2016

Effect of an Interactive Component on Students' Conceptual Understanding of Hypothesis Testing

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COLLEGE OF EDUCATION

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B Mathematics, University of Waterloo, 1970

Doctoral Study Submitted in Partial Fulfillment

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Abstract

The Premier Technical College of Qatar (PTC-Q) has seen high failure rates among students taking a college statistics course. The students are English as a foreign language (EFL) learners in business studies and health sciences. Course delivery has involved conventional content/curriculum-centered instruction with minimal to no interactive components. The purpose of this quasi-experimental study was to assess the effectiveness of an interactive approach to teaching and learning statistics used in North America and the United Kingdom when used with EFL students in the Middle East. Guided by von Glasersfeld's constructivist framework, this study compared conceptual understanding between a convenience sample of 42 students whose learning experience included a hands-on, interactive component and 38 students whose learning experience did not. ANCOVA was used to analyze posttest scores on the Comprehensive Assessment of Outcomes in Statistics (CAOS) as the dependent variable, the course placement (hands-on versus no hands-on component) as the independent variable, and the pretest score on CAOS as the covariate. Students who were exposed to the hands-on learning demonstrated greater conceptual understanding than students who were not. Based on these results, a 3-day workshop was designed to create a learning community to enable statistics instructors to address the problem of high failure, to introduce delivery methods that involve place-based examples, and to devise hands-on activities designed to reflect authentic research. This study has implications for positive social change in Qatar, in that application of the findings may result in producing trained graduates capable of filling the shortage of qualified researchers, thereby supporting the nation's goal of being a leader in research as stated in the Qatar National Vision 2030.

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Dedication

Dedicated to my parents in heaven, Harry and Mary, for your love, immeasurable support, and dedicated partnership for success in my life. You are with me in spirit, and I love you both.

Acknowledgments

It is important that I acknowledge and thank members of the Walden University faculty and staff. I offer a special thank you to my committee, Dr. Sarah Hough and Dr. Kathleen Montgomery, who have been supportive throughout this process. Thank you for the hours and hours you spent reading, critiquing, and advising.

In the spirit of this oft-quoted piece of work, I would like to make a final acknowledgement to all who made a contribution to my completion.

"I can no other answer make, but thanks, and thanks."

William Shakespeare, *Twelfth Night*

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Section 1: The Problem

Introduction

The Premier Technical College of Qatar (PTC-Q) is the largest technical institution in Qatar. It has approximately 4,600 full- and part-time students in five schools: Engineering Technology, Health Sciences, Business Studies, Information Technology, and Language Studies and Academics. The postsecondary college is coeducational with approximately 60% males and 40% females. Qatari nationals make up 63% of the student population (Institutional Research and Planning, PTC-Qatar, 2014). The teaching staff is 100% Canadian, with a Canadian curriculum designed from the mother college in Newfoundland, as detailed in the Comprehensive Agreement, 2011 (Institutional Research and Planning, PTC-Qatar, 2014).

PTC-Q offers all diploma courses in English, in traditional lecture mode with accompanying textbook, assignments, and homework. Students enrolled in statistics (Math 1670) are from the School of Business and the School of Health Sciences. All students at PTC-Q are English as a foreign language (EFL) students, with these students representing approximately 12 mother tongues. The lingua franca, or bridging language, is English. Over one-third of PTC-Q students who enroll in a first-year statistics course do not pass this course (Institutional Research and Planning, PTC-Qatar, 2014).

Research suggests that statistics education, which offers learning activities that guide students to use statistical thinking and reasoning, increases students' conceptual understanding, thus lowering the failure rate (Arnold, Pfannkuch, Wild, Regan, & Budgett, 2011; Bailey, Spence, & Sims, 2013; Bond, Perkins, & Ramirez, 2012; delMas, Garfield, Ooms, & Chance, 2007). The interactive component being tested in this study involved a myriad of practical applications necessary for developing statistical reasoning and thinking for research.

Definition of the Problem

The problem at PTC-Q was the high failure rate (39%) of students taking the statistics course Math 1670 (Institutional Research and Planning, PTC-Qatar, 2014). Each semester, approximately 120 students in business studies and health sciences, are required to take Math 1670, a difficult, one-semester course covering descriptive and inferential statistics, as shown in Figure 1. The problem was magnified by the fact that all of the students were classified as EFL learners (Institutional Research and Planning, PTC-Qatar, 2014). There were added difficulties for EFL learners, which included problems related to culture and a mode of teaching based on lectures (Abdelbasit, 2010). In addition, the language of statistics is often confusing for EFL students because many statistical words have multiple meanings in everyday English (Kaplan, Fisher, & Rogness, 2009). Because Math 1670 was a required five-credit course, the repercussions of not achieving a good grade in this course included a lower grade point average (GPA), an extension of the expected graduation date, and low self-esteem.

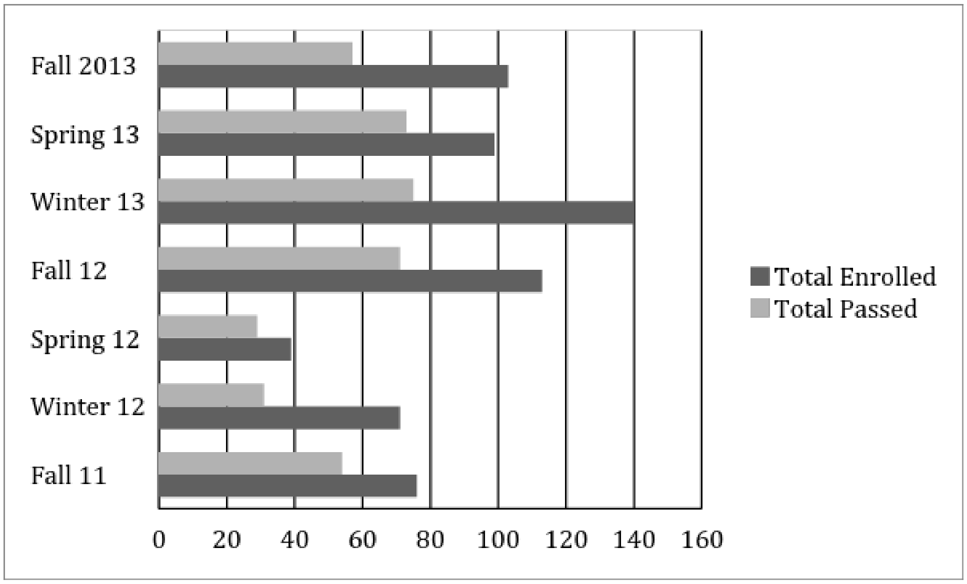

Figure 1. Number of students successful in Math 1670 vs. the total number of students enrolled from Fall 2011 to Fall 2013.

