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Student engagement and statistics education: A review of literature and future directions

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Abstract
The Business Statistics course is taught to MBA students in the first year in India and although many statistics teachers enjoy teaching the subject, they find that the joy of gaining insights and discovering hidden trends is totally lost to students. Hence, communicating in the correct way to keep the students interested is very important. A literature review of the past 30 years shows that statistics education has moved from computing information to understanding the data, engaging the student, using software and then applying the tools in the real world. As we move into a more digital world, gathering data is not a problem, analysing, getting insights and making predictions on the said data to gain advantage in business has become the urgent need of the hour. Hence, it becomes imperative for students of management to learn to use data wisely for decision making. This paper aims to uncover the secrets to imparting statistical knowledge to students through a review of papers for the past thirty years and hence act as a guide for the teachers of tomorrow.

Keywords: insights, trends, engaging the student, need of the hour, literature review

1. Introduction
The Business Statistics course is taught to MBA students in the first year in India and although many statistics teachers enjoy teaching the subject, they find that the joy of getting insights and discovering trends is at times not reciprocated by the students. A review of the past 29 years shows that statistics education has moved from computing information to understanding the data, engaging the student, using software and the applying the tools in the real world. The profusion of data from multiple sources and varying velocities should make decision making much simpler. However, this can happen only when students of management incorporate learnings in the Statistics classroom to finance, marketing and other business areas. There is a huge body of literature which encapsulates different learning methodologies for the teaching and learning of Statistics and which would make them remember the concepts that they learned and more importantly apply them when in jobs.
It is imperative to understand the reasons for most students not being enamoured of the subject and in fact experiencing “statistical anxiety”, considering the massive applications it has in decision making in today’s business life. The objective of this review is to assess to identify the statistical techniques that will be most useful to students in the business world, and the different ways in which the student should be engaged so as the learning of statistics remains with her.

2. Materials and Methods
The research started by hunting for literature online using the keywords “statistics education”, “statistical literacy”, “student engagement” and “statistical teaching”. The search was conducted on online databases such as EBSCO, JSTOR and Google Scholar. The results were further narrowed down by selecting 23 papers written in the English language. As the goal of the paper is to provide a base of the current knowledge on ways in which the student can be kept engaged, there is more emphasis on recent papers.

3. Results
The initial research resulted in 400 papers out of which 59 are considered for analysis. A systematic literature review was conducted chronologically in order to note how the teaching of statistics has evolved over a period of time.
Wallman (1993) [58] contends that "Statistical Literacy" is the ability to understand and critically evaluate statistical results that permeate our daily lives-coupled with the ability to appreciate the contributions that statistical thinking can make in public and private, professional and personal decisions. Gal (2003) [26] quotes the European Commission 1996; (NCTM 2000; Steen 2001) definition of statistical literacy as the need for people (including learners in both formal, nonformal, and workplace contexts) to develop the ability to comprehend, interpret, and critically evaluate messages with statistical elements or arguments conveyed by the media and other sources in his paper.
“Statistics anxiety” describes the apprehension that occurs when an individual is exposed to statistics content or problems and instructional situations, or evaluative contexts that deal with statistics. As statistics-anxious individuals always experience anxiety when doing statistics, statistics anxiety describes an enduring, habitual type of anxiety (Onwuegbuzie and Wilson, 2003; Macher *et al.*, 2011) [48].

Over the years the education of statistics has moved from being a computational subject to one where logic and reasoning is more powerful. The applications of statistics are in all fields of business whether it be marketing in the form of market research, or operations as in the field of quality control or logistics and so on in finance as as well as Human resources. Instructors have used various means to engage the student so as to make her more literate and less anxious.

Blalock (1987) [4] states that **r**egardless of the level of sophistication of our students it is important to think broadly about the general messages that faculty convey to students. He discusses five such goals:

(1) Overcoming fears, resistances, and tendencies to over memorize
(2) The importance of intellectual honesty and integrity
(3) understanding the relationship between deductive and inductive inferences
(4) learning to play the role of reasonable critic; and
(5) learning to handle complexities in a systematic fashion

Students should learn that the real world is indeed complex, but that the tools for studying this reality are available and these can enable the social scientist to move systematically far beyond the common sense level that is often characteristic of present-day empirical research

Cobb (1993) [13] states that the need for curricular resources in statistics is more acute than in any other subject. The reason for this is that of all subjects taught as often as statistics, no other subject is so often taught by faculty with so little formal training in the subject. He proposes that a fresh rethink of the introductory courses, the content and the methodology of delivery is essential. He comments that making students collect data themselves makes them more motivated to analyze it. Working with real world datasets stops students from thinking that it is a boring and dry subject. Using these arguments he proposes the following for an introductory statistics class:

(1) Introductory statistics need not be taught as a survey course.
(2) A first course need not be organized by statistical topic.
(3) A first course need not present topics in the standard order.
(4) A course need not rely on lectures to present the material.

Gal (1995) [25] gives a model of statistical literacy that examines statistical knowledge, mathematical knowledge and general knowledge. He claims that although a beginning has been made a lot more needs to be done in the area of statistical literacy. One such tool could be the designing of good teaching experiments and materials that help students overcome their misconceptions.

Bradstreet (1996) [10] found that students who are actively involved in defining problems and analyzing data have “emotional stakes in learning the statistical material necessary to solve their real world problem”

Gnanadesikan *et al.* (1997) [27] assert that for students to acquire a conceptual understanding of basic statistical concepts, the orientation of the introductory statistics course must change from a lecture-and-listen format to one that engages students in active learning. This is why the authors collected hands-on activities that illustrate the basic concepts of statistics covered in most introductory college courses. Such activities promote the teaching of statistics more as an experimental science and less as a traditional course in mathematics. An activity-based approach enhances learning by improving the students' attention, motivation, and understanding. For eg. writing down the dates on pennies to draw a histogram, calculate the mean and the standard deviation, draw small samples and thus illustrate the concept of the Central limit theorem.

Batanero (2002) [8] argues the need for micro level models that can be used for analysing statistics/ mathematics concepts and to guide a systematic research programme in statistics education. She outlines five interrelated components in a theoretical model to analyse the meaning of any mathematical / statistical concept such as the mean.

(1) First is the field of problems from which the concept has emerged.
(2) Second, is the representations of the concept
(3) The procedures and algorithms to deal with it.
(4) Fourth, are the definitions of the concept, its properties and relationships to other concepts.
(5) Last are the arguments and proofs we use to convince others of the viability of our solutions to the problems.

