Access to Higher Education through Distance Learning: Exploring Challenges, Innovations and Strategies for Online Statistical Education

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Abstract: **Recognition of the data-driven technological nature of society the current trend in the sociology of education is emphasis on statistical literacy. As such, many university-level sociology departments across the globe require undergraduate students to successfully complete a social statistics course to meet minimum program requirements. In an effort to increase student access to the required statistical education, courses (traditionally taught exclusively on campus) are now moving to online platforms. There are a number of significant challenges that impact both the instructor's ability to effectively teach and enrolled student's ability to successfully complete an online statistics courses. Unfortunately, the most current review of scholarship on the topic of challenges and innovations in teaching statistics examined literature published between 1993 and 2010 is outdated due to rapid advancement in educational technology. The purpose of this systematic review of literature (2010 to 2018) is to contribute to the scholarship of teaching and learning undergraduate social statistics online in two distinct ways. First, to provide a resource for educational researchers, by compiling, synthesizing, and discussing a decade of academic literature on the topic of challenges to teaching and learning undergraduate statistics online into one easily accessible manuscript. Second, to provide a resource for educators, by adding new pedagogical insights and suggestions for practical instructional interventions to address teaching and learning challenges.**

Keywords: **challenges to teaching and learning in higher education, distance learning, educational technology, e-learning, innovative pedagogy, literature review, online learning, statistics education, student success.**

I. INTRODUCTION

The deskilling of workers, credentialism, and globalization, brought out by the Wall Street era of expansion necessitates that individuals must earn a degree in order to compete in the U.S. job market (Cottom, 2017; Bosquet, 2008). As a result, the nation has morphed into an information society that is compounded by the challenges of the data-driven technological nature of society along with a complex mix of socio-economic and demographic factors that limit access to higher education. This challenge highlights the importance of statistical literacy among undergraduate students who are bombarded daily with information in the media. These media reports require statistical literacy so that students can make informed decisions based on statistical data rather than on emotions or media reports (Sharma, 2017). Undergraduate students who lack statistical literacy may not only find it difficult to discriminate between the types of information and sources, but also it may be difficult to interpret, evaluate, and effectively communicate their reactions to the media (Sharma, 2017). Since statistical literacy is a critical skill for students, enrolling in online social statistics courses widens their access to knowledge to build statistical literacy.

Problem Statement:

Higher education is the gateway to opportunity (Mannay & Wilcock, 2015). In an effort to keep up with the way in which the globalized labor force is developing within the current data-driven society, the higher educational system is transforming into information universities (Bosquet, 2008). Numerous studies highlight how the higher education system

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is shifting from the traditional on-campus mode of teaching classes to using information technologies to improve access to higher education (Bousquet, 2008; Cottom, 2017; Fielding, 2016; Garcia & Cuello, 2010; Kinghorn, 2014). Educational technology has enabled time and place constrained students to complete some if not all courses online. For example, Allen, Seaman, Poulin, and Straut (2016) reported that approximately 28% of the U.S. student population has taken at least one distance class. Further, approximately 2.85 million students reported completing all of their undergraduate coursework online (Allen, Seaman, Poulin, & Straut, 2016). In light of this enrollment trend, instructors are tasked with redesigning their traditional on-campus courses into courses that can be delivered online. For undergraduate online social statistics course instructors, this task can be particularly difficult due to the significant challenges related to teaching and learning statistics. This article explores current literature regarding the teaching and learning of undergraduate statistics online to present an overview of the challenges. Innovative pedagogical strategies as instructional interventions of teaching and learning challenges are also reviewed in an effort to provide recommendations for instructors and educational researchers.

Research Objectives:

The purpose of this systematic review of literature is to answer the following two research questions: (1) what are the current challenges for teaching and learning statistics in undergraduate-level online learning environments?; and (2) what are the data-driven instructional intervention strategies to facilitate success for distance statistics students?

II.   METHODOLOGY

Sources of Data and Article Identification:

The primary source of data for this manuscript consists of academic articles that were published in peer-reviewed journals. The intent was to conduct a systematic review of contemporary literature (i.e., published within the last ten years), as such the method remained consistent for each stage; the only change was the search term. For example, in stage one, the following procedure was used. First, Texas Woman's University's (TWU) online library database system was accessed through the internet. Next, EBSCOhost software was used to search for articles from *all* databases (Academic Search Complete, Agricola

Alt HealthWatch, Book Index with Reviews, Book Review Digest plus (H.W. Wilson), Business Abstracts with Full Text (H.W. Wilson), Business Source Complete, Child Development & Adolescent Studies, CINAHL Complete, Communication & Mass Media Complete, Computer Source, eBook Collection (EBSCOhost), Education Source, Ergonomics Abstracts, ERIC, Essay and General Literature Index (H.W. Wilson), European Views of the Americas: 1493 to 1750, Family & Society Studies Worldwide, Funk & Wagnalls New World Encyclopedia, GreenFILE, Health and Psychosocial Instruments, Health Source - Consumer Edition, Health Source: Nursing/Academic Edition, Humanities Full Text (H.W. Wilson), Information Science & Technology Abstracts (ISTA), International Bibliography of Theatre & Dance with Full Text, Legal Collection, Library & Information Science Source, Library, Information Science & Technology Abstracts, Library, Information Science & Technology Abstracts with Full Text, Literary Reference Center, MAS Ultra - School Edition, MasterFILE Premier, MedicLatina, MEDLINE, MEDLINE with Full Text, Middle Search Plus, Military & Government Collection, MLA Directory of Periodicals, MLA International Bibliography, Play Index (H.W. Wilson), Political Science Complete, Primary Search

Professional Development Collection, PsycARTICLES, Psychology and Behavioral Sciences Collection, Public Affairs Index

Readers' Guide Retrospective: 1890-1982 (H.W. Wilson), Regional Business News, Research Starters - Business, Research Starters - Education, Research Starters – Sociology, Science & Technology Collection, Sears List of Subject Headings (H.W. Wilson), Small Business Reference Center, SocINDEX with Full Text, Teacher Reference Center, Texas Reference Center,

The Serials Directory, TOPICsearch, Vocational and Career Collection, Women's Studies International, Educational Administration Abstracts, Family Studies Abstracts, MathSciNet via EBSCOhost, Legal Information Reference Center).

