ACHIEVING STATISTICS SELF-ACTUALIZATION: FACULTY SURVEY ON TEACHING APPLIED SOCIAL STATISTICS

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ABSTRACT

In this paper, we detail a convergent mixed-methods survey of faculty teaching applied social statistics courses, analyzed through a framework of learning theory. The survey explored faculty perceptions and use of recommended strategies for statistics education, perceived barriers to student success, and general recommendations for instruction in applied statistics courses. Results indicate some consistency in practice with the recommendations in the literature, but a lack of consistency was noted for strategies such as student reflections, allowing multiple attempts on assignments, and others. Particular attention is paid to connecting the results to learning theory with the discussion framed around a Statistics Self-Actualization model based on Maslow's 1943 theory of Hierarchy of Needs.

Keywords: *Statistics education research; Learning theory; Mixed methods research*

1. INTRODUCTION

Graduate programs in social sciences typically require statistics courses. Students, however, are often apprehensive about such courses (Vaughn, 2009). In graduate-level statistics, particularly at the doctoral level, there is an additional focus in these courses on students' ability to utilize the course content independently. This process of content mastery and independent utilization of statistics may be hampered by personal barriers such as statistics anxiety, low statistics self-efficacy, and lack of foundational concept knowledge (Chew & Dillon, 2014; Chiesis & Primi, 2010; Obwuegbuzie & Wilson, 2003; Schau et al., 2012; Vaughn, 2009; Williams, 2013).

Teaching graduate-level statistics in social science programs can be challenging because students typically have not had prior coursework to prepare them, students are often anxious about the topic, and there is an inherent difficulty in terms of balancing both theory and application (Henson et al., 2010; Labaree, 2003; Pan & Tang, 2005; Vaughn, 2009). Although statistics courses are typically required in these graduate programs and students must be successful to move on to other courses, the statistics courses may not be tightly connected to the content in other courses and students may not see the relationship between statistics and their own research (GAISE College Report Revision Committee, 2016; Chew & Dillon, 2014; Onwuegbuzie & Wilson, 2003; Pan & Tang, 2005). Moreover, faculty teaching such courses often receive lower student evaluations, which may negatively impact tenure and promotion in some types of institutions (Uttl & Smibert, 2017).

In response to these challenges, professors of applied statistics in psychology and education are increasingly encouraged to be creative and thoughtful in course preparation. Research on teaching strategies such as one-minute papers or the use of humor in the classroom, as well as many other

approaches, try to address the known challenges of teaching applied statistics (Chew & Dillon, 2014; Earley, 2014; Garfield & Ben-Zvi, 2007; McGrath et al., 2015; Onwuegbuzie & Wilson, 2003; Pan & Tang, 2005; Sproesser et al., 2016; Vaughn, 2009). Additionally, several theoretical approaches provide insight into students' learning processes and address their apprehension pertaining to statistics, including Vygotsky (Magalhães & Magalhães, 2014), Piaget (Bihan-Poudec, 2010; da Silva et al., 2014), and Maslow (Freitas & Leonard, 2011; Milheim, 2012; Strayhorn, 2012).

Thus, our study focused on instructor perceptions and experiences with using recommended teaching strategies and approaches found in existing literature. The objective is to understand instructor perspectives on what is effective in the applied statistics classroom, challenges instructors face, and how existing literature can be combined with instructor knowledge and experience and learning theory to provide additional understanding to the teaching of statistics in applied social sciences classrooms.

1.1. THEORETICAL FRAMEWORK

For this study, we use learning theory as a broad grounding for our inquiry into instruction in applied statistics. Piaget (1952) linked learning to cognitive development in which children's biological development and interaction with the environment create changes in cognition. In Piaget's theory, learning occurs through a process of assimilating and accommodating new information (Bihan-Poudec, 2010; da Silva et al., 2014), and depends on, and thus follows, biological development (Piaget, 1952). Therefore, although new information can be introduced within a social environment, learning is an individual process. This theory has been widely criticized for, among other things, not addressing adolescent and adult learning (Lourenco & Machado, 1996). Looking at the applied statistics education literature reviewed in this study, much of the research appears to have moved away from Piaget's approach, though discussions of individual hand calculations and homework with multiple worked examples of concepts do arguably align with this approach to learning.

By contrast, social learning theory is used throughout the statistics education literature. Vygotsky (1997) critiqued Piaget for the belief that learning follows cognitive development only, and instead posited that learning could further development, particularly learning that occurs in a social context with teachers or peers. This is related to the idea that knowledge is constructed, and that creating the conditions for students to construct their knowledge, through activities and other more active learning approaches, will result in deeper learning and understanding (Magalhães & Magalhães, 2014; Vaughn, 2009). The literature reviewed for this study, with an emphasis on group work, class discussions, applied projects using real-world scenarios and data, and related concepts appear to be rooted in the Vygotskian approach. Additionally, whereas Piaget and Vygotsky discuss the logic and process behind learning, the specific challenges faced in applied social statistics as they relate to student anxiety are not directly explored in these early learning theories. To this end, we include a discussion of Maslow's (1943) Hierarchy of Needs, a motivation theory used to understand availability to learn in educational theory.

1.2. RECOMMENDED TEACHING STATEGIES AND APPROACHES

While learning theory provides an overall grounding for this study, the direct foundation of this work is a conceptual framework developed from the existing literature on best practices in applied statistics education. Substantial research has focused on teaching strategies such as collaborative group work or the use of humor in the classroom, as well as other approaches, to try and address the challenges of teaching applied statistics (Chew & Dillon, 2014; Delucchi, 2007; Earley, 2014; Garfield & Ben-Zvi, 2007; McGrath et al., 2015; Onwuegbuzie & Wilson, 2003; Pan & Tang, 2005; Sproesser et al., 2016; Vaughn, 2009). Existing literature typically focuses on three general aspects of statistics education: pedagogical/andragogical approaches, instructional strategies, and student support structures.

Pedagogical/andragogical approaches, understood as overall approaches to course design and delivery driven by specific theories of learning, include the focus on application versus conceptual understanding, providing a variety of assessment opportunities and multiple chances for developmental learning, and emphasizing social learning through group work or class discussions (Chew & Dillon, 2014; Delucchi, 2007; Earley, 2014; Garfield & Ben-Zvi, 2007; Magalhães & Magalhães, 2014;

McGrath et al., 2015; Pan & Tang, 2005; Sproesser et al., 2016). Instructional strategies are discussed as smaller interventions as opposed to course-wide approaches, and these include recommendations such as one-minute papers to encourage student reflection, orientation letters at the start of the course, and using personal stories and real research examples to present complex content (Chew & Dillon, 2014; Chiou et al., 2014; Earley, 2014; Garfield & Ben-Zvi, 2007; Magalhães & Magalhães, 2014; McGrath et al., 2015; Pan & Tang, 2005; Sproesser et al., 2016). Finally, some recommendations in the literature specifically target student support, including using humor or cartoons in the classroom to reduce anxiety, instructor availability outside of the classroom, and providing students with ways to ask questions anonymously (Chew & Dillon, 2014; Earley, 2014; McGrath, et al., 2015; Pan & Tang, 2005). A summary of the recommendations found in the literature can be found in Table 1, which functions as the framework in this study for the survey design.