The term "statistical literacy" refers broadly to two interrelated components, primarily

a) people's ability to interpret and critically evaluate statistical information, data-related arguments, or stochastic phenomena, which they may encounter in diverse contexts, and when relevant
b) their ability to discuss or communicate their reactions to such statistical information, such as their understanding of the meaning of the information, their opinions about the implications of this information, or their concerns regarding the acceptability of given conclusions surmises Gal (2002). These capabilities and behaviors do not stand on their own but are founded on several interrelated knowledge bases and dispositions which are discussed in his paper. He outlines five parts of the statistical knowledge base.
    (1) Knowing why data are needed and how data can be produced
    (2) Familiarity with basic terms and ideas related to descriptive statistics
    (3) Familiarity with basic terms and ideas related to graphical and tabular displays
    (4) Understanding basic notions of probability
    (5) Knowing how statistical conclusions or inferences are reached

Higazi (2002) [34] comments on the usage of technology in teaching statistics at the college level. He distinguishes between teaching statistics at an introductory level in core courses, and integrating statistics as “tools” in different disciplines, and teaching statistics as a science for specialized students. He contends that teaching objectives are different for each category, and thus teaching methods should also be different. With the advent of statistical software emphasis is given to concepts and their meanings in others where the use of technology promotes active learning, enhances the teaching objectives which in turn influences the method by which statistics is taught and introduced. The use of technology helps students to:

1. Learn the basic elements of statistical thinking.
2. Put emphasis on data production and data mining techniques i.e. collecting data, surveying and consolidating it.
3. Get the feel for the variability concept which is the main pillar of statistics, and lecturing alone makes it an abstract concept. The use of technology helps to explain patterns, deviations, and mathematical models for patterns and modern data dialogue (Cobb, 1997).
4. Encourage active learning

Kayes (2002) [38] takes on John Dewey's dual reformist-preservationist agenda for education in the context of current debates about the role of experience in management learning. He argues for preserving experience-based approaches to management learning and explores the methodology of team based conversations. He also pays greater emphasis on language and manner thus bringing about the need for statistics teachers to be friendlier and to engage more with students.

As he examines approaches to teaching for statistical literacy and identifies areas that need attention Gal (2003) [26] states that educators can choose material from the thousands of press releases and executive summaries that exist and particularly from statistics agencies. As a group they can function as a clearing house for lesson plans and teaching guidelines. The analysis of the characteristics of press releases and executive summaries offers four benefits for educators who want to promote statistical literacy.

(1) Firstly, prepare students to interpret and evaluate examples for “good” statistical reporting.
(2) Secondly, to increase students sensitivity to the dilemmas involved in reporting results.
(3) Thirdly, to increase opportunities for statistical communication and
(4) lastly help to reduce logistical and time pressures on teachers.

Bakker (2004) [6] points out that statistics is seen as a science of variability and as a way to deal with the uncertainty that surrounds us in our daily life, in the workplace, and in science (Kendall, 1968; Moore, 1997). In particular it is used to describe and predict phenomena that require collections of measurements. Statistical literacy is one of those skills that are essential to the navigation of today’s technological and information-laden society. Gal (2002) characterizes it as the ability to interpret, critically evaluate, and communicate about statistical information and messages. The authors then give three instances to exemplify how citizens of modern society need at least some statistical literacy – graphs, quotas used in negotiations and quality control. The authors contend that talking through the process of data creation is more helpful than taking a topic-topic approach. Also, students should act as data analysts and learn to communicate results as well as portray results through graphs. Lastly, a practical suggestion is to have students switch off the monitors when discussing in the computer lab or have the discussion in the classroom

Basturk (2005) [7] states that “Introduction to statistics” courses serve as a general introduction to descriptive and inferential statistics theory and practice. In traditional classroom-based statistics courses, much of the learning comes from reading the selected particular textbook, attending lectures and taking notes regularly. Recent technological developments, however, offer instructors an additional method for teaching introduction statistics’ content and practice. Computer assisted instruction (CAI) continues to increase, eventually offering several advantages. Some of the benefits of using CAI include emphasis on active learning, enrichment of collaborative learning, encouragement of greater student’s independence and task-based teaching. Students were divided into two groups – lecture only, and lecture + CAI. The latter group performed much better throughout the course. This research shows that SPSS is a useful tool for teaching introductory statistics course. SPSS could be used as a first statistics package, especially for psychology, social science or education students. Statistical laboratories need to be used as part of an environment that supports student dialogue, investigation and judgment. There is strength in the close connection with the “experience” of a statistician that is, working as a numerical detective with “messy” data to solve real problems in a collegial environment.

Kolb & Kolb (2005) [41] emphasise on the importance on experiential learning and the importance of learning space for students in higher education. They quote Marrow who wrote that "the life space is the total psychological environment which the person experiences subjectively" (1969: 35). Life space includes all facts which have existence for the person and excludes those which do not. Further they refer to Bronfrenbrenner who defines the ecology of learning and development spaces as a topologically nested arrangement of structures, each contained within the next. The learner's immediate setting, such as a course or classroom, is called the microsystem, while other concurrent settings in the person's life such as other courses, the dorm, or family are referred to as the mesosystem. The exosystem encompasses the formal and informal social structures that influence the person's immediate environment, such as institutional policies and procedures and campus culture. Finally, the macro system refers to the overarching institutional patterns and values of the wider culture, such as the cultural values favouring abstract knowledge over practical knowledge, that influence actors in the person's immediate microsystem and mesosystem. The authors note that in order to promote learning in students institutes should become more experiential oriented. However, this method of learning is most effective for small classrooms and for one on one interaction.

DeCesare (2007) [16] believes that helping students overcome their "statistics anxiety" has become an important and explicit objective of social statistics courses. A common position has emerged during the last 20 years among sociologists who study the teaching of statistics; namely, that reducing students' anxiety should be a primary and explicit course objective. Also reducing exam anxiety by introducing semester long research projects go a long way in reducing fear.

Keeley *et al.* (2008) [39] examined the possibility of a curvilinear relationship between statistics anxiety and performance in a statistics course. Eighty-three undergraduate students enrolled in an introductory course completed measures of statistics anxiety and need for achievement at seven points during the semester in conjunction with six tests. Statistics anxiety scores were reliable internally and across time. Surprisingly, curvilinear models were better predictors of test performance than linear, suggesting a mid-range optimal level of statistics anxiety. However, students' need for achievement proved not to mediate the relationship between anxiety and performance. The authors suggest ways these findings may influence future research in statistics anxiety and classroom management of anxiety. Teachers may engage in a variety of techniques like humor to manage their students' anxiety. The results suggest that uniformly reducing students' anxiety may be detrimental. Anxiety is not a fire that needs to be stamped out for students to be successful in a statistics class. Some anxiety is acceptable. For students, simply knowing that some anxiety is acceptable and even helpful may stop them from catastrophizing and increasing the negative effects of the anxiety they do experience. The results suggest that STARS scores are a reliable measure of statistics anxiety. They also suggest that the relationship between statistics anxiety and performance on in-class exams is quadratic, rather than linear, and the relationship between anxiety and performance becomes stronger as exams become more difficult.

Bisgaard, Kulahci (2011) [9] in their introductory chapter on time series analysis have used examples form the American economy to illustrate various concepts. They have used data pertaining to Gross National Product from 1947 – 2009, Median sales prices of houses in the United States from 1988 – 2010. This kind of real data explains the concepts beautifully.