Then using EBSCOhost's *Advanced Search Option,* the Boolean/Phrase search mode was used with the following keywords "access to higher education AND online". Next, the following limiters were applied to refine the search results:

(a) scholarly peer reviewed journals, (b) published date from 2008 to 2018, and (c) language- English. This process was repeated for the following search terms: "online statistics course", "statistics distance education", web-based statistics", "online undergraduate statistics", "teach statistics AND online", "distance learning AND statistics class", "distance learning AND statistics course", distance education AND statistics course", and "online AND statistics course".

Article Selection Method:

The following outlines the article selection method used for this research. In addition to the limiters used within the article identification stage, only papers that satisfy the following inclusion criteria were selected: (a) research population, was applied, to include only articles with a post-secondary undergraduate student population (i.e., K-12, graduate, and continuing adult education populations were excluded); (b) course-level criteria to include only articles that focused on basic introductory-level statistics courses (advanced and specialized statistics courses were excluded); (c) course delivery method criteria to include only courses that were delivered online. This criteria was established to not only narrow the discussion about challenges from *all* college students within *any* statistics courses, but to also to discuss the pedagogical responses for undergraduate students enrolled in online statistics courses. The next selection factor, involved intentional selection of articles across multiple disciplines to build a multi-disciplinary perspective.

Analytical Strategy:

The selected articles were synthesized to answer the following two research questions. (1) Since the general consensus in the literature is that distance learning does increase access to higher education, what are the potential barriers and facilitators for student success in distance learning? (2) What are the evidence-based best practices for teaching statistics online? As each article was reviewed, a constant comparison with a content analysis method was used to code the text in each of the articles for words and phrases that stood out (Savin-Baden & Major, 2013) while constantly comparing the different articles codes with one another to identify emerging themes.

Definitions:

Various terms are used interchangeably in literature to describe internet-based higher education courses; these included: distance learning, distance education, online course, online class, online distance education, online education, online learning, e-learning, virtual classroom, and virtual learning. In this review, I use distance learning to mean the act of participation in a university or college-level educational courses that are delivered with a web-based learning platform to students (Ferrer-Cascales, Walker, Reig-Ferrer, Fernandez-Pascual, & Albaladejo-Blazquez, 2011). In this manuscript statistical literacy is defined as a goal for statistical students so that they can be good "statistical citizens" (Rumsey, 2002, p. 1). In other words, statistical literacy is a term that is used to describe students who have an understanding of statistical processes so that they can think critically, apply appropriate statistical tools, and interpret data to make informed decisions and be able to effectively participate in communicating those results to other members of society (Rumsey, 2002).

III. RESULTS

The following section highlights results from the systematic literature review. A table highlighting the main points for each of the articles is presented (see Table 1.). This is followed by with a brief synthesis of research grouped by themes which emerged within the articles.

Table 1: A summary of the discipline, methodology, main points, and emerging themes

Author & Discipline	Methodology	Main Points/Findings	Emerging Themes
Ferrer-Cascales et.al. (2011) Psychology	Quantitative	Described various instruments to evaluate both teaching and learning in distance courses. They tested the Distance Education Learning Environments Survey (DELES) that measured psycho-social factors distance learning.	Assessment of Distance Education Educational communication technology , program validation, asynchronous communication, technology transfer
Fielding (2016) English	Critical essay	The essay critiqued the misconception that online education allows students to access higher education "any time, and any from any	Online education, public & private learning spaces, ecology theories, technology, geographic

		place" (103).	barriers
Garcia & Cuello (2010)	Critical analysis	They examine the ways in which virtual education is a way to redistribute knowledge to populations such as women with families and students with disabilities. They also examine the ways in which virtual education minimizes geographical barriers (i.e. living in rural areas) which limits access to higher education for some because of the long commute.	Equity in access, redistribution of knowledge in higher education, virtual education
Gaskell & Mills (2014)		The authors identified the following four main challenges for distance and e-learning: teaching quality, student perceptions, quality assurance, outcomes and access.	Barriers for distance learning
Guravaiah (2017) Commerce	Critical analysis	International (India) study that focused on globalization, technology, and privatization dramatically impact how individuals can compete to earn a living in the global economy. As a result, higher education must respond to the challenges by improving access to education to prepare students for employability in the global market. Challenges include curriculum design, technology, quality of teaching, quality of learning, and financing the cost of education.	Educational quality, structural economic difficulties and governmental support, library infrastructure, student quality
Kinghorn (2014) Economics	Qualitative	Investigated on-line courses as a way to improve access for non-traditional students to higher education. The digital divide was cited as a significant barrier. Findings suggest that using best practices such as virtual collaboration can help students learn in small-groups.	Online courses, nontraditional college students, communication in distance education, collaborative learning
Letseka & Pitsoe (2014) Education	Critical analysis	This study in higher education focuses on the benefits and challenges of open distance learning as a means to access higher education. The challenges included: student support and dropout rate. The main benefit is that it broadens access to higher education.	Working adult students, quality of education, learner support prospects & challenges, student success
Mannay & Wilcox (2015) Psychology	Mixed methods	Higher education is a way to increase access to marginalize in Whales. This paper looked at how educational cultures serve as a barrier that perpetuated disadvantage.	Non-traditional students, articulation challenges, drop-out rate, learner support
Moloney & Oakley (2010) Education, Academic Affairs	Qualitative	Explores online enrollment trends, challenges, and opportunities to increase access.	Online enrollment growth and trends, online programs, successful implementation, institutional support
Signor & Moore (2014) Information Systems	Quantitative case study	Examined learning design for online classes that serve a diverse body of undergraduate students.	Electronic learning, nontraditional students, student diversity, student participation, evaluation methods, educational strategies, courseware
Pedagogical Responses			
Author & Discipline	Methodology	Main Points/Findings	Emerging Themes
Aragon & Wickramasinghe (2016) Mathematical Sciences	Quantitative	An innovative study that investigated the rate of student success in a distance intro to statistics course by measuring the amount of time watching instructor made videos, communication, and time spent of assignments, and exam scores.	Methods for assessing student learning in distance statistics courses, effective online teaching