Statistics education in North America and the United Kingdom emphasizes learning activities in which students use statistical thinking and reasoning by using data in context, as well as by analyzing and interpreting data (Batanero, Buttill, & Reading, 2011). Research has shown that increases in conceptual understanding occur in predominantly native-English-speaking classrooms that involve active learning (i.e., learning by doing), which promotes deeper understanding and thoughtful engagement in statistics among students (Canturk-Gunhan, Bukova-Guzel, & Ozgur, 2012; Budé, van de Wiel, Imbos, & Berger, 2011; Loch, Galligan, Hobohm, & McDonald, 2011; Mandrin & Preckel, 2009). Learning environments in these classrooms include real-life, culturally specific experiments, class activities, technology, discussion, collaboration, and varied instruction (Garfield & Ben-Zvi, 2009; Neumann, Hood, & Neumann, 2013).

It was unknown whether hands-on, concept-based learning would affect the conceptual understanding of predominantly EFL learners who attend lectures in more traditional classrooms. To test whether the interactive approach to teaching and learning statistics that is common in North America and the United Kingdom is applicable to students in the Middle East, a pilot interactive component was designed following western guidelines that embraced the use of technology, cooperative learning, and student-centered instruction.

Relationship of the Problem to the Larger Educational Setting

In 2010, the Royal Statistical Society launched an initiative in the United Kingdom—a statistical literacy program across many disciplines—with the aim of improving awareness of how statistics could be important in everyday life (Nicholson, Ridgeway, & McCusker, 2013). This initiative, called GETSTATS, evaluated statistical needs for all undergraduate programs and was designed to prepare students for involvement in research from diverse areas of study in both the social and the physical sciences. The results of this study revealed the diverse nature of the students and the faculty.

As discovered from the GETSTATS initiative, students from varied disciplines took statistics as a requirement of their program. Research showed that many students, regardless of their discipline, had little interest in mathematics or statistics (Druggeri, Dempster, Hanna, & Cleary, 2008; Griffith, Adams, Gu, Hart, & Nichols-Whitehead, 2012; Larwin & Larwin, 2011; Ramirez, Schau, & Emmioglu, 2012). The failure rate was high among students across programs, and students' lack of engagement in statistics was not limited to one major. Psychology majors, business majors, and health science majors all struggled with statistics (Griffith et al., 2012; Nolan, Beran, & Hecker, 2012; Williams, 2013).

Compounding the problem was the diverse academic background of statistics instructors, whose areas of study included psychology, behavioral science, economics, mathematics, and engineering science. The diversity of the instructors' knowledge base and training affected the andragogy, the delivery of the curriculum, assessment, and learning styles (Hassad, 2002; Martins, Nasciemento, & Estrada, 2012). In addition, few research studies have examined instructors' understanding of statistical concepts (Peters, 2011).

Statistics teaching in countries such as the Philippines, Germany, and Central America involves formulae-based approaches with nongenuine data (Burrill & Camden, 2005; Opolot-Okurut, Opyene Eluk, & Mwanamoiza, 2011). The formulae-based approaches to teaching statistics have resulted in students performing poorly on international assessments such as Programme for International Student Assessment (PISA). Twenty-five percent of the questions on the PISA test refer to statistics and probability (Martignon, 2011). This test reflects an emphasis on statistical reasoning that has led many countries to align with global reform efforts that have involved a shift in focus from procedural knowledge to statistical reasoning and thinking (Bersales, 2003; Garfield & Ben-Zvi, 2009; Sorto, Marshall, Luschei, & Carnoy, 2009).

Rationale

Evidence of the Problem at the Local Level

The statistics courses offered at PTC-Qatar and other postsecondary institutions in Qatar were delivered in lecture format with no lab component (PIRS, 2014). More varied and motivating forms of statistics instruction and assessment were required to inspire students to engage in statistical thought and reasoning as observed by an increase in conceptual understanding among students (Parsian & Rejali, 2011). Active learning environments had not been introduced in statistics education classes in this technical college in Qatar. A thorough search of the literature on statistics education, constructivism, adult learning styles, guided discovery learning, place-based learning, Middle East education, English as a foreign language learners, and statistics teaching and intervention did not reveal any innovative interventions in statistics education in the Gulf region. Therefore, it was unknown whether hands-on, project-based learning would improve conceptual understanding of statistics for predominantly EFL learners who are accustomed to lecture classes.

According to a survey by the Qatar Ministry of Development, Planning, and Statistics (2013), Qatari nationals made up only 10.2% of the workforce in Qatar, meaning that Qatar had the largest percentage of expatriates working in any of the countries in the Gulf Cooperation Council (GCC; p. 5). The mandate of the Qatar National Vision (QNV) 2030 indicates that within the next 17 years, Qatari nationals must compose 100% of the workforce (QNV 2030, 2008). For this vision to be realized, Qatari nationals have been encouraged, with government sponsorship, to pursue postsecondary diplomas and degrees.

Another pillar in the QNV is leadership in research for Qatar (Qatar National Vision 2030, 2008). The Qatar National Research Fund, a member of the Qatar Foundation, has been responsible for enabling research and development to realize the vision of Qataris being leaders in research. The objective of the Qatar National Research Fund (QNRF) is to foster a research culture in Qatar by offering grants to build Qatar into a knowledge society through research that benefits the nation and the world and by raising Qatar's profile in the international research community (QNRF, 2014). In response to this mandate requiring Qatari nationals to be trained in research, PTC-Q created a section in the strategic plan under *Educational Innovation*. The initiative's purpose, as described in the Strategic Plan 2011-2016 (Saretsky, 2011), was to "establish creative programs to maximize employee and student engagement in research projects" (p. 3). To fulfill this initiative, a culturally responsive research assistance program, which included a statistics course and a quantitative methods course, was developed at PTC-Q. Both the mission of the QNRF and the QNV 2030 pillars envisioned research as the catalyst to achieve a knowledge-based society.