Carlson & Winquist (2011) evaluated a semester-long workbook curriculum approach to teaching a college level introductory statistics course. Their project required students to read content before and during class and then work in groups to complete problems and answer conceptual questions pertaining to the material they read. Instructors answered students' questions in class. There were 59 students who experienced the workbook curriculum project. They completed the Survey of Attitudes toward Statistics (SATS) on the first and last day of the course. The students' post course ratings on the subscales of cognitive competence, affect and difficulty were all significantly higher than their pre course ratings. Additionally, the 59 students' post course ratings for these 3 subscales were also significantly higher than those provided by a comparison group of 235 statistics students who did not experience the course in the same way. The results indicated that the students experiencing the workbook curriculum

1) Had more confidence in their ability to perform and understand statistics,
2) liked statistics more, and
3) Thought statistics was more difficult than the comparison group.

This goes to prove that doing things differently adds value to the student's enagement in class as compared to a traditional classroom lecture.

Cummiskey *et al.* (2012) [15] used datasets generated by students who were asked to play Tangrams in class. Students also chose the variables they thought were significant to see why some students finished earlier than the others. The data sets were "messy" with outliers and students had to decide how to deal with it and which tests to apply. The authors found that the game-based lab gave students exposure to the entire research process while helping them to reach the appropriate conclusions. From the students perspective it alleviated boredom and taught the concepts in an engaging manner.

Campos (2013) [12] contends that users of statistics must be helped to overcome their reluctance to deal with this subject and they should become critical and responsible users of statistics. Data analysis and the study of probabilities provide a natural environment for students to set up connections between mathematics and their everyday experiences. The paradigm of statistics pedagogy has changed in the last two decades and statistics is now more than a branch of mathematics. It involves experience planning and problem-based matters that needs careful thinking and reasoning (Garfield, 2002, Garfield and Gal, 1999, Moore, 1992, 1998). Under this new paradigm, statistics can be taught with fun, using games based on a series of applied problems. These problems can be taken from news items with a statistical content found in the mass media. To this end Exploristica - Adventures in Statistics - a new itinerant exhibition was designed to teach the fundamentals and practice of Statistics and Probability for students of upper basic and secondary school (12 to 17 years). The intention was to describe the five important phases of the statistical process i.e. to Select, Collect, Describe, Estimate and Interpret. Exploristica is organized in several modules that present the main statistical concepts in the form of games and other interactive experiences. The main concepts to be taught are the types of data, location and dispersion measures (mean, median, standard deviation), graphs (box and whiskers, bar plots, histograms), random and non-random sampling, relative frequency, and probability. These concepts are taught through games based on Archery, Submarines, the Portuguese Census 2011, gorillas etc. The exhibition has been a success and has been visited by hundreds of visitors.

Klein, Dabney (2013) [40] in their book- The Cartoon Introduction to Statistics use the most imaginative and accessible introductory statistics course material ever imagined. Employing an irresistible cast of dragon-riding Vikings, lizard-throwing giants, and feuding aliens, the renowned illustrator Grady Klein and the award-winning statistician Alan Dabney teach beginners on how to collect reliable data, make confident statements based on limited information, and judge the usefulness of polls and the other numbers. Timely, authoritative, and hilarious, The Cartoon Introduction to Statistics is a very different, very essential guide for anyone who wants an understanding of statistics.

Brophy, Hahn (2014) [11] suggest that involving students with in class activities is a pedagogical method intended to promote active learning. In their paper they describe an in class experiment that is easy to implement with large groups of students, taking 15-20 minutes and involving students in solving Sudoku puzzles. Students solved one of four types of puzzles and recorded the time to completion, previous experience in solving Sudoku puzzles etc. The resulting dataset was used to describe and display datasets as well as for more sophisticated analyses which included the t test, one way ANOVA, Chi Squared test etc. Students who underwent the experiment enjoyed it and understood the complexities of working with different types of data. The experiment was conducted in the first class and it helped to keep the students engaged in the course.

Forbes *et al.* (2014) [24] note that for many years, students have been taught to visualise data by drawing graphs. Recently, there has been a growing trend to teach statistics, particularly statistical concepts, using interactive and dynamic visualisation tools. Free down-loadable teaching and simulation software and more general data visualisation tools are increasingly being used in New Zealand classrooms. The paper discusses four examples which are publically available: the use of GenStat for Teaching and Learning Schools and Undergraduate (GTL); Auckland University's iNZight and VIT (Visual Inference Tools) for teaching bootstrapping and randomisation; the CAST e-books, and the use of data visualisation tools to assist learning concepts in official statistics. Student feedback indicated that they enjoyed working with the tools and included the statement that "visual tools helped to further my understanding of different methods for presenting complex 199 data….I have found in my work that how the information is presented to decision makers is sometimes as important as how the data was collected or analysed." The authors conclude the paper by observing that regardless of the specific function the visualisation tools have been designed for they can be used in statistics classrooms for multiple purposes. Another issue for consideration is whether more of our statistics teaching should be focused on the interpretation of these new visualisation tools as they become more widely used by the media and in the public domain.

Cronin & Carroll (2015) [14] discuss the complex problems of developing quantitative and analytical skills in undergraduate first year, first semester business students. An action research project, detailing how first year business students perceive the relevance of data analysis and inferential statistics in light of the economic downturn and the challenges society faces is discussed. Students' attitudes were evaluated via an online survey consisting of both quantitative and qualitative responses. While two thirds of respondents do acknowledge the relevance of such a course for future business roles, it is shown that more work must be done to distinguish between why data analysis is relevant and how data analysis is performed. Also discussed are findings related to student learning, their intellectual development, and their motivation and expectations upon enrolling on the 'Data Analysis for Decision Makers (DADM)' module. Data Analysis for Decision Makers (DADM) was designed during this review as a module to address these two goals. Business programmes traditionally include a business statistics component that focuses on the application of statistical methods. DADM is the application of statistical techniques to describe and explore a set of data. One of the core aims in the delivery of the module is to use data analysis to highlight useful information that aids decision-making. DADM is a core module for all (circa 550 per annum) undergraduate business students and is delivered in semester 1 of first year. Statistical thinking and literacy skills are key in their future roles in the business world. The DADM delivery philosophy aligns with the GAISE recommendations on how to teach an introductory college statistics course, (ASA 2005). The GAISE recommendations are:

1. Emphasize statistical literacy and develop statistical thinking;
2. Use real data;
3. Stress conceptual understanding rather than mere knowledge of procedures;
4. Foster active learning in the classroom;
5. Use technology for developing conceptual understanding and analysing data;
6. Use assessments to improve and evaluate student learning.

This aspect of the action research project focused on student attitudes. The survey responses are consistent with earlier work in this area. They indicate that the global financial crisis has had little impact on changing the perceptions of business students as to the relevance of data analysis as a tool to aid decision-making processes. Over 84% of students enrolled in DADM achieved a sufficient level of understanding to pass the module and this is encouraging for their roles as future business leaders. However, more can be done to improve engagement and aid student quantitative skills development. The survey responses showed that students found the DADM module challenging. If the university experience is about pushing the boundaries, we should not be surprised that first year students find this a dis-comforting experience for which they do not thank us. The challenges in teaching such a mandatory module to Business students are discussed and a pedagogical framework for promoting deeper student engagement through active learning, regular continuous assessment and technology are also examined.