Beemer et al. (2018) Mathematics Statistics, Analytical Studies and Institutional Research, Instructional Technology, Biology	Quantitative	Examined the efficacy of individualized treatment intervention strategy.	Instructional effectiveness, learning analytics, persistence learning modalities, academic achievement intervention, individualized instruction
Bjornsdottir, Garfield, & Everson (2015) Educational Psychology	Quantitative	This study examined two types of collaborative tests in a distance intro to statistics class.	Methods for assessing student learning in distance statistics courses, cooperative online learning
Casement (2013) Independent Academic	Critical analysis	Outlined how distance education may make higher education more affordable. For example, instead of paying for room and board, a student can live at home saving approximately $6,000 per year. Discusses possible drawbacks such as a loss of intellectual community and critical thinking because of one sided feedback instead of intellectual classroom discussions.	Postsecondary education online course, distance education, tuition costs, enrollment, information technology
Cetinkaya-Rundel & Rundel (2018) Statistical Sciences	Critical analysis	Discuss modern statistical curriculum and suggest a toolkit for implementing a new computational infrastructure.	Instructional effectiveness-tools, statistics curricula, teaching methods, computer systems.
Delaval et al. (2017) Psychology	Quantitative	Reported findings comparing feedback in distance learning environment.	Effective web-based instruction, academic achievement, academic performance, procrastination, web-based training environments
Delucchi (2014) Sociology	Quantitative	Measured student learning with pre-test, post-test assessments.	Assessing student learning, direct assessment, knowledge gain, social statistics
Dierker et al. (2012) Psychology, Population health, Brain Sciences	Anecdotal descriptive	Reported the curricular design of a multi-disciplinary course based on GAISE and ASA guidelines.	Instructional effectiveness-tools, interdisciplinary curricula, teaching methods, project-based teaching-aids
Dunn, McDonald, & Loch (2015) Science, Health, Education, Mathematics	Quantitative and qualitative	Acknowledged the challenges of online learning and investigated the implementation of a new learning strategy, student support centers.	Computer assisted instruction, educational technology, videos, student engagement
Everson & Garfield (2008) Educational Psychology	Anecdotal Descriptive	Studied the use of collaborative online discussion board assignments to improve conceptual understandings of statistical material, statistical literacy, and foster statistical thinking. The assignments specifically focused on, "encouraging students to explain their reasoning and thinking, and to develop practice using the statistical language" (p. 4). For example, discussion prompts ask students to discuss their understanding of statistical terms, create research questions and discuss which statistical analytical technique is most appropriate, appropriate ways in which to	Instructional effectiveness, instructional design online courses, collaborative interactive learning environments with discussion boards

		display variables graphically, critique potential issues related to data collection, as well as how to interpret outputs. The goal was to provide learners with various opportunities to solve real world problems using technology.	
Fask, Englander, & Wang (2015) Economics and Finance	Quantitative	This study examined exams within distance statistics courses to measure the levels of student cheating behaviors.	Online assessment, student cheating, methods for assessing student learning and performance, academic and teaching ethics
Ferrandino (2016) Public and Environmental Affairs	Quantitative	This study described a course design that allowed for failure as a pedagogical strategy.	Instructional effectiveness and online course design, innovative teaching philosophy-learning through failure, tests/quizzes as learning tools rather than assessments
Ferrer-Cascales et.al. (2011) Psychology	Quantitative	Described various instruments to evaluate both teaching and learning in distance courses. They tested the Distance Education Learning Environments Survey (DELES) that measured psycho-social factors distance learning.	Educational communication technology , program validation, asynchronous communication, technology transfer
Gazioglu (2013) Statistics	Anecdotal descriptive	This article discusses the process of planning, developing, and creating an online statistics course.	Instructional design teaching statistics at a distance
Gundlach, et al. (2015) Statistics	Quantitative	Compared online to face-to-face classes using STATS and SRA to identify effect on exams & homework scores.	Educational technology, web-based instruction, student attitudes & performance, homework, video technology, self-esteem, competence, thinking skills, assessing student success
Hedges (2017) Mathematics	Quantitative	Quasi-experimental research to explore student attitudes and performance between face-to-face and online courses.	Persistence and statistics anxiety, student attitudes, persistence
Jerome (2011)	Anecdotal descriptive	This author discussed using Microsoft Excel software as an effective tool for distance statistics classes.	Instructional tool, Excel tutorial
Judi et al. (2017) Computer Science	Quantitative	Access student attitude and learning in Malaysia using a role-play tool.	Instructional effectiveness- tool thought & thinking
Lorenzo (2012) Educational Consultant	Literature Review	Examined the foundations for student satisfaction in online courses. Specifically, he looked at pedagogical practices and instructional design.	Student satisfaction and retention rates, educational technology, instructional design, learning
Mills (2015) Education	Anecdotal descriptive	Described effective practices and GAISE curriculum for teaching and learning statistics online.	Web-based instructional systems design, effective teaching, computer assisted instruction, online pedagogy, curriculum implementation, course organization
Mills & Raju (2011) Education	Literature review	Conducted a literature review regarding the effective implementation of online statistics courses.	Best practices in online instruction
Sami (2011) Mathematics	Quantitative	This study examined if course completion rates were impacted by the delivery (face-to-face or online) of the intro statistics course.	Outcomes of education, college curriculum, electronic learning, instructional effectiveness
Sen (2015) Biology	Quantitative	Pilot study to examine a web-2 tool using wiki's to promote active involvement.	Commercial statistics education research, active learning, educational support services,