The interactive component involved a myriad of practical applications to develop statistical reasoning and thinking necessary for research. The students select their own research within given parameters, collected and analyzed their own data, and wrote a statistics report including a hypothesis and conclusion. The students participated in a research project that was of interest to them, and they had the opportunity to design and execute the project, which included all of the sections of a statistical report. The students worked in groups and presented their findings to the class for debate. This place-based component followed constructivist learning theory, developing statistical thinking and reasoning by doing and building on previous knowledge. In addition, this research-based component placed the students in a discovery-oriented environment that encouraged collaboration and challenged their problem-solving skills. The hypothesis was that the hands-on approach to learning statistics increased students' conceptual understanding as measured by the Comprehensive Assessment of Outcomes in Statistics test (ARTIST Project).

Evidence of the Problem From the Professional Literature

History of statistics education. Statistics education is a young discipline. Statistics departments at the postsecondary level were first established in the 1940s in the United States, although there is evidence of statistics in the history of mathematics dating back to the 18th century (Snedecor & Cochran, 1989). Even today, statistics is not considered a field of mathematics but rather a mathematical science where learning or evidence came from data. Statistics involved more nonmathematical activities such as considering probabilities and expectations (Bond et al., 2012). Statistics education had its own concepts, ideas, and ways of thinking that differed from those in mathematics. For example, numbers or data were the basis of all statistical activities, but these numbers were derived from a context (Leavy, Hannigan, & Fitzmaurice, 2013).

The International Statistics Institute (ISI) set up an educational committee in 1948 to design educational activities in statistics for UNESCO and the United Nations (Vere-Jones, 1995). The reasons for statistics education at secondary and postsecondary educational institutions included appreciation and understanding of statistical concepts in business and industry in daily life, as well as the importance of data and data analysis in effective decision making (Ridgeway et al., 2013; Vere-Jones, 1995).

Collaborative learning environments and place-based interventions have been designed in many countries (Showalter, 2013). This is not surprising, given that multivariate statistics is consistent with real-world phenomena encouraging engagement with data through visualizations, hands-on activities, real-life experiments, report writing, and analogies (Dierdorp et al., 2011; Hassad, 2006). These authentic learning activities taught with constructivist pedagogy promote statistical reasoning and thinking (Canturk-

Gunhan et al., 2012). In addition, researcher Weshab (2012) reported that collaborative learning that includes decision making, team building, and problem solving is integral to problem-based learning environments and ultimately to reflective thinking.

Since the beginning of the 21st century, various interventions have been tested in statistics courses taught at the postsecondary level (Haskin & Krehbiel, 2012; Makar & Ben-Zvi, 2011). These interventions have met with small successes but have been the focus of little or no follow-up research (Holcombe, Chance, Rossman, & Cobb, 2010). It is important for students to be involved in the full investigative process by incorporating in the curriculum real-life experiments in which they are responsible for design, data collection, analysis, and conclusions (Neumann et al., 2013; Porkess & Mason, 2012). Active learning, or learning by doing, promotes deep understanding of and thoughtful engagement in statistics among students (Loch, Galligan, Hobohm, & McDonald, 2011). The learning environment in other studies included real-life experiments, class activities and culture, technology, discussion, assessment, and instruction (Garfield et al., 2009; Neumann, Hood, & Neumann, 2012).

Because students have a variety of learning styles, interventions have been adjusted to promote success for different learning styles. Gardner (1999) addressed seven styles and contended that all individuals can increase their learning in all areas. Using different presentation styles to teach college students facilitates deeper understanding of the subject matter by activating a wide assortment of intelligences (Al Muhaidib, 2011; Lockwood, Ng, & Pinto, 2007). Students who have learned to be passive learners may be reluctant to participate in classroom activities that require collaboration or what-if scenarios. Research into students’ statistical reasoning showed that students from classes with effort-based learning approaches (many homework assignments) scored lower than students in classes with different learning approaches (Zieffler et al., 2008). In most universities and colleges, statistics instruction is delivered in lecture format, with little opportunity for students to interact with the concepts and apply them successfully (Garfield & Ben-Zvi, 2009). It is important to incorporate a variety of communication styles and media to ensure that needs associated with the different learning styles of students are met (Christou & Dinov, 2010). Adler (2006) discussed the importance of "introducing students to the idea that different forms of communication work differently to create distinct meanings; each functions more or less effectively in communicating concrete and emotional information, or abstract and factual information" (p. 33).

Definitions

Guided discovery learning: In this strategy for learning, the learner is guided toward insights and generalizations. It is a style of instruction in which the learners are led to discover a predetermined outcome. Examples of guided discovery are simulations, scenarios, experiments, or team-building activities. Students are given a task and encouraged to complete it and reflect on the experience (Mandrin & Preckel, 2009; McCoy & Wake Forest University, 2011).

Instructional strategies: Instructional strategies include all of the approaches an educator might take in order to engage students in learning. Effective strategies address all learning styles and developmental needs of the learners. Examples of instructional strategies are hands-on learning, scaffolding, and independent learning (Ekwensi, Moranski, & Townsend-Sweet, 2006).

Learning styles: Learning styles are both biological and developmental characteristics reflecting how students process and remember different academic information. These differences are demonstrated in the classroom, where one teaching method may be successful for some and disastrous for others (Coffield, Moseley, Hall, & Ecclestone, 2004; Knowles, Holton, & Swanson, 2005).

Multiple intelligence theory: Multiple intelligence theory involves the premise that people do not possess one particular learning style or level of intelligence. People possess a set of intelligences that include linguistic, logical/mathematical, spatial/visual, bodily/kinesthetic, musical, interpersonal, and intrapersonal aspects.

