teachers employ productive frames when conceiving errors as resources, but then devise lessons perceiving errors as deficits, which leaves students ambivalent about the real perspective of knowledge (Alvidrez et al., 2022). Therefore, we must consider the role of instruction and natural shifting phenomena of frames which deems lesson with an opportunity to foster productive frames when we encourage students to switch from an automatic (System 1) to a deliberate mindset (System 2).

Examples of productive frames often resemble System 2 as they allocate attention to effortful mental activities, which require subjective experiences of agency, choice, and concentration. A classic example of productive frames in traditional classrooms is given by Rosenberg et al. (2006) who studied a group of 8th grade students participating in a discussion beginning through the question "How are rocks formed?" which sought to engage students in an activity attempting to explain a rock cycle. Initially, the students struggled by using complex

words that they could not understand (such as repeatedly mentioning “teutonic plates”) without progress. The authors noted how students used different epistemological resources prompting unproductive frames, such as “the organization of efforts around retrieving information from a worksheet” and an attempt to “combine information and construct sequences to present formal ordering rather than a casual sequence” (p. 271). This changed dramatically through the following intervention from the teacher (p. 272):

Ms. Phelan: Can I make a suggestion?

Bethany: Yeah.

Ms. Phelan: You're looking at a lot of papers and using a lot of words that you don't know what they mean.

Gustavo: ["Sure we do"?]. [Ryan laughs]

Ms. Phelan: And if you're doing that, for your model, it's not going to be very good. So, I want to start with what you know, not with what the paper says

This feedback led to a dramatic shift in students’ behavior as they began exerting effort toward describing information they knew and helped them become increasingly engaged as they shifted from a “cut and paste” to a “storytelling” epistemological framing once they developed their own answers to make sense of these scenarios and followed the logic of their description. This even encouraged students who previously remained silent to participate as they became active members in the construction of knowledge (Rosenberg et al., 2006).

Within the structure of a traditional classroom, a more recent example by Krupnik et al. (2018) made a comparison among two students who attended together a mathematics lecture

about rational numbers yet constructed different frames. While one student differentiated among the logical and psychological methods to understand mathematics, she envisioned the intellectual contributions of her professor as a logical basis to improve her cognitive understanding of rational numbers, thus improving the value of this lecture; meanwhile the other student understood the lecture as an attempt to enhance her perception of rational numbers, an area in which she already felt well versed and thus dismissed the value of the lecture. The authors concluded that knowing the reasoning behind a student perspective of knowledge is essential to foster productive frames.

Within group work settings, studies have also explored patterns of productive framing. For example, prompts to shift positionality among classmates would allow every student in a group to lead during discourse, rather than permitting one student to own the role as a core source of knowledge (Shim & Kim, 2019), or a shift in positionality where students can own the role of question-maker and answer-gatherer can foster multiple viewpoints to maximize their understanding of knowledge (Shaban & Wilkerson, 2019). As evidenced by these studies, research on epistemological framing indicate an emphasis on conscious thought processes and evidence the influence of teaching strategies to construct productive frames; ultimately the existence of productive frames links to student success (Hutchinson & Hammer, 2010).

Epistemological Framing and Epistemological Beliefs

To transition this literature review to student attitudes, is necessary to review the role of epistemological beliefs as a bridge that connects these areas. Epistemological beliefs affect student outcomes by altering the epistemological frames that an instructor holds and transfers to students, which affect several variables, such as student attitudes toward the subject being taught (Nasser & Birenbaum, 2005), as in the subject of interest to this study, statistics (Griffith et al.,

2012). Although the literature connecting epistemological beliefs to epistemological framing is scarce, it can nonetheless suggest a relationship.

First, beliefs in general can be described as subjective claims that an individual accepts or holds as truth (Pajares, 1992; Richardson, 1996) along with the notions of what should be, ought to be or is preferable (Basturkmen et al., 2004; Fives and Buehl, 2012). These beliefs can be important foundations for attitudes, yet they can be difficult to change (Anderson et al., 1980). Regarding epistemology, epistemological beliefs are defined as beliefs about the nature and acquisition of knowledge, which usually influence how people think and reason (Hofer & Pintrich, 1997). However, it is important to emphasize that these are still beliefs, not always actual knowledge, which is characterized by the "truth" component that can be validated through a larger community (Richardson, 1996). Therefore, a person may hold beliefs without knowledge and knowledge without beliefs (Fives & Buehl, 2012).

Epistemological beliefs are part of teachers' professional competence (Blomeke et al., 2008) and these beliefs can impact their selection of learning tasks and instructional activities in the classroom (Depaepe et al., 2016). Multiple studies justify the importance of analyzing these beliefs due to their roles as filters (e.g., Hermans et al., 2018), frameworks for decision making (e.g., Rimm-Kaufman et al., 2006) and guides for action (e.g., Hancock & Gallard, 2004; Fives & Buehl, 2012). Like beliefs in general, epistemological beliefs are difficult to change (Depaepe et al., 2016), yet epistemological frames hint to be a solution. A literature review by Chong and Druckman (2007) discussed three major characteristics of beliefs:

- People draw their opinions from a set of available beliefs stored in memory.
- Only some beliefs are accessible at a given moment.

- Out of the set of accessible beliefs, few are strong enough to be judged relevant or applicable to the subject at hand.

Framing can work on all three levels as they make new beliefs accessible and applicable in evaluation of an issue (p. 111). Therefore, exerting efforts to promote productive frames on statistics classrooms can alter misconceived beliefs about statistics courses for psychology majors and sharpen the efficacy of instruction (Ruggeri et al., 2008). The value of attending to epistemological frames can also be relevant to alter knowledge and attitudes. Fives and Buehl (2012) describe knowledge as information containing a truth component that can be externally verified using procedures accepted by larger communities, and research about general framing evidence that fostering productive frames can enhance knowledge as it becomes more available and comprehensible to the individual (Druckman & Nelson, 2003). On the other hand, attitudes act as global evaluations toward an object or issue (Myers & Twenge, 2019), and while the research conducted up to this point have not found a link from attitude to framing, research does suggest that epistemological beliefs can have at least an indirect effect on negative attitudes held by students (Nasser & Birenbaum, 2005).

Therefore, framing make beliefs accessible and applicable in the evaluation of an issue (Chong & Druckman, 2007), and as opinions are drawn from beliefs stored in memories and these can be judged as relevant to a topic at hand, they have an effect on attitudes (Nasser & Birenbaum, 2005). Although there is no evidence of a direct link between frames and attitudes, there is evidence of an connection among frames to beliefs, and beliefs to attitudes. In the context of education, epistemological frames can alter epistemological beliefs, which can subsequently affect student attitudes. The following figure can help visualize the role of epistemological beliefs as a bridge connecting epistemological frames to student attitudes.

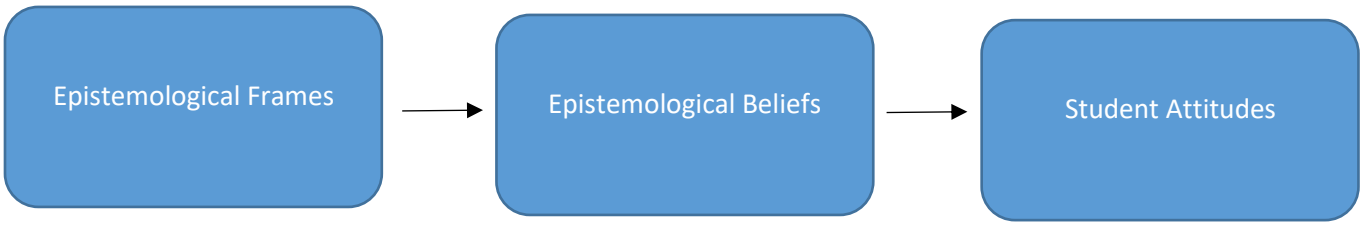

Figure 7. Theoretical connection among epistemological frames to student attitudes.

Bridging Epistemological Frames to Student Attitudes

The main interest in this study is on epistemological frames and student attitudes, however, a gap in research exists as academic literature cannot directly connect epistemological frames to student attitudes, the literature solely supports an indirect relationship by establishing epistemological beliefs as a mediator that bridges these factors. As already discussed, multiple studies link epistemological frames to epistemological beliefs (e.g., Chong & Druckman, 2007; Ruggeri et al., 2008) and additional academic reviews evidence the impact of dual processing systems (duplex mind) as moderators to the effect of beliefs (Ball et al., 2018). Consequently, evidence exists about the impact of epistemological beliefs on student attitudes (Griffith et al.m 2012; Nasser & Birenbaum, 2005).

The interest of this study tracks directly to the connection among epistemological frames and student attitudes, which leads the remaining academic review and research questions on these two variables, while pushing aside the concept of epistemological beliefs once its role as mediator is explained. This literature review will now focus on student attitudes toward statistics and their suggested relationship to epistemological frames.

Student Attitudes toward Statistics

The concept of student attitudes toward statistics courses has been studied for over 30 years, with outcomes suggesting that psychology students often hold negative attitudes (e.g.,

Conners et al, 1998; Hogg, 1991; Ruggeri et al., 2008; Schutz et al.,1998), or neutral at best (Counsell & Cribbie, 2020; Schau & Emmioglu, 2012), up to the extent at which many may perceive required statistics courses an obstacle toward reaching their academic goals (Dunn, 2000; Laher et al., 2007), and as a result, students can even avoid or postpone quantitative statistics courses (Prayoga & Abrams, 2012; Slootmaeckers et al., 2014). From a personal standpoint, I held negative attitudes toward these courses as an undergraduate student and evolved indeed to a more neutral attitude until I continued with these courses during graduate school. My perspective became positive until I had a chance to teach statistics, but surprisingly now in the role of a professor I have noticed at times how students can maintain negative attitudes when describing their experiences in these courses. This led to the interest in exploring this topic for a dissertation.

However, such negative or neutral attitudes toward statistics are not perceived equally across all disciplines. For example, business majors tend to hold more positive attitudes in comparison to psychology students, as they often understand the importance of statistics in real world settings and they are explicitly reminded about the value of these courses to their future careers, unlike psychology majors who remain limited in their perspective of statistics being helpful primarily to enter graduate school (Griffith et al., 2012). This is still helpful as opportunities for employment are limited in psychology majors with a bachelor's degree (Bureau of Labor Statistics, 2018), but unlike students from other disciplines, psychology students may not be reminded about the applications of statistics to qualitative oriented professions such as therapy or counseling, which deems quantitative oriented courses in statistics as unnecessary or irrelevant (Onwuegbuzie, 2004).

Controlling attitudes is a concept worth exploring, as studies already associate positive attitudes toward statistics with higher grades (e.g., Chiesi & Primi, 2009; Dempster & McCorry, 2009). Furthermore, student attitudes toward statistics can impact multiple factors such as the development of statistical thinking skills, the willingness to enroll in future statistics courses and general achievement (Gal & Garfield, 1997; Hilton et al., 2004). Multiple teaching techniques have already been proposed to promote positive attitudes, such as fostering mathematics self-efficacy, which is the confidence to perform mathematics-related activities (Clutts, 2010), as it prompts students to engage in deeper cognitive efforts to accomplish mathematics tasks (Neuville et al., 2007). Other strategies include time devoted to learn the history of mathematics as a way to nurture engagement with class material (Piragasm et al., 2013), giving students an opportunity to make mistakes early in low-stakes environments to alleviate initial stress and build confidence (Counsell & Cribbie, 2020), avoiding negative experiences through the start of the semester (Thanissaro, 2012) which is essential as students may begin these courses with negative preconceived notions built from past experiences in mathematics (Walker & Brakke, 2017) and allow students to switch roles as question-makers and answer-gatherer to merge multiple viewpoints to maximize knowledge (Shaban & Wilkerson, 2019). Other studies conclude that the best opportunity to promote attitude change occurs primarily over the first half of the course (Kerby & Wroughton, 2017). Above everything, the instructor becomes a primary influence toward the attitudes that these students develop, thus, among the recommendations exists the need to foster discussions detailing the usefulness of statistics and its relevancy to real world settings or their professional aspirations, such as therapy or counseling (Griffith et al., 2012).

The conclusion from these studies leads to the prediction that epistemological frames will follow different patterns among students with low (negative), medium (neutral) and high (positive) attitudes with a trend tracking productive frames among medium and high attitude students and unproductive frames being especially evident among low attitude students. The last thing to notice is that a common denominator to productive framing is the involvement of a conscious, effortful, and controlled thought process (System 2) that counteracts the automatic, intuitive, and quick thought process (System 1). As these themes connect to the concept of a duplex mind from cognitive psychology, it is divided as a dichotomy with two thought processes evoking two different types of epistemological framing, the concept of a middle (neutral) frame would not be supported by a middle (neutral thought process), thus this theory falls on a distinction of two areas: unproductive framing (automatic) and productive framing (deliberate). The following figure visualizes this distinction.

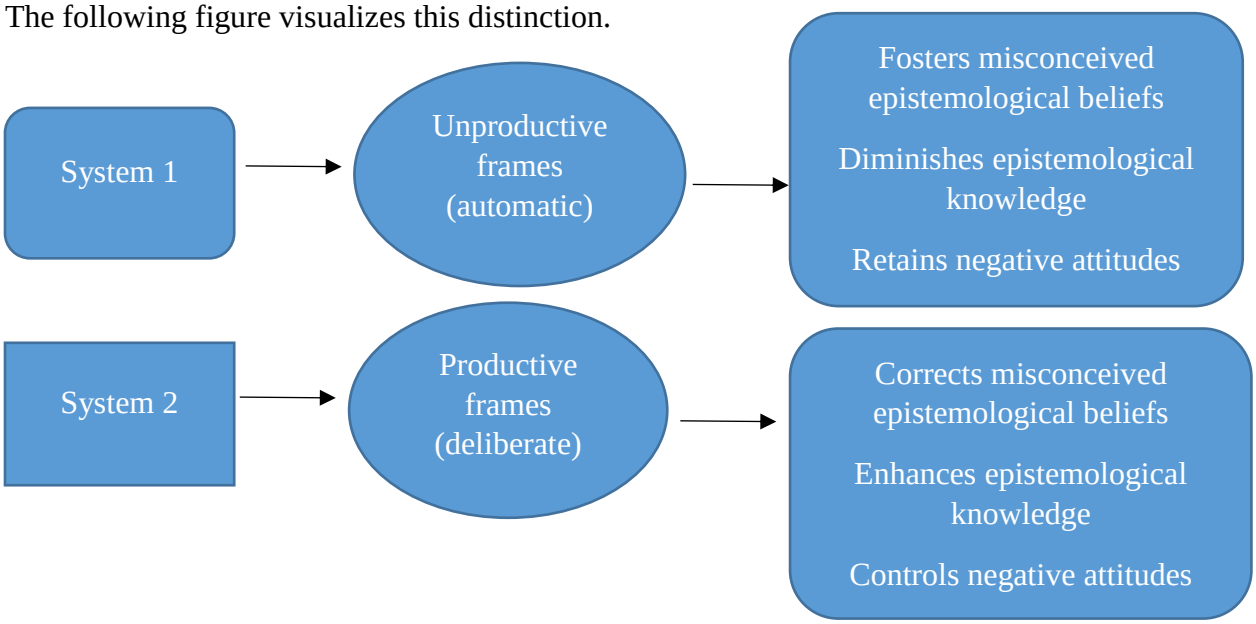

Figure 8. Productive or unproductive epistemological frames.

Conceptualizing Epistemological Framing and Research Questions

Framing refers to an interpretation to a situation, an answer to the question "What is going on here?" (Goffman, 1974). Frames act as a fast way to process information when remaining on an automatic thought process, which leave us vulnerable if we misinterpret information solely based on the way in which it is presented (Myers & Twenge, 2019), emphasizing its relevance as misconstrued frames can lead a person to take decisions with life-long consequences (Tversky & Kahneman, 1981). However, recent research suggests that framing is pervasive and dynamic (Tannen & Wallat, 2018), thus adequate strategies can shift to effortful/analytic thoughts that characterize productive frames (Bryant et al., 2012); this leads to the interest of frames in education, converging on the study of epistemological frames.

Research in learning sciences evidence the existence of frames in education within a context of knowledge, which are answers to questions such as "What do I expect to learn?" or "By what standards will my intellectual contributions be judged?" (Redish, 2004). These epistemological frames are evident from the first day in class as a student already holds years of experience that already build schemas to construct expectations of knowledge. Sometimes students and teacher match on their epistemological frames and the expectations of both are met, but other times they do not, which disrupt several factors, such as attitudes toward the course, subsequently impacting student outcomes (Dempster & McCorry, 2009). Specifically, within psychology, the concept of student attitudes toward statistics courses has been studied for over 30 years, with outcomes suggesting that psychology students often hold negative attitudes (e.g., Conners et al, 1998; Hogg, 1991; Ruggeri et al., 2008; Schutz et al.,1998), or neutral at best (Counsell & Cribbie, 2020; Schau & Emmioglu, 2012). Therefore, controlling student attitudes is a theme worth exploring and the conclusion from the literature review leads to the hypothesis

that that epistemological frames will follow different patterns among students with low (negative), medium (neutral) and high (positive) attitudes; further predicting that productive or unproductive epistemological frames establish a direct connection to these varying attitudes. However, before attempting to manipulate frames as an independent variable, this study aims to find if indeed epistemological frames are directly linked to student attitudes. An essential goal starts by understanding the epistemological frames that psychology students enrolled in statistics courses generate, as well as the extent to which teaching strategies can alter these frames. This interest leads to the following research questions:

- Q1: What are the range of attitudes from students enrolled in a psychology-based course in statistics and would such range of attitudes significantly vary among instructors?
- Q2: What type of epistemological frames do students enrolled in a psychology-based statistics course generate?
- Q3: How do epistemological frames generated by these students relate to course attitudes?

The first question is quantitively oriented as it attempts to replicate findings from multiple studies testing preconceived attitudes that psychology students generate through a statistics course while also exploring if these attitudes change among psychology instructors. Although the concept of student attitudes in statistics has been explored, a study comparing the variability among professors in the same college is yet to be analyzed. The second question is qualitatively oriented as the outcomes from the first question will lead to the selection of students with varying attitudes to assess the types of epistemological frames generated through the course. The third question will explore the relationship among students holding positive, neutral and negative attitudes to study the existence of trends in their perspectives of knowledge. This project is designed as an exploratory study; chapter 3 will describe in detail the research methods.

Summary

Cognitive psychology explores mental processes related to how we perceive, process and remember information; in essence how we think. Therefore, cognitive theory is an approach to study human behavior by understanding thought processes (VandenBos, 2007). This theory explains basic principles of thought, one of its most recognized being dual processing, the two systems of thought consisting of an automatic and a deliberate mindset (Stanovich & West, 2000), through these two mindsets we understand framing, which acts as an interpretation to a situation, or an answer to the question "What is going on here?" (Goffman, 1974). Research in learning sciences evidence the existence of epistemological frames, which can be answers to questions such as "What do I expect to learn?" and "By what standards will my intellectual contributions be judged?" (Redish, 2004). Sometimes students and teacher match on their epistemological frames and the expectations of both are met, other times the student expectations do not match those of the teacher, leaving both frustrated.