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			instruction
Stark & Krause (2009) Educational Sciences	Quantitative	Developed and tested an online program (Koralle).	Computer assisted instruction, example-based learning, learning behaviors, situated learning
Tempelaar et al. (2012) Business and Economics, Education	Quantitative	Investigated the variation in achievement emotions and the effect on choice to enroll in distance learning. Using the social-cognitive model as a framework for inquiry, the authors reported that goal setting pedagogies have less of an impact on achievement than strategies that target the student's initial views of effort.	Web-based statistics, web based instruction, achievement, goal orientation, student attitudes & achievement, psychological aspects of statistics education research
Thomas, Herbert, & Teras (2014) Psychology		Investigated how online programs expand access to underrepresented student and how to improve retention rates and learning in online classes.	Student satisfaction and retention rates
Thapliyal (2014)	Quantitative	Distance education as a mode of instruction to expand access to higher education. Studied student perceptions of their learning experiences.	Assessment of distance education
Yanjie & Siu-Cheung (2017) Mathematics, Information Technology	Quantitative and Qualitative	Investigated the student attitude of usefulness towards and implementation of new digital resources.	Academic achievement, technology uses in education, computer assisted testing and teaching methods, statistics learning platform,
Young et al. (2015) Mathematics and Statistics	Anecdotal Descriptive	Discussion about the online statistics program at Penn State University.	Curriculum statistics, educational quality
Zimmerman & Johnson (2017) Education	Quantitative	Investigated variables such as students anticipated grade, statistics anxiety, and time commitment.	Undergraduate students statistics anxiety, retention, quality statistics education

Challenges for Enhancing Access to Higher Education with Online Education:

Time and Place Constraints:

The literature on widening access to post-secondary education provides a foundation for understanding the time and place constraints online learning. There are a number of competing approaches to expanding access; however, the focus here is the use of technology to deliver courses online. In contemporary society, we are socialized to believe that America is the land of opportunities. One factor that contributes to this widely-held misconceptions are the educational inequalities that limit access to a number of different groups such as non-traditional students, older female students, student veterans, students with disabilities, first-time in college students, and students that identify their race/ethnic as non-white. The institution of education forms the foundation upon which the Welfare State facilitates equitable distribution of goods such as wealth and knowledge (Garcia & Cuello, 2010). I believe that all society members should have equal access to these goods regardless of their age, health, and their identified race/ethnicity, gender, and religion. Online courses make access to higher education easier for certain marginalized population that otherwise might be excluded (Garcia & Cuello, 2010). One researcher reports that distance learning is a revolutionary way for higher education to do business and that courses offered over the internet, "makes more knowledge more easily obtainable for more students than ever before" (Casement, 2013, p.15). In a recent study, Goodman, Melkers, and Pallais (2017) reported that the educational option for online courses significantly increased the number of students that enrolled in the program. The researchers attributed this enrollment increase to mid-career time and place constrained students (who would not have enrolled) were it not for the online option (Goodman et al., 2017).

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Another study focuses on the way in which access can be increased by minimizing the challenges posed by time and place constraints. Fielding (2016) discusses a common misconception that distance learning creates *universal* access by the way in which some institutions promote distance education as "any time, and from any place" (Fielding, 2016, p.103). It is critical for institutions (in their marketing) and instructors (within course content) to dispel this myth of over-flexibility through the mobile autonomy of online classes (Fielding, 2016). Instead, Fielding (2016) advocates for a realistic presentation of the way in which online courses are typically structured (i.e. modular assignments with time constraints) and not self-directed learning (where assignments can be completed at any time) because this may conflict with the time-constrained realities of family and work commitments. Garcia and Cuello (2010) identified the ways in which virtual education is a way to redistribute knowledge for marginalized populations such as women with families and students with disabilities. Not surprisingly, the authors also explained the ways in which virtual education minimizes geographical barriers (i.e. living in rural areas) which limits access to higher education due to infrastructural limitations in rural areas. Instructors can minimize this challenge by adopting Ellen Rooney's 'semiprivate' teaching methodology and incorporate alternative technology such as social media as a tool for completing assignments and expand access to the course (from a singular location i.e., blackboard, canvas) to both private and public spaces (Fielding, 2016). Each of the studies noted valid ways in which access was expanded through distance learning; however, the proposed solutions to address time and place challenges fail to consider student's epistemic access which may affect student success (i.e., completion and retention).

Cost:

Casement (2013) shares his optimism about the different ways in which distance education may make higher education more affordable. For example, online students eliminate the costs of traveling to take courses on campus (i.e., gasoline, parking permits) and instead of paying for room and board, students can live at home saving approximately $6,000 per year (Casement, 2013). Unfortunately, the current tuition and student fees for online courses is similar to or exceeds the cost of traditional on-campus courses (Casement, 2013).