These studies, however, are often narrowly focused involving relatively small samples of students and classrooms, often undergraduates, to explore the effectiveness of a particular approach (Bihan-Poudec, 2010; Magalhães & Magalhães, 2014; da Silva et al., 2014; Schau et al., 2012; Vaughn, 2009). Existing summaries and reports of recommendations for instructors in statistics do exist, including the *Guidelines for Assessment and Instruction in Statistics Education College Report* (GAISE College Report Revision Committee, 2016), which provides key recommendations for introductory statistics courses at the college level. Their primary recommendations are: "teach statistical thinking, focus on conceptual understanding, integrate real data with a context and a purpose, foster active learning, use technology to explore concepts and analyze data, and use assessments to improve and evaluate student learning" (p. 6), which align with many of the recommendations noted in Table 1. Although these recommendations are noted as being largely applicable for further courses, they were developed specifically for introductory statistics at the undergraduate level. Additionally, a recent call has been

Table 1. Recommended statistics teaching strategies and approaches

Survey term	Related concepts	Research support
Orientation letters / Emails	-	McGrath et al. (2015), Pan & Tang (2005)
Faculty office hours	Instructor availability	McGrath et al. (2015), Pan & Tang (2005)
Tutoring available	Out of class support	McGrath et al. (2015), Pan & Tang (2005)
Multiple attempts on assignments / Tests	Low-stakes assessment, formative assessment, failing forward	Pan & Tang (2005), Rickly & Cook (2017)
Varied assessment strategies	Multiple applications, formative assessment, emphasizing homework over tests, scaffolding	Chew & Dillon (2014), Earley (2014), Magalhães & Magalhães (2014), McGrath et al. (2015), Pan & Tang (2005)
Group work	Collaborative learning, social learning	Earley (2014), Magalhães & Magalhães (2014), Sproesser et al. (2016)
Class discussions	Socratic method, critical thinking questions	Magalhães & Magalhães (2014)
Humor and/or Cartoons	Instructor attitude, positive classroom environment	Chew & Dillon (2014), Earley (2014), McGrath et al. (2015), Pan & Tang (2005)
Real-world scenarios	Hands-on application, real data sources, applied projects	Chew & Dillon (2014), Earley (2014), Magalhães & Magalhães (2014), McGrath et al. (2015), Pan & Tang (2005), Sproesser et al. (2016)
Detailed feedback on student work	-	Earley (2014), Sproesser et al. (2016)
Student reflections on learning	One-minute papers, stickiest point	Chiou et al. (2014)
Anonymous questions system	-	Chew & Dillon (2014)

raised for further exploration of the instructor perspective on teaching statistics, providing support for the present study (Rickly & Cook, 2017).

1.3. STUDY PURPOSE

Thus, the purpose of this study is to explore the perspectives of faculty who teach graduate statistics courses to understand their perceptions and use of effective strategies for teaching statistics in the existing literature. Faculty perceptions on challenges they face were also elicited, with open-ended items provided for faculty to expound on their experiences and perceptions.

The research questions driving this study were:

1. What are the perceptions of current or former professors of applied social statistics on the effectiveness of teaching strategies recommended in the literature?
2. How frequently do current or former professors of applied social statistics report using these teaching strategies in their courses?
3. What do professors of applied social statistics perceive as the most challenging aspects of teaching their topic?

2. METHODS

This exploratory convergent mixed-methods study (Creswell & Plano-Clark, 2017) explored faculty perceptions and use of recommended strategies in the literature about effective teaching strategies for applied statistics in social science disciplines, using a researcher-designed survey that simultaneously explored quantitative and qualitative responses.

2.1. PARTICIPANTS AND PROCEDURES

Participants were former or current university faculty with experience teaching courses in applied social statistics. Detailed institution demographics were purposefully not collected to ensure participant confidentiality. Recruitment emails were sent through Qualtrics to listservs of national professional organizations in the United States and networks with unknown numbers of members, including groups within the American Educational Research Association and the American Psychological Association, focused on teaching research methods and statistics. Consequently, a true response rate cannot be computed. A total of 84 initial responses were recorded as a result of these emails. Partial responses with data only on the informed consent question were removed, resulting in a useable $n = 71$.

Of the participants in this study, 52% were primarily statisticians and methodologists, while 48% were primarily applied researchers who also teach statistics. Participants were generally from Psychology (46%) and Education (46%), with 1% selecting Economics, and 7% selecting Other and listing Family Studies, Human Development, or Teachers of Mathematics. Reporting on their institutions, 63% reported working in a large university setting (more than 15,000 students), 25% reported working in a medium university setting (5,000 – 15,000 students), and 11% reported working in a small university setting (less than 5,000 students). Respondents reported an average of 13.56 (SD = 11.40) years of experience teaching in higher education generally, with 10.91 (SD = 10.64) years of experience teaching statistics specifically. Roles of respondents were relatively split with 28% indicating they were Adjunct Faculty or an Instructor/Lecturer, 25% indicating they were Assistant Professors, 24% selecting Associate Professor, and 23% selecting Full Professor as their current role. The respondents were also spread across types of statistics courses they have taught including Undergraduate (20%), Masters Level (20%), Doctoral-Introductory covering ANOVA and correlation generally (23%), Doctoral-Intermediate covering multiple regression, regression, and specific software programs (22%), and Doctoral-Advanced focused on advanced applications such as structural equation modeling, item response theory, hierarchical linear modeling. (15%).

2.2. DATA SOURCES

Faculty perceptions were measured using a survey focused on perceived effectiveness of teaching strategies recommended in the literature, frequency of use of those strategies, and opinions on the most challenging aspects of teaching statistics (see Appendix). The survey consisted of four sections: Informed Consent and Agreement, Demographic Information, Teaching Strategies, and Open-Ended Questions. Likert type items were used to measure faculty perceptions on the effectiveness of teaching strategies and frequency of use. Participants were asked to indicate the degree to which they perceived the effectiveness of each teaching strategy presented on a five-point scale: extremely effective, very effective, moderately effective, slightly effective, and not effective at all. A specific definition of "effectiveness" was not provided, but responses should be consistent within participants on these items and allows for comparison for the first two research questions. Participants were asked to indicate the frequency with which they use these strategies using the following response choices: always, most of the time, about half the time, sometimes, and never.

A rank-order item was also included asking participants to rank six challenging aspects of teaching applied social statistics from most to least challenging. Finally, four open-ended items gave participants the opportunity to share effective teaching strategies that were not included in the Likert item, challenges they face in their courses that were not included, a specific teaching strategy or instructional approach they feel has been most effective, and any advice they would give other faculty teaching applied social statistics.