Echoing on the duplex mind, research on epistemological framing evidence the existence of productive and unproductive epistemological frames; the former involves automatic thought processes that require little to no effort or no sense of voluntary control, while the latter requires conscious efforts and prompts the student to take ownership of education. Examples of unproductive frames include classroom strategies of accumulating facts without considering their connection to real life (Hutchinson & Hammer, 2010), misunderstanding the purpose of lecture as an attempt to hoard facts without relevance (Scherr & Hammer, 2009), and a "cut and paste" mentality when unquestioningly accepting knowledge from perceived authority sources, such as a high achieving classmate (Shim & Kim, 2018). On the other hand, examples of productive frames include a comprehension of the logic behind the content being taught (Krupnik et al.,

2018), a classroom strategy of storytelling (Rosenberg et al., 2006), and shifts in positionality among classmates so every student receives a chance to lead during discourse (Shaban & Wilkerson, 2019). As evidenced by these studies, research on epistemological framing indicate an influence of teaching strategies that can foster productive frames, and their existence links to student success (Hutchinson & Hammer, 2010).

The value of attending to epistemological frames can also be relevant to alter knowledge and attitudes, these last act as global evaluations toward an object or issue (Myers & Twenge, 2019), and while the research conducted up to this point have not found a link from attitude to framing, research does suggest that epistemological beliefs can have at least an indirect effect on attitudes held by students (Nasser & Birenbaum, 2005). Therefore, the interest of this study tracks directly to the connection among epistemological frames and student attitudes. The concept of student attitudes toward statistics courses has been studied for over 30 years, with outcomes suggesting that psychology students often hold negative attitudes (e.g., Conners et al, 1998; Hogg, 1991; Ruggeri et al., 2008; Schutz et al.,1998), or neutral at best (Counsell & Cribbie, 2020; Schau & Emmioglu, 2012). Therefore, controlling student attitudes is a theme worth exploring and the conclusion from this chapter leads to the prediction that productive or unproductive epistemological frames establish a direct connection to positive or negative attitudes. The following chapter will address the research plan to conduct this project as a dissertation study.

CHAPTER III: RESEARCH METHODS

Preliminary Research Plan

According to Tashakkori and Creswell (2007), mixed methods refers to a research design collecting data and analyzing findings using qualitative and quantitative methods in one study, this approach prompts a researcher to integrate both types of data in the results, organize procedures into research designs that provide a logical reason to conduct this study and frame the outcome within its established theory and philosophical assumption (Creswell, 2014). There are many research questions suited for mixed methods, such as those that need to explain quantitative results as these in isolation can explain relationships among variables but leave detailed interpretations from individuals to speculations; however, qualitative data can elaborate on the interpretations to minimize room on speculation (Creswell & Plano Clark, 2018). On the same note, mixed methods can help compare cases of different criteria and involve participants in the study to yield meaningful changes.

The following chapter will explain the research methods as this project follows a mixed-methods explanatory sequential design beginning with quantitative data collected from the *Survey on Attitudes toward Statistics* (*SATS*; Schau, 2003) to establish a range of attitudes from psychology students enrolled in a statistics course and compare among these attitudes with different professors. These results will follow a qualitative phase by selecting students from varying ranges in attitudes to understand their epistemological frames and explore their similarities or differences, possibly explaining if attitudes toward statistics could be modified by fostering different frames as the literature review suggests that an instructor is essential in its construction and prevalence.

Philosophical Assumptions

As a rule, Creswell and Clark (2018) suggest that mixed methods researchers should clearly mention their philosophical assumptions over a research project. Philosophical assumptions refer to the basic set of beliefs, worldviews or paradigms or assumptions that guide inquiries (Guba & Lincoln, 2005). Pragmatism is perceived as the ideal philosophical assumption for mixed methods research (Johnson et al., 2007) due to different strengths such as its outcome-oriented drive (Onwuegbuzie & Johnson, 2006) and its focus on communication and shared meaning-making perspective that evokes practical solutions to social problems (Tashakkori & Teddlie, 2003). However, Shannon-Baker (2016) offered other perspectives that stretch the strengths evoked by pragmatism, one of them being dialectics, which is the philosophical assumption validating this project.

As a philosophical assumption, dialectics seek a union among multiple paradigms in "respectful dialogue" through the research process; the strength offered through this assumption lies in its acknowledgement of opposing perspectives and perceiving them as important components to the research process, thus promoting diversity in ideas (Creswell & Clark, 2018). Furthermore, this perspective emphasizes that methods depend on each study at hand, and a researcher should promote dialogue with its quantitative and qualitative data sets (Greene & Hall, 2010). The conclusion would be gathered through these "cross-dialogues" that include points that raise tensions, contradictions, and paradoxes (Shannon-Baker, 2016). As it relates to quantitative methodology, this paradigm would be valuable for its attempt to promote a dialogue, rather than dismissiveness of qualitative data.

Mixed Methods Research Design

This proposed study follows an explanatory sequential design as it begins with a quantitative phase and follows up on specific results with a qualitative phase to help explain the quantitative results. The qualitative phase explains the initial results in more depth. According to Creswell and Clark (2018), this design is most useful when the researcher and research problem are more quantitatively oriented, the researcher has access to a quantitative instrument for measuring the construct of primary interest and the researcher has the possibility of bringing back participants for a second round of qualitative data collection (p. 78). All these reasons apply to this study, primarily as psychology is quantitatively oriented and the research problem addressing attitudes will be explored from a quantitative standpoint, while epistemological frames need to be studied from a qualitative perspective. Regarding the access to a quantitative instrument, the *Survey on Attitudes toward Statistics* (*SATS*; Schau, 2003) stands as a validated scale useful to explore the research interest and through contact with college professors there is a possibility of bringing back participants for a second round of qualitative data collection.

Population and Participants

The population of interest are college students enrolled in a statistics course under the Psychology department. Most of these students would be Psychology majors, although students from other disciplines such as Kinesiology and Social Work enroll in this course as well. However, the focus is still on statistics courses offered by the Psychology department, therefore, demographic questions inquiring about discipline of study will be added to keep track of the different Majors participating in this study. From this population emerges the convenience sample as the participants are readily available; these participants were college students enrolled in statistics courses over summer and fall 2022 at both El Paso Community College (EPCC) and

The University of Texas at El Paso (UTEP). Addressing qualitative data, the convenience sample switched to purposeful sampling as participants were intentionally selected due to their experience at the central phenomenon of interest in this study (Creswell & Clark, 2018). From purposeful sampling the strategy shifted to maximal variation sampling by selecting participants from diverse ranges to hold different perspectives on the central phenomenon, in this case attitudes developed over these courses to study their epistemological frames. Therefore, this explanatory sequential design began with the collection of quantitative data, analysis and use of results for the follow-up qualitative data collection. Therefore, sampling goes over two parts of this design: in the quantitative and qualitative phase.

Quantitative Data Collection

Originally, there was the intention to run a power analysis to establish a sample size for the quantitative part of this project, however, after conversation with colleagues we realized that this study is descriptive, thus without inferential statistics as the core of the study a power analysis would not be necessary. In conversation with Dr. Osvaldo Morera, professor for the Psychology department at UTEP, there was a suggestion of running a latent class analysis (LCA), which is a statistical procedure used to identify qualitatively different subgroups within populations who share similar characteristics (Tabachnick & Fidell, 2012). However, while exploring the best guidelines for using LCA as noted by Weller et al. (2020) we found that numerous studies suggest a sample size of at least 300 participants as potential analysis problems arise with low sample sizes, such as poor functioning fit indices, convergence failures and an inability to identify classes with low memberships (Nylund-Gibson & Choi, 2018). From a practical standpoint, recruiting over 300 participants from our pool sample of students enrolled in

statistics courses in psychology deems this a very difficult task, therefore a different strategy was chosen.

Originally, data collection was planned over summer courses. At EPCC there were 5 summer courses available with a capacity of 20 students each, totaling 100 possible students. At UTEP there were 4 courses available with a capacity of 40 students each, adding to 160 possible students; this added to 260 possible students enrolled in statistics courses for the psychology department. However, assuming that those classes were capped at that number did not mean that all would be, therefore, the decision was taken to reach about 50% of available students assuming that all classes were at maximum capacity, meaning 130 students, still though, this is unrealistic if the classes were not full. Ultimately, the decision set and agreed by the committee was to reach at least 100 students over the summer. Due to a personal interest in the outcomes of these results, students from my statistics courses were not contemplated to participate.

As previously mentioned, the quantitative data was generated through the *SATS* (Schau, 2003), which is a 36-item scale with Likert items assessing attitudes toward statistics among students currently enrolled on a statistics course. The scale measures the following domains:

- Affect (6 items) – Feelings concerning statistics
- Cognitive competence (6 items) – Perceptions of students' own intellectual knowledge and skills in statistics
- Value (9 items) – The value or worth attributed to statistics in students' personal and professional lives
- Difficulty (7 items) – Perceived difficulty of statistics
- Interest (4 items) – Students' level of individual interest in statistics
- Effort (4 items) – The amount of work students spends to learn statistics

Each item is rated on a 7-point scale expressing the degree to which the student agrees or disagrees with the item: 1 = Strongly Disagree, 4 = Neither Agree nor Disagree, and 7 = Strongly Agree. Half of these items are positively worded while half are negatively worded, thus they needed to be reverse coded to compute subscale scores (Schau, 2003). Overall, higher scores on each subscale reflect a more positive attitude regarding statistics except for difficulty, as higher scores reflect a perception of statistics as an easier course. Although the author warns against adding each of the subscales for a total regarding attitudes, the expectation is that some students will score generally low across each of these subscales as previous measures from the scale do note a strong interclass correlation among the items (Schau & Emmioglu, 2012). This scale was chosen due to its good convergent validity with similar scales, along with good reliability as researchers support the proposed factor structure (Nolan et al., 2012). Other studies have similarly reported internal consistency for each subscale, although noting caution with *effort* and *difficulty* (Counsell & Cribbie, 2020).

An exploratory study was run in 2021 to test the instruments for this proposed study, the participants were 22 undergraduate students (18 women, 4 men) from three sections of a statistics and research design course (Psyc 2317) at EPCC. One section was an online summer 2021 course, the other two were face to face courses through fall 2021; all sections were identical in instructor, syllabus, textbook, and lecture material, although the delivery methods were different as the courses were structured in different formats. While validating the data for the quantitative phase, the reliability and construct validity of the scale were established by analyzing the internal consistency of scores through Cronbach's alpha ($\alpha = .95$). This mirrors outcomes from other studies using this scale (e.g., Chesi & Primi, 2009; Schau & Emmiglou,

2012). At the request of the SATS author, the scale is not included on the appendix sections of this dissertation, however, information can be found at https://www.evaluationandstatistics.com/

Qualitative Data Collection

The *SATS* (Schau, 2003) reflected varying attitudes and distinguished students that held low (negative) attitudes, from those holding medium (neutral) and high (positive) attitudes. For the qualitative phase, the plan was to select three of each range (n = 9) to study their epistemological frames through an interview based on 10 open ended questions attempting to measure three distinct framing areas: perspectives of knowledge, perspectives on teaching techniques and perspectives on course content. These interviews could evidence patterns of productive or unproductive frames and hint at their roles in such varying attitudes. Some of the expected patterns of productive frames that might hint at storytelling (Rosenberg et al., 2006), prompts to shift positionality among classmates by allowing every student in a group to lead during discourse (Shim & Kim, 2019), or a shift in positionality where students can own the role of question-maker and answer-gatherer fostering multiple viewpoints (Shaban & Wilkerson, 2019). On the other hand, these responses might evidence patterns of unproductive frames such as group work strategies solely devoted to find answers without deliberation or consultation with each other (Scherr & Hammer, 2009) or a "cut and paste" mentality echoing on the misconception of lecture as an attempt to hoard facts without relevance or accumulating facts without considering their connection to real life (Hutchinson & Hammer, 2010). These questions were designed to address different viewpoints on the perspective of knowledge through the course, thus shedding light into epistemological frames produced by the students.

As previously mentioned, nine participants were purposefully selected based on their varying scores for a follow-up interview. This interview is semi structured as this format allows a

researcher to respond to the situation at hand, to the emerging worldview of the interviewee and on ideas that might arise on the topic (Merriam & Tisdell, 2016). The structure consists of 10 questions addressing course material and probes to prompt each participant to provide more information. For example, a question asked about the definition and purpose of a standard deviation (one of the main lessons by the week in which the subject will be interviewed), and how to explain it if one classmate asked for tutoring. By selecting participants who differ in their scores on attitudes (positive, neutral, and negative) then comparing results from the interview may explain if there is a connection among the range of attitudes and the type of knowledge that these students generate.

Although up to this point much research on epistemological framing follows observational methodology (Berland & Hammer, 2012; Russ et al., 2013; Scherr & Hammer, 2009) to deduce epistemological framing from observation of behavioral and linguistic cues (Tannen, 1993; Tannen & Wallat, 1987), these cues can also be evoked using interviews and even evoke frames that mere observation cannot induce (Shaban & Wilkerson, 2019). An interview can be interactive in nature and follow a "discursive psychological approach" through techniques from conversation analysis to deconstruct pattern of conversation among the interviewer and the interviewee (Roth, 2008). Therefore, research validates the assumption of using interviews as a valid method to explore epistemological frames and perceive it as a valuable tool for education researchers (Russ et al., 2012).

An interview is defined by DeMarrais (2004) as "a process in which a researcher and participant engage in a conversation focused on questions related to a research study" (p. 55), and the definition emphasizes the point of it as a "conversation with a purpose" (Dexter, 1970, p. 136), which is to obtain a special kind of information not easily available through mere

observation, as it is the case with different types of epistemological frames. Aligned with the importance of conversation, the interview follows a constructionist philosophical orientation due to how the interview data is constructed receives most attention through tools such as discourse, narrative, and conversation analysis (Roulston, 2010). Therefore, an interview provides a valuable opportunity to observe epistemological frames as students can use it to express different perspectives of knowledge.

However, Russ et al. (2012) recommend five guidelines on an interview process, from which three were followed:

- This interview should be perceived as a casual activity without negative consequences, thus clarifying to the interviewee to not worry about wrong answers as the conversation would not have an effect on their grades. This is done to set up a casual interaction.
- The activity relies on the student describing thoughts to the interviewer, thus prompting the student to "talk as much as possible" about the scenario, conveying an idea about the student's ideas at the center of the discussion, and as noted by Siedman (2019) sticking to the idea of "Talk less, listen more."
- The interviewer must be careful about using nonverbal cues similar to those used in regular conversations to communicate attention to the students' ideas, thus the interviewer would face the student, leaning toward him, make eye contact and nod head. Furthermore, a common practice is to use short words as feedback, such as "uh-huh" and "yeah" to demonstrate attention and understanding to the ideas discussed.

Finally, the interview is structured following the guidelines explained by Siedman (2019), such as structuring basic questions based on what, why and how (p. 36) while carefully using

basic techniques such as asking questions when a response is not clear, asking the interviewee to talk more, avoid leading questions and ask open-ended questions (p. 85). A copy of the interview questions is included at the end of this paper.

Research Design

All the participants for the follow-up qualitative phase of the study were students enrolled on a statistics course taught by the psychology department at EPCC (Psyc 2317; Statistics and Research Design) or UTEP (Psyc 1303; Statistical Methods). The following figure illustrates this research design as it incorporates both the quantitative and qualitative phases of the study.