Technology and the Digital Divide:

It is not surprising, numerous academics speculate that technology increases access due to the flexibility of distance education (likely because students are able to enroll in courses while still working and caring for others) (Allen et al., 2016; Conole, 2011, Ferrer-Cascales, Walker, Reig-Ferrer, Fernandez-Pascual, & Albaladejo-Blazquez, 2011; Garcia & Cuello, 2010; Gaskill & Mills, 2014; Goodman, Melkers, & Pallais, 2017; Kinghorn, 2014; Rye & Zubaidah, 2008). This technological flexibility is not without challenges. For example, digital divide perpetuates educational inequalities for students of lower socio-economic backgrounds (Kinghorn, 2014). The digital divide challenges could be overcome with pedagogical strategies such as virtual collaboration (Kinghorn, 2014). The issue of education inequalities, is more complicated challenge because increasing human capital for students from privileged backgrounds with higher levels of computer self-efficacy and increase the divide and education inequalities for students of lower socio-economic backgrounds with lower computer self-efficacy (Kinghorn, 2014). Unfortunately, there is a gap in current literature about pedagogical strategies for increasing epistemic access for undergraduate online statistics students. A topic that I elaborate on within the discussion section of this paper.

Even with advances in technology, a lack of access to the internet remains a challenge for students in rural areas. Another technologically focused study by Rye and Zubaidah (2008) discussed empirical results from interviews in an effort to identify problems that the students encountered with distance learning, such as lack of access to the internet. A similar notion was mentioned by Letseka and Pitsoe (2014) who reported distance learning challenges such as limited access to the internet, limited access to computers, and lack of technical student support. In a recent study conducted by Guravaiah (2017), reported that technology dramatically impacts how individuals can compete to earn a living in the global economy. Again, this topic leads us back to the issue of epistemic access. If the true goal of higher education institutions is to improve access to knowledge to increase student's employability, it is critical that future educational research focus on data-driven innovations in infrastructural and instructional strategies to increase epistemic access to technology.

Student Satisfaction and Retention:

An abundance of research exists on the relationship between the variables student satisfaction and retention. This discussion focuses on current research (Ferrandino, 2016; Gundlach, Richards, Andrew, Nelson, & Levesque-Bristol, 2015, Levy, 2013, Lorenzo, 2012, Mannay & Wilcock, 2015; Thomas, Herbert, & Teras, 2014). A logical point to begin

this discussion is with Lorenzo's (2012) review of literature. This comprehensive review omitted studies with small samples and structured the review around seven factors for student satisfaction (instructor attitude, instructional factors, collaborative learning, communication, and course design) and a section on retention rates (Lorenzo, 2012). Many of the findings were unsurprising. For example, enthusiastic instructors with positive attitudes motivated online learners whereas instructors who were unengaged dissatisfied students; students reported being more satisfied with learning activities that applied to personal situations (i.e. real life); and providing frequent and timely feedback was associated with higher student satisfaction.

Otte (2007) examined CUNY's online baccalaureate program, and reported that their program increased access by re-opening opportunities for students who had previously stopped attending college. According to Otte (2007) students had different motives for taking online classes which included curiosity, convenience, and need. A sense of belonging was reported as a critical factor in retention (Mannay & Wilcock, 2015; Thomas, Herbert, & Teras, 2014). Pedagogical tools such as online discussion forums can create a sense of belonging through social networking and thus reducing the feelings of social isolation (Mannay & Wilcock, 2015). Similarly, fostering student connections not only improves the online learning experience, but also retention (Thomas et al., 2014). Davies, Morys-Carter, and Paltoglou (2015) reported findings on ways to meet the challenges of improved student learning and engagement such with innovative pedagogies such as developing online resources to address the gap in the varying levels of statistical abilities and needs. While all of the articles provided valuable information, Mannay and Wilcock's (2015) article was the only one to address the role of the educational institution and stressed the importance of initiatives that support student success in online classes. Efforts to widen access to higher education are useless without clear strategies to facilitate epistemic access that lead to academic success (i.e. course and program completion). Otherwise, institutions are only increasing access to enrollment and student's wallets.

Statistics Anxiety:

In the three years of teaching undergraduate social statistics (face-to-face and online), I have yet to have a single student not report some-level of statistics anxiety during the beginning of the semester. Dykeman (2011) reported higher levels of academic anxiety and lower levels of self-efficacy among students enrolled in statistics courses compared to other college courses. Reducing statistics anxiety is important for the obvious reason that students with high-anxiety typically struggle in class, but also because a number of departments require successful completion of an introductory statistics course for graduation (Chew & Dillon, 2014). Ferrandino's (2016) pedagogical philosophy for course design which incorporates failure as a strategy to improve learning, reduce statistics anxiety, student achievement, and student completion is brilliant. The researcher used t-tests to examine the effect of allowing his students to have unlimited test and quiz opportunities and found that failure was productive because the rate of D's, F's, and withdraws reduced from DFW 25.6% to 14.6%. (Ferrandino, 2016). I agree with Ferrandino (2016) report that the challenges of statistics anxiety, student satisfaction and retention are inter-related and require innovative approaches to support academic success.

Assessing Student Learning in Distance Statistics Courses:

Ferrer-Cascales et al. (2011) administered an assessment tool to measure the psychosocial learning environment for distance students using the following six categories: "instructor support, student-to-student interaction, relevance, authentic learning, active learning, and autonomy" (Ferrer-Cascales et al., 2011, p. 1104). The findings have valuable pedagogical implications for course designers and instructors as resources to facilitate student success (Ferrer-Cascales et al., 2011). Gaskell and Mills (2014) note that in addition to support services, educational institutions should assess and provide distance teaching resources as well.