Analysis for quantitative items was largely descriptive in nature, looking at frequencies of responses to the items connected to the three research questions. Frequency comparisons were conducted comparing responses to the question on perceptions of strategies to the responses on use of strategies, particularly looking for areas where these patterns did not agree. For the qualitative analysis, content analysis was utilized to determine most effective teaching strategies or instructional approaches identified by respondents and any advice they would give other faculty teaching applied social statistics. All coding was conducted individually by the three-person research team consisting of two faculty members and one advanced Ph.D. student who had already completed statistical course work, and then codes and process were compared at each stage. According to Elo & Kyngäs (2008), content analysis allows researchers to condense words into fewer content-related categories to uncover a common meaning. Our content analysis methodology was comprised of preparation, organization, and reporting phases (Elo & Kyngäs, 2008). In the preparation phase, we selected units of analysis connected to our survey questions and made sense of the data as a whole. Then, in the organization phase, we conducted open coding by assigning short descriptions to data segments. These generic categories represented by a simple word or phrase helped summarize the meaning of sub-categories. These codes were then grouped into sub-categories of themes that emerged from survey responses. Afterwards, we created a coding frame by collapsing generic categories into main categories and paired them with authentic citations from the data to increase trustworthiness. In the reporting phase, we created the conceptual map (see Figure 1) to illustrate the four main instructional categories that emerged from our results.

Thematic analysis (Braun & Clarke, 2006) was also conducted to identify themes in challenges faced by participants not included in our Likert items. We first coded the data into initial codes, which we matched with relevant extracts. We then generated initial themes and a thematic map for further analysis and interpretation. Finally, we collapsed final themes into categories of findings, which we paired with data examples that directly connect to our research questions and literature.

Finally, due to the mixed-methods approach in the present study, the final step of analysis involved integrating the quantitative and qualitative results for an integrated analysis. The themes developed in the qualitative portion were compared to the observed patterns in the quantitative items to provide additional understanding of the results. The quantitative results were qualitized to align with the thematic framework developed in the thematic analysis, as discussed in Section 3.3.

3. RESULTS

3.1. QUANTITATIVE ANALYSIS

Descriptive statistics are presented in Table 2 summarizing responses to Research Question 1 on faculty perceptions of the most effective strategies for teaching applied social statistics. Results indicate that most faculty perceive providing detailed feedback on student work, using real-world scenarios in the class for homework and tests, and providing varied assessment approaches as extremely effective. By contrast, the respondents indicated using a procedure for students to ask anonymous questions of the instructor and providing detailed orientation letters or emails at the start of the class to be only slightly effective strategies. Making tutoring available to students, holding office hours where instructors are available for student questions, using group work in the course, and allowing multiple attempts on assignments or tests were noted as very effective in the responses. Having students reflect on their learning, using humor or cartoons in the classroom to lighten anxiety, and engaging in discussions as a class were generally considered moderately effective strategies.

Table 2. Frequencies for responses on faculty perceptions of strategy effectiveness

Teaching Strategy	Extremely effective	Very effective	Moderately effective	Slightly effective	Not effective
Orientation Letters	4%	22%	**28%**	**28%**	18%
Faculty Office Hours	16%	**36%**	30%	13%	6%
Tutoring Available	13%	**43%**	29%	13%	1%
Multiple Attempts	16%	**29%**	**29%**	17%	9%
Varied Assessment	**46%**	41%	10%	3%	0%
Group Work	12%	**35%**	29%	13%	12%
Class Discussions	22%	30%	**32%**	12%	4%
Humor and/or Cartoons	20%	28%	**33%**	14%	4%
Real World Scenarios	**51%**	37%	9%	1%	1%
Detailed Feedback	**51%**	27%	16%	4%	1%
Student Reflections	3%	14%	**34%**	20%	28%
Anonymous Questions	8%	16%	32%	**33%**	11%

Note. Highest percentage response for each strategy is marked in **bold**.

Table 3 details the responses to Research Question 2 on how frequently the recommended strategies were used by respondents in their own courses. The majority of faculty respondents indicated that being available during office hours, using various approaches for assessment of learning, and providing detailed feedback on student work are strategies that are always used in their courses. Using orientation letters at the start of the course, making tutoring available to students, and facilitating class discussions were also mostly indicated as strategies that are always used, though by a smaller percentage of the participants and with less consistency. Orientation letters in particular appear to be split in use, as respondents were almost as likely to say they never use this strategy. Respondents indicated the use of humor and/or cartoons in the class and using real-world scenarios with homework and tests are used most of the time in their courses. Including group work in the course appears to be used about half of the time in the courses taught by the respondents, whereas having students reflect on their learning, providing students with a way to ask questions anonymously, and allowing students multiple attempts on assignments or tests were indicated as strategies that are generally never used by respondents. It should be noted though that multiple attempts has a similar bimodal pattern to orientation letters, as the next most frequent response after never used was to always use the strategy.

Table 3. Frequencies for responses on faculty use of recommended strategies

Teaching Strategy	Always	Most of the time	About half	Some-times	Never
Orientation letters	**33%**	16%	7%	21%	23%
Faculty office hours	**76%**	17%	3%	3%	1%
Tutoring available	**34%**	24%	10%	21%	10%
Multiple attempts	24%	9%	20%	19%	**29%**
Varied assessment	**69%**	24%	6%	1%	0%
Group work	14%	23%	**27%**	21%	14%
Class discussions	**30%**	29%	21%	14%	6%
Humor and/or Cartoons	23%	**30%**	25%	17%	4%
Real world scenarios	41%	**49%**	10%	0%	0%
Detailed feedback	**59%**	30%	7%	4%	0%
Student reflections	3%	1%	10%	21%	**64%**
Anonymous questions	9%	7%	11%	11%	**61%**

Note. Highest percentage response for each strategy is marked in **bold**.

Responses to both the frequency of use and perceived effectiveness questions appear to be consistent on most of the strategies (see Figures 1 and 2). Faculty office hours, making tutoring available to students, utilizing varied assessment strategies, collaborative group work, humor in the classroom, use of real-world scenarios, and providing detailed feedback are consistently viewed as effective and frequently used. Less consistency was found with strategies such as orientation letters and multiple attempts on assignments, which were both viewed as split in perceived effectiveness but orientation letters were generally always used in courses whereas responses on the use of multiple attempts on assignments was split between never and always. Engaging in class discussions and having students reflect on their learning were both noted as moderately effective, but class discussion was indicated as always used whereas student reflections were mostly never used. By contrast, allowing students to ask anonymous questions appears to be consistently seen as less effective and not frequently used.