Significance

The significance of this research was that it tested whether interventions in statistics education that had been applied in North America and the United Kingdom had the same positive effects on adult EFL learners at a postsecondary institution in Qatar as they did in western educational contexts. The National Council of Teachers of Mathematics (NTCM) and the American Mathematics Association (AMA) stated that an essential characteristic of a 21st century global citizen is understanding of statistical and mathematical concepts (Partnership for 21st Century Skills, 2011). The interactive approaches explored in this study were developed with opportunities for transferability to other cultures by allowing for place-based statistics and a variety of options for research activities exclusive to a certain region. Because students at PTC-Q showed an increase in statistical thinking and reasoning with these approaches, other interactive components using place-based statistics, collaboration, and problem solving will be implemented.

Research Questions

Conceptual understanding is an important aspect of statistical proficiency. Statistics education includes many concepts that cannot be directly observed, and the variables that illustrate the concepts cannot be easily manipulated. One intervention to increase conceptual understanding was a query-first-based learning activity designed to help students comprehend a difficult statistics concept—hypothesis testing. This pilot interactive component was designed following western guidelines that embraced the use of technology, cooperative learning, and student-centered instruction. Although research had shown that interventions similar to this pilot intervention had been successful in the western world, there was no literature to support a positive effect on students at a community college in the Middle East.

Research question: How did the experimental group (those participating in an interactive component in the hypothesis testing unit of a statistics course) differ from the control group that did not have access to the interactive component in terms of scores on the Comprehensive Assessment of Outcomes in Statistics (CAOS) for college students at Premier Technical College-Qatar?

Null hypothesis: There was no difference in CAOS scores between students who learned with the interactive component in the hypothesis testing unit and the students who did not.

Alternative hypothesis: There was a difference in CAOS scores between students who learned with the interactive component in the hypothesis testing unit and students who did not.

Review of the Literature

The following is a critical review of the literature on conceptual understanding in statistics education. I reviewed scholarly literature on constructivist learning theory, adult learning theories, and English as foreign language teaching theories in relation to statistical educational practices. I conducted a search of ERIC, the Walden University library databases, government databases such as those of the National Assessment of Educational Progress (NAEP) and the National Center for Education Statistics (NCES), ProQuest, and the Qatar National Library databases using the following Boolean search words: *statistics education, constructivism, adult learning styles, guided discovery learning, place-based learning, Middle East education, English as a foreign language learners,* and *statistics teaching and intervention.* In addition, I reviewed materials through ProQuest Dissertations and Theses and Walden Dissertations from the Walden University library.

Over 500 peer-reviewed journal articles, conference papers, online news articles, dissertations, and books were reviewed, and 60 of these sources are cited in this study. The thorough review of the literature began by examining constructivist learning theory and how it relates to statistics education. A review of the history and significance of conceptual understanding in statistics education was included to provide background for the importance of the study. Second, English as a foreign language teaching and learning theories as they relate to adult student development theories were explored. The section concludes with a review of the literature relating to conceptual understanding in statistics education.

Theoretical Framework: Constructivist Learning Theory

Constructivism, as defined by von Glasersfeld, one of the forerunners of constructivist theory in mathematics education, depicts learners as actively constructing their own knowledge, especially in mathematics and science education (Joldersma, 2011; von Glasersfeld, 1995). Constructivist theory was useful to my research, as this theory is based on the belief that conceptualization is central to learning. In this section, I describe constructivist principles that lent themselves to my research concerning conceptual understanding in statistics education. The concept of building on previous knowledge by creating real experiences is the basis of constructivism (Schecter, 2011). von Glasersfeld (1995) stated the following: “To sum up, what radical constructivism may suggest to educators is this: the art of teaching has little to do with the traffic of knowledge, its fundamental purpose must be to foster the art of learning” (p. 192).

Constructivist teaching practices encourage the learner to be an active participant in the learning process by including conceptual activities such as reflection, verbalization, and conversation (Joldersma, 2011; Overbay, Patterson, Vasu, & Grable, 2010). For students to participate as active learners, teachers must create a learning environment that encourages constructivist learning.

Constructivism concentrates on students taking ownership of their own knowledge. This requires a learning environment that stimulates the learner and creates open communication and collaboration among students and between student and teacher (Dierdorp, Bakker, Eijkelhof, & van Maanen, 2011; Pfannkuch, 2011). The students constructed their own knowledge as they engaged in this process. The teacher provides guidance, an invisible thread, to help the students construct their own solutions. “The teacher does not provide the answers but skillfully guides the students in their knowledge construction by providing the activities in which the knowledge construction can occur" (Fast & Hankes, 2010, p. 330). Constructivist teaching strategies involve "tapping into the 'fund' of mathematical knowledge students bring to the mathematics classroom" (Ukpokodu, 2011, p. 55).

A constructivist-designed learning environment is equipped with appropriate technology, which may include simulation and communication software, collaborative online learning management systems, and "what-if" scenario-based technology (Ridgeway, Nicholson, & Sean, 2013). This integration of varied technologies helps to prepare students to be successful citizens in a rapidly changing world, where proficiency in technology is essential to participate in the global community (Wilmarth, 2010). In addition, students need to be encouraged to engage in discovery learning and critical thinking by participating in cooperative learning activities that are designed from a constructivist philosophy. "Cooperative learning, hands-on activities, discovery learning, differentiated instruction, technology, distributed practice, critical thinking, and manipulatives are elements that embrace the constructivist educational philosophy" (White-Clark, DiCarlo, & Gilchrist, 2010, p. 42). This learning environment also reflects an andragogical framework: mutual planning, collaboration, formulation of learning objectives, diagnosis of learner needs, and an appropriate curriculum, instruction, and assessment plan (Knowles, Holton, & Swanson, 2005). The interactive, hands-on component is designed to create opportunities that trigger thinking, spark interest, and encourage collaboration.

English as Foreign Language Learners

In the Middle East, most of the preuniversity educational institutions teach subject matter in students' mother tongue, whereas university courses are taught in English (Abdelbasit, 2010). A large percentage of the students at the technical college in Qatar are EFL learners. These students rarely use English outside the classroom. The language of statistics is difficult for EFL learners because many of the words used in statistics are also used in everyday English, but with a different meaning (Leavy et al., 2013; Kaplan, Fisher, & Rogness, 2009). There are added difficulties such as experiencing culture-related problems, not understanding lectures, and resorting to memorization due to lack of understanding (Abdelbasit, 2010; Lesser, Wagler, Esquinca, & Valenzuela, 2013).

