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Elementary Statistics Instructors' Uptake of the Teaching Practices Recommended by the American Statistical Association

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ELEMENTARY STATISTICS INSTRUCTORS’ UPTAKE OF THE TEACHING PRACTICES RECOMMENDED BY THE AMERICAN STATISTICAL ASSOCIATION

A Thesis

by

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ABSTRACT

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Previous studies point out there has been a wide gap, in the teaching of mathematics, between the practices recommended in the credential programs and the practices teachers actually do. The purpose of this study is to explore how consistent the teaching practices of introductory statistics instructors are to the recommendations endorsed by the American Statistical Association, to understand what their attitudes to the gap are, and to identify the factors that prevent the instructors from implementing the recommended practices. Data were collected from nine statistics instructors at a state university through survey, classroom observations, and interviews. Findings indicate that the disjuncture between recommended and actual practices is wide for some instructors and suggest that various factors such as teaching experience, institutional support, instructors' beliefs on the recommended guidelines, and their eagerness to adopt new practices play an important role in instructors' implementation of suggested practices.

DEDICATION

I want to thank God who let me finish this project.

To my grandma, who was always there for me in every situation. Mami, thank you for all your love and support, I would not have been able to accomplish this without you. To my parents, sisters, and family.

I would also like to dedicate my work to my thesis advisor, Dr. Hyung Kim. Thank you.

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CHAPTER I

INTRODUCTION

Research indicates there has been a wide disjuncture in the teaching of mathematics between the practices recommended in credential programs and the practices teachers actually do. A number of scholars in math education have been studying the degree of this educational inconsistency and possible factors that contribute to this educational inconsistency. For example, Gainsburg (2012) stated that teachers identified class time as a major constraint for including practices recommended in credential programs. According to her, the nature of this disjuncture is, at the high-school level, largely associated with the fact that mathematics teachers often identify themselves as limited by their inability to generate practice-based lesson ideas and their fear of poor class outcomes after implementing the recommended practices. Findings from the study conducted by Borko and her colleagues (2000) suggest mathematics teachers' implementation of changes to their curriculum is influenced by the resources or institutional support provided, their educational beliefs, their level of satisfaction with their current methods, and how long they have been experimenting with new practices. Other studies identify previous experiences and teacher expectations as possible factors: for instance, Handal (2003) argues that the mathematical beliefs teachers acquired during their experience as a student are often inconsistent with curriculum innovation and research. He also supports the idea that teachers are expected to teach in a traditional way by parents, their professional colleagues, and the context of school instruction. For this matter, Handal identifies focusing on external examinations, adhering to a textbook, and maintaining a low level of movement in the classroom as traditional teaching style.

Efforts have been made by some scholars to reduce the gap between the recommended and actual practices. Franke and her colleagues (2001) propose the following solution to narrow the educational gap between learnt and actual teaching practices. In their empirical study, they found that teachers' growth becomes generative as they observe other teachers adapt, create, and challenge their own thinking. They suggest that teachers need to consider the framework as adaptable and to perceive their students' mathematical thinking as their own to create and investigate. According to Franke and her colleagues (2001), as teachers develop these perspectives, they can learn with understanding and engage in generative change to implement recommended teaching practices. Although some scholars in math education explored the nature of this disjuncture in certain specific contexts, the problem of how in-service math teachers translate learnt practices into actual practices still remains largely unsolved.

While there is literature, although scant, that addresses the inconsistencies between learnt and actual practices in math education, they are limited to the teaching of general mathematics and rarely focused on that of statistics. The author of this paper believes that it is important to consider the gap between learnt and actual practices in the context of teaching of statistics separately the context of teaching of mathematics due to the differences that lie between the two disciplines. According to Cobb and Moore (1997), statistics requires a different kind of thinking than mathematics. They argue that statistical data are not just numbers, but numbers with context. Cobb and Moore point out that in statistics teaching, data analysis strictly involves pattern and context. The differences between both disciplines involve a matter of interpretation. In mathematics, the ultimate focus is on abstract patterns, when in statistical data analysis, the connection of those patterns provides meaning. In the case of statistics education, problem solving depends on understanding, explaining and quantifying how variable the data is (Franklin et al., 2007). According to Garfield and Ben-Zvi (2008), intellectual skills required in teaching and learning statistics differ from the ones required in mathematics. They account that in the area of statistics, students are asked to describe, to interpret relations and to determine appropriate procedures or models for the data. Cobb, Mcclain, Ben-Zvi, and Garfield (2005) argue there are differences in the common practices of mathematics and statistics that may result in different sources of reasoning difficulty. The differences between the two disciplines give rise to the differences that the teaching strategies between mathematics and statistics emphasize. This study intends to identify the extent to which the practices implemented by statistics instructors are consistent with the practices recommended by recently endorsed guidelines and reformers of statistics education. The recommended methods used for this study were retrieved from the Guidelines for Assessment and Instruction in Statistics Education (GAISE) college reports (Aliaga et al., 2005; American Statistical Association, 2016). Two version of this college report have been endorsed by the American Statistical Association (ASA). Six recommendations have been emphasized over the past few decades by both reports by focusing on what to teach in introductory statistics courses as well as on how to teach those courses.

Like in mathematics education, the literature on the discrepancies between learnt and applied teaching strategies in statistics education is limited to the teaching and learning at the K-12 grade levels. For example, Estrada, Batanero, and Lancaster (2011) surveyed primary and secondary school teachers. Findings from their study show poor and neutral attitudes towards statistics in prospective teachers. Kim, Wang Lee and Castillo (2017) recently reported quantitatively findings, at the college level, about mathematics and statistics instructors’ attitudes towards implementing the GAISE recommendations. The results from their study suggest that statistics teaching experience and academic background could be used to predict instructors' attitudes toward statistics and its teaching practices.

Extending from the outcomes of Kim et al.'s research, this study aims to pursue the following objectives: (1) to explore, qualitatively, to what extent elementary statistics instructors' teaching practices are consistent with the GAISE college report recommendations, (2) to learn about the nature of the attitudes instructors hold against keeping their classes using these recommended practices and (3) to identify the factors that hinder the implementation of the recommended practices.

This study draws on the taxonomical construct that divides attitudes into three dimensions: cognitive, affective, and behavioral. Such construct has been previously used in other studies about teachers' attitudes towards statistics. For instance, Martins, Nascimento and Estrada (2012) used these three components in their investigation of Portuguese in-service primary school teachers' attitudes toward statistics as well as their reasons and motivations for holding these. Estrada and Batanero (2008) considered these three dimensions of attitudes in their three-part study about pre-service and in-service teachers' attitudes towards statistics.

In this investigation, qualitative research methods are employed. This study draws across the existing literature to analyze introductory statistics instructors' beliefs and applications of statistics education recommended practices. For the purposes of this study, we identify college instructors proctoring introductory statistics courses like elementary statistical methods, pre-statistics, intro to biostatistics, and statistics jumpstart remedial courses as introductory statistics college instructors. The research questions for this study are the following:

1. To what extent do statistics college instructors' classroom practices align with the GAISE college report recommendations?
2. In terms of the three dimensions of attitudes–affective, cognitive and behavioral, what attitudes do elementary statistics instructors hold against the implementation of the GAISE college report recommendations in their classroom practices?
3. What are the possible factors preventing introductory statistics college instructors from implementing, either wholly or in part, the GAISE college report recommendations in their classroom practices?

CHAPTER II

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

This chapter consists of three parts. First, I describe five teaching practices recommended in the two GAISE college reports. The second section introduces a theoretical model, called five practice model, which provides a frame for analyzing the student-teacher classroom interactions. Finally, I introduce a theory called a dialogical approach to identity, which provides a perspective to view how the introductory statistics instructors make decisions on what practices to use.

GAISE College Report

The two versions of the GAISE college report recommend six practices to help students achieve their learning goals of introductory statistics courses. Five of the six recommendations are: 1. Teach statistical thinking; 2. Focus on conceptual understanding; 3. Integrate real data with a context and a purpose; 4. Foster active learning; and 5. Use technology to explore concepts and analyze data. Although there is another recommendation, “use assessments to improve and evaluate student learning,” this study limits its scope to the first five since the instructors who participated in the study had limited autonomy on the assessment. In this section, I give a brief description of the first five practices recommended in the GAISE college report.

Teach Statistical Thinking

The type of thinking that statisticians use when approaching or solving statistical problems needs to be taught and emphasized in introductory courses (American Statistical Association, 2016). Through the introduction of basic statistical language and ideas, students could become better "educated consumers of statistical information" (American Statistical Association, 2016, p. 12). The authors of the GAISE college report recommend modeling statistical thinking to the students by making emphasis on the investigative nature and process problem solving with decision making of statistics. They recommend the use of activities that involve study design, data collection, data analysis, and interpretation to emphasize higher order thinking. David and Brown (2012) define the statistical skills students need to acquire in introductory courses: "The students should be able to look at data and see patterns and trends, to be able to interpret analysis and critically examine it, to be able to interpret graphical displays of data and infer relationships, and be able to communicate these ideas and concepts." This is the type of statistical thinking instructors should focus on when choosing and developing statistical teaching methods. Kugler, Hagen, and Singer (2003) discuss the customizable properties of statistical thinking development practices and how these can be included in every subject curriculum.

Focus on Conceptual Understanding

The American Statistical Association (2016) emphasizes the importance of the students' understanding and appreciation of underlying concepts, rather than just learning the tools and procedures to analyze data. As defined by Bude et al. (2011), a student reflects conceptual understanding by demonstrating coherent and error free knowledge structures. Such understanding is related to the quality of the knowledge structures each student develops in the statistics context. They support the idea that distributed practice and study activities with intervals enhances short term conceptual understating of statistics.

Hassad (2013) argues that technology-based activities, when appropriately and effectively used, enhance students' active learning. It also serves as an analytical tool that allows students to explore data and distributions. Technology leads students toward the discovery and construction of knowledge, meaning, and conceptual understanding. For all this, the inclusion of technology as an exploration method should be emphasized for introductory statistics courses. According to Bude et al. (2011), to choose the appropriate statistical techniques in a study and interpret correctly the study's results is a task that requires students' conceptual understanding of a definition. Then, emphasis needs to be made to help students develop conceptual understanding.

Integrate real data with a context and a purpose

The inclusion of real data in the statistics curriculum is engaging for the students (American Statistical Association, 2016). It allows them to think about the data and relevant statistical concepts while finding the course more interesting. In their study, Tu & Snyder (2017), found a significant association between students' development of conceptual understanding and the learners' engagement with real-world problems. With the activation of relevant previous experiences, the purpose of the instruction is clear. Learners are applying new acquired skills and are encouraged to incorporate such skills into their daily routines. In her article, Carr (2008) describes a pleasant approach to statistics. She argues that the development of real and personal tasks engages students' imagination and encourages their motivation. These known advantages of using real data are well-understood by many statistics educators, and thus has been emphasized in the two GAISE reports.