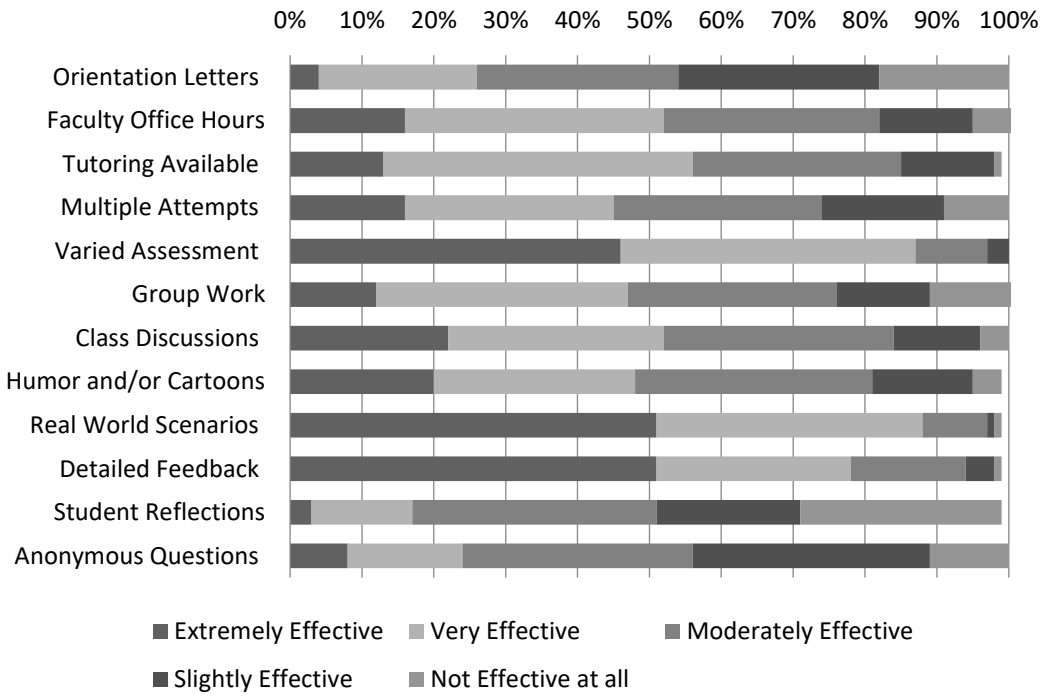

Figure 1. Stacked bar chart for responses on perceived effectiveness of strategies

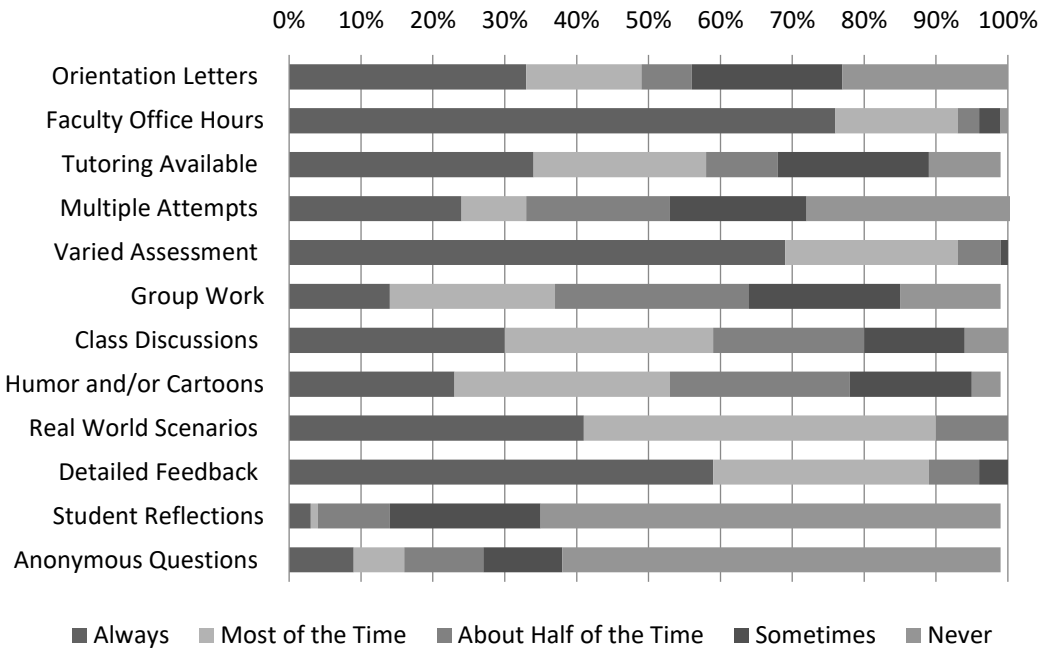

Figure 2. Stacked bar chart for responses on reported use of strategies

For Research Question 3, the most challenging aspects of teaching applied social statistics were, in order of ranking frequency: student anxiety (40% rated as #1), perceived lack of student preparation and prior knowledge (35% rated as #2), student failure to complete readings and work (26% rated as #3), technology problems or lack of software (30% rated as #4), limited time to plan (21% rated as #5), and lack of quality teaching materials (34% rated as #6). The qualitative analysis of the open-ended items explores these challenges in more depth.

3.2. QUALITATIVE ANALYSIS

Responses to open-ended items were analyzed using qualitative analysis, looking for common themes across the participants. The analysis resulted in five themes: Structural Issues, Student Factors/Influences, Instructor Mindset/Disposition, Concepts vs. Application, and Instructional Responses. The Instructional Responses theme is most directly connected to the research questions in this study, while the other four themes provide context and expand on the challenges and moderating/mediating factors impacting instruction in the applied social statistics classroom (see Figure 3). The four contextual themes will be discussed first, and then the Instructional Responses theme.

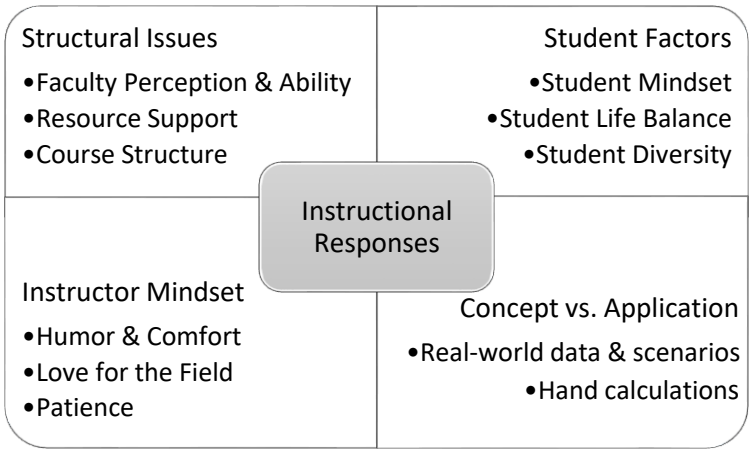

Figure 3. Themes from qualitative analysis

Structural issues When discussing challenges and the reasons behind some instructional responses, faculty participants raised the issue of structures in departments and programs that impact their courses. These are issues the faculty often have little or no say in, but which directly impact their teaching decisions. The Structural Issues theme contains three sub-components: Faculty Perception and Ability, Resource Support, and Course Structure. The comments included in the Faculty Perception and Ability theme included issues such as faculty buy-in on the value of applied statistics courses, the perception of need by other faculty for these courses, and beliefs others have about faculty qualifications for teaching applied statistics. For instance, one participant stated, "Many (at least senior faculty) think anyone can teach measurement or quantitative courses (at least the introductory ones), so they often hire adjuncts or assign it to someone who needs another course to teach."