Alavizadeh (2015) [5] states that Statistics and probability play an important role in almost all engineering and engineering technology disciplines particularly, in industrial engineering technology. Students working in such fields as quality control, manufacturing engineering, and reliability should be familiar with statistics and probability and how to use them to improve and promote quality. In addition, the Accreditation Board for Engineering and Technology (ABET) which "is a nonprofit, non-governmental organization that accredits college and university programs in the disciplines of applied science, computing, engineering, and engineering technology." suggests that students must have "an ability to design and conduct experiments, as well as to analyze and interpret data". The author describes a course conducted by him for Industrial engineering students and makes the following recommendations. For future improvement, one area is to include more relevant examples, especially for class discussion, so students would be better able to relate the lectures to real world examples. In addition, students would benefit from learning on specialized software package in solving statistical problems.

Grimshaw (2015) [28] notes that working with complex data is one of the important updates to the 2014 ASA Curriculum

Guidelines for Undergraduate Programs in Statistical Science. He asserts that 'authentic data experiences' within courses allow students opportunities to learn and practice data skills as they prepare a dataset for analysis. Authentic data experiences provide an opportunity to demonstrate connections between data skills and statistical skills leading to higher engagement and retention. The author gives examples of students working with data from different sources and formats and analyzing the data by using R programming language. He further comments that Statistics is a field of study requiring an integrated set of skills. The 2014 Guidelines define the expected skills of a statistics major and encourage programs to provide opportunities for students to connect these skills. Presently, instructors can choose from an exploding set of real data applications in their courses. Unfortunately, the end result from the student's perspective is often a clean, well organized, easily read file. A small paradigm change is to provide source data locations with sufficiently detailed instructions for the students to prepare the dataset for analysis. An added benefit of finding and writing authentic data experiences is that it forces instructors out of the comfort zones described by Horton (2015) and keeps instructors current as preferred technologies change over time. Applications that are time sensitive benefit from providing the instructions to obtain current data. The paper suggests that more can be done to develop students skills and confidence by providing authentic data experiences in other courses.

Groth (2015) [29, 30] applied Stein's five practices model which was as follows: (i) anticipating students' responses, (ii) monitoring students' responses, (iii) purposefully selecting responses, (iv) purposefully sequencing students' responses and (v) connecting students' responses. He found it useful in keeping students interest as well as in encouraging teachers to weave classroom narratives that attend to diverse patterns of student thinking while simultaneously addressing important statistical ideas from multiple perspectives.

Groth (2015) [29, 30] describes how dynamic statistics software (Tinkerplots) was used to catalyze discourse among a group of prospective elementary and middle school teachers. The prospective teachers formed their own statistical questions and then investigated them with the software. After that, the course instructor selected and sequenced work they had produced for classroom discourse. As the prospective teachers presented their work, the course instructor helped the class make connections among the different strategies and the statistical questions that were shared. The overall experience illustrated a model for the facilitation of technology-enhanced statistical discourse.

Gundlach *et al.* (2015) [31] argue on the basis of an experiment conducted by them that a web-augmented traditional lecture, fully online lecture and a flipped classroom; all taught by the same instructor with the same course schedule, assignments, and exams in the same semester, give nearly the same results. Traditional students scored higher on average on all three exams, but there were no significant differences between sections on homework, the project, or on university evaluations of the course or instructor.

Dolor J & Noll (2015) [18] contend that teacher knowledge can affect student learning. Their study investigated how teachers reinvented an informal hypothesis test for categorical data through the framework of guided reinvention. They then go on to describe how notions of variability help bridge the development from informal to formal understandings of empirical sampling distributions and procedures for constructing statistics and critical values for conducting hypothesis tests. They asked students to generate the data and then ran a chi square test on it.

Dragicevic (2015) [19] emphasizes on the fact that Statistics are tools to help end users accomplish their task. Statistical tools should support and promote clear thinking as well as clear and truthful communication. Yet areas such as human-computer interaction (HCI) have adopted tools like e., p-values and statistical significance testing which have proven to be poor at supporting these tasks. The use and misuse of p-values and significance testing has been severely criticized in a range of disciplines for several decades, suggesting that tools should be blamed, not end users. The author further contends that it would be beneficial for HCI to switch from statistical significance testing to estimation, i.e., reporting informative charts with effect sizes and confidence intervals, and offering nuanced interpretations of the results.

English *et al.* (2015) [20, 21] contend that as statistical education becomes more firmly embedded in the school curriculum and its value across the curriculum is recognised, attention should move from knowing procedures, such as calculating a mean or drawing a graph, to understanding the purpose of a statistical process and its application in the real world. Their paper outlines a four stage model for carrying out a statistical inquiry. These phases could be to ask questions, collect data, analyze data and make decisions. This process of running a statistical inquiry will however only bear fruit if class sizes are small and teachers are enthusiastic.

English (2015) [20, 21] says that climbing mountains, building bridges etc. is a rich theme for exploring some of the challenges facing mathematics education within the current STEM climate (Science, Technology, Engineering and Mathematics). This paper considers some of the issues and debates surrounding the nature of STEM education, including perspectives on its interdisciplinary nature. It is next argued that mathematics is in danger of being overshadowed by science. The writer argues that mathematics education should be made more attractive to students. One of the ways to do that would be by modelling with data which cuts across the disciplines but is not receiving the recognition it warrants. By including it in maths curricula might lead to more students being interested in maths.

Hund, L., & Getrich, C. (2015) [36] comment that traditional lecture-centered classrooms are being challenged by active learning hybrid curricula. For small classes and for non-traditional students online technology to optimize the role of the professor in the classroom is imperative. However, very little research exists in this area. For this experiment, the use of short statistical computing video tutorials was explored using a pilot study in a small Public Health Program at the University of New Mexico. Instructions for the course were given in two Master's-level biostatistics courses and student perception of the videos was assessed using quantitative surveys and qualitative focus groups. Viewing rates for the videos were high, with 15 out of 16 respondents reporting usually or always viewing the videos. Overall perception of the videos as a learning tool was positive, with 14 out of 16 respondents agreeing that the videos offer advantages to them. Two prominent themes emerged in the analysis: (1) the usability and convenience of the videos was high and (2) the learning facilitated by having the videos available was deeper and stayed with the student for a longer time.