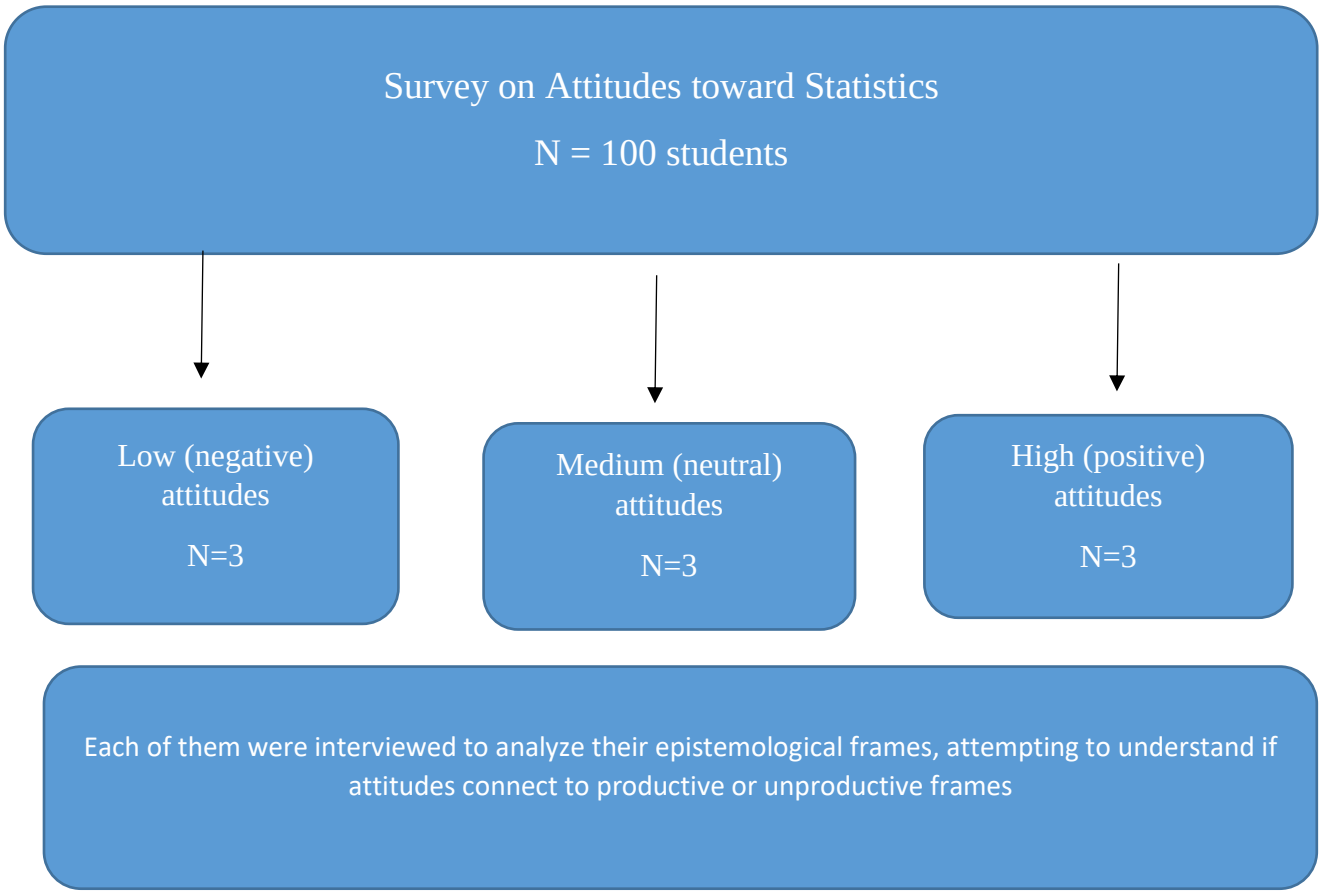

Figure 9. Research design for the dissertation study

Timeline for Data Collection and Analysis

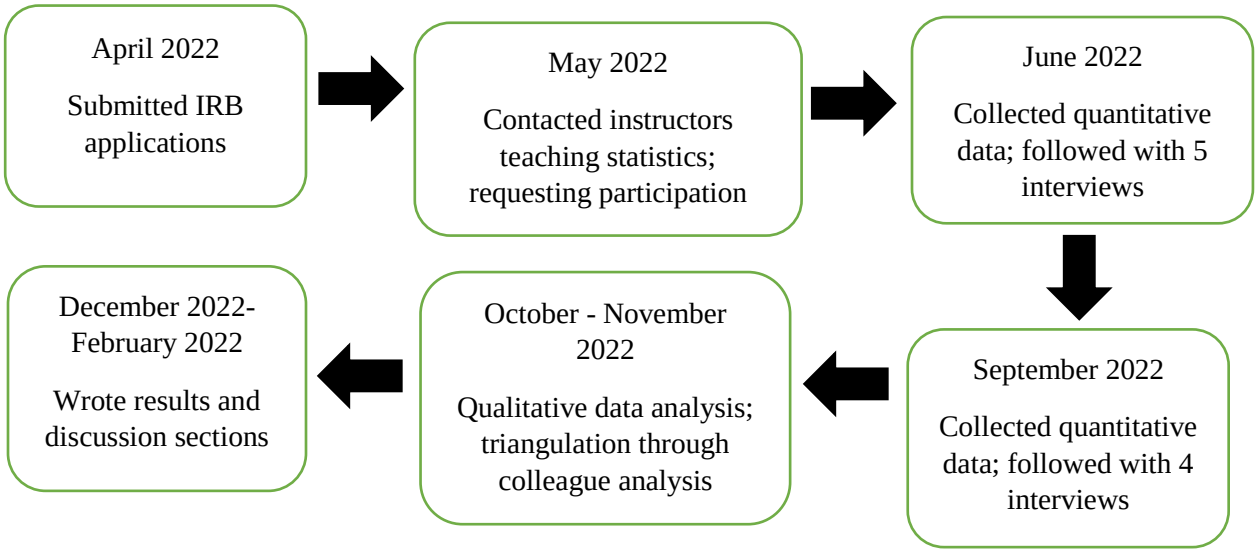

Figure 10: Timeline for Data Collection

Plan for Data Analysis

The intent of data analysis and integration is to connect quantitative and qualitative phases of the study so the follow-up qualitative phase can explain specific results from the initial quantitative phase (Creswell & Clark, 2018). The procedure for integrative data analysis occurs in three phases: the analysis of the initial quantitative data, an analysis of the follow-up qualitative data, and an analysis of how the qualitative data can help to explain the quantitative data to answer the mixed methods questions. This section will explain the content, validity, and steps for analysis of the psychometric scale selected for the quantitative portion, the rationale for selecting interviews as the qualitative method to understand epistemological frames, and a discussion on the methods of integration to explain the extent at which varying attitudes toward statistics can explain the types of knowledge that students enrolled on these courses generate.

As previously mentioned, the *SATS* (Schau, 2003) was selected due to its convergent validity, along with good reliability as researchers support the proposed factor structure (Nolan et al., 2012), while other studies have similarly reported internal consistency for each subscale

although cautioning on *effort* and *difficulty* (Counsell & Cribbie, 2020). Exploratory data was collected from 22 participants during Summer 202 and found internal consistency through Cronbach's alpha ($\alpha = .95$), further evidencing its validity. Through this exploratory study the following descriptive statistics were found on the four subscales recommended by Counsell and Cribbie (2020): *affect* (M = 4.52, SD = 2.10), *cognitive competence* (M = 4.84. SD = 2.04), *value* (M = 5.38, SD = 1.64) and *interest* (M = 5.20, SD = 1.70). As expected, those scores reflected a range of variability with mean range of scores from as low as 1.50 to as high as 7. As noted in table 1, the three students selected for the follow-up qualitative interview ranged in their mean scores for three of the subscales, except for cognitive competence at which the student holding a high attitude was below the mean score from the sample, yet this student was still selected due to the high values on the rest of the subscales, as explained by the following table.

Table 1. *Quantitative data from exploratory study.*

Student	***Affect***	***Cognitive competence***	***Value***	***Interest***
Low attitude	1.83	2.00	3.78	2.50
Medium attitude	4.17	4.67	5.22	4.50
High attitude	6.17	3.67	6.78	6.75

In the same way, variability of scores were expected for the quantitative data on the actual dissertation study. As explained by Schau and Emmioglu (2012), even differences of ½ point should be considered important as that value represents an 8% change on the possible range in the Likert scale of each item and going up by this criteria table 1 evidence substantial differences among the students selected for the low, medium and high attitudes. A similar variability of scores was expected if the sample size increased from 22 to 100 participants on the dissertation study.

The qualitative analysis should use rigorous procedures to address the qualitative research questions, to respect these, the guidelines noted by Creswell and Clark (p. 210; 2018) were followed. First, data was prepared for an analysis by transcribing the data, checking transcripts for accuracy and format the data to facilitate the analysis. Then data was explored by reading through it to obtain a sense of it all, writing memos about initial thoughts and developing a few initial codes. The next step would be to analyze the data by implementing a coding process: 1) code the data, 2) develop themes by grouping codes, and, 3) develop abstract categories into a smaller set of themes. Finally, this data analysis would be presented for the themes/description, such as quotes or phrases, presenting visual models like those already discussed in the literature review of this proposal, summarizing major qualitative findings and interpreting how the findings answer the research questions. An example of a streamlined condes-to-theory model for qualitative inquiry is provided in figure 9.

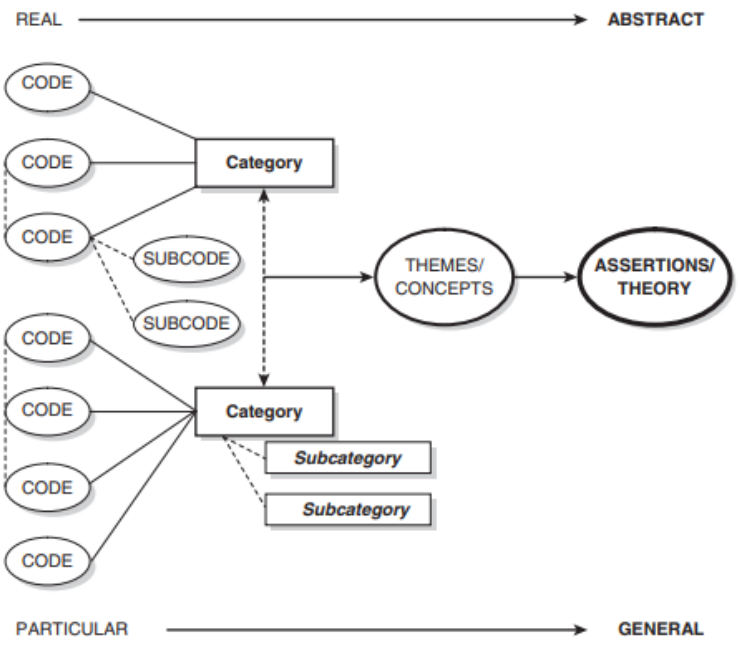

Figure 11: A Streamlined Codes-To-Theory Model for Qualitative Inquiry (Saldaña, 2021)

Furthermore, to validate the data and results the following validation strategies were used: support from a fellow doctoral student to help analyze the set of codes to transition into categories after deliberate discussion, member-checking as summaries of the findings were taken back to key participants to ask if these findings portrayed an accurate reflection of their experiences and triangulation of data as data was drawn from multiple sources to build data from different sources to build evidence for a comprehensive data analysis.

Over the exploratory study ran during Summer 2021, the qualitative analysis provided an opportunity to practice the interview questions and qualitative methods. A useful tool came from Russ et al. (2012) as it identified three unique clusters of behavior that evidenced three types of framing. According to the authors, patterns of linguistic behaviors would help detect different epistemological frames even in one-minute intervals with clear examples such as students sitting upright which goes along with clear and projected speech, contrasting to body position and gaze directed away from an interviewer with less gesturing, which commonly co-occurs with low toned speech (p.582). The three clusters of behaviors and its co-occurring behaviors were the following:

- Inquiry frame – If faced with a question that a student cannot answer immediately, this frame leads to treatment of the interview as an inquiry to construct an explanation. Therefore, instead of saying “I don’t know”, the student may attempt to discover the correct answer while interviewed. Under this assumption, a student frames the interview as an opportunity to inquire into new concepts to analyze their thoughts (metacognition) using knowledge from outside of the classroom if necessary. Along with these thoughts, the behaviors include frequent gesturing, long

pauses in speech and avoidance of direct eye contact; this type of frame leads students to demonstrate their process of making sense.

- Oral examination frame – If a student encounters a question with no immediate answer, the frame might change to perceive the interview as an oral examination. The student may believe that the interviewer expects a clear and concise response, thus providing memorized information (textbook oriented), exhibiting minimal gestures and maintaining eye contact with a monotonous voice; this type of frame leads students to treat the interview as a request to provide predetermined "correct" responses rather than to construct knowledge or share their understanding. Furthermore, a student may use scientific vocabulary (textbook oriented) to demonstrate understanding based on class information. The authors conclude that students engaging on oral examination framing respond to interviews based on preior experience with school assessments, thus they "tend to include items of factual and procedural knowledge that are relatively circumscribed in content and format and can be responded to in a short amount of time" (NRC, 2001, p.26).
- Expert frame – Unlike the two discussed frames, students may also construct a frame believing that the interview is an opportunity to discuss their thoughts, on which they are the experts, and the situation is simple for them. Similar to experts being interviewed by reporters, students engaging in this frame attempt to explain their thoughts in a way that the interviewer can better understand them. The behaviors enacted from this frame are confidence, with minimal speech hesitation and direct eye contact. Unlike the oral examination frame, a student engaged in expert frame does

not use scientific vocabulary and instead switches to colloquial terminology as an expert tries to remain clear to make responses as clear as possible to the listener.

An interview provides a valuable opportunity to observe epistemological frames as students can use it to express different perspectives of knowledge, such as these three. For example, students maintaining an inquire frame will construct knowledge based on everyday experiences, unlike those shaping an oral examination frame where they do not engage in active sense making and instead isolate facts learned from classroom knowledge with weak to non-existent connections to daily life experiences. However, unlike the oral examination frame, the expert frame draws on everyday experiences or intuitions instead of drawing information from outside sources, which mirrors an inquiry frame, but distinct to it, the students would not perceive an interview as a task to generate new knowledge and instead treat it as an opportunity to elaborate on their existing knowledge to communicate it to the interviewer.

Through that exploratory study, the focus lied on those three different frames as the explanatory sequential design requests an interpretation of the mixed methods results on a joint display to indicate how the qualitative results provide a deeper understanding of the statistical findings (Creswell & Clark, 2018). An example from the first round of interviews is shown on the figure above to compare the different perspectives generated by students with different attitudes.

Table 2. Joint display of qualitative data from exploratory study

	What stood out for you from the way your teacher taught this lesson?
High attitude	Throughout the semester I thought it was clear and there were lots of examples so there was something always to look back on
Mid attitude	I did notice that you provided two videos ... they were public on Youtube, this is the kind of material that I would look up if my professor didn't explain much
Low attitude	Like on the Youtube video that you showed us, you would actually like taught us how to do things which I feel like it actually helped a lot, especially for people like me that ain't really good at math
	If you had to explain this lesson to the class, how would you do so?
High attitude	I'd probably work through an example with them, I mean that's how I learned, seeing it get done and just explaining what are we doing and why are we doing it
Mid attitude	If we remember from previous lessons we have the Z scores and t tests, but this ANOVA test is also called the F test and it could be used to test independent and related samples, so that's what I would explain to them
Low attitude	I would first show them the YouTube videos so they can get a taste of it because I feel like for me that was what since I'm a visual learner, that what helped me and I feel like that could be something that could help them as well

	What is the overall purpose of the course?
High attitude	Regardless of what direction we go, its useful because even if our career we don't do research, college is going to ask us to do research and work should ask you to further your knowledge so you are going to have to be reading studies and reading research and everything
Mid attitude	Statistics is basically like mathematics but more in depth as you're analyzing data you're interpreting it and summarizing it to provide results of like an experiment
Low attitude	As psychologists we'll have to conduct studies at one point and is not about writing what other people are doing but actually having to work out problems and numbers, just like how you were taught to do on this course.

Although this remained a very limited sample, it began to discern among different frames evoked by these students. On a question addressing the way in which the teacher taught the lesson, the high attitude student mentioned the number of examples available, while the medium and low attitude students mentioned the tutorials uploaded on YouTube, reflecting a different approach as one student favored a hands-on approach and the others favored guided lessons, mirroring the "cut and paste" mentality noted by Rosenberg et al. (2006). On a question asking about the methods they would use to teach the lesson the high attitude student favored the same hands-on approach ,while the medium attitude student referred to the use of terminology without really addressing the question, perceiving lecture as an attempt to hoard facts without considering their connection, a type of frame noted by Hutchinson and Hammer (2010), and the low attitude student remains vague while still demonstrating a "cut and paste" mentality,

regardless of how the question changed. As a third example, the last question referred to the purpose of the course and all three students framed the course considering college education or academic purposes, which replicates the results found by Griffith et al. (2012) as psychology majors remain limited in their perspectives of statistics being helpful primarily within an academic context, instead of finding applications in the real world or their professions.

Following the theoretical model of the duplex mind, the oral examination frame mirrors an automatic mindset as the student perceives the interview solely as a question about knowledge without attempting to analyze the meaning behind the question and prompt frames leading to strategies such as "cut and paste" mentality. On the other hand, the inquiry and expert frames evoke a deliberate mindset as the student slows down the thought process to either elaborate on the meaning of a question to construct a response on the spot, or switch modes of thought to explain the answers to the interviewer as if the interviewee was an expert whose knowledge serves to the understanding of others, such as the "storytelling" strategy common in productive frames. This data helped to solidify the research questions and methods used for the dissertation study, although the qualitative analysis would not be limited to these three frames as the responses could evoke different types of epistemological frames.

Limitations and Validity

A limitation with this study lies on sample size when addressing the quantitative phase as latent class analysis requires at least 300 participants and this deems it a daunting task; data collection would extend to multiple semesters as enrollment in statistics courses is small in comparison to other content courses like introduction to psychology. Therefore, the study aims for at least 100 participants, but the number is still low for the expectations to run a latent content analysis (Nylund-Gibson & Choi, 2018; Weller et al., 2020). Furthermore, the quantitative data

collection can anticipate a homogeneous sample as data is recruited from students enrolled at EPCC and UTEP, institutions that serve a predominantly Hispanic population. Although there is no evidence to suggest this could be a major limitation, it would still be beneficial to gather a more diverse student population to study different levels on the student attitudes toward statistics.

As with any qualitative study, there can be common limitations such as a limited sample size, since only 9 cases are chosen to explore their epistemological frames, which may still deem it a small sample to suggest generalizations (Griffin, 2002). Nonetheless, they can still evidence a connection among epistemological frames if they are consistently different to students with varying attitudes. Another potential limitation goes with the decision to use an interview to test epistemological framing, rather than an observation of classroom interactions as other studies have done (e.g., Redish, 2004; Rosenberg et al., 2006; Hutchinson and Hammer, 2010). However, as an exploratory this method serves best to perceive patterns of these frames as a conversation with a purpose can help us to not only observe, but also analyze thought patterns from the participant. Finally, in an attempt to limit potential bias there will be triangulation of data in the code process and support from other doctoral students trained in qualitative methodologies for an analysis of the data.

Summary

This proposed study follows an explanatory sequential design as it begins with a quantitative phase and follows up on specific results with a qualitative phase to help explain the quantitative results, this approach prompts a researcher to integrate both types of data in the results, organize procedures into research designs that provide a logical reason to conduct this study and frame the outcome within its established theory and philosophical assumptions

(Creswell, 2014). The quantitative phase begins by collecting data from the *Survey on Attitudes toward Statistics* (*SATS;* Schau, 2003) to establish a range of attitudes from psychology students enrolled in a statistics course. This scale was chosen due to its good convergent validity with similar scales, along with good reliability as researchers support the proposed factor structure (Nolan et al., 2012). The results will provide varying attitudes and distinguish students that hold low (negative) attitudes, from those holding medium (neutral) and high (positive) attitudes. For the qualitative phase, three students of each range (n = 9) will be chosen to study their epistemological frames through an interview based on 10 open ended questions; these interviews could evidence patterns of productive or unproductive frames and hint at their roles in such varying attitudes.

Following the theoretical model of the duplex mind, the different frames might mirror an automatic mindset, for example if the student perceives the interview solely as a question about knowledge without attempting to analyze the meaning behind the question, thus prompting a "cut and paste" mentality (like on the oral examination frame). On the other hand, different frames might resemble a deliberate mindset if the student exerts effortful thoughts to elaborate on the meaning of a question (inquiry frame) or switch modes of thought to deconstruct an answer to the interviewee (expert frame), prompting strategies such as "storytelling" which is common in productive frames. These frames will be analyzed following the guidelines described by Russ et al. (2012) but would not rely solely on them as the responses might evoke different types of epistemological frames. The main focus will be on exploring consistent patterns of productive or unproductive frames, which may help explain if there is indeed a clear connection among them and student attitudes toward statistics courses.

Conclusion

As psychology is growing in popularity, is time for the discipline to prepare students for the challenges ahead on the field. In the end a course on statistics acts as a class of skill that yields benefits, such as our ability to understand and analyze information directly from a scientific article without a middle source that may distort information, and this is useful regardless of the specialization area. Therefore, the negative or neutral attitudes held by our students warrants consideration for a close study assessing its cause, as we know that such negative outlook is not similar across other disciplines like business and finance (Griffith et al., 2012).

This study might validate the assumption that college educators approaching a pedagogical activity with different epistemological frames from that of students will lead them to learn different outcomes than what is expected. Therefore, there might be a connection among epistemological frames and student attitudes, and this could point statistic instructors to reconsider teaching strategies that incorporate prompts fostering productive epistemological frames, such as discussions detailing the usefulness of statistics and relevancy to real world settings or their professional aspirations, and through these lead a change from the negative and neutral attitudes to positive, which can even subsequently enhance student success.