It was important to incorporate opportunities for the students to relate their learning to their everyday experiences. Everyday experiences were important resources employed in the cognitive process of making sense of mathematical problems (Domínguez, 2011). Cultural differences coupled with language differences challenged EFL learners to understand the statistical challenges.

In a study by Webster and Hazari (2009), four main strategies were considered by the majority of teachers to be effective in helping EFL learners to acquire language: (a) visual cues, (b) opportunities for practicing skills, (c) use of real props and hands-on materials, and (d) multisensory approaches. To integrate the strategies into a content course requires the use of multimedia, enhancement of students' thinking skills, and student-centered instruction (Watson, 2004). Project work, especially group work that focuses on cross-cultural differences, can help to build confidence and understanding among EFL students (Abdelbasit, 2010; Harumi, 2011). The hands-on interactive component in this study was designed to enable students to work collaboratively on research problems of specific interest to Qatari students.

Importance of Statistics Education

One of the inherent contributions of my study is that it reinforces the importance of statistical literacy, reasoning, and thought for postsecondary students in Qatar. Statistics help people learn from the past and influence the future by understanding and performing scientific collection, analysis, and interpretation. Statistics are essential in creating and understanding evaluation and assessment, including constructing and reforming standards. A conceptual understanding of statistics is required to understand and participate in research (Herreid, 2010). Wilks, mathematician and statistician, paraphrased a quote from a presidential address given by H.G. Wells in 1951, to illustrate the importance of conceptual understanding of statistics: “Statistic thinking will one day be as necessary for efficient citizenship as the ability to read and write” (David & Morrison, 2006, p. 46). Making sense of information and applying previous knowledge are predictors of future success in solving multistep, nonroutine problems (Jakubowski, 2013).

To express the imperative for the State of Qatar’s investment in postsecondary education, the State included in its mission statement for the year 2030 high-quality education, accessible for lifelong learning designed to equip the citizens to meet the needs of the nation. This commitment was addressed in the Qatar National Vision 2030 (2008). To show the State’s commitment to research and its importance in a knowledge-based society, 2% of the gross national product was earmarked for research (QNRF, 2014).

Ward (2013) found that among undergraduates in varied disciplines, conceptual understanding of statistics and statistical methods was essential for success in the workforce. For Qatar to be a knowledge-based society with an emphasis on research, it is essential that its citizens are statistically literate in order to navigate the information-laden global society (Peters, 2011). Statistical literacy, reasoning, and thinking are necessary to make sense of information in the current era of big data.

Student Development

In order to facilitate student engagement in a constructivist learning environment, the curriculum must include learning opportunities that are indicative of statistics usage in the 21st century (Watson & Chance, 2012). These should involve creativity and visual thinking, problem solving, communication, and collaboration. An excellent example of experiential learning is Clemson University's creative-inquiry project (Creative-Inquiry Program, 2014). In this program, each student is required to participate in a project involving small groups of students and faculty. The group decides on a project and then writes a research paper including data collection and analysis. This promotes active learning, and when students are empowered to choose their own project, they are more likely to choose something of interest to them personally, culturally, and academically.

In addition to experiential learning with culturally based research, a successful student-centered learning environment designed from a constructivist perspective must integrate appropriate technology. In statistics education, the impact of technology is on "how" statistics are taught instead of "what" is taught (Baglin, 2013). The addition of appropriate technologies to this learning environment has resulted in a greater achievement in mathematics for the students compared to the students in the learning environment without technology. “Using technology in school settings where teachers practiced a constructivist approach to teaching showed greater mathematics achievement than using technology in school settings where teachers practiced a traditional approach to teaching” (Li & Ma, 2010, p. 243). Whole-student learning engages the learner in reflection, empowerment, and personal growth inside and outside the classroom (Dahlstedt, Fejes, & Schonning, 2011). As stated in Qatar’s Vision, citizens are required to *apply* knowledge, not just *acquire* it. According to Wiles and Bondi (2010), “learners will need the four As: access, analyze, authenticate and apply” (p. 291). The four As, as described by the Partnership for 21st Century Skills (2011), are the basis of the scientific method and statistics formed the cornerstone of the design of the hands-on interactive component explored in this study.

Education needs to prepare students for knowledge-based jobs using cutting-edge technology. This technology reflects multiple learning styles with individualized learning components and applied 21st century digital and networking tools (Hill & Johnston, 2010). Progressive institutions strive to offer experiences that encourage the four 21st-century skills: communication, collaboration, creativity, and innovation. Simulation allows for project-based assessments that encourage the development of these skills. In a study at the University of North Georgia, Bailey, Spence, and Sinn (2013) found through discovery projects that students learned statistics better by actively engaging in multiple tasks required in statistical inquiry. Advances in technologies allowed for pictorial forms of teaching to complement verbal forms. Other research (Arnold et al., 2011) suggested that understanding was enhanced by the addition of visual representations that generated mental images (Arnold et al., 2011). These new technologies alter communication, collaboration, and conceptualization, allowing students to link multiple representations that promote understanding. For students to be competitive in the global community, they need to engage in mathematical activities that are intellectually stimulating, representing multidisciplinary content and cultural contexts (English, 2011).

Conceptual Understanding in Statistics

Conceptual understanding, as defined by Kilpatrick (2001), entails "comprehension of mathematical concepts, operations, and relations" (p. 426). For example, if students were to discover the concepts addressed in descriptive statistics, the instructor would have the students perform data-collecting activities to help them discover relationships and develop understanding of data, charts, and tables (Mandrin et al., 2009). Students require experiences that build conceptual background knowledge and develop their critical thinking skills (Jones, Jones, & Vermette, 2011; Petal & Newberry, 2010). In addition, involving students in guided-discovery learning allows them to be active in their cognitive development (Foreman, 2011). Of equal importance are experiences designed to develop the learner's ability to see the interconnectedness of concepts. The idea of creating experiences to invisibly guide students' learning, referred to as *hypothetical learning trajectories* (HLTs), was first proposed by Simon in 1995. He envisioned teachers as action researchers. The key components of HLTs are "learning goals, predicted growth paths in a specific domain, and aligned activities" (Dolor, 2013; Wright, 2014;). This is accomplished through instructional tasks or activities that promote progression of thinking. There is close interdependency between the activity and the learning process (Daro, Mosher, & Corcoran, 2011). The learning activities are designed to aid in conceptualization and to guide student learning through well-defined, interrelated tasks (Empson, 2011).