Signor and Moore (2014) case study at the Swinburne University of Technology revealed that the no entry requirements facilitated access for the diverse students enrolled in distance learning. Another interesting study comparing the gender online students found higher that final course grades were related to time spent logged into the online course (Guru-Gharana & Flanagan, 2012). Aragon and Wickramasinghe (2016) also used time as an assessment variable, when they measured the time spent watching instructor-made videos along with time spent competing assignments to predict student success. Ried's (2010) quasi-experimental study of four groups of distance learners measured relationship of time spent streaming mp3 and mp4 video simulations and found that they were an effective pedagogical tool. Each of these studies used different methods to empirically assess pedagogical strategies or tools with distance learners. The value in these studies is not just in the findings for each tool but also they provide a base-line for future research.

Instructional Design:

Ferrandino's (2016) ground breaking study was briefly mentioned earlier in this paper when discussing the challenges of statistics anxiety and student retention. This research is also important when discussing instructional design because the redesign resulted in a significant reduction in the number of students who did not successfully complete the class (from 25.6% to 14.6%) whereby supporting the "unlimited opportunity to achieve" strategy (Ferrandino, 2016, p. 6). Additionally, this technique improved the percentage of students attempting to learn the material (i.e., complete assignments) from 2,193 total attempts, meaning 21.2% (of student missed assignments in the originally designed course) to a significant increase of attempts with the newly designed course to 9,477 attempts (Ferrandino, 2016). In other words, the course change resulted in a higher level of participation by students who choose to take advantage of the new course structure of unlimited opportunities. Ferrandino (2016) drew our attention to the fact that not only did the retention rate in his class significantly improve because more students were completing the online statistics course, but also that in the new structure more students participated in the process of actively learning statistics. Gazioglu (2012) described in detail her process for designing an undergraduate online introduction to statistics course including: creating course objectives, structuring the course with weekly modules, the types of assessments such as homework, quizzes, and exams, how to facilitate active learning with discussion boards, and the grading policy. Despite the lack of empirical rigor, the article may be beneficial for new instructors who need a model to build their online course.

IV. DISCUSSION AND CONCLUSION

Unexpected Finding: A Gap in Sociological Literature:

One of the main objectives for this article was to examine multi-disciplinary literature in an effort to add to the discourse on expanding access to education through online classes across multiple disciplines. As a sociologist, I was disappointed to find a lack of current, data-driven, sociological research, which focused expanding access to undergraduate-level statistics education for several reasons. The first, is that for many sociology departments, successful completion of an introductory social statistics course is typically required for graduation. Most importantly, of all disciplines, we specialize in the study of social stratification and inequalities (such as educational inequalities). I am certainly not suggesting that there were no sociological articles published about online statistical education at the post-secondary level. I found a few that were too old for this review, several that focused on face-to-face course delivery, and others whose focus was online graduate education. The trend in higher education is to increase equity for marginalized populations by expanding access for the underrepresented students by delivering courses online. A future researcher might want also want to consider critical analysis of the implications of educational mobility and epistemic access in higher education using the works Morrow (2009), Gamede (2005), Robertson and Hill (2001) or the works of Slonimsky and Shalem (2006), Moll (2004), or Jansen (2008), as conceptual frameworks to inform curricular or pedagogical research aimed at facilitating epistemic access to increase statistical literacy.

A gap was also identified in the literature for current empirically based that seek to build critical insights into mobility and epistemic access for online statistics education courses. While many of the articles reviewed for this paper mentioned importance of accessing higher education access or how online education enhanced access none defined what they meant by the term. The articles seem to elude to term *access* to referring to some type of formal access (i.e. admission to a university or ability to enroll in a course) only two or three mentioned epistemic-type access (i.e., successfully accessing the powerful knowledge within the context of the statistics course). Future online statistical education research should not only focus on the conceptualization of the term access but also on the relationship between pedagogical/curricular strategies and epistemic access to explore how those variables effect student outcomes (i.e., completion rates, success rates, student satisfaction).

Practical Applications for Instructors:

The following outlines instructional interventions to lessen the impact of and/or alleviate potential barriers to facilitate access to educational opportunities online. (a) Thapliyal's (2014) students reported feeling anxious about the number of course objectives that they would be able to achieve by the end of the class. Thus, Thapliyal (2014) suggested that instructors should include how the student learning objectives were going to be measured or achieved by the different learning activities, then perhaps it would provide a better blueprint for students to follow. (b) Instructors should provide

students with a list of student support services that are available to them and where and how to access them (Thapliyal 2014). (c) Online statistics instructors should encourage students to increase their online participation which is predicted to raise their final score (Guru-Gharana and Flanagan 2012). (d) Instructors should make video lessons for their courses and advices students that research indicates that students who watch videos are more successful in distance statistics classes than students who do not view the videos (Aragon and Wickramasinghe 2016). (e) Ferrandino's (2016) results support allowing unlimited attempts on quizzes and tests to promote failure as an opportunity for students to more actively engage with the course content.

V. CONCLUSION

This review of the current teaching and learning scholarship is a helpful resource for statistics educators and researchers by adding new insights into the topic of teaching and learning statistics online. The article also contributes to the body of knowledge on this topic by articulating and discussing the teaching and learning challenges and offering practical interventions.

REFERENCES

[1] E. Allen, J. Seaman, R. Poulin, and T. T. Straut, "Online report card: tracking online education in the United States," (Research Report). Retrieved from Babson Survey Research Group and Quahot Research Group website: https://onlinelearningconsortium.org/survey_report/2015-online-report-card-tracking-online-education-united-states/, 2016.

[2] R. Aragon and I.P Wickramasinghe, "What has an impact on grades? Instructor-made videos, communication, and timing in an online statistics course," Journal of Humanist Mathematics, Vol. 6, pp. 84-95, 2016.