Anderson (2016) [1] presents his paper on the Learning Incentive Program (LIP), which is an innovative teaching resource designed to enhance a range of learning-relevant outcomes by increasing student engagement while maintaining motivation. The LIP involves interactive weekly online formative quizzes, primarily designed to encourage engagement. As incentive for regularly engaging in course content, completion of weekly tasks allows access to course materials for that topic (e.g., lecture notes can be obtained prior to the lecture as an incentive for engaging with the LIP). The LIP encourages online student-driven engagement with the material, provides interactive feedback by explaining incorrect answers, and assists students to track their progress across the semester. The online nature of the LIP makes it an ideal candidate for a wide range of student circumstances, including full-time or part-time workloads, and distance based or on-campus modes of learning. It is suitable for use by a range of student capabilities, it allows high-achievers to excel whilst also allowing those struggling with content to identify and understand areas that need improvement. The data presented in the paper was from a class on Research Design and Statistics, however, it could be used in any subject. The LIP allows students to track the amount of work they are doing outside of class hours, and which components of the course they are excelling in or which areas of the course need attention. It also acts as a tool for revision. However, a topic that has not yet been discussed is how the LIP might be beneficial to educators. It can allow the educator to see where the class (at the individual level, or at the cohort level) is excelling or struggling, which can inform the educator how to best allocate revision time and to refine course content for following years. The LIP could be developed as a smart phone or web-based application. This would allow the LIP to be extended to include engagement during the lecture. For example, students could take quizzes throughout the lecture to ostensibly check that the content is being understood, with the real aim of sustaining engagement. Second, technology used to record lectures could be used to turn small portions of the lecture into clips (similar to a video podcast), which could then be linked to feedback system in the LIP. In this way, students frequently answering incorrectly about a topic could be given access to a ‘replay’ of the related portion of the lecture to clarify any misunderstanding.

Anyikwa & Rapp (2016) [2] conducted a study on an online course on research methods and noted that learning is not necessarily easier or less anxiety-provoking online, and classes require well-planned strategies by both instructors and students for success. Whether education occurs in a face-to-face format or online the instructor is still responsible for understanding where each student is situated and integrating strategies that reach them. In the end educators are still responsible for reducing barriers (e.g., anxiety) and for being present in the learning of each student. For their part, online students are responsible for active engagement with the course material, their peers and their instructor. In addition, educators may help students change their beliefs about learning away from a receptor or passive learner to an independent and active participant by assigning activities that facilitate learning apart from the instructor. For instance, activities that can be added include small group projects and peer interactions/exercises which then allow for instructors' positive and frequent feedback individually to students. Scaffolding (Hammond & Gibbons, 2005) is another instructional strategy which assists in strengthening confidence as students slowly build their knowledge and skills as the content progressively increases in difficulty.

Artut (2016) [3] conducted a study to investigate the opinions of prospective teachers about the effect of the cooperative learning method on non-routine problem-solving levels and on solving problems by means of this method. He divided his sample of ninety nine into two: one experimental group and one control group were randomly formed. A problem-solving test consisting of non-routine problems was used as a pre-test and a post-test. A great majority of the prospective teachers stated that they had never come across non-routine problems in mathematics classes before, but using this kind of problems in the classroom environment might contribute in the cognitive development of the students and make the mathematics classes more enjoyable. Many prospective teachers mentioned the positive effects of this method such as being able to see different opinions, gaining different perspectives, appreciating differences, and working on problems longer and they emphasized that they would use this method in their future teaching career. A few prospective teachers expressed some negative opinions, such as finding non-routine problems unrelated with mathematics and seeing the cooperative learning method inappropriate for themselves. Covariance analysis was conducted on the data obtained from the problem-solving test to determine whether the difference between the experimental group and the control group was statistically significant. The conclusion was that the problem-solving performance of the prospective teachers in the experimental group was better than that of the prospective teachers in the control group. The collated interview findings showed that the prospective teachers mentioned positive effects of working on non-routine problems in a cooperative learning group. Although the experiment is for the subject of mathematics the same methodology can also be applied to statistics education.

Fitzallen (2016) [23] argues that although students are taught about measures of central tendency and variability they do not interpret it correctly. His paper reports on how students understood covariation through an interpretation of scatterplots. The outcomes of the study suggest that incomplete understanding of the characteristics of a graph and the data displayed can lead to students applying knowledge of statistical concepts relevant to one graph type to misinterpret a different graph type. The results reported in this paper are limited as the study only involved 12 students. They do, however, offer insights into the way in which students make sense of and interpret various exploratory data analysis representations. They also draw attention to the need to extend research to encompass student interpretation of non-traditional graphs made possible through innovative graphing software.

A search of the literature did not reveal any research that explored specifically how students transfer understanding of statistical concepts to various graphical representations. To date, research has treated the exploration of student use of graph types discreetly (e.g. Watson & Donne, 2008) rather than focusing on the interconnectedness or not of various graph types. Further exploration of the development of key concepts such as data, distribution, centre, variability, outliers, sampling, and comparing groups (Biehler *et al.*, 2013) within the context of multiple graph types, is required.

Goshu (2016) [29] describes the experiences gained from the established statistical collaboration canter at Hawassa University in May 2015 as part of LISA 2020 network. The center has got a similar setup as LISA of Virginia Tech. Statisticians are trained on how to become more effective scientific collaborators with researchers. The University has a well established and strong academic graduate programs of statistics. The master programs are in Applied Statistics and Mathematical and Statistical Modelling launched in 2008 and 2010, respectively. They are research based studies. The programs have produced about one hundred ninety graduates to-date, with current enrollment of over fifty students. The doctoral program started in 2013 with an enrolment of ten students. The graduate students are the main role players as statistical collaborators at the centre. The collaboration scheme seems to work well and to have an impact on research quality of the non-statistician researchers. The collaboration practice has a potential to enhance the statistics education and research at the department itself. However, the center needs to be strengthened and expanded for greater services and sharing experiences with other similar higher institutions.

Hardin (2016) [32] comments that datasets used in statistics classes are often cleaned, and wrangled prior to any student working with the observations. She however contends that an important part of teaching statistics should include actually retrieving data from real world datasets. Nowadays, there are many different sources of data that are continually updated by the organization hosting the data website. The R tools to download such dynamic data have improved in such a way to make accessing the data possible even in an introductory statistics class. Her paper provides four full analyses on dynamic data as well as an additional six sources of dynamic data that can be brought into the classroom. For each of the projects below, there is an R Markdown file which scrapes the data from an outside web source (presumably kept current and public by some other organization). Using the data, the analysis starts by performing

(1) a graphical representation of the data
(2) An inferential analysis of the data.

For each example students are forced to think carefully about what the inference actually says about the underlying mechanisms that led to the data collection. In some cases the conclusions are easy to justify and communicate, in other settings they are not. These kind of real time datasets will make the student of statistics see the different ways of accessing data and feel empowered to gather more information on their own. She reiterates that our courses must remain relevant to both the student experience and the research community or we run the risk of become irrelevant. Small relevant steps like these will get us where we need to be.

Hare & Kaplan (2016) [33] believe that intRo, which leverages the power of R and Shiny, and is a web-based application for performing basic data analysis and statistical routines is a perfect tool for an introductory statistics class. The implementation is easy and there are not too many choices which would prevent confusion. It is meant to assist in the learning of statistics rather than as a stand-alone delivery of statistics education, with the intention of being used in conjunction with a guided class. An accompanying R package, titled intRo and available on GitHub, assists in the downloading, running, and deploying of intRo instances. It is easy to use and can be an exciting part of learning statistics. The simplicity lends itself to a natural presentation in an introductory statistics course as a substitute for other commonly used statistical software packages like SPSS and R. The authors also point out that loading large datasets tends to be slow. However, students would benefit from a package like intRo which would then also help them to get into using R at a later stage.