The Resource Support sub-component captured comments related to faculty time constraints, the support provided for instructional and planning activities, limitations of funding, and availability of labs or tutoring support. For instance, one participant identified "My own time limitations for lecture/handout/course preparation, office hours, tutoring, test preparation" as a challenge in their ability to teach applied social statistics effectively. Finally, participants identified challenges related to Course Structure such as online or hybrid courses and courses that only meet once a week. These challenges are particularly salient in applied statistics courses, as one participant notes, "Another challenge is at my university the courses are always once a week three hours at a time and this is not great for learning since it is an overwhelming amount of information."

Student factors and influences Student factors were identified as another component outside of the control of faculty participants that directly impacts instructional responses. Codes included in this theme are Student Mindset, Student Life Balance, and Student Diversity. Student Mindset codes included mention of motivation to learn statistics, statistics anxiety, and student buy-in. As one participant stated, "Statistics courses in the social sciences are possibly not the typical student's favorite! Because of this there are sometimes avoidance issues that must be overcome." Applied statistics is a particularly challenging course for many students as they need to develop an appreciation for, in the words of one participant, "The value of, say, 'tolerance for ambiguity' and the need to stay current (press forward don't wait until you have mastered prior material ... often a problem with some), the need to be an active learner in class and the related need for engagement," which does not come naturally to many students. Instructors of applied social statistics can help facilitate student mindset changes, but these factors are not directly within the control of the instructor. Student Life Balance is another challenge in applied social statistics, particularly in graduate courses where students are working full time and/or may have family obligations. Participants discussed the challenge for working students, including "Student lack of time to complete assignments due to work schedules as administrators in schools."

Finally, Student Diversity in courses was noted as a challenge, involving both diversity of levels of prior knowledge, and diversity of students in terms of culture, age, experience, and disability status. Participants specifically noted the academic challenges in applied social statistics at the graduate level, as "Variability across statistics training from programs/institutions leads to wide variability in understanding among incoming graduate students." These student factors are often unpredictable in that each class and each group of students have a unique set of challenges in terms of mindset, life balance, and diversity, but these factors may mediate the relationship between instructional responses and student learning.

Instructor mindset and disposition Alongside the importance of student factors such as mindset, participants also discussed the importance of instructor mindset and disposition in teaching applied statistics. Codes in this theme included ideas of using humor and providing comfort for students around the topic, developing a love for the field of statistics, being patient as an instructor, and meeting students where they are in their ability. As one participant stated, "I think what is most effective … is having an attitude that students CAN learn statistics and use them competently. I try to meet the students 'where they are' and help empower them to … do many aspects of statistics, and become competent … users." Another participant identified "Soft skills—flexibility, encouragement, regard for hard work/effort. Try to develop a love for the field." as being particularly important when teaching these courses. Instructor mindset and disposition directly impacts instructional responses, and the decisions instructors make in their teaching practice. Whereas student mindset is harder for an instructor to influence directly,

instructor mindset is within the control of the instructor and attention should be given to this aspect of teaching statistics.

Concept versus application A dichotomy of sorts was identified in the responses of participants around instructional strategies and beliefs about teaching statistics. On the one hand, participants identified the use of real-world data and scenarios as an effective strategy for teaching applied statistics. Recommendations included allowing students to use their own data, connecting course materials to real data or issues in the field, and providing explicit examples for the application of concepts. Participants recommended integrating "Hands on experience with real data and using software …" and "… Having a 'real world' final assignment where they have to analyze their own data and write up the results" into the course design.

Somewhat by contrast, responses were identified that highlight the importance of hand calculations and conceptual understanding in teaching applied statistics. These recommendations included using written equations, stepped-out analyses, and repetition to support student understanding of the calculations and concepts behind the statistical tests. One participant responded that "I do all work by hand – I show them on the board and then using similar data have them walk through it, all during the class period." A balanced approach using both real-world applications with computer software and conceptual lessons with hand calculations may be best, but participants appear to have differing opinions about what level of balance is appropriate.

Instructional responses Finally, the overarching focus throughout our study was on the strategies and approaches participants used and perceived to be most effective in their own statistics courses. In the open-ended items, the Instructional Responses theme expands on the quantitative responses regarding instructional strategies. Three sub-components were identified for this theme: Educational Technology, Formative Approaches, and Instructional and Pedagogical Models. Comments coded for Educational Technology included discussions of computer software such as R or SPSS, use of videos or simulations in class to exemplify complex concepts such as the central limit theorem, and use of PowerPoint or other tools to provide instruction. Participants particularly emphasized the use of educational technology to assist students with applying content, recommending "detailed and slow lessons in computer software (SPSS/syntax)" and "Videos for demonstration of concepts − available from the instructor, but sometimes from YouTube."

Comments related to Formative Approaches emphasized the need for repeated practice and checks of learning. This was presented as particularly important in applied social statistics courses where student anxiety can be a barrier to student learning. Recommendations included using low-stakes assessments, building in lots of homework or repetition to allow for more practice, and allowing students to "fail forward" in their graded work. The "fail forward" approach was explained by one participant as "… an approach informed by game design that allows students to level up their skills by failing forward through penalty-free repetition (i.e., mastery learning)."

Overall Instructional and Pedagogical Models were also discussed, including the flipped classroom model, the "I do, We do, You do" approach, and differentiation of instruction. The flipped classroom model was mentioned repeatedly, described by one participant as "a 'flipped' model where the students watch videos online before class and then actively practice." The differentiated instruction approach was also mentioned repeatedly, and one participant advocated for multiple strategies in combination to "Differentiate the instruction; find ways to reduce math anxiety; provide concrete examples … let students experience … data collection and analyses, and allow them to learn … from the things they do wrong in the process." However, participants also acknowledged the difficulties of effectively teaching applied social statistics even with these strategies. Alongside their recommendations, participants would note "I know this is not practical for many situations" or "You can't possibly teach everything, so strive to teach something useful" as a caveat to their response.

3.3. MIXED RESULTS INTEGRATION

As the study was designed as a convergent mixed-methods study, it was critical that the data be merged (Creswell & Plano-Clark, 2017). A merged analysis in this study involved qualitizing the quantitative data. In this case, this meant examining and organizing the quantitative data utilizing the

qualitative themes to garner additional insights. These themes were Structural Issues, Instructor Mindset/Disposition, Concept versus Application, and Student Factors/Influences. In examining the quantitative results, the teaching strategies encompassed three of the four themes.