Dynamic visualizations are graphs or charts that have the ability to change. Some visuals may be influenced by a data feed, whereas the user may manipulate others (Cottam, Lumsdaine, & Weaver, 2012). These visualizations encourage students to generate mental images and multiple representations that improve learning (Budgett, Pfannkuch, Regan, & Wild, 2012). Dynamic software can allow students to visualize statistical processes as they develop, encouraging intuitive thinking that creates mental conceptualization knowledge, enhancing students' learning and reasoning without requiring mathematical manipulation. One example of dynamic visualization is a statistical graph created for reasoning and thinking. Such dynamic visualizations require students to engage with the concepts rather than simply perform rote memorization (Arnold et al., 2011). Meaningful practice occurs when students apply what they know to new situations (Budgett et al., 2012). Other resources that have been developed to assist the teaching and learning process include the American Statistical Association's research-based guidelines for teaching statistics (GAISE) and a multidisciplinary project, Institute for Quantitative Education Research Infrastructure (INQUERI ; Zieffler et al., 2008). Research has confirmed that if students collect their own data and understand authentic statistics problems, their ability to understand statistics and make sense of them increases (Dierdorp, Bakker, Eijkelhof, & van Maanen, 2011). Well-designed sequences of activities that incorporate technology support students' conceptual understanding of important statistical ideas because students are engaged in statistical research (Makar & Ben-Zvi, 2011; Pearl et al., 2012).

Implications

This study has significant implications for influencing a change in the teaching methods of first-year statistics courses taught at postsecondary institutions in the GCC. It could provide the Supreme Council on Education, Higher Education with data to determine whether implementing this intervention would benefit higher education students in the GCC. It could initiate major change in delivery methods for other courses in postsecondary education. This study could initiate considerable social change by providing instructors and administrators with a model for intervention that increases conceptual understanding in statistics education. Implications for social change include an improved instructional process to help instructors implement hands-on activities.

Summary

The purpose of this project study was to determine the effect of an interactive component based on adult learning theory, guided-discovery learning theories, learning styles, and EFL best practices on PTC-Q students' conceptual understanding of hypothesis testing. The importance of this research was that it tested whether an intervention in statistics education that had been applied in North America and the United Kingdom had a similar positive effect on the EFL adult learners at a postsecondary institution in Qatar. Because one of the essential characteristics of a 21st-century global citizen is conceptual understanding of statistics and mathematics, the results of this study may have far-reaching effects on statistics education in the Middle East. In addition, the interactive component was a flexible design allowing for seamless transferability to other cultures and a variety of options for research activities exclusive to a particular region. Because the students at PTC-Q showed an increase in statistical thinking and reasoning, other interactive components using place-based statistics, collaboration, and problem-solving will be implemented with training manuals for the educators to encourage instructional change. Success in statistics education is important in Qatar, as the state strives to be a knowledge-based society.

Section 2: The Methodology

Introduction

The purpose of this quasi-experimental, quantitative study was to determine the effect of an interactive component on students' conceptual understanding of hypothesis testing. As a career statistics instructor, I have been involved in teaching statistics courses in Qatar for the past 7 years. My ongoing formative assessments have shown that students have little conceptual understanding of the problems but are able to obtain answers by rote methods. To help students to gain a conceptual understanding of statistics, I developed an interactive component to improve students' understanding of hypothesis testing at the conceptual level. My research question was the following: Does participation in an interactive course component in a hypothesis testing unit during a college-level statistics course increase conceptual understanding of hypothesis testing as measured by Comprehensive Assessment of Outcomes in Statistics (CAOS)? Section 2 contains an explanation of the research design and approach used to answer the research question, the setting and sample, instrumentation and materials, data collection and analysis, and measures to ensure the protection of participants' rights.

Research Design and Approach

The research design that was most effective given the constraints of class and instructor assignments was quasi-experimental. The participants could not be randomly assigned to the class with the interactive component (experimental group) or the class with regular lectures and no interactive component (control group). In other words, because of nonrandom assignment of participants to groups as a result of constraints placed on the study, a quasi-experiment needed to be used (Creswell, 2010). Both classes followed the prescribed course outline and assessments. The experimental group received the hypothesis module of the course with a change in lesson delivery that included hands-on learning components dealing with real quantitative research activities and report writing. The control group was taught with traditional teaching methods, including lectures, notes, practice problems, and assignments from the textbook.

Quasi-experimental design has threats to internal validity such as history, maturation, statistical regression, selection, experimental mortality, testing, instrumentation, and design contamination (Creswell, 2010). Because both groups experienced the same subject matter or developmental process, neither maturation nor history was a threat. Given that the group assignment was randomly assigned and not selected by previous performance, and because there was no prerequisite for this course, statistical regression and selection were not a threat. The hypothesis-testing module occurred after the drop date for the students. This reduced experimental mortality to a nonissue (Lodico, Spaulding, & Voegtle, 2010).

Threats to external validity included particular program features. Both groups were following the prescribed course and assessments in the Project Information Retrieval System (PIRS) outline for 2014. Because all of the participants were in their second year at PTC-Q, the settings were the same. In addition, demographics and range of ability were similar for the majority of the students.

Setting and Sample

The community college offered eight sections of the statistics course every semester with a maximum of 18 students per class. The students profiled to take statistics during the semester were assigned to a section by the college registrar based on their timetable. Students did not choose their section. However, the instructor for the control group and another instructor for the experimental group taught the six classes selected for this research. Purposive sampling was used. Power, the probability that a test finds a difference, given that a difference exists, was 0.8. Assuming a moderate to large effect size required a sample size of approximately 40 students in the experimental group and 40 students in the control group (Triola, 2012).