[3] J. Beemer, K. Spoon, J. Fan, J. Stronach, J.P. Frazee, A.J. Bohonak, and R.A. Levine, "Accessing instructional modalities: Individual treatment effects for personalized learning," Journal of Statistics Education, Vol. 26, No. 1,pp. 31-39, 2018.

[4] A. Bjornsdottir, J. Garfield, and M. Everson, "Evaluating two models of collaborative tests in an online introductory statistics course," Statistics Education Research Journal, Vol. 14, pp. 36-59, 2015.

[5] M. Bousquet, How the University Works: Higher Education and the Low-Wage Nation. New York, NY: New York University Press, 2008.

[6] W. Casement, "Will online learning lower the price of college?," Journal of College Admission, pp. 15-18, summer 2013.

[7] M. Cetinkaya-Rundel, and C. Rundel, "Infrastructure and tools for teaching computing throughout the statistical curriculum," American Statistician, Vol. 72, No. 1, pp. 58-65, 2018.

[8] P. K. Chew, and D. B. Dillon, "Statistics anxiety update: refining the construct and recommendations for a new research agenda," Perspectives on Psychological Science, Vol. 9, No. 2, pp. 196-208, 2014.

[9] G. Conole, "Stepping over the edge: the implications of new technologies for education. "In Lee, J. J. W. and McLoughlin, C. (eds) Web 2.0 based e learning: applying social informatics for tertiary teaching. Hershey, PA: IGI Global, 2011.

[10] T.M. Cottom, Lower Ed: The troubling rise of for-profit colleges in the new economy. New York, NY: The New Press Publishers, 2017.

[11] E. L. Davies, W. L. Moyrs-Carter, and A. E. Paltoglou, "Helping students to climb the mountain: A study to inform the development of a resource to improve the learning of statistics in psychology," Psychology Teaching Review, Vol. 21, No. 1, pp. 56-67, 2015.

[12] M. Delaval, N. Michinov, O. Le Bohec, and B. Le Henaff, "How can students' academic performance in statistics be improved? Testing the influence of social and temporal-self comparison feedback in a web-based training environment," Interactive Learning Environments, Vol. 25, No. 1, pp. 35-47, 2017.

[13] M. Delucchi, "Measuring student learning in social statistics: A pre-test-posttest study of knowledge gain," Teaching Sociology, Vol. 42, pp. 231-239, 2014.

[14] L. Dierker, E. Kaparakis, J. Rose, A. Selya, and D. Beveridge, "Strength in numbers: A multidisciplinary, project-based course in introductory statistics," Journal of Effective Teaching, Vol. 12, No. 2, pp. 4-14, 2012.

[15] P.K. Dunn, C. McDonald, and B. Loch, "StatsCasts: Screencasts for complementing lectures in statistics classes," International Journal of Mathematical Education in Science and Technology, Vol. 46, No. 4, pp. 521-532, 2015.

[16] B. F. Dykeman, "Statistics anxiety antecedents and instructional interventions," Education, Vol. 132, No. 2, pp. 441-446, 2011.

[17] M. G. Everson, and J. Garfield, "An innovative approach to teaching online statistics courses," Technology Innovations in Statistics Education, Vol. 2, No. 1, pp. 1-18, 2008.

[18] A. Fask, F. Englander, and Z. Wang, "On the integrity of online testing for introductory statistics courses: A latent variable Approach," Practical Assessment, Research, and Evaluation, Vol. 20, pp. 1-13, 2015.

[19] J.A. Ferrandino, "Student achievement in undergraduate statistics: The potential value of allowing failure," Journal of the Scholarship of Teaching and Learning, Vol. 16, pp. 1-18, 2016.

[20] R. Ferrer-Cascales, S.L. Walker, A. Reig-Ferrer, M.D. Fernandez-Pascual, and N. Albaladejo-Blazquez, "Evaluation of hybrid and distance education learning environments in Spain," Australasian Journal of Educational Technology, Vol. 27, pp. 1100-1110, 2011.

[21] H. Fielding, "Any time, any place: The myth of universal access and the semiprivate space of online education." Computers and Composition, Vol. 40, pp. 103-114, 2016.

[22] T. Gamede, "The biography of "access" as an expression of human rights of South African education policies," (Unpublished PhD. thesis), Pretoria: University of Pretoria, 2005.

[23] A.M.D. Garcia, and R.O.A. Cuello, "A model of equitable and sustainable redistribution of knowledge," Educational Technology Research and Development, Vol. 58, pp. 781-790, 2010.

[24] A. Gaskell, and R. Mills, "The quality and reputation of open, distance and e-learning: What are the challenges?," Open Learning, Vol. 29, No. 1, pp. 190-205, 2014.

[25] S. Gazioglu, "Online course design: a statistics course example," Teaching Statistics, Vol. 35, pp. 98-102, 2013.

[26] J. Goodman, J. Melkers, and A. Pallais, "Can online delivery increase access to education?," (Working Paper 22754), Retrieved from National Bureau of Economic Research website: http://www.nber.org/papers/w22754.pdf, 2017.

[27] E. Gundlach, K. Richards, R. Andrew, D. Nelson, and C.A. Levesque-Bristol, "A comparison of student attitudes, statistical reasoning, performance, and perceptions for web-augmented traditional, fully online, and flipped sections of a statistical literacy class," Journal of Statistics Education, Vol. 23, No. 1, pp. 1-33, 2015.

[28] P.A. Guravaiah, "A review of higher education issues, challenges, and responses in India," International Journal of Research in Commerce and Management, Vol. 8, pp. 49-53, 2017.

[29] S. Hedges, "Statistics student performance and anxiety: Comparisons in course delivery and student characteristics," Statistics Education Research Journal, Vol. 16, No. 1, pp. 320-336, 2017.