The first theme that seemed clear in the quantitative data was concept versus application. This theme was indicated in real world scenarios. Real-world scenarios was specifically raised in the open-ended questions as a strategy that faculty used and found effective. The quantitative data was similar, with 51% of respondents rating them as extremely effective and 49% reporting that they used them most of the time. The second theme apparent in the quantitative data was Structural Issues. In the quantitative responses, the orientation letters, faculty office hours, and tutoring can be considered structural in nature. Of these three, orientation letters and tutoring was indicated as being used always by approximately a third of the participants, while office hours were always used by over three-quarters of respondents. Both tutoring and office hours were reported as being very effective strategies, while orientation letters were considered either moderately or slightly effective.

The third, and most robust, qualitative theme that seemed obvious in the quantitative data was instructor mindset/disposition. We coded multiple attempts, varied assessment, group work, class discussion, humor and/or cartoons, detailed feedback, student reflections, and anonymous questions as all indicative of this theme. These items, for the most part, were reported to be moderately or very effective, although varied assessment and detailed feedback were considered extremely effective. In contrast, anonymous questions were ranked only slightly effective. Use was also reported as high for detailed feedback, class discussion, and varied assessment; all were reported as always used. Humor was utilized most of the time, and group work was reported to be used about half the time. Multiple attempts and student reflections, though, were not used as frequently. Almost two-thirds of faculty never used anonymous questions. The modal response for providing students with multiple attempts was 29%, even though 58% reported that doing so was moderately or very effective. A third of respondents reported student reflections were moderately effective, again the modal response, yet almost two-thirds of respondents (64%) reported never using them.

4. DISCUSSION

4.1. STUDY DISCUSSION

The primary goal of this study was to evaluate instructor perceptions and use of existing strategies for teaching applied social statistics. In relation to Research Question 1, using real-world data and scenarios, providing detailed feedback on work, and using varied assessment strategies were consistently identified as effective teaching approaches. This aligns with prior research on these large-scale approaches in statistics education (GAISE College Report ASA Revision Committee, 2016; Chew & Dillon, 2014; Earley, 2014; Garfield & Ben-Zvi, 2007; Magalhães & Magalhães, 2014; McGrath et al., 2015; Pan & Tang, 2005; Perepiczka et al., 2011; Sproesser et al., 2016). Using group work, providing tutoring, and faculty availability during office hours were all noted as generally very effective, again in line with prior recommendations for pedagogical/andragogical approaches and supports for students (GAISE College Report ASA Revision Committee, 2016; Chew & Dillon, 2014; Delucchi, 2007; Earley, 2014; Magalhães & Magalhães, 2014; McGrath et al., 2015; Pan & Tang, 2005; Sproesser et al., 2016). Finally, orientation letters, multiple attempts on assignments and/or tests, class discussions, student reflections, and anonymous questions were seen as slightly to moderately effective, somewhat in line with literature though perceived as less helpful than prior research would suggest (Chew & Dillon, 2014; Chiou et al., 2014; Earley, 2014; Magalhães & Magalhães, 2014; McGrath et al., 2015; Pan & Tang, 2005; Sproesser et al., 2016). These strategies perceived as less effective are largely student support strategies as well as instructional approaches, suggesting the large-scale approaches may be more accepted across the field, whereas specific strategies and supports may be more individual to the instructor or context.

For Research Question 2 on the use of these strategies, responses appear to be more diverging. Faculty office hours, varied assessment strategies, providing detailed feedback, making tutoring available, providing orientation letters, and using class discussions were all selected as always used for the most common response. Group work, humor or cartoons in the classroom, and real-world scenarios were used less frequently, about half to most of the time. By contrast, multiple attempts on

assignments/tests, student reflections, and allowing students to ask anonymous questions were marked as never used. It is interesting to note that these least used recommendations are the ones most commonly noted to help reduce anxiety in the classroom, raising questions of why these might not be used in courses (Chew & Dillon, 2014; Chiou et al., 2014; Hasan & Fraser, 2013; McDonald, 2013; McGrath et al., 2015; Pan & Tang, 2005; Perepiczka et al., 2011; Roiter & Petocz, 1996). Student anxiety was also the highest rated challenge participants face in their work, further complicating this result.

The results of qualitizing the quantitative data agree with this inconsistency. Instructional mindset/disposition was seen as a key factor in assisting students with learning statistics. In the concept versus application theme seen in real-world scenarios in the quantitative data and the structural issues theme seen in quantitative items of orientation letters, faculty office hours, and tutoring, the effectiveness attributed and the use reported seem consistent. What is effective is utilized frequently and what is not considered as effective is used less frequently or not at all.

When analyzing instructor mindset/disposition category this pattern is not as clear. Whereas the results for anonymous questions were consistent, other responses were less so. For example, class discussion was rated as moderately effective, but used always. Group work was rated very effective, but only used about half the time. Finally, allowing students multiple attempts was considered moderately or very effective, and using student reflections was reported to be moderately effective. However, both of these were reported being utilized much less frequently.

One possibility for these results is the amount of faculty time and effort required by these strategies. Class discussion is a relatively easy strategy to implement, even though it is only moderately effective, hence it is reported as always used. Incorporating group work, student reflections, and multiple attempts, in contrast, are more time consuming and difficult for faculty, and so are used less often even though faculty indicate these strategies are moderately or very effective. These results seem to make sense as faculty are being asked to be more productive, assessment requirements have grown more robust, and students have not gotten less demanding. Thus, faculty time becomes an ever more scarce resource, as one respondent in the qualitative data indicated. Yet, to implement some of the strategies faculty themselves report as most effective requires time and effort. Clearly these are competing interests. Faculty are, of course, concerned with student progress, while also being pressed for time. As a result, faculty report implementing strategies that are relatively easy to incorporate, even if they are not as effective.

4.2. CONNECTING RESULTS TO THEORY

The theoretical frameworks previous scholars have utilized to explore statistics education, as introduced earlier, are primarily from the works of Piaget (1952) and Vygotsky (1997). The quantitative data pertaining to the effectiveness and use of group work, tutoring, and office hours seem to indicate that faculty believe learning takes place in settings with other individuals and is constructed though interaction with faculty and peers. This is in alignment with Vygotsky's ideas of learning occurring in social contexts and at different rates for students, even when they begin at seemly similar levels. Additionally, the use and perceived effectiveness of real world scenarios may be constructivist, which would align with Vygotskian theory.