Foster active learning

The inclusion of active learning methods in class allow students to do and think about what they do through the engagement in statistical thinking and interacting with statistical important ideas (American Statistical Association, 2016). Lesser et al. (2013) identified the motivations and hesitations instructors hold for including modalities of fun. These are activities that align with the experience of intrinsic motivation in their classroom practices. Some of the instructors' motivations were that modalities can be effective in improving statistic students' attitudes, increasing student interest, participation, and conceptual understanding. These hesitations included not having enough time, lack of amusement skills, and lack of fun resources. Many educators are incorporating active learning strategies as a better way to engage students. Roehl and her colleagues (2013) argue active learning methods require students to assume more responsibility for their individual learning experience. And according to Bonwell and Eison (1991), active learning methods require students to engage with higher-order thinking skills such as analysis, synthesis, and evaluation.

Use technology to explore concepts and analyze data

Students need to view the use of technology, hardware and software as an aid to learn to think statistically, to discover and visualize concepts, explore conceptual ideas, and enhance learning (American Statistical Association, 2016). Chance et al. (2007) promote the use of technology in introductory statistics courses arguing that it improves students' learning. It accelerates students' calculation and production of many graphs leaving them with more time to analyze data. Technology facilitates instant access to multiple visual representations of abstract ideas, random processes, and concepts, enhancing their ability to study and describe results (Chance, et al., 2007).

In a study, 227 instructors of introductory statistics reported to include real-world data in class demonstrations and assignments (Hassad, 2013). 76% of the instructors claimed to use a computer program to explore and analyze data usually. 72% of them believed using computers livens teaching introductory statistics up. 49% instructors perceived difficulty or were undecided about the use of active learning strategies. Results from this study suggest technology plays a crucial role in statistics education. They also suggest instructors find it easier to include technology in the curriculum than to implement active learning strategies.

In general, the implementation of these five teaching recommendations are encouraged at the college level introductory statistics classes by various statistics education communities. In this study, I used these recommendations as a taxonomical frame to evaluate instructors' classroom practices: to what extent the instructors adopt the recommendations.

Five-Practice Model

Stein and his colleagues (2008) presented a pedagogical model that identifies a set of five practices for facilitating discussions in mathematics classrooms. This model describes the action of orchestrating mathematics discussions that build on student thinking and lead toward the development of important mathematical ideas. The five practices, which they named "anticipating," "monitoring," "selecting," "sequencing" and "connecting," are defined, respectively, as follows (p. 321):

(1) anticipating likely student responses to cognitively demanding mathematical tasks;
(2) monitoring students' responses to the task during the explore phase;
(3) selecting particular students to present their mathematical responses during the discuss-and-summarize phase;
(4) purposefully sequencing the student responses that will be displayed; and
(5) helping make connections between different students' responses and between their responses and the key ideas.

This model supports students' authority and accountability to the discipline without undermining students' engaged sense-making, which are two norms needed for teachers to embody in their classrooms in order to help students develop important ideas in the discipline

(Engle & Conant, 2002; Stein et al, 2008). The model supports the students' self-development of concepts through peer discussion and interaction while being indirectly guided by the teachers' wisdom. This pedagogical model was grounded by Stein and his colleagues in a theory for promoting productive disciplinary engagement.

The five-practice model is presented as a tool to orchestrate classroom discussions (Stein et al., 2008). The five-practice model is limited to the preparation and execution when carrying out a classroom discussion. The discussion could be about important aspects in the curriculum and students' contributions could be used to improve these. Instructors may guide students' shaped discussions to obtain feedback on the efficiency of their instruction. The five-practice model could also be included in the general education context, with the exception that the model promotes problem solving discussions. If a subject covey a series of past events or fixed information, some practices in the model would not be suitable. Since the practice of sequencing student responses during the discussion phase could only be applied in a situation with a correct answer, the model is applied only to the mathematics teaching context. In a discipline without correct answers or having open questions only, there is not correct direction, and it would be difficult to find a suitable sequence.

The first practice of the model is to anticipate students' mathematical responses. That is to envision how students might mathematically approach the instructional task that they will be asked to work on (Stein et al., 2008, p. 20). The second practice is to monitor student responses. Instructors pay close attention to the mathematical thinking in which students engage as they work on a problem during the explore phase. The goal of this step is to identify the mathematical learning potential of strategies or representations used by the students. In the third practice, teachers monitor available student responses in the class. Then, they can select particular students to share their work with the rest of the class. The fourth practice requires the teacher to purposefully sequence particular students to present. So, the instructor can make decisions about how to sequence the students' presentations with respect to each other. "By making purposeful choices about the order in which students' work is shared, teachers can maximize the chances that their mathematical goals for the discussion will be achieved" (Stein et al., 2008,). Finally, during the fifth practice, teachers help students draw connections between the mathematical ideas that are reflected in the strategies and representations that they use.

In the case of statistics education, there are correct answers and different approaches for problem solving. For the study, we used the five-practice model to evaluate statistics college instructors' behavior in the first five recommendations of the GAISE college report. As recommended by Stein and his colleagues (2008), the five-practice model is an important component of effective pedagogical practices. To analyze instructors' classroom discussions, the five-practice model proposed by Stein and his colleagues (2008) was embedded into the statistic field. These were the steps from the five-practice model used for the study : (1) to anticipate students' statistical responses and try to envision how students might statistically approach the instructional task they were asked to work on; (2) to monitor student responses, paying close attention to the statistical thinking in which students engage as they work on a problem; (3) to select particular students' to present their statistical analysis and procedures to model data; and (4) to help students draw connections between the statistical ideas that are reflected in the strategies and representations they used. The five-practice model was reduced to four practices only, since the course sessions observed for the study were limited to student-teacher conversations.

Dialogical Approach to Teacher Identity

In this study, I consider the idea of teacher identity as a theoretical perspective to view how the elementary statistics instructors negotiate between learned and actual practices. The definition of teaching identity has evolved simultaneously with the historical development of thinking about identity. According to Akkerman and Meijer (2011), the post-modern notion of identity stepped away drastically from its previous notions. In their study, they perceived three recurring characterizations of teacher identity: multiplicity, discontinuity, and the social nature of identity. This contrasts to the previous notion that emphasized singularity, continuity, and individual components of identity. These characterizations suggest teacher identity is not a fixed nor stable entity. Beijard, Verloop and Vermunt, (2000) described teacher identity as multiple, consisting of three components: the teacher as a subject matter expert, teaching professional, and didactical specialist. In addition, Beijard, Meijer, and Verloop (2004) determined that a teachers' professional identity is composed by sub-identities corresponding to their different contexts and relationships. Regarding the idea of discontinuity, Rodgers and Scott (2008) concluded that identity is variant and irregular. Beijard and his colleagues (2004) outlined identity as a continued process of explanation and re-interpretation of experiences. Ultimately, in relation to the social nature of identity, Alsup (2006) emphasizes the socially significant reasons for identity development. She argues that identities are formed in social and communicative contexts. Rodgers and Scott (2008) support the idea that identity is developed by interacting with others in different contexts.

The idea that considers identity as something that is multiple, discontinuous, and social contrasts with viewing it as an entity that is uniform, continuous, and individual. Alsup (2006) distinguished identity as complex and dynamic while being stable and coherent at the same time.

These characteristics suggest identity if not a fixed but a variating entity. Rodgers and Scott (2008) associate individuals' identities as the plot or the meaning made and the self as the narrator. They perceived the self as a process instead of as an entity. They identified identity as an inner voice narrating a course. Identity is considered individual and continuous in the sense that all its sub-identities belong to the same person.

Akkerman and Meijer (2011) define I-position as a voice position or a speaking personality introducing a perspective. Following the vision of Rodgers and Scott (2008), Kim (2018) identifies individual's substantial self as an I-position and the context-dependent situational selves as a me-position. The dialogical approach to identity provides the theoretical foundation for this study. The substantial position of a teacher's identity (I-position) is defined as the narrator or voice position being driven by the instructor's inner self. In other words, an instructor adapts an I-position in a teaching-learning moment, when he perceives himself as the lead of the situation. On the other hand, the situational self of a teacher's identity (me-position) is defined as the minor character being influenced by the situation. So, this situational or me-position is driven by the teacher's surroundings. An instructor would be considered to take a me-position in the classroom, when he perceives herself or himself as part of the affected portion of the situation. This proposed structure of identity suggests it is composed by multiple I-positions and me-positions, these variating according to the setting. The post-modern idea that identity is constructed and reconstructed between those two positions is the one considered for the study. It will be used to view how teachers adopt the recommended teaching practices and how they negotiate between learned practices and the practices they believe they must use.

CHAPTER III

METHODS

The purposes of this study are: (1) to explore how consistent the teaching practices of introductory statistics instructors are in accord with the recommendations promoted by the GAISE college report, (2) to determine what are their attitudes towards the application of these recommended practices in their teaching methods, and (3) to identify the factors that prevent them from including such practices in full. Chapter III provides a description of how data were collected, and the methodology used to analyze data to answer the research questions. In particular, this chapter includes a detailed description of the design nature of the research inquiry study, site data collection information, and the participants of the study.

These were the questions raised:

1. To what extent do introductory statistics college instructors' classroom practices align with the GAISE college report recommendations?
2. In terms of the three dimensions of attitudes–affective, cognitive and behavioral, what attitudes do elementary statistics instructors hold against the implementation of the GAISE college report recommendations in their classroom practices?
3. What are the possible factors preventing introductory statistics college instructors from implementing, either wholly or in part, the GAISE college report recommendations in their classroom practices?

Methods of Inquiry

Site

The range of the data collection site is limited to a state university. The university is a mid-size Hispanic institution. As per the university's enrollment profile of the Fall 2018 semester a population of 87.9% Hispanic students was enrolled. Out of the university's total enrollment in the Fall 2018, 87.8% of the students were undergraduates with an average age of 22 years old.

Population

The data for this study was collected from nine college instructors. College instructors participating in the study would be working at a state university. Instructors were selected based on their teaching courses, and only instructors teaching introductory statistics courses were considered and recruited for the study. Table 1 summarizes the background of the instructors participating in the study.

Table 1: Pedagogical Background of the Instructor Participants

Instructor	Gender	Highest Degree	Experience in Math Teaching (Years)	Experience in Stats Teaching (Years)	Class Observed
1	Male	Master's	3	1	Pre-Statistics
2	Male	Master's	5	1	Pre-Stats / ESM
3	Male	Master's	20	10	ESM
4	Male	Master's	8	2	ESM
5	Male	Master's	20	10	None
6	Female	Master's	4	0	Pre-Stats / ESM
7	Female	Master's	2	1	None
8	Female	Doctoral	5	5	Intro to Biostats
9	Male	Doctoral	29	18	none

Note: ESM = Elementary Statistical Methods

Survey

Nine college instructors completed an online survey consisting of 33 questions. The survey consisted of two sections: biodata and attitudes towards the GAISE report recommendations. In the biodata section, participants were asked to provide insight into their educational and teaching experience. Participants provided their gender, highest degree with major, college attending period, and the number of taught statistics related courses. The survey asked participants to state their level of agreement with 56 components retrieved from the GAISE college report recommendations. Out of those 56 components, 24 items addressed cognitive attitude components and the rest addressed the behavioral components of attitude (See Table 2). Participants would have to state whether they agreed or disagreed with each component. Scores were assigned to their answers, (2)-Strongly Agree through (-2)-Strongly Disagree. Table 2 summarizes the results from the survey components.