CHAPTER IV: RESULTS

Chapter Overview

This chapter presents the data analysis results to answer the research questions from this study. The first section reports the quantitative analysis from the *Survey on Attitudes toward Statistics* (*SATS*; Schau, 2003) structured among descriptive analyses from both the entire data set and for each professor as data was collected from 10 different classes taught by 6 different professors at El Paso Community College and the University of Texas at El Paso; furthermore, a series of analyses compared range of attitudes among students for each of these professors to inquire if there were different ranges of attitudes in the responses generated from each class. The second section reports results for the qualitative analysis as 9 students were selected for the follow-up interview based on their different attitude levels: 3 for low attitudes, 4 for medium attitudes and 2 for high attitudes. Through the end of this section a joint display will integrate data analysis from the quantitative and qualitative analyses to strengthen the results from this mixed-methods design. A discussion on validity and reliability will ensue by the end of this section.

Participants

Participants were 108 undergraduate students (77 women, 31 men) enrolled on introductory statistics courses taught by the psychology department at El Paso Community College (Psyc 2317; n = 45) and the University of Texas at El Paso (Psyc 1301; n = 63) during Summer and Fall 2022. At EPCC, data was collected from 6 courses that were taught by 4 different professors; at UTEP, data was collected from 3 courses taught by 2 different instructors. Participants were predominantly Psychology majors (71.30%), although other majors included Kinesiology (10.19%), Social Work (10.19%), Criminal Justice (2.78%), Rehabilitation Sciences

(2.78 %) and Public Health (2.78%). Participants were predominantly Hispanic (94.44%) and had a mean age of 21.86 years (SD = 4.40). Data from the professors was not requested, but the only available information was their professional status as all EPCC instructors were full-time faculty and both UTEP instructors were doctoral students and not full-time faculty. The course is an introduction to statistics and research design with the same curriculum and is transferable among institutions; in essence is the same course in both places.

Quantitative analysis

The first research question led to a quantitative data analysis as it combined two interests: What are the range of attitudes of students enrolled in a psychology-based class in statistics and would such range of attitudes significantly vary among psychology instructors? To answer the first part of this question data was collected from statistics courses both at El Paso Community College (Psyc 2317; n = 45) and the University of Texas at El Paso (Psyc 1303; n = 63) during Summer and Fall 2022. As previously mentioned, at EPCC data was collected from 6 courses that were taught by 4 different professors; at UTEP, data was collected from 3 courses taught by 2 different instructors. The following table provides basic descriptive statistics from the entire data set (n = 108).

Table 3. *Descriptive statistics from sample*

Subscales	**M**	**SD**
Affect	4.91	1.79
Cognitive competence	5.51	1.62
Value	5.01	1.79
Difficulty	4.02	1.66
Interest	4.92	1.64
Effort	6.19	1.29

Note. Each mean is based on a range of scores from 1 to 7.

As noted in previous sections, the *SATS* is structured in six subscales, representing different aspects of attitudes concerning classes in statistics (Schau & Emmioglu, 2012). According to the authors, the following descriptions can help understand what each subscale measures:

- Affect: Positive and negative feelings concerning statistics
- Cognitive competence: Attitudes about their intellectual knowledge and skills when applied to statistics
- Value: Attitudes about the usefulness, relevance and worth of statistics in personal and professional life
- Difficulty: Perceived difficulty of statistics as a subject of study
- Interest: Level of individual interest in statistics
- Effort: Amount of work expected to learn statistics

Despite the curiosity to compare the mean and standard deviations among each subscale, the authors cautioned against doing so as each subscale is measured independent from each other, and their scores should not be perceived as a whole unit. Therefore, there is no valid assumption to be made among the values of central tendency and variability, other than to solely describe the data set (Schau, 2003). However, a point worth considering is the similarity of scores from this sample to the one reported by Schau and Emmioglu (2012) when data was initially collected to generate scores from a large sample of introduction to statistics students before the course began and after the course ended. In both samples the differences lie less than ½ standard deviation point, which would have been considered an important difference as the authors pointed that it would represent an 8% change on the possible range of scores in the

Likert scale of each item. Thus, the scores collected from our sample mirror statistically the scores collected by Schau and Emmioglu (2012) as evidenced on the following table.

Table 4. *Scores for Subscales according to Schau and Emmioglu (2012)*

		Pretest		Posttest	
Subscales	**n**	**M**	**SD**	**M**	**SD**
Affect	2209	4.16	1.12	4.30	1.32
Cognitive competence	2192	4.94	1.04	5.03	1.16
Value	2186	5.04	0.99	4.72	1.12
Difficulty	2204	3.75	0.81	3.90	0.96
Interest	2219	4.51	1.27	4.00	1.44
Method	2246	6.32	0.90	5.84	1.09

The second part of the research question inquired about different values among the scores for each professor, as student attitudes might vary substantially if one specific instructor used techniques that allowed a shift in average attitudes, or if regardless of the instructor and class technique, the range of attitudes would remain similar. A major challenge to address this question lied on the unequal sample size as data collection for the quantitative portion of this study was entirely based on availability of participants and the willingness from each professor to volunteer his/her class for data collection. Therefore, two sets of data analysis were run, one using non-parametric tests to minimize chances of error by unequal sample size, and an analysis of variance without including data from the highest sample size, attempting a fair comparison by minimizing the discrepancy of unequal sample size. Regardless, tests resulted in the same conclusion: range of attitudes did not significantly vary among psychology instructors. The following tables will summarize descriptive statistics among scores from each subscale.

Table 5. *Descriptive statistics for Affect subscale*

P	M	SD	N
1	4.55	1.56	11
2	5.44	1.32	6
3	4.95	1.86	52
4	4.64	1.89	11
5	5.30	1.94	9
6	4.82	1.68	19

Note. P stands for Professor as each received a code to protect anonymity

Descriptive Statistics for Cognitive Competence subscale

P	M	SD	N
1	5.61	1.30	11
2	5.42	1.42	6
3	5.58	1.65	52
4	5.29	1.68	11
5	5.76	1.78	9
6	5.29	1.65	19

Descriptive statistics for Value subscale

P	M	SD	N
1	4.45	1.85	11
2	4.72	1.62	6
3	5.11	1.81	52
4	5.05	1.86	11
5	5.49	1.68	9
6	4.91	1.67	19

Descriptive statistics for Difficulty subscale

P	M	SD	N
1	3.88	1.43	11
2	4.12	1.84	6
3	4.07	1.69	52
4	4.17	1.62	11
5	4.32	1.74	9
6	3.68	1.60	19

Descriptive statistics for Interest subscale

P	M	SD	N
1	4.25	1.82	11
2	4.88	1.30	6
3	5.07	1.68	52
4	4.57	1.58	11
5	5.25	1.84	9
6	4.95	1.37	19

Descriptive statistics for Effort subscale

P	M	SD	N
1	5.77	1.64	11
2	6.13	1.60	6
3	6.33	1.13	52
4	6.09	1.43	11
5	6.36	1.02	9
6	6.03	1.37	19

At first glance, the descriptive statistics show remarkable consistency across all six subscales. For *Affect*, the students slightly favor positive emotions toward their statistics courses as all six means stand above the median point of 4. However, none of them yield a value

significantly different in comparison to the rest, and the discrepancy in sample size is also evident when one professor only gathered 6 students to participate in one class while another gathered 52; this is the reason why a fair assessment across each professor is challenging. For *Cognitive Competence*, values are similar as accentuated by averages of 5 for each professor; these results imply that students maintain a slightly more positive attitude toward their capacity of knowledge and skills applied to statistics, in other words, they trust their intellect while learning content from this course. For *Value* all means lie above 4, which evidence a slightly more positive attitude toward the relevance, usefulness and worth of statistics on professional life. However, a compelling distinction exists with *Difficulty*, as mean levels drop, and students reflect a slightly more neutral or even negative attitude toward their courses. This implies that students on average do not believe that their course is easy, yet this fascinating trend is evident across all professors as once again these values are surprisingly similar. Moving to *Interest*, values once again shift on average toward a slightly positive phase as across all samples the mean values lie higher than 4, suggesting that students find statistics courses slightly more interesting than uninteresting. Lastly for *Effort*, average levels are near the top implying that students believe that the course requires a substantial amount of work, yet again these levels are remarkably similar across all six samples.

As previously mentioned, no statistical analysis was conducted to compare subscales with each other at the caution of the authors, but inferential statistics were conducted to test if range of attitudes significantly varied on each subscale when comparing scores from all six professors. To conduct this comparison, the first round of analysis was taken by running a Kruskal-Wallis one-way analysis of variance as this method is recommended to compare two or more independent samples of unequal sample sizes (Kruskal & Wallis, 1952). As a nonparametric method, the

Kruskal-Wallis test does not assume a normal distribution of scores, which leads to a null hypothesis that central tendency of all groups is equal and an alternative hypothesis that at least the central tendency of one sample will be different (Corder & Foreman, 2009). As evidenced on the following table, six separate tests were run, one for each subscale. As hinted by the similar means across all subscales, the significant value for each test lied above .05, concluding on retention of the null hypothesis.

Table 6. *Hypothesis Test Summary*

Null Hypothesis	Test	Sig.	Decision
The distribution of Affect is the same across Professor	Independent-Samples Kruskal-Wallis Test	0.555	Retain the null hypothesis
The distribution of Cognitive Competence is the same across Professor	Independent-Samples Kruskal-Wallis Test	0.629	Retain the null hypothesis
The distribution of Value is the same across Professor	Independent-Samples Kruskal-Wallis Test	0.273	Retain the null hypothesis
The distribution of Difficulty is the same across Professor	Independent-Samples Kruskal-Wallis Test	0.471	Retain the null hypothesis
The distribution of Interest is the same across Professor	Independent-Samples Kruskal-Wallis Test	0.378	Retain the null hypothesis
The distribution of Effort is the same across Professor	Independent-Samples Kruskal-Wallis Test	0.277	Retain the null hypothesis

Despite these results there was still an interest in comparing scores if the largest sample size was not part of the computation. To test this idea a parametric Analysis of Variance assuming equal distributions was run for each subscale, and again as evidenced on the previous analyses, results were not statistically significant. The following tables reflect these results, and a conclusion is evident on the first research question: Range of attitudes of students enrolled in a psychology-based class in statistics do not differ among psychology instructors.

Table 7. *Analysis of Variance for Affect*

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	195.49	4	48.87	0.79	0.54	2.55
Within Groups	3142.50	51	61.62			
Total	3337.98	55				

Analysis of Variance for Cognitive Competence

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	68.72	4	17.18	0.39	0.82	2.55
Within Groups	2256.13	51	44.24			
Total	2324.86	55				

Analysis of Variance for Value

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	467.32	4	116.83	1.23	0.31	2.55
Within Groups	4844.52	51	94.99			
Total	5311.84	55				

Analysis of Variance for Difficulty

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	161.16	4	40.29	1.10	0.37	2.55
Within Groups	1866.82	51	36.60			
Total	2027.98	55				

Analysis of Variance for Interest

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	98.52	4	24.63	0.93	0.45	2.55
Within Groups	1352.84	51	26.53			
Total	1451.36	55				

Analysis of Variance for Effort

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	28.46	4	7.12	0.46	0.76	2.55
Within Groups	780.97	51	15.31			
Total	809.43	55				

These results confirm that scores within each subscale do not vary among professors, regardless of the college where they teach and regardless of their experience teaching this course. Another t-test compared scores among students enrolled at EPCC and UTEP, but again no significant results were found and displaying data for those among each subscale is redundant, so

this data is omitted. The interpretation of this research question as addressed by the result will be discussed further in the last chapter of this dissertation.

Qualitative analysis

According to Creswell and Guetterman (2019), there are six steps necessary to analyze and interpret qualitative data: (1) prepare and organize the data for analysis, (2) engage in an initial exploration of the data through the process of coding it, (3) use the codes to develop a general depiction of the data, (4) represent the findings through narratives and visuals, (5) interpret the meaning of the results by reflecting on the impact of the findings on the existing literature, and, (6) conduct strategies to validate the accuracy of the findings. As the design of this dissertation is an explanatory sequential design, the collection of quantitative data led to the selection of participants for a qualitative data collection (Creswell & Clark, 2018). This subsection will now focus on the analysis of qualitative data, and following the above-mentioned guidelines, the first step lies on the preparation and organization of data for analysis.

As discussed in the methods section, the *SATS* provided varying attitudes and distinguished students holding low (negative), medium (neutral) and high (positive) attitudes. The proposal for this dissertation originally pursued a follow-up interview with three students of each range (n = 9) and the collection of data gathered 103 students for a quantitative analysis, from this sample 17 were selected and invited for a follow-up interview, however, only 8 responded (3 low, 3 medium, 2 high). In need of another interview, one more statistics course at EPCC allowed for the collection of 5 more participants, from which one was selected for being the one with the highest attitude, unfortunately the ratings from this last student held more similarity to medium, rather than high, attitudes. Therefore, the data analysis incorporates 3 students with low attitudes, 4 students with medium attitudes and 2 students with high attitudes.

Despite this limitation the follow-up qualitative analysis allowed for the exploration of trends, the following table summarizes the descriptive statistics for these 9 students.

Table 8. *Descriptive statistics for students selected for qualitative analysis*

Student	Affect	Cognitive competence	Value	Difficulty	Interest	Effort
Low attitude 1	1.00	2.00	1.56	1.71	1.00	7.00
Low attitude 2	1.17	1.83	2.44	1.86	2.75	7.00
Low attitude 3	3.83	3.50	3.11	4.00	3.00	6.25
Medium attitude 1	4.83	4.50	5.00	3.43	5.00	6.00
Medium attitude 2	5.00	5.83	5.78	4.57	4.25	6.25
Medium attitude 3	4.67	5.67	5.56	4.14	4.25	6.00
Medium attitude 4	5.00	5.33	4.67	3.86	5.00	6.25
High attitude 1	7.00	6.83	6.89	4.86	7.00	7.00
High attitude 2	6.50	6.33	6.67	4.14	5.50	6.25

Note. Each mean is based on a range of scores from 1 to 7.

These attitude levels will also be used for identification, for example, low attitude 1 student will be identified as LA1. Low attitude student 2 will be identified as LA2 and so on.

The interviews were semi structured to allow for better responses about the situation at hand, to the emerging worldview of the interviewee and the ideas arising on the topic (Merriam & Tisdell, 2016). The initial structure consisted of 10 questions addressing three main areas of interest: perspectives of knowledge, teaching techniques and knowledge of course material. These three areas were chosen to represent the most common interests when addressing epistemological framing, as studies have focused primarily on perspectives of knowledge (e.g. Hutchinson & Hammer, 2010; Redish, 2004; Scherr & Hammer, 2009), the influence of teaching techniques (e.g. Greeno, 2009; Rosenberg et al., 2006) and the framing evoked when inquired about knowledge of course material (e.g. Hammer et al., 2005; Krupnik et al,. 2018). The full set of questions are found on Appendix B.

The 9 students selected were predominantly Psychology majors (n = 4), although there were also Social Work majors (n = 2), Kinesiology (n = 1), Speech Pathology (n = 1) and Criminal Justice (n = 1). An unexpected factor is that not all students enrolled in these courses are Psychology Majors, as students holding a Psychology Minor also needed to complete this course as part of their degree plan, and if related disciplines also require this course as part of their degree plans, they might require their students to complete it through the Psychology department; hence reflecting on these diverse discipline orientations. Over the upcoming paragraphs responses from each question will be summarized to begin exploring trends in responses from a qualitative perspective.

Question 1: Describe the main lessons from this week

The first round of quantitative questions was collected at least two weeks into the summer courses and four weeks into the semester courses to allow students to generate perspectives on the course by the time they completed the *SATS*, furthermore, they were reached out a week later for the follow-up interviews, allowing all participants to complete either half or nearly half of their courses by that moment. This is evidenced by the range of different responses gathered from this first question as these varied with students reporting lessons on correlation (LA1, LA2), scatterplots (LA1, LA2, MA2), regression (LA2, HA2), mean and standard deviation (LA3, MA3, MA4), Z scores (MA 2, MA 3), probability (HA1, HA2) and t-tests (MA1). This section will discuss findings from each interview question.

Question 2: What do you believe is the purpose of the lessons from this week, how could they be useful?

The second question directly inquired about their perspective of knowledge from the weekly lesson, which varied as students had learned different concepts at the time of their

interviews. Therefore, the second question builds from the responses given through the first question and some trends are evident. Low attitude students struggled to find usefulness, as noted by responses such as “I guess it would be useful for class, but personally I wouldn’t use it” (LA1) or “I guess they use it for a reason” (LA2) and “To prepare us for the exam he will give us” (LA3). While LA1 directly states that this information is not useful, when prompted for more responses the student cannot envision anything directly from her viewpoint, instead remarking what the professor said. Similarly, LA2 struggles to find an answer and when prompted for more responses he provides a guess while expressing uncertainty. LA3 provides a response limited to class material, and like the other two students cannot find another usefulness, once prompted for more responses she cannot provide any.

The pattern of responses differs if compared to responses generated from medium attitude students as one provides an adequate, almost textbook oriented definition (MA1), yet remains limited to class content as LA3 did:

MA1: *It’s a different way to collect data from scientific research, from my understanding there were two methods to conclude if we were to use a paired samples t test when it’s between subject rather is a sample group divided into two, which only get one IV and we later correlated for analysis, where compared to the other one is repeated with the same group and that same group will be tested with the different levels of the IV and the data will be recorded afterwards*.

While there is an effort to provide a response when inquired about the purpose of the lessons for the week, the student cannot explain its usefulness outside of what was memorized. In other words, the student repeats what is the usefulness based on what the professor said, but cannot explain why it is useful, this mirrors the “cut and paste” frame described by Krupnik et al (2018). The other three middle attitude students similarly offer a response to the question but

remain vague on the usefulness of the class lesson. One student explains that statistics are useful for different workplaces, a point on which she elaborates when stating that in psychology statistical values help understand what affects people and which type of people (MA 2), without offering an example to strengthen this point. Another student mentions that statistics are useful to understand how data varies, but remains vague on its usefulness as noted by "uhm really helps a lot of fields you know, like, yeah" (MA3), and another student mentions that a standard deviation is useful, but cannot address why as evidenced in the following excerpt:

MA4: *Well for standard population when it comes to, no standard deviation when it comes to population, hmm for me well is very important, especially if you're going to psychology or anything like that, because like you, like any study that you will make, you will want those numbers, they are just important in general for any type of study that involves population, so is interesting.*

However, the responses from high attitude students hint at productive epistemological frames as they find applications to real life scenarios when describing the course lesson and immediately reinforcing it with real world scenarios and providing specific examples like the use of statistics in lottery, casinos, or politics (HA1) and property tax or house prices (HA2) as evidenced in the following narrative:

HA2: *Well, I work on property tax so we deal with a lot of statistics that I didn't realize before taking the class, but we can see where our, we can predict where our clients house or building may stack up next to the rest of the city using some of these equations, not exactly what is used to, but I'm sure there is a way to twist it into that*

At least in this question, there are evident differences in the patterns of responses among low, medium and high attitude students. As previously mentioned, these hint at the distinction among productive and unproductive frames, a point that will be further discussed over the integrative analysis section within this chapter.