Whereas Piaget and Vygotsky discuss the logic and process behind learning, however, the specific challenges faced in applied social statistics as they relate to student anxiety are not directly explored in these early learning theories. To this end, we include a discussion of Maslow's (1943) Hierarchy of Needs, a motivation theory used to understand availability to learn in educational theory. The hierarchy details five levels of basic human needs: Physiological needs, Safety needs, Belonging needs, Esteem needs, and Self-Actualization needs. This model is based on the principle that these five basic needs and the search for their satisfaction are essential components of the human psyche. Behavior is motivated by these basic needs in a generally sequential pattern, starting with basic physiological needs and progressing up towards self-actualization. As each level of needs is at least somewhat satisfied, the next level of needs becomes the primary motivation for the individual's behavior. For instance, if an individual is starving, their primary motivation is to find food. An individual will always need food, but once a source of consistent food is identified, the basic need is generally met and is no longer a primary

motivation for behavior. The individual can then turn their attention to issues of safety, belonging, and so on.

In education, Maslow's (1943) Hierarchy of Needs is a common theory used to discuss classroom culture and instructional design, particularly in K-12 settings. In contrast, the Hierarchy of Needs theory is less frequently covered in higher education contexts, although the general principles of Maslow's hierarchy do not disappear when students enter higher education. Some researchers have applied Maslow's Hierarchy of Needs to higher education (Freitas & Leonard, 2011; Milheim, 2012; Strayhorn, 2012), particularly to online learning contexts (Milheim, 2012) and underrepresented students' experiences (Strayhorn, 2012). This particular framework may have a meaningful application in applied statistics education due to the inclusion of both self-esteem and belonging needs and their relation to student anxiety and low self-esteem, common problems faced in social statistics classrooms. To apply this theory in the way we suggest, there is a shift away from basic human needs and instead a focus on needs of the student in an educational context, as seen in Milheim (2012). Physiological needs, for instance, become focused on access to the physical materials needed to participate in a course, instead of being focused on the basic needs of food and shelter. Safety needs focus on students feeling safe within the classroom, and being given permission to explore ideas without punishment. Belonging needs focus on the sense of community within the classroom, and can be supported by interactions between students and faculty. Esteem needs build students' sense of self within the content, supporting their development as a scholar in this application. Finally, self-actualization would become an intrinsic motivation to learn and master the particular content, not achieved by all students but often the goal in course work. To this end, we have drafted a model of Statistics Self-Actualization to align the strategies from the present study with Maslow's Hierarchy of Needs theory (see Figure 4).

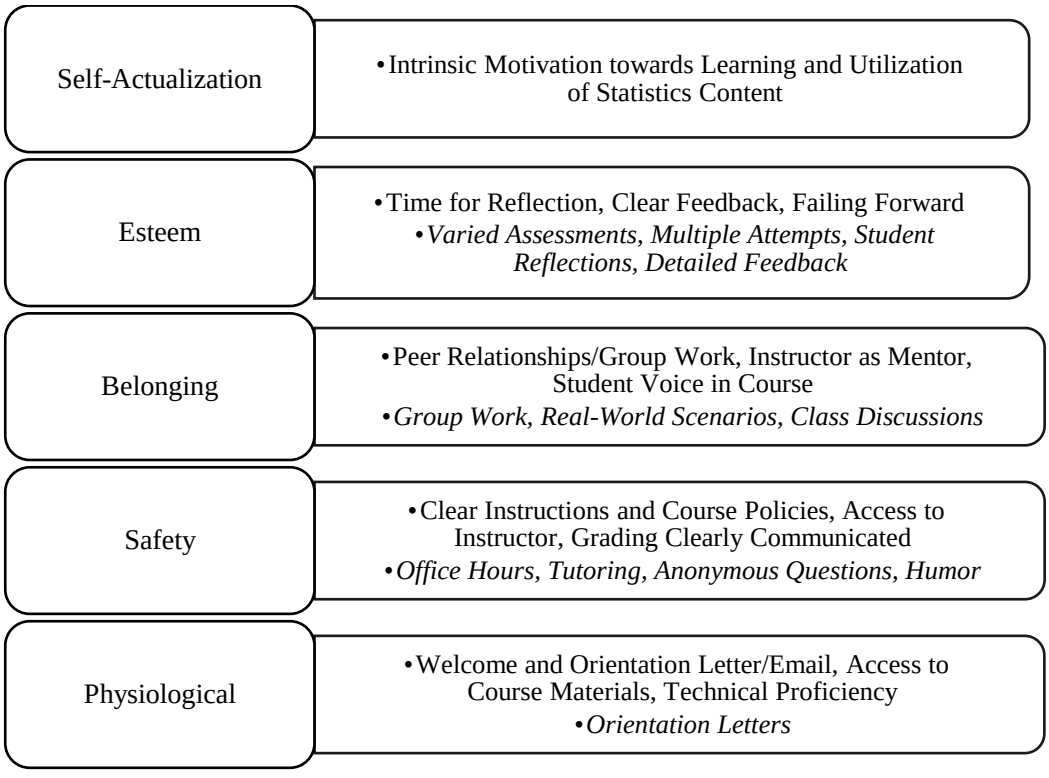

Figure 4. Maslow's Hierarchy of Needs in statistics, some material modified from Milheim (2012)

In this application of Maslow's work, orientation letters, students' access to course materials, and technological competencies are basic requirements for success in a statistics course, corresponding to basic physiological needs. Safety needs are a major component of statistics education due to student anxiety. In the qualitative data, the theme Student Factors and Influences reinforces the idea that students' mindsets can be a challenge in graduate statistics courses due to anxiety levels. This supports that students must first feel safe before they can begin learning, supporting the use of humor or cartoons

in the classroom to reduce tension, providing access to the instructor through office hours and/or tutoring, and allowing students to ask anonymous questions. Belonging needs follow, according to Maslow, once safety needs are addressed. These belonging needs seem to align with the quantitative results pertaining to the perceived effectiveness of group work, class discussions, and using real-world scenarios, as these contribute to students' sense of belonging. Esteem needs may be indicated in the quantitative results pertaining to the effectiveness of varied assessments, multiple attempts, and student reflections, as these are all opportunities for students to demonstrate a comprehension of concepts and reflect on their learning. Finally, self-actualization is seen as the goal of graduate statistics education, reflected in the qualitative responses about instilling a passion for the subject in the students. The strategies mentioned here might fit into multiple levels in the hierarchy, depending on the individual student or specific focus of the strategy, which is indicative of the flexibility and uniqueness of this theoretical approach. Our goal is to provide a framework for instructors to think about the interconnectedness of these strategies as meeting the various needs of students in their courses, and ultimately moving students towards esteem and self-actualization in their content.