Katoma *et al.* (2016) [37] believe that a learning organization is capable of renewing itself as it consistently reflects and vigorously seeks improvement. Their research paper focused on course management of a basic statistics course at a university in Namibia in which multiple groups were taught by different lecturers, a setting also known as parallel teaching. Their research revealed that there were significant variances in assessment marks within and between four out of the five groups which could be attributed to a lack of concrete coordination among lecturers and a possible deficiency in academic peer interaction between students in the separate groups. Their results also showed that part-time students were more likely to pass compared to their full-time counterparts who took the same course. This finding could be an indication that full-time students needed different levels of motivation or study strategy that resonated with the predominant class management styles. The authors suggest that it is better to run large classes rather than multiple groups with different lecturers if the course coordination and teacher training in class management proves to be unattainable, especially with less resources.

Lester (2016) [44] contend that many students perform poorly in courses on psychological statistics, and it is useful to be able to predict which students will have difficulties. The author conducted a study of 93 undergraduates enrolled in Statistical Methods (18 men, 75 women; average age 22.0 years) and notes that performance was significantly associated with gender (female students performed better) and proficiency in algebra in a linear regression analysis. Anxiety about statistics was not associated with course performance, indicating that basic mathematical skills are helpful to perform well in statistics courses and faculty can usefully be stream students into classes by mathematical ability.

Maat *et al.* (2016) [45] believe that statistics is widely used in various fields of study. However, understanding statistics is not easy for students. They conducted a study to examine anxiety towards statistics using a descriptive study. The problem arises due to the subject's numerical nature which entails strong mathematical foundations as well as statistical knowledge. Statistics anxiety can emerge whenever any quantitative situational aspects occur which contradicts the requirement that students should have understood basic statistics. Through anxiety, barriers in the understanding of statistics are developed. For the study, 182 students from postgraduate level were chosen randomly; these comprised of 39 males and 143 females. A questionnaire of 50 items containing questions on anxiety towards statistics was distributed to them. The collected data was analysed using SPSS version 22. The findings revealed that the students' anxiety towards statistics was at a moderate level. All research projects required them to at least use simple statistics when presenting data. Another interesting point was that students prefer if the method of evaluation in the statistics course focuses on individual assignments and examination. Although, this would lead to anxiety, students' conception of statistics would be better if they could grasp the content knowledge of statistics. Concerning the approaches used in learning statistics, students have to be taught that statistics is beneficial in many ways. Enhancing pedagogical techniques would be one of the solutions which would impact the students' cognitive and non-cognitive factors.

Mahmud *et al.* (2016) [47] conducted a study on how students difficulties in learning statistical topics are in some ways related to their learning styles and preferences. They feel that these difficulties can be overcome when both the students and instructors are aware of how different learning styles impact learning of statistics. Some students tend to search for convenience and comfort when learning statistics while others will employ strategies that will enhance their effective learning of statistics. They used Kolb‟s Learning Model and categorized students learning styles and preferences into the four categories of Converging, Assimilating, Accommodating and Diverging. They conclude by saying that regardless of which category they fall into, the students found that their learning styles are effective in helping them overcome difficulties in learning a range of statistical topics. This study also classifies a big majority of the students into the Converging category as they seemed to prefer doing practice exercises as well as study on their own in their effort to understand some of these statistical topics. Students that were categorized in the Assimilating group are more likely to read textbooks and look up for notes from other sources such as the internet. They would also prefer to meet their lecturers in an effort to seek a better understanding of the topics. Finally, students that are classified under the Accommodating and Diverging group will generally seek to understand statistical concepts by studying in a group and reading notes that are provided to them. So Statistics teachers should employ a number of ways to impart knowledge keeping all learning styles in mind.

Mónica *et al.* (2016) argue that probability and statistics has been taught to engineering students in different ways, in the past few years, with very little retention among the students. During 2015, a baseline of the platform named 'e-status' was designed in order to establish the future impact of learning these subjects. Problems related to probability were assigned on the platform. The results were analyzed considering conceptual difficulties, appreciation of the platform and the degree of usage. The data collected showed that the majority of the students solved only the minimum set of problems, thus it was concluded that monitoring by the teacher in the process of self-regulated learning is also necessary.

Rashwan (2016) points out that using a concept map for teaching students applied statistics as a subsidiary course is invaluable. As the goals of statistics educational reforms are to change attitudes towards statistics, and to improve the teaching and learning of statistics the students anxiety can be eased by using a concept map with the most available tools, Normal Calculator and Microsoft Excel to create a collaboration between using the technology tools and teaching the concepts. She concludes by pointing out the benefits of using software as:

1) The statistics concepts should be understood not memorizing their formulas;
2) The most available tools such as the normal calculators and Microsoft Excel is better to use in teaching statistics;
3) One must know what the case of study is;
4) It is important to know how to interpret the results when using a software for statistical analysis;
5) Statistics taught in labs is better to ease the calculations and concentrate in the concepts;
6) Theoretical statistics exam involves questions about the concepts and their meaning;
7) Discussing graduate projects, that have statistical ideas to know how to choose the right concepts and method to apply, is worth, more than teaching theoretical examples;
8) Statistical background and statistical software skill are necessary in solving statistical problems in different areas.

Applied Statistics course description should split into three parts. The first is teaching the statistics concept and its link to the students' field. The second part is how to use the tools to solve the statistical problems. The third includes some applications to real time problems.

Phillips & Phillips (2016) [49] comment that statistics is that required competency in numerous college majors which students approach with anxiety. Their paper describes an undergraduate statistics course that was "flipped," with most of the content delivery moved online and class time devoted to application and practice. Students were given a menu of learning tools from which to choose and were free to utilize as many or as few as they felt was appropriate, giving them ownership of their learning experience and the opportunity to tailor the course to their personal needs. The classroom experience included brief segments of lecture but consisted mostly of exercises and group exercises. Course grading was based on four exams, a comprehensive final exam, and a major end-of-course project. The grades for the comprehensive final exam were significantly higher (an average of almost one full letter grade), and course pass rates also rose using the flipped course format.

The authors also sound a warning that a course redesign like this requires extensive work on the part of the teacher and as flipped class practitioners note, the creation of online tools such as quizzes and podcasts is time consuming and may appear overwhelming. These resources are however an investment with the initial hard work paying dividends for many future generations of students. Statistics teachers should take the advice they give to students and collaborate to help one another implement improved teaching techniques and methods. Like our students we tend to work alone, rather than collaborating. If learning statistics is more productive in community, then learning to teach statistics will be as well.