Question 3. What stood out for you from the way your teacher taught the lessons this week?

The next three questions shifted the focus from class lessons to teaching techniques to measure a different perspective of knowledge. Question 3 explores these perspectives first by inquiring if anything stood out by how the teacher taught the lesson, although the results from the quantitative analysis suggests that professors did not significantly affect variability of attitudes. Similarly, the responses gathered from this question did not display any significant patterns, except for one interesting trend which is the importance of teachers answering questions, as mentioned by students in low (LA1) and medium (MA1, MA2, MA4) attitudes, but not by high attitude students. The next two questions inquired about teaching techniques with results similarly remaining ambiguous.

Question 4. If one of your classmates asked you to explain the lessons from this week, how would you do so?

Question 5. If you had to explain these lessons to the entire class, how similar or different could it be?

Questions 4 and 5 explored perspectives of knowledge generated by teaching techniques, however, the variability in responses were spread out across all different ranges of attitudes and could not evidence a significant trend, which remains consistent with the null results of the

quantitative analysis. One student could not envision a technique for teaching because she could not understand the material (LA1), while other students mentioned the use of a PowerPoint (LA2), class notes (LA3, MA2, MA3), class textbook (HA1), the application of course material "step by step" (LA3, MA1) or simply teach like the professor did so far (MA3, MA4, HA2). Questions 3, 4 and 5 left unclear patterns from teaching techniques, yet the exploration of epistemological frames shifted to a particular class lesson and the perspective of class in general again through the remaining interview.

Question 6. What is a standard deviation? How is it useful?

This was the only question inquiring about specific class material, attempting to measure perspectives of knowledge related to a key, yet often confusing, concept in any course of introductory statistics. The responses among students with different levels of attitudes are evident, first because low attitude students either cannot respond as noted by responses such as "From the top of my head, no" (LA1) or "I can't give you an exact definition but if I were to write out the formula on the board then I'd be able to explain what is such and such (LA3). Or, there is an attempt to respond but without any solid substance as evidenced by the following quote:

LA2: *It compares numbers, it will tell you the sum of something, you can see their, ahh I can't remember how he explained it, but it used to be like, like for research, for doing research they would do a standard deviation and its supposed to be like, if it's good, if it's probability or not, by chance or something like that. That's the way I understand it.*

In contrast, medium attitude students attempt to provide a definition for a standard deviation, such as "the difference among the sample means and how far apart they are within the data set" (MA1) or "just how much the data varies" (MA3), although one of these students

struggles to find a definition when defining it as “the number that represents the whole population” (MA4). When prompted to respond as to why the standard deviation is useful these students struggled to respond as evidenced by comments such as ”I think its useful because it helps us determine how far the data set really is when it comes to finding and I guess understanding the little set of the data” (MA1) or “it represents like the whole group as a general like in whatever study you’re trying to get like in whatever study you’re trying to get, is like a standard number for the whole thing” (MA4). From this group of students only one attempts to explain the usefulness of a standard deviation with an applied example when stating that “I want to be a psychologist, and let’s say there is a group therapy or something and I have like the levels of anxiety of my clients and I want to know how much it varies because I can’t just attack one point of anxiety because the other person will not feel like it applies to them*”* (MA3), although the response is on the right track she immediately lost confidence when admitting that she got this question wrong on an exam.

Furthermore, the ambivalence in these responses are evidenced by the detailed explanation provided by another medium attitude student who could not offer a definition for the standard deviation, but instead described the steps taken to compute it. Ironically, despite not being able to define it, he does provide an accurate response when prompted to explain why it is useful. The following excerpt evidence the discrepancy in responses evident across all medium attitude students as they could either offer a definition or explain its usefulness, but not consistently do both:

MA2: *A standard deviation is when you get a mean out of certain values, and then you mean, after that you subtract … give me a second. Ok, so I remember when we did this, we got the mean, then we subtracted each value from the mean and then we would get a score and after that*

each of those scores would be divided and averaged again, and the standard deviation is what you put in the root. So once you put it in the calculator it's the root and yeah, that's the standard deviation … I think is useful because once you get the standard deviation you get more of an idea of how it correlates the mean to the other scores, so the scores and then once they're averaged, and then once they're averaged again they give you a better idea of how they all correlate to each other and how far apart the scores are from each other and yeah just the relationship between scores and their average

The most evident pattern exists here as the two high attitude students provide both a correct definition for what is a standard deviation and a concrete example of its usefulness, either by using the IQ (HA1) or the Z scores (HA2). In this case, the excerpts of both narratives are provided here for a better understanding of these responses:

HA1: *Ok, so the standard deviation is kind of intuitive for me, kind of hard to explain but I'll try. Is kind of like the average of the average, and how far you are from the average, the way I would see it is with the IQ test, that's how I would explain it, where 100 is the average and standard deviation is 15, and the typical IQ test, so if you are within 15 you are still kind of average, nothing too exceptional, or an outlier once you get away from that average of the average, then you're an outlier*

HA2: *The standard deviation is how many average distances you are from the actual average … You can see how your score fare against other people's scores, like if you talk about z scores that's how many standard deviations you are away from the mean, so you can basically use the z score to basically compare your scores to others up to the best of your support.*

Question 7. Is your overall perspective on this course positive or negative? Why?

Remarkably, all nine students reported a positive perspective on this course, regardless of their varying levels of attitudes to statistics. However, the reasons differ as students in the low and medium attitudes attribute their positive evaluations to hopes of passing the course (LA1, LA2, MA2) or the efforts given by their instructors (LA3, MA1, MA3). A common trend among these responses is the attribution of a positive evaluation despite their negative perception of mathematics courses (LA3, MA2, MA3). To illustrate the pattern of these responses, the following quote summarizes the response from a student who maintains a positive evaluation of the course while consistently framing it as a math course:

MA4: *Is positive because I've never been good at math, and that's one of the reasons why I was like oh I want to do social work because I won't have to do math (laughs) and now is like you have to take statistics and like what, no, but is very different from a regular math class like I don't know how, is hard because of the formulas, but is different because it talks about a different thing, it has a different context, like it gives you more context.*

From these low and middle attitude students only one offers a positive evaluation due to its connection to other fields, although is strikingly unrelated yet it is still reported as a reason why the student maintained a positive attitude, which is further accentuated by the effort provided by the instructor:

MA1: *I think overall my perspective is positive, I found it very interesting on how to read the data sets now and the technical terms that come along with the statistical class. For example, I am also taking a speech course and when we were looking at scientific journal articles I was able to understand the terminology that was in the journal articles, I just thought it was fascinating how these terms in real life scenarios and situations this is how scientists think and the way they learn, the way they have to work with numbers and the way they process the data*

set, I actually find it very interesting and she (the professor) has made it very easy to understand. Yeah I think it is a spectacular class

Conversely, high attitude students do not directly connect their positive evaluations to their instructors, but instead express innate interest either by identifying statistics as a fun subject (HA1) or by perceiving it as an easy class (HA2), and on both cases the students report a broader application either on real world settings (HA1) or their personal life (HA2). The following excerpt can further visualize these perspectives:

HA1: *I would say is positive, and it has to do for what I've said before about real world application, I really like the pacing, it's also a fun subject, it's not something where I get bored or anything, it really keeps my interest so I really like the class and I enjoy it.*

Question 8. Has your perspective changed from the first day of class to this moment? If it does, how?

Not all students answered this question explaining if their perspective changed, one student did not explain any previous expectation (LA2) and two others reported neutral expectations (MA3, HA1), while the rest of students agreed to have initial negative perspectives in the class either due to negative experiences with mathematics (LA3, MA2, MA4) or due to comments they heard from other classmates (MA1); nevertheless, they all transitioned to positive perspectives as the semester progressed. The only trend explaining these transitions to positive perspectives are attributed to the diminished difficulty in the class, a comment shared by students across all attitude ranges (LA1, MA2, MA4, HA2). As a clear example, the following excerpt illustrates the extent to which perspectives can change if the student understands the usefulness of class material, even if the student cannot envision such value outside of research paradigms:

MA1: *Honestly I would say it has because at the beginning a lot of people told me that statistics would be boring, you would never use it, it's probably a waste of time, why would you need this and especially being in psychology, some of the psychology majors would tell me that they didn't understand the meaning of it and even other friends I have or they probably had a bad experience with it, but honestly now at this moment of time that I've had right now I have found out how useful it can be when it comes to analyzing data and how vital it is when it comes to scientific research*

Question 9. So far, which lessons have you considered the most valuable? Why?

The last two questions directly focused on the perspectives of knowledge generated up to that point in the semester, although it explored different contexts. Question 9 directly asked the student if one main lesson stood out and the range of responses varied significantly, probably more so than with any other question. First, three students picked their lessons because they were useful in certain areas like work, education or the military (LA1, LA2, HA2). Three other students could not choose one lesson but for different reasons: one because math was not a useful subject to psychology majors (LA3) and the other two because all lessons were important, so none stood out (MA4, HA1). One student chose a lesson on scales of measurement because she had encountered this concept in other courses but could not understand it, and on this course she finally was able to do so (MA2), and another student chose formulas in general "because they are easy to memorize" (MA3). However, the response from MA1 stands out as he becomes introspective through the interview while explaining how a lesson on the null hypothesis allowed him to understand not only the usefulness of all data, but even transferred this to a lesson on a broader scope which even became an analogy for life, truly a remarkable transition to productive

framing. For this last student the comment here is a small excerpt as the full response will be further analyzed on the integrative analysis of this section.

MA1: *One lesson that I probably learned and I don't know why it stuck with me, when we were learning about the nasty null. I believe it was on week 2 when we were learning how to write hypotheses, she ended up telling us that right now in the class we're taking we don't want the null to be true, but one think she did say that researchers actually sometimes when the null is proven true and the alternative hypothesis is proven correct that is ok cause that is what data is, sometimes you're going to get good results, sometimes you'll get null results and sometimes you'll get decreasing results and that's ok if it happens. I like to relate that to the ying and yang symbol, which I guess I'm very fascinated in because it represents the bad and the good and when she told me that that's what it kind of reminded of*

Question 10. So far, what do you believe is the overall purpose of a course in statistics?

The last question attempts to measure an overall approach to the usefulness of the course and trends are evident when low attitude students cannot generate a concrete purpose as they either connected this course to fields unrelated to theirs (LA1) or could not envision a connection from class material to their disciplines. On one hand, despite being a Kinesiology major, LA1 could perceive the course as useful for teachers or accountants; on the other hand, LA2 as a social major could only speculate as evidenced by comments such as "is forced to take it for a reason, maybe like for social you have to work with different people, it can show an example of at risk people or those not at risk or high or low risk, stuff like that" and LA3 as a psychology major is honest when stating "I just pretty much see it as a course I have to take to complete my degree plan … I mean not that I know there is any math like that dealing with psychology."

For middle attitude students there is variability as one student connects these lessons to the field of psychology from a research perspective a (MA1), while others believe is useful, but remain vague in explaining why as they cannot explain a specific reason for it (MA2, MA3, MA4). Unlike these students though, the students on a high attitude range provide specific applications to different fields like psychology, social work (HA2) and speech language pathology (HA1) as evidenced by the following narrative:

HA1: *This can be applied to what I eventually want to do which is speech language pathology, using data, interpreting data and just knowing what to do with it instead of not having a foundation and I think this class is a good foundation, is nothing too crazy, everything they're explaining as long as you do your work you will understand it.*

Integrated data analysis

A common mistake in mixed methods research designs in the misconception that its usefulness is solely limited to collect and analyze both quantitative and qualitative data (Bryman, 2006). Therefore, recent trends in mixed methods research conclude that integrating data is the centerpiece as a nonintegrative approach minimizes the true value of mixed methods, which increases when insight expands from what can be understood separately from quantitative and qualitative results (Creswell & Clark, 2018). To do this, the qualitative data was subjected to an analysis by hand due to my interest in remaining close to the data and have a hands-on feel without the intrusion of software (Creswell & Guetterman, 2019). The first step was a preliminary exploratory analysis to obtain a general sense of the data, which was explained through the previous subsection of this chapter. The next step was to code the data by segmenting and labeling text to develop descriptions and broad themes in it. The recommendations by Creswell and Poth (2018) provided the guidelines in this process: (1) Read

all transcriptions carefully and jot down in the margins some ideas as they came to mind, (2) pick one interview and review it asking the question "What is this person talking about?" and consider the underlying meaning, (3) begin the coding process by identifying text segments, place a bracket around them and assign code words or phrases that describe the meaning of the text segments within the perspectives of epistemological framing previously noted through the literature, (4) make a list of all code words, (5) take the coding list and refer back to the data to organize a scheme and (6) reduce the list of codes to set the major themes of the settings.

A code in qualitative data analysis is a generated construct that symbolizes or "translates" the data (Vogt et al., 2014), which provides a meaning to detect patterns, find categories and build theories (Saldana, 2021). The process of coding in this integrative analysis began with a first round of *In Vivo Coding* as each drew directly from the language of each participant (Charmaz, 2014), as a natural transition the second round transitioned into *Focused Coding* to search for the most significant categories and finished it with a third set of codes to establish the two themes of interest: productive and unproductive frames.

As previously mentioned, the emerging theory on epistemological framing favors a dichotomy among two themes by dividing productive from unproductive epistemological frames, although an argument exists to believe that similar to medium attitude students, there can also be neutral epistemological frames, but in essence those refer to students who are not creating any perspective on the course; in other words, they are not inquiring what do they need to learn or by what standards will their intellectual contributions be measured. At least in this study, none of the interviewed students displayed such dismissive perspective of knowledge, and if they openly expressed confusion regarding their course knowledge, it fit within the theme of unproductive framing. In other words, there is no research supporting the existence or interest on neutral

framing, thus the integrated data analysis focuses on the suggested dichotomy among productive and unproductive epistemological framing (Hammer et al., 2005; Krupnik et al., 2018).

At this point, the data will be explained in a joint display to show the integration data analysis by arraying outcomes from the quantitative and qualitative data, which will facilitate the comparison of results and display a merging of both data sets (Creswell & Clark, 2018).

First set of codes

The interview consisted of 10 questions addressing three different areas of epistemological framing. The first area set on perspectives of knowledge, which consisted of questions 2, 7, 8, 9 and 10; these questions addressed the usefulness of course lessons, perspectives on the course and overall purpose of a class in statistics. The second area set on teaching techniques, these consisted of questions 3, 4 and 5; these questions inquired if anything stood out by the way the teacher taught the lesson, and what would the student do if placed on the position of the professor either as a tutor or lecturer. Finally, the third area set on actual course knowledge as it applied to question 6, which focused solely on the standard deviation. In an effort to ensure validity, data was coded by hand and revised with the collaboration of a fellow PhD student, Julio Solis. First, a coding book was created by revising the transcription from each interview to begin with the first set of codes; a codebook is especially important when multiple team members collaborate on the analysis of the same data (Saldana, 2021). Following the recommendations by Bernard et al (2016) each of the first set of codes were labeled along with a short description, inclusion criteria and typical exemplars to help narrow the purpose of each code within the analysis scheme.

Past the creation of a codebook, each coder revised the data independently to create categories and converge the data in two themes: productive and unproductive frames. Once the data from each coder was finalized, an analysis of inter-rater reliability compared the number of codes for each theme using Cohen's Kappa statistic as it is considered a more rigorous measure of agreement (Tinsley & Weiss, 1975). As the qualitative data divides in three areas, inter-rater reliability computations were carried for each as it compared the codes from Julio and myself. For perspectives of knowledge Cohen's Kappa set a value of 0.79, for teaching techniques it resulted in 0.84 and for course material it reflected a 0.80. In general terms, a Cohen's Kappa inter-rater score ranging from 0.61 to 0.80 reflects substantial agreement, which validates the coding process (Gisev et al., 2013).

As the following dataset will display with each of the three areas, the first set of codes are not inferring nor categorizing anything. The codes are taken straight out of the raw data from student responses, thus employing the technique of *In Vivo Coding* as it draws from the own language of each participant for codes (Charmaz, 2014). In some cases, there is a whole phrase used, such as "Nor as hard as I thought" or "I don't enjoy math, but I enjoy this class" and in other cases it will be keyword sentences such as "How to read data sets with technical terms" or "No use for statistics." This first round of codes emerged from the collaboration of the coding process with Julio Solis by organizing the codes listing them on a text editing page and then pasting them into outlined clusters as recommended by Saldana (2021).

Table 9. *First set of codes for perspectives of knowledge*

Code ID	Questions on perspective of knowledge	# of codes	Codes listed by attitude
1	How to read data sets with technical terms	4	3 MA 1 HA
2	Not as hard as I thought	4	1 LA 2 MA 1 HA
3	No use for statistics (psychology, kinesiology)	4	3 LA 1 MA
4	A lot of fields require statistics	3	3 MA
5	I was forced to take it but is for a reason	3	2 LA 1 MA
6	Useful for psychologists	3	3 MA
7	Useful for excel	2	2 LA
8	Hope to get a good grade	2	1 LA 1 MA
9	Hope to pass the class	2	2 LA
10	Not good at math	2	1 LA 1 MA
11	Useful for my field (Property tax, speech language)	2	2 HA
12	Real world application	2	1 LA 1 HA
13	Statistics can be used in lottery, casinos, politics	2	2 HA
14	Teacher said statistics helps you better yourself	1	1 LA
15	Teacher said statistics helps you get better jobs	1	1 LA
16	Useful for teachers or accountants	1	1 LA
17	Useful for the military	1	1 LA
18	I don’t understand it	1	1 LA
19	Never taken a math class	1	1 LA
20	Useful for social work (can show groups at risk)	1	1 LA
21	The lesson is to prepare us for the exam	1	1 LA
22	Just math, any other subject it would have a meaning	1	1 LA
23	Different way to collect data from scientific research	1	1 MA
24	Use terms in real-life scenarios and situations	1	1 MA
25	Any result from the data is useful information	1	1 MA
26	Understand the different things affecting people	1	1 MA
27	Negative view based on previous experiences	1	1 MA
28	Categories of data are useful	1	1 MA
29	I don't enjoy math but I enjoy this class	1	1 MA
30	Does not include big mass formulas	1	1 MA
31	Formulas because they're easy to memorize	1	1 MA
32	Not a regular math class, gives more context	1	1 MA
33	I'm sure I won't use all the formulas, but the basic ones	1	1 MA
34	Fun subject	1	1 HA
35	This class is a good foundation	1	1 HA
36	Simple math	1	1 HA
	Total	58	

This area held a broad range of responses which led to 36 different codes, and as noted by their frequencies, few were used more than once, however, these were still chosen as they were inspired by participants and were considered to crystallize meanings from their responses (Charmaz, 2014), which is a recommended measure. Some of the main highlights from this first set of codes are the high frequency both from perspectives that were productive, such as the usefulness of a course in statistics to read data sets and the understanding that different fields require statistics, but under the same rate of frequencies there were instances of unproductive frames when students reported that they had not use for statistics and that they were forced to take it for a reason, which could not be understood at least by the time of the interview.