Selection of Participants

The participants were students participating in four purposefully selected statistics classes that were taught by two instructors; each instructor was randomly assigned to one experimental and one control group. One of the two classes was randomly assigned as the experimental group and the other was assigned as the control group for each of the two instructors. The students in each class were from health science, or business. All of the students were EFL students. There were 12 languages spoken in the two schools, with the common language among the students being English. Men and women were represented in both classes. The average age of the students was 19.6 years. The majority of the students came directly from secondary education.

Instrumentation and Material

Data Collection Method

This quasi-experimental pre- and posttest study was carried out during a unit on hypothesis testing. Hypothesis testing was the third module in Math 1670, and it took 3 weeks to cover all of the material. The participants were assessed using the Comprehensive Assessment of Outcomes in Statistics (CAOS), administered by a college representative at the beginning and end of the unit. Student scores on the CAOS were the dependent variable. The independent variable was participation in the hands-on component. The CAOS test is a popular tool used to track the amount of statistics literacy students have developed.

Data Collection Instruments

The ARTIST project (Assessment Resource Tools for Improving Statistical Thinking) is an online resource to help instructors access statistical thinking, reasoning, and literacy. The resources were based on a variety of disciplines and were designed to help faculty assess students' learning and understanding of statistics (delMas, Garfield, Ooms, & Chance, 2007). The ARTIST project developed an instrument to evaluate students' conceptual understanding of statistics. The Comprehensive Assessment of Outcomes in a First Statistics Course (CAOS) is an instrument that measures conceptual understanding of statistics, not just statistics computation. This instrument was studied and revised by a team of statistics educators, advisors, and researchers over a 5-year period and was judged to assess the learning of important statistics concepts. Reliability and validity were previously established for the CAOS (delMas et al., 2008).

The CAOS consisted of 40 multiple-choice questions related to statistical concepts taught in a first-year postsecondary statistics course. All of the students took the CAOS test at the beginning of the module on hypothesis testing and again after the module was completed. The participants' scores were the sum of the number of questions answered correctly out of 40. Separate scores for the pre- and posttest were recorded. In addition, the difference in the scores between the pre- and posttest for each student was recorded. An example of a CAOS test question is given below (Appendix A).

The following situation models the logic of a hypothesis test. An electrician uses an instrument to test whether or not an electrical circuit is defective. The instrument sometimes fails to detect that a circuit is good and working. The null hypothesis is that the circuit is good (not defective). The alternative hypothesis is that the circuit is no good (defective). If the electrician rejects the null hypothesis, which of the following statements is true?

a. The circuit is definitely no good and needs to be repaired.
b. The electrician decides that the circuit is defective, but it could be good.
c. The circuit is definitely good and does not need to be repaired.
d. The circuit is most likely good, but it could be defective.

Reliability and Validity

Testing validity as it relates to the CAOS test refers to how well the questions on the test actually measure what they are intended to measure. In addition, validity is reflected in the extent to which the conclusions drawn from the scores are supported (Lodico et al., 2010). Eighteen experts rated the CAOS test to ensure that the test measured important basic learning outcomes. Ninety-four percent of the raters agreed that the CAOS test was a valid measure of important learning outcomes in a first course in statistics (delMas et al., 2006). Reliability refers to students' performance consistency over time. The CAOS study for reliability was based on 10,287 students. The consistency of the test produced a coefficient alpha of 0.77 (ARTIST project, delMas et al., 2006).

Data Collection and Data Analysis

Research question: How did the experimental group (those participating in an interactive component in the hypothesis testing unit of a statistics course) differ from the control group who did not have access to the interactive component in terms of scores on the Comprehensive Assessment of Outcomes in Statistics (CAOS) for college students at Premier Technical College-Qatar?

Null hypothesis: There was no difference in the CAOS scores between students who learned with the interactive component on hypothesis testing and the students who did not.

Alternative hypothesis: There was a difference in CAOS scores between students who learned with the interactive component on hypothesis testing and the students who did not.

The appropriate statistical analysis for this quasi-experimental study was ANCOVA using the post CAOS score as the dependent variable, course placement (hands-on versus no hands-on component) as the independent variable, and the pretest score on CAOS as the covariate. Inclusion of the covariate, ANCOVA statistically controlled for the differences in the pretest scores of the two groups. These data met all of the assumptions required to perform an ANCOVA, including dependent and covariate measured on a continuous scale, the independent variable having two categorical groups, and the groups being mutually exclusive (Laerd Statistics, 2015). The scores on the module test were the dependent variable, and course placement was the independent variable in testing whether there was a significant difference in the scores received in the module test by each group. In addition, a descriptive statistics table was included, containing mean, median, mode, range, and standard deviation to describe the data, as well as side-by-side box plots to compare the data and identify any outliers (Triola, 2012).

Assumptions, Limitations, Scope and Delimitations

The scope of this study was limited to students enrolled in four sections of Math 1670 (Statistics) at one technical college. Any characteristic that limits the scope of research is a delimitation of a study (Creswell, 2003). This study was limited to the Math 1670 students enrolled in January 2015.

Assumptions. The following assumptions were made:

1. Students would transfer the learning from the interactive learning activities to the module test.
2. The faculty involved in the study followed the course curriculum as defined in PIRS for the winter semester of 2015.
3. The sample was representative of the population of students enrolled in Math 1670 at PCT-Q in the winter semester of 2015.

Limitations. The limitations of the study were characteristics of either the methodology or the design that set parameters on the application or interpretation of the results (Creswell, 2003).

1. Because the study involved postsecondary students, variables existed that were not measured, such as race, secondary education, and sponsorship.
2. Another limitation was that PTC-Q was a singular postsecondary educational institution because it was a coeducational Canadian-based institution. Therefore, the results of this research are not transferable to dissimilar institutions in the Gulf region. For example, Qatar University holds all classes in Arabic.
3. The topics chosen to make connections between statistics and everyday life in

Qatar would not be important to students in other countries.