Classroom Observations and Interview

From the surveyed participants, six college instructors were selected for classroom observations followed up by an interview. Out of the six instructors only four agreed to participate in the interview. On this account, CHAPTER IV only presents the result for four instructor participants. Observations were conducted in the introductory statistics course sections being taught by the selected instructors. During the observations, I would focus on documenting the instructors’ class structure activities, probing questions, and instruction methods. I would take notes according to the Classroom Observation Protocol (See Appendix B). This protocol would include a section focused on components from the GAISE report recommendations. The notes that were taken during the observations would record the instructors’ behaviors and students’ responses to these behaviors. Observations notes would include major instructor-student interactions, important class discussions, activities conducted in class, and important instructor and student roles in the classroom. Interviews were recorded for transcription purposes. Then, based on the results of the observations, some of the interview questions were modified according to each of the instructors' practices respectfully. According to Rubin and Rubin (2005), "each interviewee is an individual with distinct experience, knowledge and perspective, not interchangeable with anyone else" (pp. 7). This being the case, instructors were selected to provide explanation on their ability to instruct with a variety of perspectives.

The ALEKS Program

Four out of the six observed courses used software, called ALEKS, as a major component for class instruction, but only the results of four classes have been analyzed in CHAPTER IV. The university implemented this program for remedial courses such as Pre-Statistics and Pre-Statistics / Elementary Statistical Methods. ALEKS is an online learning and assessing tool used for many lower level math and statistics classes, including introductory statistics courses, but it is not statistical program that is used for data analysis. It is an online tutoring and assessment program named ALEKS, which stands for Assessment and Learning in Knowledge Spaces. The ALEKS program covers 224 topics at the introductory or pre-introductory statistics level. It allows students to work at their own pace. The ALEKS program prepares and evaluates students as they go through the sections and their respective exercises. It works as follows: Students are provided with a definition, along with its application and some examples. Then, after students read and review the information provided, they are asked to complete at least four problems related to it. Each student is provided with a different set of problems. These problems challenge their understanding of the concept. When a student does not answer one of the problems correctly, the program allows him a second chance to review and correct his answer. When failing to correct the answer, the student is provided with another similar problem. If the student is not able to answer these problems, he is asked to begin the section again. Every time a student answers a problem, whether the answer submitted is correct or not, the work and explanation on how to find the solution is provided.

Data Analysis

Interviews were transcribed. Line-by-line coding was used to begin to conceptualize ideas and to study the data closely. Then, focused coding was applied to sort and synthesize the data collected during the classroom observations and interviews (Charmaz, 2006).

Line-by-line Coding

In her book, Charmaz explains that line-by-line coding can help identify implicit concerns, explicit statements and to develop theoretical categories (pp. 50-51). This coding approach helped to identify influences on the development of pedagogical identities of college statistics instructors. From the nine instructor participants, four were more open to share their thoughts. During the line-by-line coding process, only the data from these four participants was considered. Statements from the transcripts that were considered informative were summarized. Interview transcripts were analyzed for the implementation of the first five GAISE college report recommendations and the instructors' position in the classroom. According to the researcher's interpretation of answers, instructors' pedagogical components and sources were captured. In addition, I focused on analyzing how the instructors' pedagogical components developed according to students' responses, how the development of these affect their course curriculum, and the position instructors take to address these challenges.

Focused Coding

It is possible to move across interviews and observations comparing people's experiences, actions and interpretations through focused coding (Charmaz, 2006). During this coding step, it was attempted to keep the codes active and close to the data. The codes were created with reference to the GAISE recommendations, the five-practice model, and the dialogical approach to identity. Through comparing data to data and data to these codes these focused codes were developed and refined. These codes were used to re-organize data and obtain analytical overall sense of the data. The codes are categorized as follows: pedagogical attitudes (revealed by the instructor participants' survey responses), pedagogical practices (revealed by instructors' during the interviews and classroom observations), and pedagogical identity development (the positions they hold towards educational situations, and how these influence their practices).

Validity

In the case of qualitative research, according to Kirk and Miller (1986), the problem of validity is a question of whether the researchers' observations are what they think their observations are. They define validity as the "extent to which a measurement procedure gives the correct answer. (pp. 19)" For the study, existing instruments were used to measure attitude and statistics educational knowledge. As per Philipp (2007), a case-study methodology that provides detailed descriptions about the beliefs of a small number of teachers rely on data collected through a combination of classroom observations, interviews, and surveys, which are often triangulated. We decided to construct a variation of the Likert-type survey used by Estrada, Batanero, and Lancaster (2011), as they pointed out that attitude is a psychological construct that cannot be measured directly. The Likert-type survey required participants to decide on their level of agreement with statements related to components of attitudes, using a five-point scale. To construct the Likert-type items to measure instructors' attitudes towards suggested guidelines, we used the GAISE report recommendations (2016).

Content Validity

In the case of a scale designed to measure a theoretical construct, content validity is defined as the degree to which the scale represents the study area and reflects the components of its structure (Rungtusanatham, 1998). According to Adcock and Collier (2001), content validity assesses the degree to which a measure represents the area of the content entailed in the systematized concept being measured. To secure content validity, we drew on the taxonomical construct that divides mathematics discussion in five steps and retrieve five representative recommendations from the recent GAISE college report. It was decided to secure content validation as it is considered an important component in education that involves conceptual reasoning (Carmines & Zeller, 1979). According to Hardesty and Bearden (2004), to establish content validity, a proper representation of the domain of a construct should be obtained. From the five GAISE recommendations, a set of 56 representative items was obtained by carefully narrowing all the suggestions made by Carver and his colleagues in their college report (2016). These 56 representative items were organized using the classification of attitudes into three pedagogical components found in previous studies: cognitive, behavioral, and affective. The items selected and classified helped us understand some attitudes statistics instructors hold towards suggested statistics teaching guidelines. Participants would have to state the level of agreement on the different items representing the suggested guidelines. Mention that the author of this paper worked with a scholar with expertise in statistics education back and forth together to make sure that (1) it covers all three pedagogical aspects of attitudes toward teaching and (2) it covers major domain of current teaching recommendations.

Face Validity

According by Hardesty and Bearden (2004), face validity is defined as the degree of measurement an assessment instrument have matching the intended construct according to the judgement made by the respondents. And according to Gaber and Gaber (2010), face validity is defined as an assessment tool that planners use to recognize when community comments can be understood as grounded qualitative observations. As per Anastasi (1988), our survey has face validity if it appears valid to respondents who take it, personnel who administer it and other untrained observers. For the criterion of face validity to be met, we asked a potential participant for the study to provide feedback on the final survey model. We consider him as a potential participant because he had been teaching introductory mathematics and statistics courses at the university for three years. He started teaching after completing his master's degree in mathematics. We asked him to provide his perspective as a participant on the phrasing and content of the items included in the survey, on how to improve the clarity of the questions, and to provide an overall opinion of the survey in general. We would use his opinion and feedback to fix and improve the items and the overall online survey.

CHAPTER IV

RESULTS

Individual reports of the four instructors in the study are presented in the following sections. In order to analyze the statistics instructors' behavior, we are going to look at their actions inside the class-room, responses to the interview questions, and information provided in the survey using a lens that includes the aforementioned first five recommendations of the college GAISE report, a dialogical self-theory or dialogical approach to identity, and the five practice pedagogical model. For each instructor, we discuss the classroom environment in the observations section. Then, a description of the teaching practices or comments each instructor made, and how these are consistent with the first five recommendations of the college GAISE report.

Overall Description of the Teaching Practices

Table 2 shows the survey response scores for the participant instructors. The numbers on the row of "Survey # Items" show how many items there were, in the survey, that belong to a particular aspect (cognitive or behavioral) of a teaching recommendation. For example, seven items addressed the cognitive aspect of *statistical thinking*, and eight items addressed the behavioral aspect of *using real data*. The scores on the row of each instructor show the instructor's mean score of the cognitive/behavioral aspect of a recommendation: each survey item was evaluated on a scale from -2 to 2, where -2 indicates "strongly disagree" and 2 indicates "strongly agree, and the mean score was calculated based on the scores of the survey items belonging to its group. The scores on the row of "All instructors" show the average scores of the nine instructors for each aspect/recommendation. The table shows that most of the scores lie at or above 0, which stands for neutral position, for each of the nine instructors. Only two of the 90 scores are negative: the cognitive aspect of technology for Instructor 1 (score: – 1) and the behavioral aspect of using real data (score: – 0.5). The table further shows that both in component and in behavioral aspects, technology had the lowest instructor averages (1.06 for cognitive and 0.38 for behavioral) and conceptual learning had the highest instructor averages (1.75 for cognitive and 1.52 for behavioral). Also, the scores from the cognitive attitude component were higher than the behavior component score for all of the instructors. This outcome suggests these instructors believe these recommended practices should be implemented, but their action level is not consistent with such beliefs.

Table 2: Survey Outcomes Summary

GAISE recommendation	Statistical Thinking		Conceptual Learning		Real Data		Active Learning		Technology	
Attitude Component	**C**	**B**	**C**	**B**	**C**	**B**	**C**	**B**	**C**	**B**
Survey # items	**7**	**7**	**4**	**5**	**4**	**8**	**4**	**6**	**6**	**5**
Instructor 1	1	0.75	1.75	0.83	0.67	- 0.5	1.25	0.5	-1	0.83
Instructor 2	1.86	1.13	2	1.5	2	1.25	1.5	1.14	0	0
Instructor 3	1.43	1.38	1.75	1.6	1.33	0.88	1	0.5	1.17	1.2
Instructor 4	1.14	1.63	2	1.6	2	1.5	1.75	1.17	1.17	1.2
Instructor 5	1.14	1.25	1.5	1.4	0.33	1	0.5	0.17	1	0.6
Instructor 6	1.29	0.75	1.25	0.8	1	0.83	0	0	--	0
Instructor 7	1.86	1.63	2	1.6	2	1	1	0	0.8	1.5
Instructor 8	1.86	1.38	2	1.6	1.33	0.13	1.5	0	1.67	0.4
Instructor 9	1.17	1.38	2	2	2	1	0.75	0.67	1.33	1
All Instructors	1.5	1.25	1.75	1.51	1.37	0.7	1.12	0.53	1.06	0.38

Note: C = Cognitive Component, B = Behavioral Component

Instructor 1

Instructor 1 holds a bachelor's degree (completed five years prior to the study) and master's degree (completed three years prior to the data collection), both in mathematics. He has been teaching mathematics for three years and statistics for one year. The statistics course taught by Instructor 1, which I observed for this study's data collection is called *Pre-Statistics Jumpstart.* This course is an introductory course, which was designed to provide students with the mathematical background necessary for success in Elementary Statistical Methods and Introduction to Biostatistics courses. This Pre-Statistics course does not form part of the University core curriculum requirements. It precedes all the probability and statistics courses, even the introductory statistics one, since it is a remedial course. The course I observed was taught during the summer of 2019 and had a student enrollment of 28.