4.3. LIMITATIONS

Several limitations are noted in this study. First, the sample is limited to only 71 participants, which, although including a variety of experiences and topics, cannot be considered representative of the whole population of instructors of applied social statistics courses. Second, the researchers did not provide a definition for the term "effectiveness" to the study participants, although we believe that letting participants use their self-definition of "effectiveness" did not significantly detract from the overall meaning of the survey data and results. Third, because we recruited through listservs of national professional organizations and networks, we were unable to produce survey response rates. Moreover, using open-ended survey questions might have discouraged more participation. Additionally, our approach did not take into account objective measures of instructional effectiveness, but rather self-reports on use and perceptions of effectiveness. Students were not included in the study, and their perspective on these responses may provide another layer of understanding to this data. And as one participant noted, there was no option to opt-out of a response, such as saying "I have never used this strategy" when asked to rate perceived effectiveness. This addition could be made for future iterations of this type of study to provide additional clarity.

4.4. FUTURE DIRECTIONS AND IMPLICATIONS

Learning theory may offer instructors of applied social statistics guidance on approaches and strategies, integrated across recommendations in the literature. Future studies may focus on testing learning theory to determine the best fit for fully understanding students' learning processes, which, in turn, would assist faculty with structuring their courses. Questions about varied assessments and multiple attempts and their fit with Maslow's hierarchy may be addressed through future research. Additional research focused on what motivates faculty to try new approaches, how they choose among them, and how to ensure the success of new approaches is also recommended. Furthermore, research examining the role of faculty demographics and any association between them and teaching strategies employed may be fruitful research. Finally, student anxiety and lack of previous experience with statistics are consistent challenges. Anxiety can interfere with students' ability to learn, depending on its severity. Thus, it is critical that additional research be conducted on ways to reduce students' anxiety so that they are available to learn and can be successful.

There are no easy solutions to the challenges faced in teaching applied social statistics, especially related to choosing particular teaching strategies, but perhaps there are some suggestions for implementing strategies perceived as effective, but not widely utilized. One possibility is using research or graduate assistants to assist with setting up multiple attempts at assignments or creating group activities. Another may be to use peer grading for multiple attempts, with only the final attempt graded by faculty. Peer reading and discussion could also be used to incorporate student reflective exercises. A third idea is co-teaching, combining sections, or lowering class size limits. These would all give faculty some flexibility and assistance. However, it is difficult to judge from these data the level of urgency faculty members feel about improving outcomes for students. High levels of urgency prompt

the most rapid responses. Given the reality of faculty time and its very real limits, finding the time to implement changes will be difficult, even if in the longer term they could improve student outcomes.

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APPENDIX: SURVEY QUESTIONNAIRE ITEMS

Do you currently or have you previously taught graduate level applied social statistics courses? This could include applied statistics in Psychology, Education, Sociology, Business, Economics, Political Science and other fields.

- o Yes, currently teach applied social statistics
- o Yes, previously taught applied social statistics
- o No, never taught applied social statistics

In your own graduate school training, was your degree/program primarily focused on statistics/methodology or an applied specialization (e.g. Clinical Psychology, Curriculum & Instruction, Family Studies, etc.)?

- o Statistics/Methodology Focused
- o Applied Specialization

Do you consider yourself to be primarily a statistician/methodologist, or a professor/instructor of statistics with a primary interest in other areas?

- o Primarily a statistician/methodologist
- o Teach statistics, primarily interested in other topics

In what area of applied social statistics do you primarily teach?

- o Psychology
- o Education
- o Sociology
- o Business
- o Economics
- o Political Science
- o Other: _____

How many years have you taught in higher education?

_____

Of these years, how many were you actively teaching applied social statistics courses?

_____

What kinds of applied social statistics courses have you taught? Please select all that apply:

- ▪ Undergraduate Statistics
- ▪ Master's Level Statistics
- ▪ Doctoral Level Statistics - Introductory (correlation to ANOVA type courses)
- ▪ Doctoral Level Statistics - Intermediate (regression, technical program use, etc.)
- ▪ Doctoral Level Statistics - Advanced (specific applications such as IRT, SEM, longitudinal modeling, etc.)

Thinking about the university you currently teach at OR the university you were at when you last taught applied social statistics courses, what is (or was) the student population at the university?

- o Small (less than 5,000 students)
- o Medium (between 5,000 and 15,000 students)
- o Large (more than 15,000 students)

What is (or was) your role at the university where you teach (or taught) applied social statistics?

- o Adjunct Professor
- o Lecturer/Instructor
- o Assistant Professor
- o Associate Professor
- o Full Professor

Below is a list of strategies in teaching applied social statistics that appear in the literature. How effective do you perceive these teaching strategies to be when teaching your own applied social statistics courses?

	Extremely effective	Very effective	Moderately effective	Slightly effective	Not effective at all
Orientation letters/emails prior to class start	○	○	○	○	○
Faculty available during office hours	○	○	○	○	○
Tutoring available for students from faculty or others	○	○	○	○	○
Multiple attempts on assignments or tests	○	○	○	○	○
Varied assessment approaches (i.e. some combination of homework, class assignments, tests, group work, etc.)	○	○	○	○	○
Collaborative group work	○	○	○	○	○
Class discussions on content, articles, research, etc.	○	○	○	○	○
Humor and/or cartoons in lectures and class materials	○	○	○	○	○
Real world scenarios for homework or test applications	○	○	○	○	○
Detailed feedback to students on work	○	○	○	○	○
One-minute paper or student written reflection of lessons	○	○	○	○	○
Process for students to ask questions anonymously	○	○	○	○	○

How frequently do you use these teaching strategies in your own applied social statistics courses?

	Always	Most of the time	About half the time	Sometimes	Never
Orientation letters/emails prior to class start	○	○	○	○	○
Faculty available during office hours	○	○	○	○	○
Tutoring available for students from faculty or others	○	○	○	○	○
Multiple attempts on assignments or tests	○	○	○	○	○
Varied assessment approaches (i.e. some combination of homework, class assignments, tests, group work, etc.)	○	○	○	○	○
Collaborative group work	○	○	○	○	○
Class discussions on content, articles, research, etc.	○	○	○	○	○
Humor and/or cartoons in lectures and class materials	○	○	○	○	○
Real world scenarios for homework or test applications	○	○	○	○	○
Detailed feedback to students on work	○	○	○	○	○
One-minute paper or student written reflection of lessons	○	○	○	○	○
Process for students to ask questions anonymously	○	○	○	○	○

Are there any teaching strategies we did not mention that you find to be effective and use in your own courses? Please describe below:

Please rank the following items from the most challenging to the least challenging aspects of teaching applied social statistics:
_____ Lack of student preparation for courses (prior course work or knowledge)
_____ Student anxiety about statistics and statistics courses
_____ Technology problems or lack of needed technology programs
_____ Limited time and/or funding to plan interactive activities/assignments/etc.
_____ Lack of quality of teaching materials such as pre-made assignments, test banks, etc.
_____ Student failure to complete readings, homework, etc.

Are there any challenges you have faced in teaching applied social statistics that we did not mention? Please describe below:

What specific teaching strategy or instructional approach do you feel has been most effective in helping students succeed in your applied social statistics courses?

What advice would you give other faculty teaching applied social statistics on the most effective ways to design and teach their courses?