Prayoga & Abraham (2016) [50] speculate that students of social sciences often hate statistics and therefore cannot utilize statistics optimally. In their study the authors investigated five possible antecedents in a hypothetical model. Using the method of structural equation modelling and by using path analysis, it was found that mathematics self-efficacy and appreciation towards history of mathematics can predict attitudes towards statistics, while ambiguity tolerance can predict previous bad mathematics experience. The study concluded by noting that attitude towards statistics can be explained not only by present but by past factors (previous bad mathematics experience), individual's disposition in dealing with new situation (ambiguity tolerance), behavioral tendency (statistics appropriation), beliefs (mathematics self-efficacy), and a stimulus trigger that has the potential to spark interest and encourage students to make a greater effort (history of mathematics).

Schauffler *et al.* (2016) [51] point out that the ability to analyze and interpret data is central to scientific inquiry. Interpreting data, in turn, requires understanding that a collection of data is not just a group of data points, but is an aggregation with properties of its own and there is variability of the data within the aggregation. A variety of studies have shown that it takes time for students to develop the ability to think in terms of data aggregations and variability. Knowing where students are at in this learning process is important not only to helping them improve their data skills, but also to designing scientific investigations that are well-matched to their ability to use data as evidence. Their paper presents and describes an instrument called the Assessment of Student Knowledge of Variability (ASK. Var) that measures students' progress in learning to think about data aggregations and variability. They present both the instrument and data about its performance as a contribution to a broader conversation about measuring students' ability to analyze and interpret data and conclude by asserting the utility of the tool to measure students understanding of variability.

Schwartz *et al.* (2016) [52] comment that Flipping the classroom refers to a pedagogical approach in which students are first exposed to didactic content outside the classroom and then actively use class time to apply their newly attained knowledge. In most cases they learn the content through online videos and then work on exercises or projects in class. The idea of the flipped classroom is not new, but has grown in popularity in recent years as the necessary technology has improved in terms of quality, cost, and availability. Many biostatistics instructors are adopting this format, but some remain unsure whether such a change would benefit their students. One potential barrier to adopting a flipped classroom is the common misconception that only a single approach is available. Having adopted the flipped approach in their own courses, the authors participated in an invited panel at the 2014 Joint Statistical Meetings held in Boston, MA entitled "Flipping the Biostatistics Classroom." A theme emerged from the panel's discussions: rather than being a one-size-fits-all approach, the flipped biostatistics classroom offers a high degree of flexibility, and this flipped approach should be tailored for students.

Silver (2016) [53] discusses the ways in which teachers of statistics can make the subject interesting for students and reduce the anxiety associated with it. He starts by saying that teaching statistics to undergraduate students of social sciences is a daunting task while adding that most survive the course. He notes that using humor and relating to real life problems helps to keep the student engaged. He also discusses the usefulness of using mnemonics or SPSS. He ends by saying that teaching statistics should be similar to teaching any course and if the student obtains a rudimentary understanding and appreciation of the topic then that is a reasonable outcome.

Taylor *et al.* (2016) comment on the recent research that has explored comparative classroom experiments on student attitudes towards statistics. For example, Gundlach *et al.* (2015) [31] investigated attitudes among students taking a statistical literacy course in traditional, online, and flipped classes. Winquist and Carlson (2014) also looked at the effects of flipped classrooms for introductory statistics, but they considered the impacts a year after instruction and reported significantly higher retention for students in the flipped-classrooms. Ciftci, Karadag, and Akdal (2014) examined the impacts of using computer-based tools in statistics instruction for teacher candidates through a variety of scales to measure student attitudes and anxiety related to statistics. A small research study conducted by Autin, Marchionda, and Bateiha (2014) investigated the effects of a student-centered collaborative-learning class on student attitudes toward statistics and indicated some potential benefits to student-centered collaborative learning. The authors go on to say that student's views towards statistics depend upon the faculty's views towards statistics.

Tsaroucha and Randall (2016) [57] paper studied the development of a research and statistic training course for staff members and postgraduate students within the Faculty of Health Sciences at Staffordshire University. The authors emphasize that:

- Research methods training is needed at all levels, from basic to advanced
- Face-to-face pilot basic statistics course were well received
- Attendance to face-to-face session was hampered by busy work schedules
- Consideration should be given to delivery via blended learning

Zhan (2016) [59] contends that students of engineering can add a lot to their course by studying statistics. He believes that although Six Sigma has been widely deployed in industry, service, government agencies, and other sectors and feedback from the industry has been positive the curriculum needed to be enhanced through the use of statistics in engineering design and analysis in the Electronic Systems Engineering Technology (ESET) program. Hence, ESET started to develop a new course, Six Sigma and Applied Statistics, in 2012. His paper discusses the detailed contents for the lectures, laboratories, and course projects. A continuous education workshop was also offered based on the materials from this course. The course covered topics like histograms, probability distributions, Regression etc. Students from other departments also took up the course. The feedback from students was positive and it was felt that the knowledge of statistics learned during the course was helpful during interviews for jobs.

Dierker *et al.* (2017) [17] write that upward trends in data-oriented careers threaten to further increase the underrepresentation of women and individuals from racial minority groups in programs focused on data analysis and applied statistics. To begin to develop the necessary skills for such a career, project-based learning seems the most promising given its focus on real-world activities which also engage student interest and enthusiasm. The authors used pre and post survey data to examine student background characteristics, learning experiences and course outcomes for a cohort of 33 rising high school seniors involved in a two-week, accelerated version of a project-based data analysis and applied statistics curriculum. They found that on an average, students rated the experience as rewarding and the vast majority (78.1%) felt that they had accomplished more than they had expected. About half of the students reported increases in confidence in applied skills (i.e. developing a research question, managing data, choosing the correct statistical test, effectively presenting research results, and conducting a statistical analysis of data), while more than 80% reported increased confidence in writing code in SAS to run statistical analyses. Fully 84.4% of students reported interest in one or more follow-up courses with interest in computer programming being endorsed by the largest number of students (53.1%). These findings thus support previous research which shows that real-world, project-based experiences afford the best hope for achieving analytic and statistical literacy necessary for meaningful engagement in research, problem solving and professional development.

Figueroa & Perez (2017) [22] note that the increasing automation in data collection, as well as the development of reading, concatenation and comparison algorithms along with the growing analytical skills which characterize the era of Big Data, are not only a technological achievement, but are also an organizational, methodological and analytical challenge for knowledge. Big-Data can improve the understanding of concepts, models and techniques used in both statistical inference and economic theory, and it can also generate reliable and robust short and long term predictions. These facts have led to the demand for analytical capabilities, which in turn encourages teachers and students to demand access to massive information produced by individuals, companies and public and private organizations in their transactions and interrelationships, which in turn is causing a shift in the approach to statistics and economics teaching, considering them as a real way of thinking rather than just technical disciplines. The question is how teachers can use automated collection and analytical skills to their advantage when teaching statistics and economics. The authors argue that the Big Data environment is an excellent opportunity to reposition the teaching of Statistics in the centre of the acquisition of knowledge, integrating concepts and creating new methodologies in line with the advances in data technologies. For that purpose, professors and researchers need a mental shift and they should start working with massive data wherein, the methodology of inferential statistics can be applied to structured, unstructured as well as semi structured data. The availability of all kinds of data on different platforms should enamour the students as compared to dry testing which is what most statistics syllabus comprise of.