[30] J.D. Jansen, "Reflections on meaningful access to education," South African Child Gauge. Cape Town: Children's Institute, University of Cape Town, 2009.

[31] L. Jerome, "Teaching statistics online using Excel," Mathematics and Computer Education, Vol. 45, pp. 17-27, 2011.

[32] H.M. Judi, A.N. Sahair, and Z. Eksan, "Enhancing interest in statistics among computer science students using computer tool entrepreneur role play. AIP Conference Proceedings, 1830(1), 1-7, 2017.

[33] J.R. Kinghorn, "The new digital divide: Peer collaboration as a bridge," Association for University Regional Campuses of Ohio, Vol. 20, pp. 117-132, 2014.

[34] M. Letseka, and V. Pitsoe, "The challenges and prospects of access to higher education at UNISA," Studies in Higher Education, Vol. 39, pp. 1924-1954, 2014.

[35] Y. Levy, "Comparing dropouts and persistence in e-learning courses," Computers & Education, Vol. 48, No. 2, pp. 185-204, 2013.

[36] G. Lorenzo, "A research review about online learning: Ae students satisfied? Why do some succeed and others fail? What contributes to higher retention rates and positive learning outcomes?," Internet Learning, Vol. 1, pp. 45-54, 2012.

[37] D. Mannay, and C. Wilcock, "What students want? Exploring the role of the institution in supporting successful learning journeys in online distance education," Widening Participation and Lifelong Learning, Vol. 17, pp. 49-63, 2015.

[38] J. Mills, "A conceptual framework for teaching statistics from a distance," Journal of Effective Teaching, Vol. 15, No. 1, pp. 59-68, 2015.

[39] J. D. Mills, and D. Raju, "Teaching statistics online: A decade's review of the literature about what works," Journal of Statistics Education, Vol. 19, No. 2, pp. 1-27, 2011.

[40] I. Moll, "Curriculum responsiveness: The anatomy of a concept," In Griesel, H. (ed.). Curriculum responsiveness: Case studies in higher education, pp. 1–19. Pretoria: South African Universities Vice-Chancellors Association, 2004.

[41] J.F. Moloney, and B. Oakley, "Scaling online education: increasing access to higher education," Journal of Asynchronous Learning Networks, Vol. 14, No. 1, 55-70, 2010.

[42] W. Morrow, "Bounds of democracy: Epistemological access in higher education," HSRC Press, 2009.

[43] G. Otte, "Online instruction as local education: CUNY'S online baccalaureate," (Research Report). Retrieved from Online Learning Consortium website: https://onlinelearningconsortium.org/jaln_article/online-instruction-as-local-education-cunys-online-baccalaureate-2/, 2007.

[44] L.H. Robertson, and R. Hill, "Excluded voices: Educational exclusion and inclusion," In Hill, D. & Cole, M. (eds.). Promoting equality in secondary schools. London: Cassell, 2001.

[45] D.J. Rumsey, "Statistical literacy as a goal for introductory statistics courses," Journal of Statistics Education, Vol. 10, No. 3, pp. 1-12, 2002.

[46] S.A. Rye, and I. Zubaidah, "Distance education and the complexity of assessing the internet," Open Learning, Vol. 23, pp. 95-102, 2008.

[47] F. Sami, "Course format effects on learning outcomes in an introductory statistics course," Mathamatyc Educator, Vol. 2, pp. 48-51, 2011.

[48] M. Savin-Baden, and C.H. Major, Qualitative Research: The Essential Guide to Theory and Practice, New York, NY: Routledge, 2013.

[49] S. Sen, "Learning statistics made easy through WIKI: A web-2 tool. KIIT," Journal of Management, Vol. 11, No. 2, pp. 127-134, 2015.

[50] S. Sharma, "Definitions and models of statistical literacy: A literature review," Open Review of Educational Research, Vol. 4, pp. 118-133, 2017.

[51] L. Signor, and C. Moore, "Open access in higher education-strategies for engaging diverse student cohorts," Open Praxis, Vol. 6, 305-313, 2014.

[52] L. Slonimsky, and Y. Shalem, "Pedagogic responsiveness for academic depth," Journal of Education, Vol. 40, pp. 35–58, 2006.

[53] R. Stark, and U.M. Krause, "Effects of reflection prompts on learning outcomes and learning behaviour in statistics education," Learning Environments Research, Vol. 12, No. 3, pp. 209-223, 2009.

[54] D.D. Tempelaar, A. Niculescue, B Rienties, W.H Gijselaers, and B. Giesbers, "How achievement emotions impact students' decisions for online learning, and what precedes those emotions," Internet & Higher Education, Vol. 15, No. 3, pp. 161-169, 2012.

[55] U. Thapliyal, "Perceived quality dimensions in distance education: Excerpts from student experiences," Turkish Online Journal of Distance Education, Vol. 15, pp. 60-67., 2014.

[56] L. Thomas, J. Herbert, and M. Teras, "A sense of belonging to enhance participation, success and retention in online programs," The International Journal of the First Year in Higher Education, Vol. 5, pp. 69-80, 2014.

[57] S. Yanjie, and K. Siu-Cheung, "Investigating students' acceptance of a statistics learning platform using technology acceptance model," Journal of Educational Computing Research, Vol. 55, No. 6, pp. 865-897, 2017.

[58] D.S. Young, G.F. Johnson, M. Chow, and J.L. Rosenberger, "The challenges in developing an online applied statistics program: Lessons learned at Penn State University," American Statistician, Vol. 69, No. 3, pp. 213-220, 2015.

[59] W.A. Zimmerman, and G. Johnson, "Exploring factors related to completion of an online undergraduate-level introductory statistics course," Online Learning, Vol. 21, No. 3, pp. 191-205, 2017.