The remedial course taught by Instructor 1 was technology based. Students attended class to work on problems generated by the ALEKS program. In the observed class, Instructor 1 gave supplemental quizzes outside the ALEKS program. To a large extent, the instructor worked as a facilitator of the tasks given to students and kept guiding the students for the given tasks. Each student would be working on a desktop computer individually, responding to exercises being generated by the ALEKS program. The program guides students through a set of notes that include definitions, procedures and examples, as they go through each of the different topic sections. During the observation, I found that students were working on the topics: Unions and intersections involving the empty and universal sets, finding standard normal probability, computing expected value in a game of chance, determine outcome for compound events, summation of indexed data, comparing standard deviations without calculation, experimental and theoretical probability for compound events, determining a sample space and outcomes for a compound event, determining samples for compound events and complements, try to make conclusions about the behavior of experimental and theoretical probabilities in relation with the number of trials, among others.

Teach statistical thinking. During the interview, Instructor 1 commented about some of the teaching strategies he implements during his non-ALEKS regular lecture-based courses:

> Excerpt A: I always [prepare] handouts to help students because *there are so many definitions*[1]. [This way,] *they can just follow along*[2] and do not have to write too much. Since I have only taught [elementary statistical methods] once, I try to teach it traditionally. […] It saves a lot of time [for me and the students], especially when they must write down too much. I try to keep it *to the minimum, so they can ask questions*[3].

Instructor 1's comments (A^2) indicate that he is focused on enhancing students' understanding of concepts rather than just making them go through a rushed note-taking marathon each meeting session, which, according to the GAISE report, is often divorced from understanding. His comment (A^1) also suggests he feels constrained by the large amount of material to be covered during the class sessions. One of the main reasons he prefers to provide students with the class notes is because he wants them to be participating and asking questions during the lecture instead of copying the information displayed on the board (A^3).

Conceptual Learning. By the way it is designed, ALEKS-based courses are supposed to promote active learning since students oversee their own learning as they learn. Since students work at their own pace, they get to choose how much time they spend on each section. The repetition feature after getting two consecutive wrong answers in the same section, allows students to spend extra time focusing on concepts and methods they might be struggling with. But a comment made by Instructor 1 in Excerpt B suggests the ALEKS program has a side effect on his learning methods(B^1).

> Excerpt B: *The nature of an online (no lecture) course makes it hard for students to move from procedural knowledge to conceptual knowledge.*[1] […] *Students are caught up more in making the graph right instead of reading the graph correctly.*[2]

During the observations, students would only work on the ALEKS program for the whole class session. As per the program procedures, students would have to answer problems correctly in order to move to the following sections. For each of the observed sessions, there was no time left during the course meetings to implement course activities. This could be a possible reason why students struggle to acquire conceptual knowledge (B[1]). During the observations conducted, students would ask for help whenever they were not able to mimic the procedures to find solutions in the examples provided. As students would go through the different topic sections, they were often only interested in moving on. Instructor 1 brought up this aspect during the interview too (B[2]). Students were not paying attention to understanding the procedures, instead they were only trying to find the correct answer.

Integrate real data with a context and purpose. When asked about the inclusion of real or class-generated data, Instructor 1 responded he does not include any (C[1]). His comments (D[1]) suggest he is already prepared to include technology in his statistics courses to ease students' computations, enhance their learning, and allow them to have a greater emphasis on interpretation of results. In consistency with the survey results (See Table 2), Instructor 1 agrees with the GAISE report recommendations. He believes real data should be included in the statistics curriculum, yet his behavior does not reflect such belief.

> Excerpt C: So far, I have not implemented class-generated data. *[I only use] the data provided in the textbook or some data sets available online.*[1] But I would like to improve [this aspect] in the future.

> Excerpt D: It would be nice to have students collecting data on campus to complete small projects. […] I should do this is in the future. *I would like to have students do some sampling or data collection and making them inference from that data collection.*[1]

Foster active learning. Due to his short experience teaching the subject and the nature of the course(F[1]), the only opportunities he had to help students discover, construct, and understand important statistical ideas were through the inclusion of probing high order thinking questions during the course meetings. In Excerpt F, he explains the reason for having a limited curriculum in this course (F[1]). His comments suggest he feels limited by his short experience with the ALEKS program and the course content. In this case, Instructor 1 adopts a me-position.

> Excerpt F: I have not really implemented teaching methods, and I have not really looked up different methods to implement. […] *Being knew with technology and teaching the course is what it is constraining me from including other teaching methods and higher order thinking activities*.[1] During my regular lecture-based courses, I have students working in groups to complete Quizzes.

Instructor 1 explained his goals for the course (G[1]). He would like to have students applying their statistical knowledge outside the classroom. He would like his students to become educated consumers of statistical information. This goal is consistent with the first recommendation of GAISE college report, teach statistical thinking. Moreover, he would like students to question statistical analyses encountered throughout their lives (G[2]).

> Excerpt G: Once they acquire data interpretation skills, *they can take them into their everyday life*[1]. So, *they can question how the article presents the information, the data*[2], whether its sports, their hobbies, medical journals. I think it would be nice for them doing that.

Use technology to explore concepts and analyze data. According to the answers provided by Instructor 1 during the interview (F[1]), his introductory statistics course has been limited to the inclusion of the ALEKS as technology teaching aid. Instructor 1 is already making plans to implement new technology tools to help students explore conceptual ideas and develop statistical thinking (H[2]).

> Excerpt H: *I really want to transition into showing how to use excel or R.*[1] [I am leaning towards] Excel, since it is well known and free for the students. […] I [help students] get the idea on how to use the formula, [but] I want to try to incorporate a little bit more technology. […] *When I do teach statistics again, I will be trying to infuse a little by hand and a little technology as well*.[2]

Instructor 1 adopts different identity positions in class, depending on the statistics course level. When possible, he takes an I-position by deciding to go traditional and shows students paper-pencil arithmetic computations (I^2).

But when being forced to include large data sets in his course, he opts to adapt and takes a me-position in the classroom (E^1).

> Excerpt I: *Not all students have a nice calculator* [1], and the fact that *I had already showed them how to find computations by hand* [2], makes it easier for me not to depend on the calculator that much. I would like to use Excel [to unify the calculations system].
>
> Excerpt E: *In situations where students work with large data sets, [they] are not going to do that by hand.*[1] [They] cannot do that with a table, since they would have to create thousands of rows and thousands of columns. [In this case,] it is recommended to use computer statistical tools like the R program.

Instructor 1 has not been implementing as many technology tools in class as he should be doing for several reasons (F^1, I^1, I^2). He explains that usually each student brings different types of calculators, and I believe he finds it very time consuming to be explaining to the students the procedure of making computations in different types of calculators.

Instructor 2

Instructor 2 holds a bachelor's degree in mathematics, which he earned 7 years prior to the data collection. Instructor 2 has a master's degree in mathematics education, which was completed one year prior to the data collection. He does not hold a doctoral degree. Instructor 2 has been teaching mathematics courses for five years and statistics courses for one year. The observed course Instructor 2 taught was the same course observed for Instructor 1, during a different term. Observations for the course *Elementary Statistics Jumpstart* sessions proctored by Instructor 2 were conducted during the fall semester. This course is an introductory course, which was designed to provide students with the mathematical background necessary for success in Elementary Statistical Methods. The student enrollment for the observed course was 23.

Instructor 2 taught other mathematics courses during the semester, but the course section observed was the only statistics course he was proctoring during that term.

The classroom environment in the elementary statistical methods course observed for Instructor 2 is a little bit different than the environment in a conventional lecture-based classroom. In this course, students work on their own using the ALEKS program. They are encouraged to become learners, since they take care of their own learning. For this course, Instructor 2 acted as a facilitator. Each student was working on a computer and logged into the ALEKS program. For the course, Instructor 2 became students' more knowledgeable other, in terms of the scaffolding theory (Albert, 2012).

Teach statistical thinking. During one of the course meetings, there was a student working on the section "Constructing a frequency distribution and a histogram." Instructor 2 was walking around, stopped next to this student and asked her: "do you understand why the classes have 0.5 decimals?" He posed the question while pointing at the histogram being displayed as part of the problem at the screen of the computer. After posing this question, Instructor 2 began to anticipate possible student's analysis of the case, the first step in the five-practice model. The student replied: "Because those are the values in the graph." After listening to her response, Instructor 2 asked: "What would it happen if we construct the classes with whole numbers, and the data includes a value that falls in between two classes?" He posed this question to guide the student to the right answer, as he monitored her answers, second step in the five-practice model. The student remained silent after listening to Instructors 2's questions. Then, Instructor 2 modeled the case to the student with a value not found in the table. He explained to her why the class values in the frequency table and histogram needed to have 0.5 decimals. Later, while still modeling the case to the student, he began to use the term "gap" to refer to the space between classes when no

0.5 decimal was included. By asking the student to analyze the situation and try to find a solution for the question posed (the one about having values finding in between classes), Instructor 2 encouraged her to develop statistical thinking. This is the type of statistical thinking statisticians used when finding methods for constructing class boundaries that include all the values in the set without having any gap. Instead of providing the student with an answer, with an example or with a book reference, Instructor 2 triggered the student's problem-solving skills. He tried to help her develop her statistical thinking skills. As Instructor 2 answered in the survey, he understands the importance of having students understand the connections among statistical ideas.

Instructor 2 was constantly posing probing questions to the students during the observed sessions. He seemed confident about the terminology and phrasing he used to formulate the questions. When having to provide an answer to his questions, students often remained silent after the question s was posed. Some other times, when they attempted to answer, their answers would show no statistical thinking or would approach to another (wrong) direction. When this was the case, Instructor 2 would model the definitions and procedures to students using the ALEKS program. He would show them how to find a solution to the problem or other similar ones. Using this class setting, Instructor 2 would model solutions to the ALEKS program problems one student at a time. During the observations, Instructor 2 would support open-ended questions and problems that trigger students' critical thinking among statistical issues. However, he would not insist on rephrasing the question nor would provide the students with more time to reflect on questions. These actions suggest he might feel constrained by the reduced class time. His actions suggest he believes there may not be enough time to approach all students' questions without modeling a solution path. In Excerpt J, Instructor 2 explained how he uses probing questions not to give students a direct solution but a guide to find the answer (J[1]).

> Excerpt J: You don't give answers to students. [When] they ask a question, you answer with a question. *You guide them to the answer rather than giving them the answer*.[1] I probe the entire time until they basically solve it themselves.

Instructor 2 adopts an I-position in the sense that he uses his experiences as a student to help students develop statistical thinking (K[1]). At the same time, students' reaction to probing questions posed by Instructor 2 impels him into adopting a me-position (L[1]). During the observations, students would hold-back the flow of the class for a moment whenever he posed a probing question. And his comment suggests he feels somehow constraint by students' responses to probing questions (L[1]).

> Excerpt K: *One of my favorite Instructors [when I was an] undergrad, that's exactly how he answered, and I would leave [class] frustrated*.[1] However, I realized exactly what he was doing later.

> Excerpt L: [XXI century students] want just quick results. When you don't give them that instant satisfaction, *they are hesitant in asking questions*[1].

Conceptual understanding. Instructor 2's classroom environment follows the same description from Instructor 1, except for it being a remedial course combined with an elementary statistics course. Students work on their own, learning and practicing concept definitions, using the ALEKS program, and having Instructor 2 as a tutor or facilitator for the course (M[1], M[2]).