Hilliam & Calvert (2017) [35] assert on the need to equip today's workforce to deal with the increased amount of data. They contend that at The Open University they have devised a highly successful first level statistics module which is simultaneously studied by students across a range of different disciplines. This has mainly been achieved by using topics which are of interest to everyone rather than being discipline specific. The module has produced some impressive results particularly when analysing the progress of different cohorts of students, not just from varying disciplines, but also across a broad spectrum of students with differing backgrounds. However with such a diverse cohort of students, rather than aligning the statistics teaching to any particular discipline, the module takes the approach of using areas of importance to all people regardless of discipline, employment or background, these being Money, Education and Health. These topics are used to exemplify the ideas and techniques, where the emphasis is on the importance of statistics and statistical thinking. By using these three topics the relevance to society is stressed and therefore appeals to all students regardless of subject discipline. In addition to ensuring the material is delivered through key examples in Money, Education and Health, there is also a strong emphasis on the interactive nature of the material. There has been much evidence to suggest that students benefit greatly from a problem solving method of teaching statistics (Marriott *et al.*, 2009). There are a number of online resources which complement the printed material, including over 70 screencasts which demonstrate key statistical topics. They also took end of module surveys and found that students who study this module as part of a non-mathematical qualification find the subject and way of presenting the material valuable as they are able to relate the techniques to their own place of work. The module has even made students reconsider their study goals and has made others appreciate the importance of statistics in the workplace and everyday life. This way of choosing generic topics may be of particular interest to teachers of statistics.

Lai & Williams (2017) [42, 43] point out there is an exponential growth of diverse data and as a consequence of that American graduate students are expected to be high on Statistical literacy, statistical reasoning, and statistical thinking. To respond to this demand, the accredited colleges of business school in the United States require business students to take at least an introductory business statistics course in their degree program. However, because they are not good at Math in school, they struggle in their undergraduate courses too and find the courses difficult and do not find value in it at the post graduate level too. Therefore, it remains a constant challenge for statistics educators to develop innovative instructional methods to educate the management student. In order to understand the anxiety that students face the authors conducted a study on 11 participants who were drawn from undergraduate business students at a southern university in the

United States
The study found that students who have low-esteem in math learning tend to struggle in learning statistics, because they conceived statistics to be another math class. Students' statistics anxiety is negatively related to their statistics performance, and positive statistics attitude is associated with better statistics performance. As statistics instructor, we need to constantly remind students that mathematics and statistics are two distinct disciplines and we should shift our instructional focus from mathematical computation and procedure to statistical literacy, statistical reasoning, and statistical thinking. Also, students would like to experience their instructor's constant empathy in understanding their statistics learning struggle, and accordingly modify their instructional pedagogy to enrich their learning experiences and enrich their academic performance. Such empathy can be demonstrated in providing students with various supplementary justin-time learning support, for example, various learning resources available on Moodle. Recent years have witnessed a resurgence of resource-based learning in various learning environments. Research has showed that technology can impact teaching and learning of statistics.

Lai *et al.* (2017) conducted an experiment to gauge if online video tutorials could enhance undergraduate business students' academic performance in a required introductory business statistics course as a supplement to traditional classroom instruction. The study showed the availability of video tutorials enriched students' learning experiences and enhanced their academic performance. The results suggest that the learning benefits of the video tutorials were especially beneficial to those students who scored a final course grade of B or C, maybe, because these students were struggling to understand the course materials in the class. The case was different for those who got a final grade of A, D, or F as they might believe that they either totally understood everything or they were absolutely lost in the class. Whether they scored high or low, these students believed that studying the video tutorials added no more value to their understanding of the materials presented in the class**.**

Song and Kong (2017) [54] conducted a study to investigate university students acceptance of a statistics learning platform in a blended learning context. Three kinds of digital resources, that is simulations, online videos, and online quizzes, were provided on the platform. These were uploaded on MOODLE which is a Learning Management System. They adopted a model consisting of four external factors (self-efficacy, facilitating conditions, subjective norm, and anxiety) that could influence student's perceptions and acceptance of the platform. A mixed research method was used on a total of 102 participants. Data collection included questionnaires survey, individual interviews, and focus group discussions. The findings showed that students' intention to use the platform was affected by their attitude toward the platform, which is significantly influenced by perceived usefulness. Surprisingly, students felt that the technology should be paired along with traditional lectures and that the videos should be short. This preliminary study provided valuable insights into further refinement of the platform and development of a learning analytics platform in the future for better learning of students in statistics

Spedding *et al.* (2017) [55] comment that **t**he initial year of university is often a sensitive period for new students. The authors contend that one way in which students demonstrate academic benefits is Peer Assisted Study Sessions (PASS). PASS is a structured peer led study group where students collectively share knowledge and solve course-related tasks. To get more knowledge on this their study used both a cross-sectional (sample size of 264) and a matched longitudinal (sample size of 76) survey design. They sampled a first-year psychology cohort enrolled in an introductory statistics course, and both cross-sectional and longitudinal analyses found a positive relationship between PASS attendance and academic performance. The authors cite various other literature to push forward the point that PASS is designed as a targeted intervention for traditionally difficult courses that often serve as a ‘‘gate keeper’’ for degree progression. Students experience negative emotions when enrolling in these courses which can lead to reduced help seeking and delayed enrolments which could lead to reduced student performance. This kind of peer learning can be easily integrated into the existing course curriculum with minimal disruption.

Thropp (2017) [56] argues that students performance can be improved by making them reflect on their own learning processes and identify areas that they understand as well as areas that they require to work on. This awareness and understanding of one's own thought processes is especially beneficial for students facing challenging material, like statistics coursework. To this end the author conducted an experiment wherein students' grades from two different sections of a graduate-level introductory statistics course were compared. For the experimental section, students were encouraged to complete a weekly reflective journal about their learning progress and related experiences in the course. The control section followed the same course structure as the experimental section, but did not complete the journals. Independent samples t-tests were conducted on assignment and test scores as well as the final course grade for the experimental and the control sections. The experimental section performed significantly better than the control section on two assignments and one test. The results show support for the use of reflective journaling to improve the student learning experience.

4. Conclusions
The findings can be summed up as follows:
1. Students should be made to interpret and critically evaluate statistical information and discuss reactions
2. The instructor should be knowledgeable
3. Students should be given long projects preferably semester long projects as these will help in removing statistical anxiety and exam anxiety
4. Theoretical Concepts should be introduced and explained with games
5. Students should be exposed to working with real world datasets as relevant examples will be rich material for class discussions
6. Students would benefit from learning on specialized software package in solving statistical problems. Software like SPSS and R should be used.

7. Good teaching experiments like explaining concepts of t test, logistic regression etc. through tangrams and Sudoku puzzles should be applied.
8. Students should collaborate on projects as this will help in peer learning.
9. The use of videos or online classes did not add to learning. If used they should be supplemented by classroom lectures.

The above results are a summary of the observations and experiments carried out by the authors. They are not an exhaustive list, but can be used as a guide by aspiring teachers for effective teaching of Statistics.

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