The first set of codes for the second area, teaching techniques, explored for trends suggesting a specific tactic that could correlate with student attitudes at the different levels. However, the results from the quantitative analysis suggest that no teaching technique would modify dramatically the extent to which students develop attitudes. The following data set can validate these findings.

First set of codes for teaching techniques

Code ID	Questions on teaching techniques	# of codes	Codes listed by attitude
			2LA 2MA
1	Go back to notes / review step by step	5	1HA
2	Answer questions	4	1 LA 3 MA
3	Adapt to whatever a student needs to understand better	3	2 MA 1 HA
4	Patient / relaxed / quirky personality	3	2 MA 1 HA
5	Use the whiteboard	2	1 LA 1 MA
6	Good pace	2	1 MA 1 HA
7	Start at a fundamental level and then add on it	2	1 MA 1 HA
8	Supplement the material along with the book	2	1 MA 1 HA
9	Review material	2	1 LA 1 MA
10	Use the powerpoint	2	1 LA 1 MA
11	Pertain to personal life	2	1 LA 1 MA
12	Know the material	2	1 LA 1 MA
13	Make sure students are paying attention / engage	2	2 MA
14	Figure it out in pairs or groups	2	1 LA 1 HA
15	Check if students are lost	1	1 LA
16	Create phrases such as "we don't want the nasty null"	1	1 MA
17	Color codes	1	1 MA
18	Repetition of the formulas	1	1 MA
19	Read and just do it one check at a time	1	1 HA
	Total	40	

For these first set of codes is important to note that the number was smaller than the previous area as the analysis gathered only 19. However, as will be noted by the second set of coding, there is indeed ambivalence on the coding set which reflect on the results from the quantitative analysis as the professor does not affect different attitude levels. Lastly, the third area explores perspectives of knowledge with actual course content.

First set of codes for standard deviation (course material)

Code ID	Questions on standard deviation (course material)	# of codes	Codes listed by attitude
1	Cannot provide an exact definition	2	2 LA
2	Cannot explain why is useful	2	2 LA
3	Difference among sample means, how far they are within the data set	2	2 MA
4	How much the data varies	2	2 MA
5	How many average distances you are from the actual average	2	2 HA
6	Compares numbers, tells you the sum of something	1	1 LA
7	Useful for research (without a concrete example)	1	1 LA
8	Understanding the data	1	1 MA
9	Explains how to compute it instead of providing a definition	1	1 MA
10	To get an idea about the midpoint of data	1	1 MA
11	Explains it using an example of anxiety treatment	1	1 MA
12	A number that represents the whole population	1	1 MA
13	A standard number for the whole group (nothing concrete)	1	1 MA
14	Compares it to the IQ test to explain an outlier	1	1 HA
15	You can see how your score fare against other people's scores	1	1 HA
	Total	20	

For this first set of codes on this first area the number reduced to 15, which is expected as it just focused on one question prompting two responses (definition and usefulness of standard deviation). The topic of a standard deviation was purposefully selected as the concept is essential in the study of statistics, yet despite its usefulness many students can struggle to understand both its meaning and importance, although this can only be verified from personal experience, not through any study exploring this topic.

Second set of codes

Although In Vivo Codes can be used as the sole coding method for small-scale studies like this, they can also limit the perspective from the data (Saldana, 2021), therefore, a second round of data analysis proceeded independently from each coder to develop categorical and thematic organizations to the first set of codes. The natural choice for this analysis is *Focused*

Coding as it follows In Vivo Coding in searching for the most significant codes to develop the most salient categories (Charmaz, 2014). The second set of codes sought categories within the initial round of codes, furthermore the analysis focused on the number of codes listed by attitudes, providing total number of codes within each category, and splitting them up among low attitude students (LA), medium attitude students (MA) and high attitude students (HA). There are evident trends among the first and third areas of epistemological knowledge (perspectives of knowledge and course content), but not so evident on the second area (teaching techniques).

Table 10. *Second set of codes for perspectives of knowledge*

Categories for perspectives of knowledge	Number of codes	Codes listed by attitude
1 - Statistics are useful		
1.1 - Statistics are useful in research and psychology		
How to read data sets with technical terms	4	3 MA 1 HA
Useful for psychologists	3	3 MA
Different way to collect data from scientific research	1	1 MA
Understand that any result from the data is useful information	1	1 MA
Categories of data are useful	1	1 MA
1.2 Statistics are useful in other fields		
A lot of fields require statistics	3	3 MA
Useful for excel	2	2 LA
Useful for my field (Property tax, speech language)	2	2 HA
Real world application	2	1 LA 1 HA
Statistics can be used in lottery, casinos, politics	2	2 HA
Teacher said statistics helps you better yourself	1	1 LA
Teacher said statistics helps you get better jobs	1	1 LA
Useful for teachers or accountants	1	1 LA
Useful for the military	1	1 LA
Useful for social work (can show groups at risk)	1	1 LA
Use terms in real-life scenarios and situations	1	1 MA
Understand the different things affecting people	1	1 MA
I'm sure I won't use all the formulas, but the basic ones	1	1 MA
	Total	29
	Total LA	8
	Total MA	15
	Total HA	6
2 - Difficulty in statistics		
Not as hard as thought	4	1 LA 2 MA 1 HA
Fun subject	1	1 HA
This class is a good foundation	1	1 HA
	Total	6
	Total LA	1
	Total MA	2
	Total HA	3

3 - Statistics as a math class		
Not good at math	2	1 LA 1 MA
I don't enjoy math but I enjoy this class	1	1 MA
Does not include big mass formulas	1	1 MA
Formulas are easy to memorize	1	1 MA
Different from a regular math class, gives more context	1	1 MA
Had negative view of math classes based on experiences	1	1 MA
The class is just math, if it was any other subject it would have a deeper meaning	1	1 LA
Simple math	1	1 HA
Never taken a math class	1	1 LA
	Total	10
	Total LA	3
	Total MA	6
	Total HA	1

4 - Statistics are not useful		
4.1 - Statistics are not useful for my field		
No use for statistics (psychology, kinesiology)	4	3 LA 1 MA
I was forced to take it	3	2 LA 1 MA
I don’t understand it	1	1 LA
4.2 - Statistics value is in grade		
Hope to get a good grade	2	1 LA 1 MA
Hope to pass the class	2	2 LA
The lesson is to prepare us for the exam	1	1 LA
	Total	13
	Total LA	10
	Total MA	3
	Total HA	0

Multiple trends emerge from this second set of codes. The first category relates to a perspective of knowledge addressing the usefulness in statistics, and students across all attitude ranges conceive it, yet they cannot always explain why. For example, high attitude students state that statistics are useful not only for their fields (tax property and speech language pathology), but for other real-life circumstances such as politics, casinos or even nutrition; on the other hand, low attitude students can also acknowledge the usefulness of the course but not because it relates

to them, they do so because their teacher said it. Over the second category exploring the difficulty in statistics, all the students responded with a positive impression on its difficulty as it was not perceived as hard as thought, and it was even addressed as a fun subject, such category was mostly supported by medium and high attitude students. The most evident trends though are noted in the last two categories as it addressed statistics as a math class and as a field not useful. These perspectives were predominantly held by low and medium attitude students. When coding the data for these emerging categories is almost obvious why students can hold such negative attitudes toward this course, and why they can contrast substantially with the positive perspectives held by the high attitude students.

Second set of codes for teaching techniques

Categories for teaching techniques	# of codes	Codes listed by attitude
1. Teacher personality / attitude		
Patient / relaxed / quirky personality	3	2 MA 1 LA
Good pace	2	1 MA 1 HA
	Total	5
	Total LA	1
	Total MA	3
	Total HA	1
2. Teacher directed learning		
Answer questions	4	1 LA 3 MA
Adapt to what a student needs to understand better	3	2 MA 1 HA
Use the whiteboard	2	1 LA 1 MA
Start at a fundamental level and then add on it	2	1 MA 1 HA
Supplement the material along with the book	2	1 MA 1 HA
Review material	2	1 LA 1 MA
Use the powerpoint	2	1 LA 1 MA
Pertain to personal life	2	1 LA 1 MA
Know the material	2	1 LA 1 MA
Make sure students are paying attention / engage	2	2 MA
"we don't want the nasty null"	1	1 MA
Check if students are lost	1	1 LA
Color codes	1	1 MA
Repetition of the formulas	1	1 MA
	Total	27
	Total LA	7
	Total MA	17
	Total HA	3
3. Student oriented learning		
Go back to notes / review step by step	5	2 LA 2 MA 1 HA
Figure it out in pairs or groups	2	1 LA 1 HA
Read and just do it one check at a time	1	1 HA
	Total	8
	Total LA	3
	Total MA	2
	Total HA	4

From the student responses on the second set of codes exploring teaching techniques only three categories emerge: teacher personality / attitude, teacher directed learning and student-oriented learning. Unlike the previous area of study, for neither of these categories does one set of student attitudes stand out for having a higher or lower frequency of codes. As previously discussed, this is coherent with the results from the quantitative analysis as the results concluded that students held a similar range of attitudes, regardless of who was their professor. At least within this dataset, the course itself creates the range of attitudes, not the professor.

Finally, the third area of interest lied on actual course knowledge by addressing an essential concept in the study of statistics, the standard deviation. From personal experience, students can at times struggle to understand the definition and importance of this statistic, therefore, the question prompted two responses, what is the standard deviation and why is it useful. The following dataset summarized this second set of codes.

Second set of codes for standard deviation (course knowledge)

Categories	# of codes	Codes listed by attitude
1. Understands the standard deviation		
1.1 - Defines it in their own words		
Difference among sample means, how far they are within the data set	2	2 MA
How much the data varies	2	2 MA
How many average distances you are from the actual average	2	2 HA
You can see how your score fare against other people's scores	1	1 HA
1.2 - Provides an application to explain it		
Explains it using an example of anxiety treatment	1	1 MA
Compares it to the IQ test to explain an outlier	1	1 HA
	Total	9
	Total LA	0
	Total MA	5
	Total HA	4
2. Attempts to explain but is vague		
Compares numbers, tells you the sum of something	1	1 LA
Useful for research (without a concrete example)	1	1 LA
Understanding the data	1	1 MA
Explains how to compute it instead of providing a definition	1	1 MA
To get an idea about the midpoint of data	1	1 MA
A number that represents the whole population	1	1 MA
A standard number for the whole group (nothing concrete)	1	1 MA
	Total	7
	Total LA	2
	Total MA	5
	Total HA	0
3. Does not understand the standard deviation		
Cannot provide an exact definition	2	2 LA
Cannot explain why is useful	2	2 LA
	Total	4
	Total LA	4
	Total MA	0
	Total HA	0

Three categories emerge from the dataset: (1) students understand what is the standard deviation by providing a definition in their own words or an application to explain it, (2) students attempt to explain it but remain vague as they struggle to understand it, and (3) students do not understand the standard deviation. On this question is where the variation in attitudes lead to the most evident differences, and the contrast is clear. For students who fall within the category of understanding the standard deviation all of them are either medium or high attitudes, which drastically contrast to the students attempting to explain but remain vague, who are only low and medium attitudes. As expected, the category for students who cannot provide a definition nor explain why is useful all fall within the low attitudes. If comparing results across the three areas of interest is evident that students can hold different perspectives of knowledge, although the conception of statistics as a useful class is held primarily by high and medium attitude students, while the misunderstanding of the course solely as a math class with limited usefulness which is held mostly by low attitude students. This is further evidenced by the different insight that each student holds for course material, for example with a concept as important as the standard deviation. Furthermore, these perspectives are not necessarily driven by their professors, and consequently their teaching techniques. At least as evidenced by this sample, none of the students held a negative view of their class nor their professor.

Third set of codes

To integrate data from the quantitative and qualitative analysis, a third set of codes added each category within the different areas of interest to explore the extent at which they reflect on productive or unproductive frames; these were used as the concluding themes and outcomes of the coding process (Saldana, 2021). These themes are meant to bring meaning to the experience as noted by DeSantis and Ugarriza (2000), which in this case refers to the epistemological

frames. By themeing the data the analysis can explore a participant's psychological world of beliefs and constructs (Giorgi & Giorgi, 2003). As expected, the themes evidence a substantial difference among students on a different attitude range on the first and third areas of interest, but not on the second. To elaborate on this, a joint display will illustrate closer examples from productive and unproductive frames.

Table 11. *Third set of codes for perspectives of knowledge*

Themes for perspectives of knowledge	
A) Productive frames	
Statistics are useful in research and psychology	
Statistics are useful in other fields	
Difficulty in statistics	
Total	35
Total LA students	9
Total MA students	17
Total HA students	9
B) Unproductive frames	
Statistics as a math class	
Statistics are not useful	
Total	22
Total LA students	13
Total MA students	9
Total HA students	0

Third set of codes for teaching techniques

Themes for teaching techniques	
A) Productive frames Student oriented learning	
Total	9
Total LA students	3
Total MA students	2
Total HA students	4
B) Unproductive frames Teacher personality / attitude Teacher directed learning	
Total	32
Total LA students	8
Total MA students	20
Total HA students	4

Third set of codes for standard deviation (course material)

Themes for standard deviation	
A) Productive frames Understand the standard deviation	
Total	9
Total LA students	0
Total MA students	5
Total HA students	4
B) Unproductive frames Attempts to explain but is vague Does not understand the standard deviation	
Total	11
Total LA students	6
Total MA students	5
Total HA students	0

To determine if there is a significant association between the categorical variables a 2x3 Chi-square test of independence was performed to assess the difference between epistemological framing and student attitudes using the final data count from the third set of codes. For

perspectives of knowledge, there was a significant difference between the variables, $X^2(2) = 9.73$, $p < .05$. For course content, there was a significant difference between the variables, $X^2(2) = 9.89$, $p < .05$; however, for teaching techniques there is ambivalence due to an outcome yielding on a borderline of significant difference, $X^2(2) = 5.97$, $p = .05$ which may still be offset due to the unbalanced ratio of medium attitude students in comparison to low and high attitudes, thus making an assumption of statistical significance a risky decision, thus erring on the side of caution and concluding this a non-significant difference. For each of these values a 2x3 contingency table describes the data below.

Table 12. *Attitude*Knowledge Crosstabulation*

			Productive	Unproductive	Total
Attitudes	Low attitude	Count	9	13	22
		% within knowledge	40.9%	59.1%	100.0%
	Medium attitude	Count	17	9	26
		% within knowledge	65.4%	34.6%	100.0%
	High attitude	Count	9	0	9
		% within knowledge	100.0%	0.0%	100.0%
Total		Count	35	22	57
		% within knowledge	61.4%	38.6%	100.0%

*Attitude*Course Content Crosstabulation*

			Productive	Unproductive	Total
Attitudes	Low attitude	Count	0	6	6
		% within knowledge	0.0%	100.0%	100.0%
	Medium attitude	Count	5	5	10
		% within knowledge	50.0%	50.0%	100.0%
	High attitude	Count	4	0	4
		% within knowledge	100.0%	0.0%	100.0%
Total		Count	9	11	20
		% within knowledge	45.0%	55.0%	100.0%

*Attitude*Teaching Techniques Crosstabulation*

			Productive	Unproductive	Total
Attitudes	Low attitude	Count	3	8	11
		% within knowledge	27.3%	72.7%	100.0%
	Medium attitude	Count	2	20	22
		% within knowledge	9.1%	90.9%	100.0%
	High attitude	Count	4	4	8
		% within knowledge	50.0%	50.0%	100.0%
Total		Count	9	32	41
		% within knowledge	22.0%	78.0%	100.0%

As mentioned through the literature review, other studies have explored patterns of productive and unproductive framing, which were expected from this study. Some of the patterns of productive frames that were evoked from these responses evidence storytelling (Rosenberg et al., 2006), prompts to shift positionality among classmates by allowing every student in a group to lead during discourse (Shim & Kim, 2019), or a shift in positionality where students can own the role of question-maker and answer-gatherer fostering multiple viewpoints (Shaban & Wilkerson, 2019). On the other hand, other responses evidence patterns of unproductive frames such as group work strategies solely devoted to find answers without deliberation or consultation with each other (Scherr & Hammer, 2009) or a "cut and paste" mentality echoing on the misconception of lecture as an attempt to hoard facts without relevance or accumulating facts without considering their connection to real life (Hutchinson & Hammer, 2010). These frames were evident on the questions addressing perspectives of knowledge. For example, an unproductive frame was evidenced by LA3 who cannot envision any use in a course of statistics as it can only be perceived as a math class.

Table 13. *Integrative data analysis*

	Unproductive framing
Interviewer	So far is there a lesson you consider the most valuable?
LA 3	*Hmm no, is just math. Ok if it was government or any other subject that had a deeper meaning like English I'd walk away with a lesson, but this is just math*
Interviewer	What is your major?
LA 3	*Psychology*
Interviewer	What do you think is the purpose of a class in statistics?
LA 3	*I just pretty much see it as a course I have to take to complete my degree plan*
Interviewer	But you can't find any usefulness to your career?
LA 3	*No I mean not that I know there is any math like that dealing with psychology*

These perspectives can contrast substantially when comparing it with medium attitude students who can maintain a more positive attitude toward the class, yet still remain ambivalent when explaining the usefulness of a course as exemplified by MA3 and MA4 who still consider the course within the boundaries of a mathematics class but may not find it useful beyond.

	Unproductive framing
Interviewer	Did anything stood out for what you learned so far
MA 3	*I do like the formulas because they're easy to memorize*
Interviewer	So you're asked in the class to memorize the formulas
MA 3	*We actually aren't but its very easy for me to memorize them even though we weren't supposed to in a way*
Interviewer	What do you believe is the purpose of taking a class in statistics?
MA 3	*Hmm well, I obviously did it for the credit, but I think that is also interesting, because you can see how companies work with their data, what they do. How people come out with these numbers or like statistics, because is everywhere you know, like oh 97% population bla bla bla, this percent bla bla bla, and I think its really important to just know, not be in a way very ignorant so its really nice to just know how things work.*

Unproductive framing	
Interviewer	Is your overall perspective on the course positive or negative, and why?
MA 4	*Is positive because I've never been good at math, and that's one of the reasons why I was like oh I want to do social work because I won't have to do math (laughs) and now is like you have to take statistics and like what, no, but is very different from a regular math class like I don't know how, is hard because of the formulas, but is different because it talks about a different thing, it has a different context, like it gives you more context. Than a regular class of math, they just give you numbers and with statistics is always like a whole thing, a lot of context and population and numbers*

Conversely, students holding positive attitudes perceive the course beyond the boundaries of a math class to provide a real-world application, both in areas related to their profession and field of study, but also to areas beyond like politics, casinos, or nutrition.