> Excerpt M: *The students are basically learning themselves*[1], and *you're just guiding them*[2]. It takes away from traditional you know college setting, where it's self-learning with assistance rather than lecturer Instructor-based learning and them [students] doing a little it on their own.

As he mentioned, ALEKS provides students with tools and procedures used to analyze data. This helps them understand the concepts (N[1]). The program is supposed to present materials in ways that facilitate students' development of understanding conceptual information. But, according to Instructor 2, the ALEKS program also has some disadvantages (N[2]), which force him to adopt a me-position in the situation. In Excerpt N, Instructor was asked if he would keep implementing the ALEKS program for future courses. He explained how he felt about the program.

> Excerpt N: *It's a very good program for students that struggle with math*.[1] But for students that already get math, it's more less kind of boring. It doesn't pique their interest. *It's repetitive*.[2] Part of the reason why it is good for students that struggle with math, it's because it's repetitive. And when you are talking students that math is not an issue, then they lose interest because they are bored with the level that they're going through, the amount of material, there's no challenge. *It's all medium to lower questions, and you don't really go into the theory of statistics too much*[3] in the ALEKS program. […] *I prefer students to struggle and get to a higher level and vice versa, but ALEKS is basically almost holding their hand through the math content.*[4]

His comments on the program, let us know how the program may be constraining his consistency with some of the five recommendations from the GAISE college report (N^3). Instructor 2 would prefer to work with a different teaching method not including the program because of its poor academic standards (N^4). In consistency with the survey results (See Table 2), Instructor 2 expressed his believes that students should be engaging in higher-order thinking skills, which is achieved through active learning methods. But he couldn't accomplish this because of the limitations of the ALEKS program.

Instructor 2 adopted a me-position against the constraint the ALEKS program provides for his usual teaching methods. But he keeps trying to provide students with opportunities to make decisions about appropriate ways to visualize, explore and analyze data. Evidence from the classroom observations suggests Instructor 2 provide students with conceptual learning methods while performing teacher-student discussions. This would be when he attends students' questions in class. During one of the observed sessions for Instructor 2's course section, about half of the students were having trouble to work out addition/subtraction of fractions. They would also be struggling with other basic mathematics computations needed to solve for x. This was the form the different problems they had: y=(a/b) (x+z) for integers a, b. Students did not know how to begin to work on it. Instructor 2 kept asking students what the opposite computation of multiplication/ fraction are, or addition/subtraction. But, student's' reply to his questions would limit to nodding saying no. Since Instructor 2 did not provide them with answers right away, they had to analyze his question until they were able to figure out the opposite computations. This way, Instructor 2 fostered conceptual understanding of the concepts covered in each chapter.

During these student-teacher small discussions, we could notice that Instructor 2 would implement some of the five-practice model steps presented by Stein and his colleagues (2018). Instructor 2 would anticipate some of the student's statistical responses. He would envision how they might statistically approach the instructional task the ALEKS program asked them to work on. Instructor 2 guided students to the opposite relation for basic arithmetic operations. Then, he monitored student responses, paying close attention to their statistical thinking. Students engaged with statistical thinking as they worked on the problems. Instructor 2 also paid attention to the conceptual understanding students need to work on other similar questions. In order to appropriately respond to students' questions and attend their learning needs, instructor 2 kept monitoring their development as he walked around in the classroom asking and answering questions. He would guide students to an appropriate solving method by posing probing questions. Then, he would help students' draw connections between the statistical ideas that were reflected in the strategies and representations that they were provided with while working with the ALEKS program.

Integrate real data with a context and purpose. In Excerpt O from the survey, instructor 2 explained how he uses class generated data of interest to students to engage them in statistical thinking (O^1).

> Excerpt O: I collect class generated data to work and manipulate as a statistics course, *in my traditional lectures*[1]. *I take surveys with them about their favorite type of soda*.[2] *I believe this type of class participation is a necessity*.[3]

He includes class-generated data collection in his regular lecture courses (O[2]). But, according to the observations, he has not been able to include such activities in the ALEKS course. As per the cognitive attitude component toward this GAISE recommendation, Instructor 2 believes the inclusion of class generated data is a necessity (O[3]). In addition, during his regular introductory statistical courses, he encourages students to use the collected data to formulate statistical questions and to answer these based on how the data were produced and analyzed (P[1]).

> Excerpt P: As an example of getting students engagement is cult surveys, I would do so through Google survey. I collect data from the students. *I have them do surveys and then from there create the lecture and the examples that I am going to cover*.[1] With this activity, students are exposed to data they interact with on a regular basis. This data is generated by online social networks and could be tracked regularly on their mobile smart devices.

Foster active learning. When Instructor 2 was asked about other teaching strategies or methods he might not have included in the observed sessions, he responded he includes comparison methods for his non-ALEKS courses (Q[1]).

> Excerpt Q: In the case of the ALEKS program no, but in my major lectures *there is a constant method where I asked students to do comparison exercises*[1]. [...] If you can demonstrate something students already know and guide them through that process, then when you [ask them to] do the comparison with the variables, they normally [find] it frustrating and confusing. First time students see it in its pure abstract form, then *when they start to build pair and contrast methods from the lecture, they notice their subtle differences as well as the comparison between*[2].

With the inclusion of these comparison teaching methods in his lectures, Instructor 2 adopts a me-position. He avoids activities that lead students step-by-step through a list of procedures (Q[2]). When being asked about which practice components he considers important, Instructor 2 adopted an I-position. He believes that building students' confidence would be the most important practice component (R[1]).

> Excerpt R: *I think the most important [practice component] would be grow mindset*.[1] Students that fail your first exam, fail your second exam. *Encouraging them*[2] [saying:] 'you will improve' should be implemented more, even in just a traditional lecture style or lecture to test quiz. It needs to be taught. It needs to be encouraged more. That's one of the most important.

Inside the classroom, Instructor 2 does not only consider himself a facilitator (M[2]). He acts as a support arm for the students' self-trust development and confidence building (R[2], R[3]). He shared what his definition is for growth mindset is (R[3]).

Use technology to explore concepts and analyze data. As we observed in his ALEKS course, Instructor 2 encourages students to use technology to facilitate computations. While students worked on the section converting between percentages and decimals, Instructor 2 explained them how to move from decimal to percentage. And he encouraged them to confirm their responses using their calculator. When being asked about how to decide when to encourage students to use their calculators, he replied he would encourage them when they struggle with the multiplication tables only (T[1], T[3]). In Excerpt T, Instructor 2 explains how he prefers to guide students into developing mental arithmetic skills than just allowing them to use the calculator to facilitate computations (T[2]). By doing so, he adopts an I-position. Instead of adopting a path where students rely on calculation devices, he decides to support students' use of mental computation.

> Excerpt T: I encourage them *when they seem to struggle with multiplication tables*[1], [but] normally, I don't. For example, *if they don't know what 8 times 7 is. I ask them to say, what's something you do know? What's 8 times 8? Usually if they do respond, then I go from there and say: alright subtract 8 and get back to 8 times 7*[2]. If they struggle with their times table which is [often], then *I kind of guide them to use their calculator only to start memorizing certain numbers within the times table to build off*[3]. For example, like 8 times 5. If they can get 8 times five, then they don't need their calculator. We can work from that. If they don't know any of their times tables, usually with 8, 7, and 6, then I guide them to use their calculator.

Besides using technology to facilitate computations, Instructor 2 claims to use technology to explore conceptual ideas (U[3]). He shows a positive cognitive attitude component as he believes the use of technology to explore concepts and analyze data is encouraging (U[2]). When being asked about his attitude towards the use of technology as an aid for students to learn how to think statistically and discover concepts, he shared his experience with Microsoft Excel (U[1]). His comment suggests he holds a positive thought about it.

> Excerpt U: *There's a great chapter on statistics, where they teach excel and how to compute the same statistics using that*.[1] I cover that very thoroughly within my lecture, right around week 4 in my traditional setting. *I think it's encouraging*.[2] *It's just another tool to help, like the calculator to help kids understand the application and theory of statistics*[3].

Instructor 3

Instructor 3 has been teaching mathematics courses for 20 years. Ten years ago, he started teaching statistics courses. He accomplished a bachelor's degree in mathematics 19 years prior to the study and completed his master's degree in mathematics 13 years prior to the data collection. Only one course section for this instructor was observed. It was a regular lectured-based *elementary statistical methods* course. This is a statistics introductory course designed to provide an elementary overview of the nature and uses of descriptive statistics, inferential statistics, and probability. The student enrollment for this course section was 102 students. Observations for this course were also conducted during the fall semester. Instructor 3 was proctoring four sections in total of the same elementary statistical methods course during the term.

The classroom setting for Instructor 3 was a regular elementary statistics lecture-based course. The course system for the semester was as follows: students attended to lecture classes on Tuesdays and worked on in-class labs on Thursdays. During a lecture meeting, Instructor 3 would go over the chapter definitions and examples in the front of the classroom using the projector and a PowerPoint presentation. Students were just listening and occasionally asked questions when they needed to. Outside the class meetings, students would work on Quizzes, projects, and would use the ALEKS program to complete the homework assignments. The agenda for each of the course meetings was the following: students were presented concepts with their respective applications and examples. Then, their understanding of these is evaluated the next class meeting. During the lecture meetings, on Tuesdays, Instructor 3 introduced that day's topic with an engaging example. Later, he began to display the concepts for the respective the section and worked some examples in the front. He would also show students how to apply the concepts in the real world. He uses the calculator and Excel computation methods to show the students what are the tools they can use to find calculations faster. As well as how to visually represent computations and values. On Thursdays, students worked individually completing online labs.

The labs consisted on a set of multiple-choice questions evaluating their knowledge on the material covered during the Tuesday session. Then, students would work in a provided set of exercises reviewing previous concepts covered in class. Students were encouraged to work in groups or ask a classmate for help. While students were working on the exercises, Instructor 3 walked around the classroom offering help to students who had or could have a question. There were three tutors walking around the classroom assisting students' needs too. So, when students had a question, they could ask Instructor 3 or any of the tutors. During the lab sessions, students were allowed to use their notes, class PPT presentations, their book, and other materials provided in class.

Teach statistical thinking. During the observed lecture sessions, Instructor 3 emphasized the type of thinking statisticians use when approaching statistical problems during lecture, during labs, or when a student asked a question, or whenever he had the chance. In one occasion, a student posed a question about samples. This was Instructor 3's reply to the student and the rest of the classroom:

> Excerpt V: We are creating samples, and *you need to look at it from a statistical point of view, what would a statistician do?*[1] You are not working with interviews (referring to individual subjects), but with surveys and pools (referring to a group of subjects).

Instructor 3 answered the student's question with a straightforward path on how to approach the situation. He triggered the student's statistical thinking while emphasizing the type of thinking that statisticians use when approaching statistical problems (V^1). In this case, Instructor 3 adopted an I-position as he acted towards the use of statistical thinking in the course. He identified a teachable moment and used it to emphasize the multivariate nature of the statistics discipline. While doing so, he went right away to the fourth step of the five-practice model (Stein et al., 2018).

During the interview, Instructor 3 was asked about his comfort level with respect to the implementation of statistical thinking in the course. His response to the question suggests he feels constrained about the course level because of the nature of the class (W^1). Instructor 3 also explains the reason of his discomfort with the course (W^1, W^2, W^3).

> Excerpt W: *I can't go overboard or do a lot of [projects*[1],] because of the nature of the class. I need to cover some basic concepts. *The nature of the class is a freshman level statistics course*.[2] So, I [must] keep that in mind. Eventually, if [students] want to take more stats, they will see more other concepts. *They will be engaged more in critical thinking later*.[3] *It is what it is*.[4]

The last sentence in his comment suggests he adopted a me-position when it comes to the statistical thinking level he implemented in his introductory course (W^4). He couldn't apply as much statistical thinking he would have liked nor as much as he believes students needed (W^1).

Instructor 3 identified class size as a factor having an impact on the students' development of statistical thinking (X[1]). He explained how he was constantly trying to add more probing questions in the lecture part of the course.

> Excerpt X: *I see that when I have a very large class, I have to add more probing questions than usual*.[1] […] When I have a class of 30-40 [students,] I can [have] more contact with the students. But *[for] a very large class, I [move a lot more] in the classroom, and I must design the lecture a little bit different* [2].

As per the five-practice method adapted for this study (Stein et al., 2018), probing questions allowed Instructor 3 to monitor students' development as they approached the problems provided. Instructor 3 adopted a me-position in the sense that the class size affected his teaching methods and strategies (X[2]) .

Conceptual understanding. During one of the observed course meetings, at least three students asked for a clarification about what a sample of randomly selected subjects is. To answer one of these students' questions, Instructor 3 went over the concept of population. Then, he moved on how it could be hard for statisticians to study a large population. He explained that they choose group(s) of that population to study instead. He uses the students' population at the university as an example of population. Then he set the class students to be a sample of that population. By using comparison examples, Instructor 3 teaches statistical thinking and presents the material in ways that facilitate students' development of deep understanding of concepts and ideas. He adopts an I-position as he takes action to focus on students' conceptual learning.

On another occasion, Instructor 3 opened the class session with an example of him and some other professor competing. He said they would be bragging about whose students got a better grade, since both of their classes had the same average of 75. He drew two dot plots one the board. One had the values very close to 75 gathered in the 60-80 grade sections of the graph. The other class graph had the grades spread out on the graph. He introduced the term variability with this example. Then, he presented the value called standard deviation that tells us how spread apart the values are. He asked: "[Knowing this,] what does it mean if I get a standard deviation of 0?" Although, only one student answered saying "that everybody got the same 75 score for the grade," Instructor 3 used this example to focus on students' understanding of the key concepts, variability and standard deviation. He illustrated these definitions using two dot plots instead of covering a multitude of techniques having minimal focus on underlying ideas.

Often, during the observed course sessions, Instructor 3 would rephrase or present key concepts using informal definitions that enhanced students' understanding of the concepts. Instructor 3 supported the idea that having a strong conceptual understanding of the concepts eases the students' use of necessary tools and procedures to approach questions about a data set. He adapted key concepts definitions to students, and some examples of adapted definitions are as follows: "The mode is the number that repeats the most," "symmetric distribution is where most of the values are in the middle," and "the median is the number that splits the data in half, when you have [the data] in order." He was always encouraging students to use definitions they already know and work from there. His favorite suggestion for students would be: "make it into money and you'll never get it wrong," as he would say very often in class.

Integrate real data with a context and purpose. As mentioned in the previous section, Conceptual understanding, Instructor 3 would rephrase statistical definitions using basic daily vocabulary terms. In one of the observed meetings, he defined the range as the value that "will give us the spread of the distribution." Then, he illustrated this abstract concept using a simple example involving a simulation. He talked to the students about how car companies have machines or robots simulating the weight and shape of a person sitting up and sitting down. He explained that the environmental components as wind, sunlight, etc. would also be simulated.

According to his example, statisticians would use such simulations to see how long the car will last in good conditions or how resistant it is. Instructor 3 explained how the range is the first step into this checking process.

In a different observed course meeting session. Instructor 3 showed students how to read bar graphs and how to interpret percentages. He presented some bar graphs to the class to expose students to data sets they with on a regular basis. These would engage them in statistical thinking and concepts. The bar graphs displayed how frequently students arrive late to class during weekdays. Then, he asked the students to interpret the bar graph and try to make assumptions of what is going on.

Foster active learning. During the interview, Instructor 3 explained, in Excerpt Y, how he has implemented a flipped model approach in his statistical introductory courses. When he talks about doing a class activity, he means the lab session students had on Thursday meetings. The he explains how he leads student-teacher conversations or small group student-teacher discussions through the lab sessions(Y^2).

> Excerpt Y: *I try to make it available for the students to preview the material as much as possible before they come to class. [. . .] Then I do a mini lecture or small little lecture, when I do meet with them, one day during the week*.[1] The other day, *I have them follow up to the lecture, when they do a class activity*[2].

During these small conversations or grouped discussions, Instructor 3 adapts an I-position as he monitors students answers and development to appropriately approach their needs, paying close attention to the statistical thinking they engage in. The classroom conversations and discussions help students discover, construct, and understand important ideas they might have missed during the mini-lecture sessions (Z^1) . During the lab sessions, students engage in statistical thinking as they achieve higher learning gains within activities than lecturing (as mentioned in GAISE college report).

> Excerpt Z: *The problems that I have in my labs are for me to spark a conversation*[1], for them to start reviewing the material that they saw in my lecture, they saw in the previous material that they probably looked at before they came to class, during my lecture. This is how I engage them. I engage them in that lab, trying to make sure that they at least get some of the basic ideas of that week's lesson.

When being asked about the reason why he chose to use these teaching methods, instructor 3 explained how he finds them a necessity due to the nature of the students that we now see (AA[1]).

> Excerpt AA: *The student is not the typical student I grew up with*.[1] I would go to the library, pick up books, start working on the problems, or whatever. They have a very short [period] in during the day to master let's say a concept or go to class. The other time they work on some other things. So, I think that this method maximizes the time, or try to utilize the [in-class] time as much as possible. [Students] crave for videos. *They crave for things that they can look online. They are online 24/7*.[2] *That's driving me changing the way that I teach a class, it's the students and how they do things.*[3]

Thus, as we discussed in the previous paragraph, Instructor 3 adopts an I-position when it comes to leading classroom discussions. But he does so to approach a situation where he finds himself constrained by the nature of the XXI century students, as Instructor 2 explained during his interview (AA[2]). We can say that Instructor 3 finds himself combining a me-position along with an I-position when it comes to the nature of his students needs and how to attend them (AA[3]). When being asked about his level of comfort with the implementation of these teaching methods, Instructor 3 expressed that he just keeps trying to adapt (AB[1]).

> Excerpt AB: It's a little bit different, because I am used to learning material one way, and now the students are used to learning in another way. *I am adapting to how they are learning [by going] to trainings or [conducting] research [about it] as much as possible*.[1]

Use technology to explore concepts and analyze data. As it was discussed in the previous section, foster active learning, Instructor 3 uses technology to provide students with conceptual ideas to explore and opportunities that help them learn to think statistically, before they attend to the mini-lecture sessions (Y[1]). When he was asked about his comfort level using technology to introduce statistical concepts, he responded saying he is forced to be comfortable using technology as a learning tool (AC[2]). He considers it mandatory (AC[1]).

> Excerpt AC: *[Technology mandatory.] It must be part of the discussion*.[1] You don't do calculations by hand, you do them using technology. *So, you have to be comfortable*.[2]

In this case, the comment Instructor 3 makes about technology being mandatory suggests this compels him to adapt a me-position when it comes to technology used to introduce statistical ideas. Then, for bigger computations, Instructor 3 explains how he supports the students use of technology as a method to avoid step-by-step methods (AD[1]).

> Excerpt AD: *I always encourage students if they want to solve the projects with SPSS, they can do that*.[1] But usually, they use excel, because the book comes with [instructions on how to work using] Excel.

In Excerpt AE, Instructor 3 comments suggest he adapted a me-position towards the ALEKS program, because it was recommended by the committee (AE[1]). He said he is open to work with other possible suggested programs too (AE[2]).

> Excerpt AE: *[When there is a] discussion about [a new] type of software that we can use to better prepare the students as they go to the next level in stats, I would, of course, consider it and implement it*.[1] [. . .] So, *I am also hearing recommendations from other colleagues or the committees*.[2] That's also an integral part of me adapting and changing things over the content that we cover. And it's a challenge also to cover everything and then also maybe introduce something new.

Besides using technology to facilitate computations and to explore conceptual ideas, during observations, Instructor 3 performed simulations to show abstract concepts and used tools that help students visualize the concepts. During one of the observed sessions, Instructor 3 referred students to the website Google trends. He used a browser and the projector to display the website in the screen at the front of the classroom. Then, he asked students: "What are some of the applications of these time series are graphs? [what is] the statistics behind them? Find out what are some of the down times based on the time series graphs." Instructor 3 showed students the cases when trending searches were related to the study's university. Then, he asked probing questions about when the down times were. He helped them make some analysis on why this would happen. In addition, instructor 3 explained students how to retrieve data from the university's website, and how to find useful information regarding its campuses, students, and academics. Instructor 3 showed students some time series graph examples involving the university related searches in Google.

Instructor 4

Instructor 4 has been teaching mathematics courses for eight years, and statistical courses for only two years. He graduated from his bachelor's degree in science mathematics 9 years prior to the study and completed his master's degree seven years prior to the study. The course section observed for this instructor was also a regular lecture-based elementary statistical methods course during the fall semester with a student enrollment of 34 students. The course section observed was the only statistics course Instructor 4 proctored during that semester.

The course meetings itinerary was as follows: the instructor presented some definitions along with some of their applications. During lecture, he would ask the class to perform basic computations as additions and multiplications. In addition, he provided students with a set of physical class notes he would prepare in advance. He would use a combination of projector and white board to present the examples and definitions. After going over the definitions and the exercise solving procedures, Instructor 4 would provide students with an example problem or a set of similar problems to work on by themselves, in teams composed of 1-4 students.

Teach statistical thinking. During one of the observations conducted*, after explaining one example using the projector and the board, Instructor 4 displayed an example exercise in the projector. The example involved frequency tables, and asked students to work on their own to complete it. He refers to these small group discussions as try-it themselves. As he walked around the classroom checking students' work, he would encourage them to work with a classmate or ask their neighbors for help. He included small group discussions in each of his course meetings. By doing so, he would foster students' understanding of connections among statistical ideas. As he walked around the classroom, some students would raise their hand to clarify any doubts they could have. In one occasion, a group of students were discussing the reason why they must divide the range by the number of classes to find the class width. One of the student's comment was: "because that's how many classes you want?" Eventually, students began to ask each other for help. As I listened to some of their conversations, I realized the following: By having students working and discussing the different problem situations, Instructor 4 offered them considerable practice with selecting appropriate ways for choosing an appropriate technique to address statistical questions being posed in the course. The inclusion of small discussion in the classroom helped students think critically about statistical issues, since they would engage in statistical thinking conversations. The students ' comments on the questions asked would be predicted and monitored according to the five-practice model. When he walked around the classroom, he would track students' statistical learning progress through conversations. This would allow him to take a strong I-position in the classroom. The class became student-centered instead of teacher centered, because students engaged in statistical discussions. I referred to this class as student-centered as the action was taking place on the students' side of the classroom.