Productive framing	
Interviewer	What do you believe is the purpose of the lesson?
HA 1	*Well, for me, it's things you can use in the real world so it's real world application, so you learn it and you apply it, well that's the way I see it, it would be a waste of time to just sit there and regurgitate information for a test, so the way I see it is how can I use it? For me is real world application, what I like about his lessons, for example yesterday he talked about how it can be used, like in lottery, for casinos, politics and things like that.*
Interviewer	Then what do you think is the overall purpose of a class in statistics?
HA 1	*Well this can be applied to what I eventually want to do which is speech language pathology, using data, interpreting data and just knowing what to do with it instead of not having a foundation and I think this class is a good foundation, is nothing too crazy, everything they're explaining as long as you do your work you will understand it. There's nothing too hard or anything*

	Productive framing
Interviewer	What would you believe is the purpose of the lesson? Or how is it useful?
HA 2	*Well, I work on property tax so we deal with a lot of statistics that I didn't realize before taking the class, but we can see where our, we can predict where our clients house or building may stack up next to the rest of the city using some of these equations, not exactly what is used to, but I'm sure there is a way to twist it into that*
Interviewer	So far which lessons have you considered the most valuable? And why?
HA 2	*I think standard deviations and z scores are very important but in real world application I think transitioning those to percentiles is pretty valuable, I can see myself using that on my job. If a house is valued at the 75% percentile then the value is too high*
Interviewer	Ok, I think I just have one last question. Tell me, if this is a class that is required in your degree plan, what do you believe is the overall purpose of a class in statistics?
HA 2	*Hmm probably to be able to interpret statistics in life after college because it shows up quite a bit, not just in science but in politics, nutrition*

These patterns can also hold for the questions regarding the standard deviation, such is the case of LA2, MA2 and MA4 who all attempt to provide a definition for it, or explain its usefulness, but none can provide a concrete point, rather remaining vague. The following excerpts illustrates these patterns.

	Unproductive framing when addressing the standard deviation
LA 2	*It compares numbers, it will tell you the sum of something, you can see their, ahh I can't remember how he explained it, but it used to be like, like for research, for doing research they would do a standard deviation and its supposed to be like, if it's good, if it's probability or not, by chance or something like that. That's the way I understand it.*
MA 2	Yes a standard deviation is when you get a mean out of certain values, and then you mean, after that you subtract … give me a second. Ok, so I remember when we did this, we got the mean, then we subtracted each value from the mean and then we would get a score and after that each of those scores would be divided and averaged again, and the standard deviation is what you put in the root. So once you put it in the calculator it's the root and yeah, that's the standard deviation
MA 4	*Hmm the standard deviation for me is basically like the number that represents the whole population, like the mean and basically everything to be honest with you, I think is very interesting, it just means everything and like it helps because is the number that represents the whole group*

Furthermore, an example of a productive frame can not only provide a definition but explain the importance of the standard deviation as explained by MA3 and HA1 as both attempt to explain it by using an applied example, although is not clear if such examples were given by their instructors or if they understood them on their own.

	Productive framing when addressing the standard deviation
MA3	*Well is useful because you'd get an idea about the midpoint of the data. Like for example in my example, I want to be a psychologist, and lets say there is a group therapy or something and I have like the levels of anxiety of my clients and I want to know how much it varies because I can't just attack one point of anxiety because the other person will not feel like it applies to them*
HA 1	*Ok, so the standard deviation is kind of intuitive for me, kind of hard to explain but I'll try. Is kind of like the average of the average, and how far you are from the average, the way I would see it is with the IQ test, that's how I would explain it, where 100 is the average and standard deviation is 15, and the typical IQ test, so if you are within 15 you are still kind of average, nothing too exceptional, or an outlier once you get away from that average of the average, then you're an outlier*

A response worth exploring came near the end of an interview with MA1 who solidified a course lesson that not only connected to his understanding of statistics in the classroom, but with its importance in the real world as he connected the lesson to a relevant topic in his life, this is one of the most insightful lessons from the interviews.

Shift in framing to storytelling	
Interviewer	So far, which lesson or lessons have you considered the most valuable and why.
MA 1	*One lesson that I probably learned and I don't know why it stuck with me, when we were learning about the nasty null. I believe it was on week 2 when we were learning how to write hypotheses, she ended up telling us that right now in the class we're taking we don't want the null to be true, but one think she did say that researchers actually sometimes when the null is proven true and the alternative hypothesis is proven correct that is ok cause that is what data is, sometimes you're going to get good results, sometimes you'll get null results and sometimes you'll get decreasing results and that's ok if it happens. I like to relate that to the ying and yang symbol, which I guess I'm very fascinated in because it represents the bad and the good and when she told me that that's what it kind of reminded of*
Interviewer	Is this something you created in your mind or is this something that she mentioned? This ying and yang
MA 1	*Oh no that was something completely me*
Interviewer	I've never thought about it that way so that makes total sense. Did you felt, I'm curious, did you felt a sigh of relief knowing that is ok you find null results? That's the feel I'm getting from your results
MA 1	*Yeah for sure, I think any outcome is a good outcome because one little thing that I like to tell friends and family that all knowledge is good knowledge and when you get any result from the data set that's data there that's useful information that can be analyzed and help researchers to find an answer*

When inquired about this shift to productive framing when developing this analogy, the student states that this came out of himself, yet it can give an insight into strategies that teachers could use to evoke similar perspectives of knowledge. This is an idea worth exploring over the last chapter of this dissertation.

Validating the data and results

Qualitative research tends to focus on validity rather than reliability (Creswell & Clark, 2018), and for the different strategies available to determine validity the recommendation is to use at least three of them. To ensure validity with the data and results the first strategy relied in the support of a fellow doctoral student, Julio Solis, who helped analyze the set of codes to transition into categories after deliberate discussion and the same method prevailed on the third round of coding which ultimately led to the themes; furthermore, a Cohen's Kappa measure of interrater reliability was measured with scores ranging from 0.79 to 0.84 as previously mentioned, which results in substantial agreement (Gisev et al., 2013). A second strategy lied in member-checking (Saldana, 2021) as summaries of the findings were taken back to key participants (LA3, MA1, MA4, HA1 and HA2) and asked if these findings portrayed an accurate reflection of their experiences, to which they all agreed; the rest of the participants did not respond to the request for validation. The third strategy is triangulation of data as it was drawn from different sources as the quantitative and qualitative data allowed to build evidence from different areas for a comprehensive analysis.

Summary

This chapter presents the data analysis results to answer the research questions from this study. The first section reported the quantitative analysis from the *SATS* (Schau, 2003) structured among descriptive analyses from the entire data set and each subscale as a comparison across the range of attitudes for each of the professors who provided participants on this study. Through a series of non-parametric and parametric comparisons on attitudes the results evidence similarity across attitude levels, regardless of the professor teaching the course; these results suggest that student attitudes do not significantly vary across professors.

The second section reported results for the qualitative analysis as 9 students were selected for the follow-up interview based on their different attitude levels: 3 for low attitudes, 4 for medium attitudes and 2 for high attitudes. The interviews were structured in 10 questions tailored to explore epistemological frames held in three different areas: perspectives of knowledge, teaching techniques and course content knowledge. Through the end of the section a joint display coded the data to highlight categories, which led to the emerging themes of productive and unproductive frames among students with different range of attitudes to strengthen the results from this mixed-methods design. The results evidenced patterns of unproductive frames among low and medium attitude students differing from high attitude students on perspectives of knowledge and course content knowledge, but not on teaching techniques. These results further validate the quantitative data analysis as student attitudes varied similarly regardless of which teacher taught the course, and the qualitative data analysis further evidenced the different patterns of teaching techniques that did not differ among students, regardless of their attitude level.

Conclusion

The major findings from the results section is the ambivalent role of teachers in shifting frames that students enrolled in statistics courses generate, and the extent to which perspective of knowledge and course content knowledge differs among students from low, medium and high attitudes, regardless of the professor or the teaching techniques used in class. However, just because this study suggests that professors do not evoke shifts in framing does not mean that there is nothing that can be done. Following on the guidelines of previous researchers, the results section will be interpreted at length over the next section to explain the role of professors in switching frames if there is knowledge on the importance on switching epistemological frames to

prompt changes to productive framing. In the end, prompting change to productive framing is beneficial to students not only for their class performance, but in their understanding of the usefulness in statistics to their professions, and not solely as a course completed as a requirement to their degree plan.

CHAPTER V: DISCUSSION

Framing refers to an interpretation to a situation, an answer to the question "What is going on here?" (Goffman, 1974). Research in learning sciences evidence the existence of frames in education within a context of knowledge, which are answers to questions such as "What do I expect to learn?" or "By what standards will my intellectual contributions be judged?" (Redish, 2004), an effort to promote productive frames in statistics classrooms can alter the misconceived beliefs about statistics courses for psychology majors (Ruggeri et al., 2008) which subsequently holds an effect on the attitudes generated by students in these classes (Nasser & Birenbaum, 2005). The notion of student attitudes toward statistics courses in psychology has been studied for over 30 years with outcomes suggesting that psychology students often hold negative attitudes (e.g., Conners et al, 1998; Hogg, 1991; Ruggeri et al., 2008; Schutz et al.,1998), or neutral at best (Counsell & Cribbie, 2020; Schau & Emmioglu, 2012), and learning how to manage attitudes is worth exploring when studies associate positive attitudes with higher grades (e.g., Chiesi & Primi, 2009; Dempster & McCorry, 2009), the development of statistical thinking skills and even the willingness to enroll in future statistics courses (Gal & Garfield, 1997; Hilton et al., 2004). Therefore, this study explored the connection between epistemological framing and its effect on student attitudes toward a course in statistics, the research interest led to two research questions.

What are the range of attitudes of students enrolled in a psychology-based class in statistics and would such range of attitudes significantly vary among psychology instructors?

The first question is structured in two parts, the first attempted to replicate findings from multiple studies testing preconceived attitudes that psychology students generate through a statistics course, and the second part explores if these attitudes change among psychology

instructors. To test for student attitudes the scale chosen was the *Survey on Attitudes toward Statistics* (*SATS*; Schau, 2003) which is structured in six subscales testing for different aspects of attitudes: affect, cognitive competence, value, difficulty, interest, and effort. As mentioned, the data collected from this sample evidence remarkable similarity to the sample reported by Schau and Emmioglu (2012) as a base of comparison, which provided a response to the first part of the first question.

The second part of the research question inquired about different values among the scores for each professor, as student attitudes might vary substantially depending on the pedagogical orientation or teaching techniques of each professor. To test this question two sets of data analyses were run, one using non-parametric tests to minimize chances of error by unequal sample size and an analysis of variance excluding data from the highest sample size to reduce the discrepancy of unequal sample size; regardless, the range of attitudes did not significantly vary among psychology instructors. The descriptive statistics for each subscale evidenced remarkable similarities as students favored slightly positive emotions toward their statistics courses (affect), maintained a slightly more positive attitude toward their capacity of knowledge and skills applied to statistics (cognitive competence), perceived a slightly more positive attitude toward the relevance, usefulness and worth of statistics on professional life (value), reflected a slightly neutral or even negative attitude toward their courses (difficulty), acknowledged a slightly more positive view on the interest for the course material (interest) and believed that the course required a substantial amount of work (effort). These range of scores further validates those from the findings by Schau and Emmioglu (2012) evidencing a natural trend, students hold these attitudes based on their perspectives from the class, but not due to their professor. This result was

further reinforced by the qualitative analysis as all interviewed students reported a positive evaluation of their course, despite having different instructors.

As already mentioned, data was collected from six different professors teaching in two different institutions, and professional experience varied as all instructors from EPCC were full-time faculty with at least 5 years of experience and taught on a small classroom setting where student count does not go above 25, while from UTEP both instructors were doctoral students with less than 2 years of experience teaching the course and on a student count that capped at 80 students. However, on a comparison of attitude levels from their students there was not a statistically significant difference, thus concluding that at least from this data set the professor does not induce varying attitude levels, but rather the course does.

These findings support the notion that psychology students tend to hold neutral attitudes toward statistics (Counsell & Cribbie, 2020; Schau & Emmioglu, 2012), though it challenged the perspective of negative attitudes. Traditionally, these attitudes are explained by adverse experiences with mathematics through primary education, thus prompting negative emotions toward any related math-topic, such as statistics (Onwuegbuzie, 2000), which are further accentuated by the different frames evoked by low and middle attitude students who continuously refer to the course as a math course while dismissing its attribution to the discipline of psychology or scientific research in general. These attitudes are also relevant among psychology students due to the misconceived connection of the discipline with qualitative oriented methods when associating the field with careers in therapy (Murtonen et al., 2008) while not understanding the strengths of skill-based courses in this field of study (Griffith et al., 2012).

However, the difference among this study and all the previously cited lied in its connection of student attitudes with epistemological framing, which helped decode a connection

for how students feel about the course and its relationship to the perspectives of knowledge generated by them (how they think about it). To explore this connection the second question led to the collection of qualitative data and an integrative data analysis.

What type of epistemological frames do students enrolled in a psychology-based statistics course generate?

As this study followed an explanatory sequential design, the analysis of quantitative data led to the selection of participants for qualitative data collection (Creswell & Clark, 2018). As the *SATS* provided varying attitudes and distinguished students holding low, medium, and high attitudes, the interviews addressed three main areas of interest: perspectives of knowledge, teaching techniques and knowledge of course material. These three areas were chosen to represent the most common interests when exploring epistemological framing, as studies have focused primarily on perspectives of knowledge (e.g. Hutchinson & Hammer, 2010; Redish, 2004; Scherr & Hammer, 2009), the influence of teaching techniques (e.g. Greeno, 2009; Rosenberg et al., 2006) and the framing evoked when inquired about knowledge of course material (e.g. Hammer et al., 2005; Krupnik et al,. 2018).

Regarding perspectives of knowledge, low attitude students struggled to find usefulness either by directly responding that the course was not useful, by expressing uncertainty or by being incapable of finding any value beyond a class grade; this is further accentuated when inquiring about an overall purpose of a course in statistics to which low attitude students could not envision a connection from course content to their disciplines, regardless of them being a Kinesiology, Social Work or Psychology major. This pattern varied in medium attitude students as there was ambivalence because students offered responses, but they were limited to class content or remained vague by stating that the course was useful without addressing a particular

reason for it; this ambiguity is further noticed when inquired about the purpose of a statistics course when only one of these students connected the lessons to psychology, but solely from a research perspective. In contrast, high attitude students found applications to real life scenarios by describing course lessons and reinforcing their points with specific examples like the usefulness of statistics in lottery, casinos, politics, property tax or house prices; furthermore, when inquired about the usefulness of a statistics course they connected it to different fields such as psychology, social work and speech language pathology. The patterns for low and medium attitude students strongly resemble the findings from Griffith et al. (2012) when comparing student attitudes toward statistics among different disciplines with a contrasting difference for example among business and finance majors who are often reminded about the value of a statistics course in real world settings and their professions, which is perceived different with psychology students who remain limited in their perspective as a course useful primarily to enter graduate school. Although graduate school is useful, is important to remember that most Psychology majors seek qualitative oriented professions such as therapy or counseling, deeming quantitative oriented courses such as statistics as unnecessary or irrelevant (Onwuegbuzie, 2004). This is not evident in all cases though, as high attitude students do perceive the usefulness of a course outside academia but seem to gather this perspective from their own epistemological frames, not because the course fostered it in them.

Remarkably, all nine students reported a positive perspective on the course, regardless of their varying attitude levels, and the majority did acknowledge a shift from initial negative perspectives either due to their own negative experiences with mathematics or comments passed by friends or classmates. The only evident trend to explain the transition to positive perspectives were attributed to the diminished difficulty in class, which is also evident when these students

reported a positive evaluation due to hopes of passing the course and the efforts placed by their instructors. However, questions inquiring about teaching techniques did not led to any particular trend standing out among students with different attitude levels, thus implying that professors were not responsible for the general attitude levels, nor the variability in perspectives among these interviewees. The exploration of trends in this area did not let to any significant trend as no evident patters was suggested by the quantitative, qualitative or integrated analyses. At least in this sample, students generated similar attitudes toward the course regardless of who their teachers were; the course prompts the epistemological frames, not the instructors.

Regarding framing evoked when inquiring about knowledge of course material, the question addressed a basic, yet often confusing, concept within statistics, the standard deviation. The trend was evident when low attitude students could not respond or attempted to respond with concrete examples as neither a definition nor a usefulness were explained, instead all comments remained vague. However, medium attitude students provided a definition for a standard deviation, but struggled explaining its usefulness either by admitting that they did not know of it, or by losing confidence when admitting that they received negative feedback from their professors. Even in one case a medium attitude student explained the steps to compute it but could not offer neither a definition nor a use for it, mimicking the unproductive frame of lecture as an attempt to hoard facts without relevance or a connection to real life (Hutchinson & Hammer, 2010). Yet the most evident pattern was present when high attitude students provided both a correct definition and a concrete example of its usefulness by relating it to the IQ or Z scores. In other words, a perspective of knowledge differs in two ways when exploring knowledge of class material as one thing is knowing the concept and another its application. Low attitude students could not reach either, medium attitude students understood one but not the

other and high attitude students grasped both. As far as findings from the qualitative analysis, this is the most evident trend.

How do epistemological frames generated by these students relate to course attitudes?

The literature on epistemological framing structures it in a dichotomy among two themes, productive and unproductive frames (Hammer et al., 2005; Krupnik et al., 2018), the integrated analysis split the data on the three structures to compare responses among students holding productive and unproductive epistemological frames. As the qualitative analysis evidenced, the pattern of frames was not clear on the area of teaching techniques as a coding analysis did not display any significant difference on the number of codes for productive and unproductive frames in students with different attitude levels. However, the pattern varied noticeably along the structure of perspectives of knowledge not only due to them being higher on the ratio for medium and high attitude students evoking productive frames, but especially for the number of unproductive frames that were predominantly evoked by low attitude students while no high attitude students evidenced them. The pattern was even more apparent on course material, as all productive frames were evoked by medium and high attitude students and the coding analysis reflected a pattern of unproductive frames evidenced mostly by low attitude students and again, no high attitude students indicated them.

The integrative analysis compared excerpts from responses among students evoking productive and unproductive epistemological frames. The most common unproductive frames were work strategies devoted to find answers without deliberation nor consultation (Scherr & Hammer, 2009) evident in the responses from medium attitude students when they could provide a definition for the standard deviation without understanding its purpose or usefulness, a pattern clearly different from high attitude students who did both. Furthermore, a common pattern on

unproductive frames lied on the “cut and paste” mentality when hoarding facts without relevance or accumulating facts without consideration to real life (Hutchinson & Hammer, 2010) evident both in low and medium attitude students who continuously had difficulty perceiving the usefulness of class lessons outside of class material as their responses were limited to knowledge tailored on course performance or by perceiving the course solely as a math course without finding an application to their disciplines. Even if students held a positive perspective of the course, the low and medium attitude students would continuously envision the course within the boundaries of a mathematics class.