Conceptual understanding. Consider the same occasion observed in the previous section (*). During these small group discussions setting, students were explaining each other the steps they used to construct their frequency tables. During the first minutes of the grouped discussions, students' conversations would only involve procedural questions: "how did you find these values? Is the frequency the same as the tally? For the tally, do I just count the values? How do I know which ones are my boundaries?" Eventually, their conversations gradually transitioned from procedural to conceptual. By allowing students to have small-group discussions instead of whole classroom discussions, Instructor 4 fostered conceptual knowledge. In this class setting, students helped each other develop conceptual knowledge.

Instructor 4 presents statistics course material in ways to facilitate students' development of deep understanding of concepts and ideas (AF[1]).

> Excerpt AF: I have created some lecture notes. *From that lecture notes all they have left to do is fill in the blanks*.[1] It has some vocabulary and some technical computations. [. . .] In the notes I give them, they must fill in the blank, [because] it has [incomplete] definitions. Once we do a couple of definitions, then we relate those definitions to the problem solving.

Professor 4 adopted an I-position during his lecture sessions in the sense that he provides students with an understanding of the concepts to help students identify necessary tools and procedures to answer questions about a data set. As he explains in Excerpt AG, the flow of his lectures fosters students' development of conceptual understanding as is builds up.

> Excerpt AG: It starts out with a definition. Then, you give different examples from that definition. Once students have [worked out] these examples, we try to derive a question or a problem from the definition and [draw connections between the ideas].

Integrate real data with a context and purpose. As he expressed in the interview, Instructor 4 would have students develop their own data for several projects in class (AH). Later on, they would manipulate this to conduct an analysis.

> Excerpt AH: I assign the projects. There are four projects. One of them is a survey of the students' class heart rate. They take their pulse and write it down in Blackboard. Then, they do 25 jump jacks and take their heart rate again and put it in Blackboard. I try to have the whole class do it so we can have enough, data values. Once they do that, I give them the data values and they must create a grouped frequency distribution, histogram, and ogive giving the data.

Instructor 4 explains how he implements activities that involve study design, data collection, data analysis, and interpretation for the preceding projects in the other sections (AI).

> Excerpt AI: [For some projects] I collect the data from the students. [I ask them to provide] their age. Once students have access to the data collected from the class, I tell them to do the mean, median, mode, range, variance, and standard deviation of the classroom age. Then, [students must find the z-score of a student of 29-year-old [respond to the following question:] would it be usual to have a 29-year-old student in class? and determine the skewness of data.

Since these activities are assigned as a project (AH, AI), they don't take an entire session and remain rich and valuable, as suggested in the GAISE report.

Foster active learning. For Instructor 4, I would consider class-generated data as a hands-on learning approach. This is because Instructor 4 would have students collecting their own data. He would feel a little bit constrained about assigning a project where students must collect their own data from a question they generate and would like to analyze (AK[1]). In this case, Instructor 4 adopts a me-position, since he let the activities' grading difficulties influence the learning methods he includes in his lectures.

> Excerpt AK: Since for the homework assignments, data is already given to them, and all they have to do is substitute values. But when it comes to providing students with student-centered class activities involving real data sets of interest to engage students in thinking about the data and relevant statistical concepts. […] *Such type of project would be harder to grade*.[1]

During the interview, Instructor 4 says he also uses active learning methods to find whether students are struggling or not (AL). Thus, through the application of active learning methods, Instructor 4 would monitor students' statistical development in the course, as well as help them draw connection among statistics ideas presented in the class and the strategies they use.

> Excerpt AL: Active learning activities help me know [and] to see if the students are struggling or not.

Use technology to explore concepts and analyze data. When being asked about the technology he uses in the class and his level of comfort with the inclusion of it, Instructor 4 replied he only uses the calculator in class (AJ[1]).

> Excerpt AJ: *Technology that could [be] used for this course is pretty much calculator.* [1] [...] The book by Alan Blueman, at the end of each chapter, it tells them how to use the TI-83 or 84 or also, excel. It tells them how to use it. *I try to tell them to use the calculators to help them better understand.* [2] […] *Most of the data, [as it gets] more complex, [it needs to be] done by computer.*[3]

Thus, Instructor 4 uses technology as an aid to engage students in statistical thinking, discovering concepts, and facilitating computations (AJ[2]). Instructor 4 provided his level of comfort with the use of calculators in the course adopting a me-position as it is part of the nature of the course (AJ[3]).

CHAPTER V

DISCUSSION

The purposes of this study were (1) to examine the degree to which the teaching practices of elementary statistics instructors are consistent with the recommendations of the GAISE college report, and (2) to learn about the nature of the attitudes that instructors hold against using these recommended practices in their courses, and to identify the factors that impede their implementation of these. For this, I raised the following questions:

1. To what extent do the classroom practices of statistics college instructors comply with recommendations of the GAISE college report?
2. With respect to the three dimensions of attitudes–affective, cognitive and behavioral, what attitudes do elementary statistics instructors hold toward adopting the GAISE college report recommendations in their classroom practices?
3. What are the possible factors that prevent introductory statistics college instructors from implementing the GAISE college report recommendations in their classroom practices, whether wholly or partially?

Regarding the first research question, this study found that the four instructors have various degrees of how much they align with the GAISE reports recommendations. For example, Instructors 1 and 4 were reluctant in using technology as a learning tool to explore concepts and analyze data. They would include only the use of calculators to facilitate computations, but they would not include any statistical software (See Excerpts H, I, and AJ). However, the use of

Microsoft Excel to conduct statistical analysis would be introduced by Instructors 2 and 3 as found in Excerpts U and AD.

Regarding the second research question, survey results (See Table 2) show that instructors believe that recommended practices of the GAISE college report should be adopted. However, their degree of action towards these practices is not consistent with those beliefs. For example, as per the cognitive component of attitude, Instructor 1 agrees that the inclusion of real and class-generated data is important for the students' development of data interpretation skills (See Excerpts D and G) . But for his courses, he had only been using data provided in the textbook or data sets available online (See Excerpt C). In the same way, Instructor 2 expressed he would like to have students engaging in higher-order thinking skills that can be accomplished through active learning methods (See Excerpt N). But he couldn't accomplish this because of the major component of his course section, the ALEKS program. Instructor 2 also believes it is important to include class generated data (See Excerpt O). But again, the ALEKS program would hinder the implementation of data collection methods in his course. Concerning the behavior component of attitude, Instructor 3 would take action to incorporate basic statistical language and ideas (See Excerpts V) as well as to emphasize conceptual learning. Similarly, Instructor 4 would act toward the collection of class generated data in his course (See Excerpt AI). These two events suggest they hold positive attitudes towards the integration of statistical thinking, conceptual learning and class-generated data in their introductory statistical courses.

Regarding the third research question, the study found that some teaching practices were affected by various factors among the four instructors. The complexity of an online course was identified by Instructor 1 as preventing him from effectively incorporating conceptual learning methods in his course (See Excerpt B). He also identified his lack of experience as keeping him from including other teaching methods and higher-order thinking skills (See Excerpt F). Identifying these two variables reveals he takes a strong me-position in the course. The essence of *XXI students*, as described by Instructors 2 and 3, influences their implementation of changes to their curriculum (See Excerpts L and AA). Their introduction of curriculum changes means that, although their students' reaction affects their teaching methods, they show a strong I-position in the course. This is because some of their teaching practices are not hindered by the students' nature. In addition, Instructor 3 described the essence of an introductory course as keeping him from engaging students in higher-order critical thinking (See Excerpt W). In this case, Instructor 3 takes a strong me-position as he allows the nature of the course to affect his use of this teaching practice.

This research provides an explanation of the inconsistency between what teachers do in the classroom and the practices recommended by the GAISE college report by laying emphasis on how statistics instructors determine which teaching practices to implement. As this is an imminent disjuncture, instructors need to self-understand about what kind of position they are taking in the classroom. The results from this study can give meaningful information to the statistics education community. I believe this study can contribute to the statistical education community in three ways. First, it can help identify some factors preventing statistics instructors from implementing recommended practices. Second, it underlines the need to give greater attention to the problems caused by such factors preventing instructors from integrating recommended practices in their statistics teaching methods. Third, it aids to identify the attitudes or views that statistics instructors have towards the recommended guidelines and some of their reasons for maintaining them. There may also be some recommendations for improving teaching practices in introductory statistics courses. For instance, conducting short training sessions presenting ASA guidelines to lectures, faculty seminars to discuss teaching practices, and not having some online tutoring program as the main component of an introductory statistics course.

Future Research

The current study could be extended to try to analyze the extent to which teaching experience of instructors influences their use of recommended practices. Some instructors maybe be listed as novices in this report. Differences between novices and experienced instructors may lead to a new line of research. For example, novices and experienced teachers may have had different professional training and may have developed different teaching identities as a result. Teaching experience can also affect whether teachers feel motivated or constrained to take different positions (I/me) in the classroom. In a future study, this last could also be discussed.

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APPENDIX A

APPENDIX A

ONLINE SURVEY

Hello,

I am a graduate student at the School of Mathematical and Statistical Sciences (SMSS) of the University of Texas Rio Grande Valley (UTRGV). I would like to invite you to participate in my research study to investigate the attitudes that college instructors of elementary statistics hold toward the teaching practices recommended by the statistics education community. This interview applies only for college instructors who are currently teaching (or have taught) elementary statistics course.

This research study has been reviewed and approved by the Institutional Review Board for the Protection of Human Subjects (IRB) at UTRGV.

In order to participate you must be 18 years or older. Participation in this research is completely voluntary, you may choose not to participate without penalty.

As a participant, you will be asked to complete an online survey which should take about 15-20 minutes. At the end of the survey, your email address will be requested for further recruitment. Besides your email address, there is no other personal information collected in the survey. Please, be aware that during the survey, you may refuse to respond any question you might feel uncomfortable with. After participating in the survey, you could be recruited for other procedures such as observations and interviews.

If you would like to complete the survey, click on "Yes" answering the question: "Do you consent to participate in the survey?" If not, simply exit the web browser or click on "No" when answering the question.

If you have questions related to the research, please contact me by telephone 868-796-1653 or by email at marisol.sanchezcortez01@utrgv.edu. You may contact instead my faculty advisor Dr. Hyung Kim by telephone at 956-665-2372 or by email at hyung.kim@utrgv.edu. If you have any questions regarding your rights as a participant, please contact the Institutional Review Board (IRB) by telephone at (956) 665-2889 or by email at irb@utrgv.edu.

If you have any questions regarding your rights as a participant, please contact the Institutional Review Board (IRB) by telephone at (956) 665-2889 or by email at irb@utrgv.edu.

Thank you for your cooperation!

Marisol Sanchez Cortez

Graduate Student

Do you consent to participate in the survey?

Yes / No

- What is your gender?
  Male / Female

- What is the highest degree you hold?
  Bachelor's degree / Master's degree / Doctoral degree
- What was your undergraduate degree on?
  Mathematics / Statistics / Math Education / Other
- What was your master's degree on?
  Mathematics / Statistics / Math Education / Other
- What was your doctoral degree on?
  Mathematics / Statistics / Math Education / Other
- What year did you receive your bachelor’s degree?
- When did you graduate (YYYY) from your master’s degree?
- When did you graduate (YYYY) from your Doctorates degree?
- How many years have you been teaching mathematics?
- How many years have you been teaching statistics?
- Please, list the statistics courses or other relevant courses you have taught or are currently teaching beyond elementary statistics (for example, mathematical statistics, statistical methods, etc.).
- Regarding elementary statistics courses you teach/have taught, how much do you agree with each statement?
  strongly agree / somewhat agree / neutral / somewhat disagree / strongly disagree

  1. It is important for students to see the connections among statistical ideas.
  2. It is important to emphasize that most statistical questions can be solved with a variety of procedures.
  3. Students must develop the type of thinking that statisticians use when approaching or solving statistical problems.
  4. Teachers have to prepare students for challenging questions that require investigating and exploring relationships among more than two variables.
  5. It is important to teach statistics as an investigative process of problem-solving and decision-making.
  6. My classes focus on helping students think critically about statistical issues.
  7. My classes focus on helping students recognize the need for data and the importance of data production.
  8. I emphasize the type of thinking that statisticians use when approaching or solving statistical problems.
  9. I emphasize the use and interpretation of statistics in everyday life.
  10. It is important to teach statistics as an investigative process of proposing questions, testing assumptions, and drawing conclusions from data.
  11. I implement classroom activities that involve study design, data collection, data analysis, and interpretation.
  12. It is important to emphasize the multivariate nature of the discipline.
  13. I give students open-ended problems (including projects).
  14. I give students real-life scenarios with multiple variables that can help students appreciate the role that statistics plays in everyday life.
  15. I offer students considerable practice with selecting an appropriate technique to address a particular research question, rather than telling them which technique to use and having them implement it.

16. Students’ learning of the tools and procedures that can be used to analyze data must be accompanied by their understanding of the underlying concepts.
17. Having a good understanding of the concepts will make it easier for students to use necessary tools and procedures to answer particular questions about a dataset.
18. Students must learn how to make decisions about appropriate ways to visualize, explore, and analyze data.
19. I present the materials in ways to facilitate students’ development of deep understanding of concepts and ideas.
20. I provide students with strong conceptual information.
21. A primary goal of introductory statistics course is to learn about discovering and applying statistical concepts.
22. I focus on students’ understanding of key concepts, illustrated by a few techniques, rather than covering a multitude of techniques with minimal focus on underlying ideas.
23. I use formulas that enhance the understanding of concepts and avoid computations that are divorced from understanding.
24. I pare down content of an introductory course to focus on core concepts in more depth.
25. Using real data in context is crucial in teaching and learning statistics.
26. The context of the data becomes an integral part of the problem-solving experience in statistics learning.
27. Students should practice formulating good questions and answering them appropriately based on how the data were produced and analyzed.
28. I encourage students to formulate and answer questions based on how the data were produced and analyzed.
29. I use real data sets of interest to students to engage them in thinking about the data and relevant statistical concepts.
30. I have my students use real data.
31. I use data with context as the catalyst for exploration, generating the questions, and informing interpretations to conclusions.
32. My classes use class-generated data to formulate statistical questions.
33. I minimize the use of hypothetical data sets.
34. I expose students to data they interact with on a regular basis, such as data generated by online social networks or data tracked regularly on mobile smart devices.
35. I discuss the messiness of real data before using it in a course.
36. In-class active learning methods help students discover, construct and understand important statistical ideas as well as engage in statistical thinking.
37. It is important to implement in-class active learning methods.
38. Learning gains are achieved more with activities than via lecturing.
39. Whereas some rich activities can take an entire class session, many valuable activities need not take much time.
40. I implement in-class active learning methods to help students discover, construct, and understand important statistical ideas.
41. I ground activities in the context of real data with a motivating question.

42. I consider the student need for physical explorations (e.g., die rolling, card drawing) prior to the use of computer simulations to illustrate or practice concepts.
43. I implement class activities that encourage students to predict the results before analyzing the data.
44. I avoid activities that lead students step-by-step through a list of procedures.
45. I allow students to discuss and think about the data and the problem.
46. Technology should be used as a way to explore conceptual ideas.
47. Most computations should be facilitated by technology.
48. The use of technology enhances student learning.
49. Technology aids students in learning to think statistically and to discover concepts.
50. Technology tools should be used to help students visualize concepts.
51. It is important to use technology to aid students in learning to think statistically and discovering concepts.
52. I perform routine computations using technology to allow greater emphasis on interpretation of results.
53. I perform simulations to illustrate abstract concepts.
54. I implement computer-intensive methods to find p-values and de-emphasize t-, normal and other probability tables.
55. I generate and modify appropriate statistical graphics, including relatively recent innovations like motion charts and maps.
56. I perform simulations to illustrate abstract concepts for students.

APPENDIX B

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CLASSROOM OBSERVATION PROTOCOL

During the classroom observations, I focus on the following matters regarding the first five teaching recommendations endorsed by GAISE college report (2016):

- The extent to which the instructional strategies - actions (what the teacher does) and methods (how he does it) - align with each recommendation?
    - To what extent does the instructor adopt the teaching strategies associated with each recommendation?
    - How does the instructor react to student responses to the teaching strategies associated to each teaching recommendations?
- What feelings the instructor reveals in implementing teaching strategies related to each recommendation;
    - How comfortable does the instructor appear in taking actions, and in implementing teaching strategies, associated to each recommendation?
    - How comfortable does the instructor appear in reacting to student responses when implementing teaching strategies associated to each recommendation?

Topics covered in the course meeting:

Strategy (what)	
Strategy (how)	
Association to each recommendation	
#1 Recommendation	
#2 Recommendation	
#3 Recommendation	
#4 Recommendation	
#5 Recommendation	

APPENDIX C

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INTERVIEW PROTOCOL

After having collected data via survey and classroom observations, a focus group of teachers/instructors was selected for an in-depth interview. Findings from the survey and actions/activities found in classroom observation influenced the context for some of the questions in the survey. Here are the questions, I asked each teacher/instructor subject:

1. Would you tell me how you teach your statistics classes?
    - How do you prepare?
    - What teaching methods do you use?
    - What activities do you implement?
2. (For each observed method) I saw you doing … activities/methods/strategies in your class.
    - How frequently do you do …?
    - Would you tell me where you came to use the methods, or what made you do …?
    - Do you feel comfortable implanting …? Would you tell me about it?
    - What challenges have you faced implanting …?
    - What resources support your use of …, or what constrains you from using … more often?
    - How do you find student reacting when you use …? And how do you perceive the kind of reactions you receive from students? Or to what extent do you take the reactions to form your teaching practices?
    - I might have missed some of your major or even minor teaching strategies. Are there any other teaching methods or strategies you use that I did not notice? Would you tell me a little bit about it? (if they don't explain why they use it ask: what makes you use that particular strategy?)
3. (For each recommendation) In the survey, you marked that you are doing … in you class.
    - How comfortable do you feel implementing …?
        - Teaching statistical thinking
        - Foster active learning
        - Focus on conceptual understanding
        - Use real data
        - Use technology to explore concepts and analyze data
        - Lead discussion
    - Can you tell me more about it? What causes discomfort doing …?
    - What are the learning practices/activities you would be more comfortable with? Why?

4. What are some important practice components you believe are important?
    - Now that you think … are important, how frequently do you actually implement …?
    - (If not implemented enough) Why not? Please, tell me about it.
5. What kind of statistics teaching methods have you been encouraged to implement?
    - Where did you learn those from?
    - Do you agree to those methods?

APPENDIX D

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IRB APPROVAL

The University of Texas
Rio Grande Valley

July 17, 2019

PI: Marisol Sanchez Cortez

Advisor: Hyung Kim

Title: Research on Introductory Statistical Courses Educational Practices

Re: IRB Exempt Determination for Protocol Number – 19-0150

Dear Marisol:

A University of Texas Rio Grande Valley IRB reviewer had determined that this project meets the below criteria for Exemption under DHHS 45 CFR 46.104(d). The determination is effective as of July 17, 2019 within the exempt category of:

Category 2 - Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording); Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation.

Research that is determined to be Exempt from IRB review is not exempt from ensuring protection of human subjects. The Principal Investigator (PI) is responsible for the following through the conduct of the research study:

1. Assuring that all investigators and co-principal investigators are trained in the ethical principles, relevant federal regulations, and institutional policies governing human subjects research.
2. Disclosing to the subjects that the activities involve research and that participation is voluntary during the informed consent process.
3. Providing subjects with pertinent information (e.g. risks and benefits, contact information for investigators, and IRB/ORC) and ensuring that human subjects will voluntarily consent to participate in the research when appropriate (e.g. surveys, interviews).
4. Assuring the subjects will be selected equitably, so that the risks and benefits of the research are justly distributed.
5. Assuring that the privacy of subjects and confidentiality of the research data will be maintained appropriately to ensure minimal risk to subjects.

Exempt research is subject to the ethical principles articulated in The Belmont Report, found at the Office of Human Research Protections (OHRP) Website:
www.hhs.gov/ohrp/humansubjects/guidance/belmont.html

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Unanticipated Problems: Any unanticipated problems or complaints must be reported to the IRB/ORC promptly. Further information concerning unanticipated problems can be found in the IRB procedures manual.

Continuing Review: Exempt research is not subject to annual review by the IRB.

Modifications: Any change to your protocol requires a Modification Request for review and approval prior to implementation. The IRB may review the exempt status at that time and request an application for approval as non-exempt research.

Closure: Please notify the IRB when your study is complete through submission of a final report. Upon notification, we will close our files pertaining to your study.

If you have any questions please contact the Office of Research Compliance by phone at (956) 665-2093 or via email at irb@utrgv.edu.

Sincerely,

Kimberly Fernandez

Kimberly Fernandez
Senior Research Compliance Specialist
Office of Research Compliance

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BIOGRAPHICAL SKECTH

Marisol Sánchez Cortez was born in H. Matamoros, Tamaulipas, México, on October 7, 1995. She is the first child of Mr. Agustín Sánchez Bonilla and Mrs. María Concepción Cortez Urbina, who are a mechanical/electrical engineer and a former nurse, respectively. Marisol was raised in Matamoros city and completed her studies at the bilingual schools "Colegio Bilingüe Juventus" and "Bachillerato Tecnológico Villarreal."

Marisol completed the Bachelor degree of Science in Mathematics at The University of Texas Rio Grande Valley on May 2017. A few years later, in December 2019, she finished her Master’s degree of Science in Mathematics Teaching Concentration. As a graduate student, Marisol became a Graduate Teaching Assistant for several course areas as: contemporary math, algebra, introductory statistics, and calculus. Her GTA duties involved the instruction of some of these courses. She proctored the courses Elementary Statistical Methods and Math for Liberal Arts during Fall 2018 and 2019 semesters, respectively.

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