The pattern of productive frames was evident among high attitude students who often evaluated the course beyond the boundaries of a mathematics class to provide real-world application related to their disciplines, current jobs, and areas beyond such as politics, nutrition and casinos. However, the most relevant example came from the response of a medium attitude student who transitioned in the interview to a productive frame when explaining how a lesson on the null hypothesis prompted a shift to productive frame when he connected the lesson with his perspective of a yin/yang; as researchers we want positive results (yang), but sometimes results are null (yin), yet it is still useful data as it is normal to occasionally not get the desired results and life strengthens when it remains balanced. Rather than repeating information, the student solidified the lesson by connecting it with his personal perspective, which can be expressed to others as a story, thus prompting a storytelling frame (Rosenberg et al., 2006). When inquired about this frame, the student admitted that it arrived at this conclusion on his own, again evidencing how shift in frames are primarily evoked by the students, not by the instructor. This all supports the notion brought by Greeno (2009) who explained that every student in a classroom can construct a framing that may differ with that constructed by other students, a

statement reinforced by studies evidencing how students with diverse epistemological frames can understand the same lesson differently since the interpretation of a lesson is not tied to the lecture, but to the perspective generated by the student (Krupnik et al., 2018).

Limitations

As with any study, there are multiple limitations that limit the extent to which these results could be generalized. One of the first limitations is the collection of data which relied on convenience sampling as every participant agreed to be part of this study voluntarily, however, the problem with convenience sampling is that it limits the extent to which the students who participate mirror those that would rather not (Creswell & Clark, 2018), thus leaving room to speculate if students who did not participate might have evoked different responses. Furthermore, data for the quantitative section was collected from 10 different courses taught by 6 different professors at EPCC and UTEP, although the invitation was initially given to 12 professors, but due to different reasons 6 preferred not to volunteer their class, again leaving room to question about varying responses if data from these courses were analyzed as well. Additionally, once the quantitative data was collected, 17 students were selected and invited for a follow-up interview (6 low attitudes, 5 medium attitudes, 6 high attitudes), though only 8 responded, which forced a late round of quantitative collection in need of the last interview with a high attitude student. Unfortunately, the student invited to participate did not hold a high, but rather medium attitude; this left the groups of students participating on the qualitative analysis unbalanced as there were 3 low attitude, 4 medium attitude and 2 high attitude students, an unfortunate flaw through the study design.

Another limitation worth addressing is the homogeneous sample as data was collected from El Paso, a city with a predominant Hispanic population, thus the student sample reflects on

this lack of diversity as 94.44% of participants were Hispanic, and although there is no evidence justifying a distinction of values due to ethnicity, it may still lead to an interest in testing if the results from this study would replicate on a more diverse student population. Another point worth discussing is that the literature review and theory lied around perspectives of knowledge evoked by statistics students from a Psychology discipline, however, a factor overlooked in the design is the amount of students from diverse disciplines who would also enroll on this course. Some students enrolled on this course as a requirement to their degree plans, but their disciplines would not offer the course, instead directing them to take it with the Psychology department, and some students enrolled even though they were not Psychology majors, but minors, and as part of their degree plan also had to complete the course under the Psychology department. Although the majority of participants were Psychology majors (71.30%), the original design envisioned a study in which over 90% of participants would be students hoping to attain a bachelor's degree in psychology, this was not the case with the sample from this study.

Another limitation lies on the focus of this study on epistemological framing, while neglecting the role of positional framing, which refers to the methods in which an individual is expected or required to participate on interactions of an activity, such as a classroom lesson (Greeno, 2009). This limitation happened due to a focus on the literature review about epistemological framing, while not noticing the research on positional framing that usually tends to receive less attention (Alvidrez et al., 2022). This limitation becomes especially relevant when acknowledging that storytelling could be categorized as positional framing due to the expectation from the student to interact with the course lesson. Future studies could address this distinction to help refine the construct and role of framing by differentiating epistemological from positional in efforts to better understand its impact on student attitudes toward statistics courses.

Future directions

An important factor of consideration is that even though our results did not evidence any substantial difference in attitudes by different teaching techniques, it does not mean that we cannot do anything about it. If we exert conscious efforts to control unproductive frames or evoke productive frames, we could indeed prompt shifts in these perspectives of knowledge. Previous studies have explored teaching techniques to promote change in attitudes, such as fostering mathematics self-efficacy as it encourages students to exert stronger efforts to accomplish mathematics tasks (Clutts, 2010; Neuville et al., 2007). Other proposed strategies include time devoted to learn the history of mathematics to nurture engagement with class material (Piragasm et al., 2013), give students an opportunity to make mistakes early in the semester creating a low-stakes environment to alleviate stress and build confidence (Counsell & Cribbie, 2020; Thanissaro, 2012) since students start developing early attitudes toward the course which may already be preconceived negatively from past mathematics experiences (Kery & Wroughton, 2017; Walker & Brakke, 2017). Other strategies include allowing students to switch roles as question-makers and answer-gatherers to merge multiple viewpoints (Shaban & Wilkerson, 2019) and flipping the classroom by using class time to complete assignments while providing recorded lectures for students to watch at home (Cili-Turner, 2015). Each of these methods evidence change in attitudes, yet they have not been studied while exploring the extent to which they could affect epistemological frames, and these can all significantly alter the preconceived notions ingrained within the student, which are evidently problematic if they hold on to foundations of unproductive epistemological frames.

Reinstating the point above, evidence suggests that attitudes can change, but a study is yet to test the degree to which professors can alter epistemological frames under controlled

conditions to test for cause and effect if there are conscious efforts to do so. For example, research notifies a need to foster discussions detailing the usefulness of statistics and its relevancy to real world settings or their professional aspirations, such as therapy or counseling and not only frame the course from a research perspective (Griffith et al., 2012). Future research could explore if a project leading students to create their own applied scenario could alter their perspectives of knowledge and ultimately impact attitudes toward the course, and even to maximize its effect students could present these results with each other providing an opportunity to shift positionality among classmates, thus allowing every student in a group to lead during discourse to maximize content knowledge through different information venues (Shim & Kim, 2018).

An important theoretical factor that deserves attention is the concept of epistemological beliefs, as no study could evidence a direct link between epistemological frames and attitudes and its theoretical connection was established through epistemological beliefs since evidence existed of a connection among frames to beliefs (Druckman, 2007; Ruggeri et al., 2008), and beliefs to attitudes (Griffith et al., 2012; Nasser & Birenbaum, 2005). However, cognitive theory rarely supports the existence of linear thought models as the figure 5 on the literature review chapter proposed to visualize epistemological beliefs as a bridge connecting epistemological frames to student attitudes. Future studies can refine the connection on these three variables as epistemological beliefs can just as likely alter epistemological framing or student attitudes can adjust epistemological beliefs. This is an area worth exploring through future research as the main interest in this study focused on epistemological frames and student attitudes and the role of epistemological beliefs was pushed aside once its role as a mediator was explained.

Implications of the findings

The current study explored student attitudes about a course in statistics and the extent to which these can be impacted by perspectives of knowledge generated through the course. This interest led to the hypothesis that despite the range of attitudes generated through the course, there would be substantial variability at least from the course of one professor; our results failed to support this hypothesis. The second part of the hypothesis predicted a connection between student attitudes and different perspectives of knowledge generated by these students, and this was indeed supported as evidence shows a consistent pattern of productive frames held primarily by high attitude students, while a pattern of unproductive frames was held primarily by low attitude students, with medium attitude students remaining ambivalent as they projected a positive impression of their course, which was coupled by an assertion on the usefulness of statistics in their fields of study; yet when prompted to provide concrete examples they often failed to provide one. However, these patterns were evident with questions addressing perspectives of knowledge or the understanding of a standard deviation (class material), not quite so with questions related to teaching techniques as the patterns did not hold for one specific group of attitudes. This is coherent with the results from the quantitative analysis that could not define substantial attitude change by the respective professor; the results suggest that students hold a range of attitudes due to the class as it is structured, not due to the professor.

Tracing this study back to its theory, an over-reliance on System 1 of thought leads us to become lazy thinkers, and the problem with lazy thinking is a reluctance to engage in System 2 which leads us to systematic errors, such as the development of unproductive frames. Addressing these errors by engaging in the conscious thought process of System 2 is important for multiple aspects of life, including education. As the theory tailors to the study of statistics and research design, this study evidenced that students generate perspectives of knowledge and develop a

range of attitudes regardless of the instructor, but it does not test if conscious strategies to evoke productive frames make a difference. The professor should not be relegated to be a supplier of information with the student perceived as a static source contained to receive and repeat knowledge as this process constructs an unproductive frame of "knowledge propagated from authority" (Hutchinson & Hammer, 2010); the professor can do more. For example, a recent study by Alvidrez et al. (2022) evidence frame inconsistency in mathematics teachers who may employ both productive and unproductive frames when conceiving errors as resources, but then devising lessons perceiving errors as deficits, an inconsistent perspective of knowledge leading the authors to conclude that framing is rarely intentional. In a way, this solidifies the reason why teaching techniques may not affect frames as consistently as the course itself. Nonetheless, there is still no evidence exploring how conscious efforts to exert productive frames in a statistics course of Psychology can substantially alter not only epistemological framing, but also attitude levels.

The results from this study should encourage every statistics professor to question not only if the delivery of material is effective to generate knowledge, but if this knowledge transitions to the construction of productive epistemological frames that can alter the understanding of a course in statistics as more than just math, more than just a grade and more than a course useful only for researchers. For example, instructors can apply principles from Vygotsky by constructing a zone of proximal development, a term used to describe the skills that a person can exercise with assistance but not yet independently (Berger, 2019), encouraging students to construct lessons outside of the limited scenarios taught by textbooks that emphasize the course solely from a math perspective, and not to its application. How would a counselor know if a new therapy technique is worth practicing? Not by testing it with their clients nor by

word of mouth. Rather by reading from scientific research its strengths or weaknesses, and a course in statistics is useful for this. How can a similar scenario be constructed to deliver the application of the course lessons to Kinesiology or Social Work majors? Professors in statistics should be encouraged to question if current teaching methods aid in the construction of productive epistemological frames, as this study evidence that these frames will invariably affect student attitudes toward the course, solidifying the strength of the course not only for academics, but for professionals in applied fields related to Psychology. In the end, a course in statistics is more than mathematics, its analysis and interpretation of data, its understanding relationships between variables to predict outcomes (Ollson-Collentine et al., 2019), and this is useful knowledge not only in our professional, but also our personal life.

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APPENDIX A: Informed Consent Form

University of Texas at El Paso (UTEP) Institutional Review Board

Informed Consent Form for Research Involving Human Subjects

Protocol Title: Understanding epistemological frames of statistics students in psychology education

Principal Investigator: Carlos M. Vargas

UTEP Teaching, Learning and Culture Department.

You are being asked to take part voluntarily in the research project described below. You are encouraged to take your time in making your decision. It is important that you read the information that describes the study. Please ask the study researcher or the study staff to explain any words or information that you do not clearly understand.

Why is this study being done?

The project attempts to understand the perceptions of knowledge (epistemological frames) that psychology students enrolled in a statistics course generate; in order to do so, the first step in this research project is to gather data on their perspective of knowledge while enrolled in this course.

Approximately, 100 students, will be enrolling in this study at El Paso Community College and the University of Texas at El Paso.

You are being asked to be in the study because you are currently enrolled in a statistics and research design course entailed to psychology majors.

If you decide to enroll in this study, your involvement will last one or two days. Further information is provided on the next section.

What is involved in the study?

If you agree to take part in this study, I, Carlos M. Vargas, will initially provide the Survey on Attitudes toward Statistics (Schau, 2003), which is a 36-item scale that usually takes 5 to 7

minutes to complete. Based on your responses, you may be invited for a follow-up interview to contrast the perspectives of knowledge generated through the course.

This follow-up interview is made of 10 open questions asking about your perspective of knowledge regarding the statistics course in which you are currently enrolled. This interview will be conducted through the middle of the course and is scheduled to last about 30 to 45 minutes. Your responses will be held confidential and after careful analysis of the responses this data will be discarded. This interview will be conducted through Blackboard Collaborate, no in-person interaction. The use of Blackboard is preferred over other online applications such as Zoom because of suggestions from El Paso Community College on confidentiality protection.

This interview will be recorded through audio and video and transcribed through blackboard collaborate for a thorough analysis. Furthermore, by the time this project seeks to be published all reported data will be held under pseudonyms to protect confidentiality.

The interview will be answered voluntarily only among consenting participants in this study and will not be used for course grading nor for extra credit and all subjects will remain under a pseudonym in efforts to maintain privacy.

What are the risks and discomforts of the study?

The risks associated with this research are minimal, although is impossible to assess all potential outcomes that these interviews may have on you, as a participant. A potential risk is discomfort by the interview questions, therefore, if at any point a question causes discomfort you have a right to stop the interview.

Another potential risk is loss of confidentiality, but through the use of pseudonyms and access to the recordings solely by the principal investigator then this risk is minimal.

Your grade will not be impacted in any way through your participation in this study.

If you are currently experiencing severe stress as a result of this experiment or of this course, you can always reach counseling services at EPCC through counseling@epcc.edu or at 915-831-2642.

Are there benefits to taking part in this study?

As a participant you will not gain any particular benefit from this study; however, education in psychology can benefit from understanding the perspectives of knowledge held by students enrolled in statistics courses since education in quantitative statistics is a valuable skill developed by students of psychology as they pursue careers in academia or other research-based professions.

What are my costs?

There are no direct costs.

Will I be paid to participate in this study?

You will not be compensated for taking part in this research study.

What other options are there?

You have the option not to take part in this study. There will be no penalties involved if you choose not to take part in this study.

If you are a student of the principal investigator, Carlos M. Vargas, you still have an option to not take part in this study, and the decision to do so will not impact your performance on your course.

What if I want to withdraw, or am asked to withdraw from this study?

Taking part in this study is voluntary. You have the right to choose not to take part in this study. If you do not take part in the study, there will be no penalty or loss of benefit.

If you choose to take part, you have the right to skip any questions or stop at any time. However, we encourage you to talk to a member of the research group so that they know why you are leaving the study. If there are any new findings during the study that may affect whether you want to continue to take part, you will be told about them.

The researcher may decide to stop your participation without your permission, if he or she thinks that being in the study may cause you harm.

Who do I call if I have questions or problems?

You may ask any questions you have now. If you have questions later, you may call Carlos M. Vargas at either 915-502-9156 or cvarga71@epcc.edu

If you have questions or concerns about your participation as a research subject, please contact the UTEP Institutional Review Board (IRB) at (915-747-6590 or irb.orsp@utep.edu.

What about confidentiality?

Your participation in this study is confidential. The following procedures will be followed to keep personal information confidential: Your name will not be used through this project, instead a pseudonym. All data will be held by the principal investigator in a USB requiring password for access, which will be solely known by him.

After gathering data from the interviews, it will be transcribed by the principal investigator (Carlos M. Vargas), then all personal information will be permanently deleted. All of the data gathered for this study will be permanently deleted after 2 years.

The sole trace of your participation in this study will be a consent form, which will be kept under a separate USB requiring password for access, which will only be known by him. The results of this research study may be presented at meetings or in publications; however, your name will not be disclosed in those presentations.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include, but are not necessarily limited to:

- Office of Human Research Protections
- UTEP Institutional Review Board
- EPCC Institutional Review Board

Because of the need to release information to these parties, absolute confidentiality cannot be guaranteed. All records will be saved in a folder inside the USB drive held by the principal investigator until the results from this study are authorized for publication.

Authorization Statement

I have read each page of this paper about the study (or it was read to me). I will be given a copy of the form to keep. I know I can stop being in this study without penalty. I know that being in this study is voluntary and I choose to be in this study.

_____

Participant's Name (printed)

_____ _____

Participant's Signature Date

_____ _____

Signature of Person Obtaining Consent Date

APPENDIX B: Interview protocol

Today I want to ask you some questions about your course in statistics and research design. These questions relate to what you've learned in this class, it's okay if you don't get these answers right, I'm just really interested in how you think about these things. I'm not interested in whether you get answers right or wrong. So, I'm hoping you'll tell me as much as you can about what you think about the questions that I'm going to ask. Just talk, and I'll listen and ask questions.

Q1: Describe the main lessons from this week.

- Prompt the student to get more details if necessary

Q2: What do you believe is the purpose of the lessons from this week? How could they be useful?

- Prompt the student to get more details if necessary.

Q3: What stood out for you from the way your teacher taught the lessons this week?

- Prompt the student to get more details if necessary

Q4: If one of your classmates asked you to explain the lessons from this week, how would you do so?

- Prompt the student to get his/her thoughts and rationale if necessary

Q5: If you had to explain these lessons to the entire class, how similar or different could it be?

- Prompt the student to get his/her thoughts and rationale if necessary

Q6: What is a standard deviation? How is it useful?

- Prompt the student to get more details if necessary.

Q7: Is your overall perspective on this course positive or negative? Why?

- Prompt the student to get more details if necessary

Q8: Has your perspective changed from the first day of class to this moment? If it does, how?

- Prompt the student to get more details if necessary

Q9: So far, which lessons have you considered the most valuable? Why?

Q10: So far, what do you believe is the overall purpose of a course in statistics?

APPENDIX C: Observation Rubric

1. Making use of my five senses, describe what is going on in the interview.
2. Describe the appearance of the participants, in addition to the gestures and expressions they use through the dialogue.
3. Describe the conversations that took part in the meeting.
4. Describe my opinions, preconceived notions, and working hypotheses.
5. Address if I notice shifts in framing.
6. Describe the role that framing plays over the responses in the interview. Pay attention to patterns in the responses to notice the most consistent types of frames.

VITA

Carlos Manuel Vargas started his professional career as a clinician for psychiatric hospitals after graduating with a Master's degree in Experimental Psychology from the University of Texas at El Paso in 2013. After learning about an open position to teach one class at El Paso Community College, he sought the opportunity and taught his first course in Spring 2014; he immediately found his life purpose.

Despite working in different psychiatric institutions, his passion for education eventually led him to a career as a Psychology professor, which capitalized with a full-time position beginning on Fall 2017 and earning tenureship by Spring 2022. Carlos has taught many classes and mentored many students, while also building bridges outside the classroom. Beginning in 2017, Carlos began leading study abroad programs, and as of this time he has led dozens of students across 4 different programs to destinations such as England, France, Netherlands, Austria, Spain and Japan. Currently he holds programs for 2023 and 2024. In 2018, he joined Teen Survivor, a student club offering mentorship to middle school children about the adolescent stage. Through Teen Survivor, college students at EPCC and UTEP have brought student fairs to 4 local middle schools reaching over 1,000 children. This semester Teen Survivor will continue its mission by visiting Borrego middle school with the support of 90 club members and hoping to reach 300 children.

Carlos will earn a Doctoral Degree in Education by Spring 2023; he will continue teaching at EPCC and UTEP while still pursuing community outreach through Teen Survivor while also taking students abroad.

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