Measures of Protection

The test marks from the CAOS test are being held in a secure database to be destroyed on May 15, 2018. The secure database was designed and is maintained by the Research and Development Department at PTC-Q. The research project was assigned a special filing cabinet to which only I have a key. After 3 years, I will shred the files. Informed consent was not required from the students completing the CAOS test. However, the participants' identities were protected through the use of code names. Ethical considerations for this study included a Research Ethics Review application submitted to the Institutional Review Board (IRB) of Walden University and to PCT-Q. This research examined changing traditional statistics learning environments to improve students' conceptual understanding of statistics and research, in particular hypothesis testing and descriptive statistics. The materials used in both groups were validated by standards from PIRS and the textbook issued by PTC-Q.

Presentation and Analysis of Data

The research in this study was conducted for the purpose of explaining the effects of different approaches to teaching statistics on conceptual understanding while using statistical techniques to isolate variance in the CAOS results attributed to differences in the two groups prior to the intervention. The analysis procedure employed was analysis of covariance (ANCOVA).

Testing ANCOVA Assumptions

Assumption of Normality

ANCOVA required that the dependent variable was normally distributed in the population for any specific value of the covariate and for any one level of a factor (the independent variable). Standardized residuals for the interventions and for the overall model were normally distributed as assessed by the Shapiro-Wilk test. The significance value was greater than .05, indicating that the data were normal.

Table 1

Shapiro-Wilk Test for Normality

	Statistic	Degrees of freedom	Significance
CAOS	.949	42	.060

Assumption of Linearity

The covariate was linearly related to the dependent variable for both groups, as visually displayed in the scatter plot below (Figure 2). The graph shows the two groups having a linear relationship between the covariate and the dependent variable.

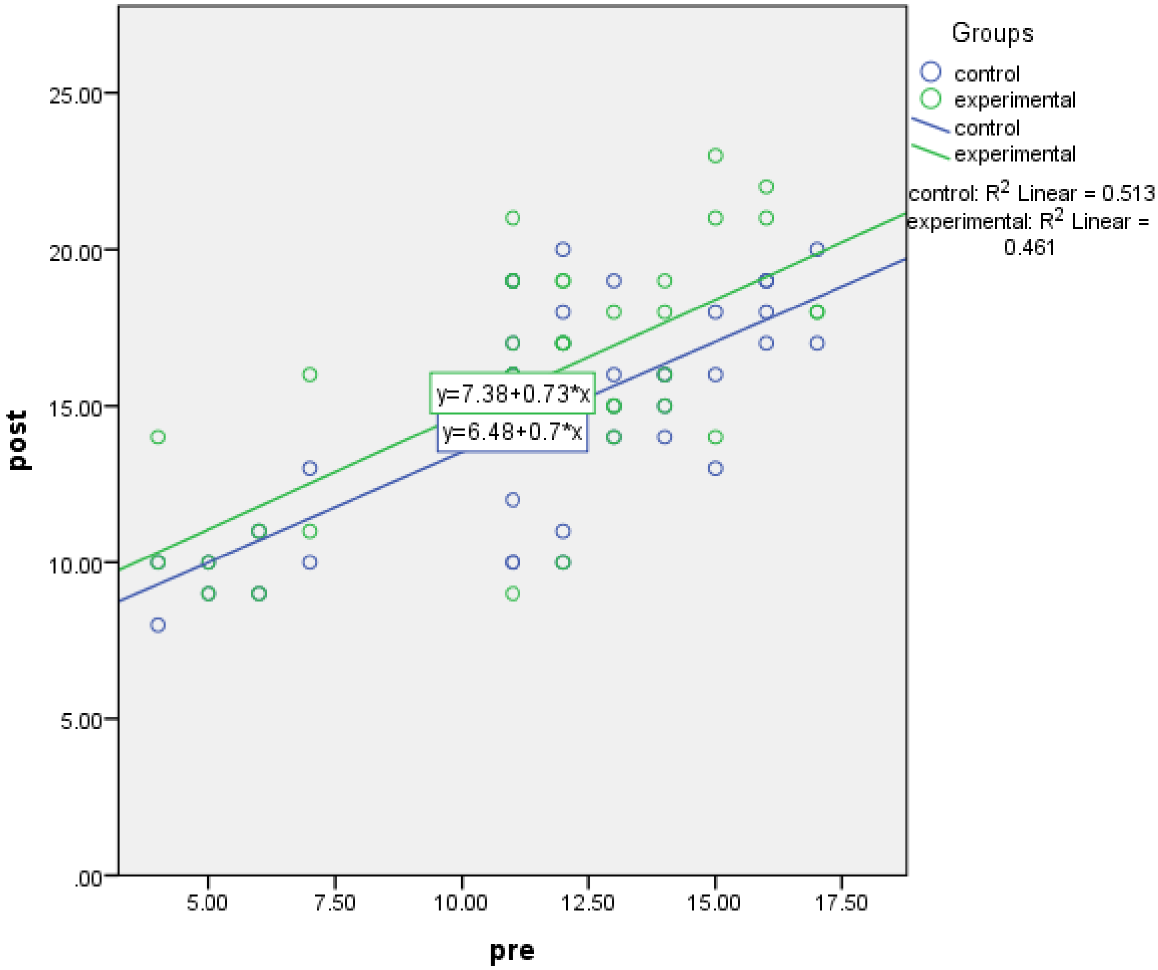

Figure 2. Scatter graph comparing the covariate (pretest scores) to the posttest scores for each of the groups.

Assumption of Homogeneity of Regression Slopes

The purpose of this assumption was to guarantee there was no interaction between the covariate, the pretest, and the independent variable, for the two groups. This was shown visibly in the graph (Figure 2) above, since the slopes were parallel (slope=0.7). To test for homogeneity of regression slopes, an ANCOVA test was run to test for a significant interaction term between the covariate and the independent variable (group*pre). Such an interaction effect would indicate that the slopes of the regression lines were not parallel. In this case, the ANCOVA assumption of homogeneity of regression slopes would be violated (Laerd Statistics, 2015). Statistically, there was homogeneity of regression slopes as the interaction term was not statistically significant $F(1,78)=.006$, $p=.930$.

Table 2

Tests of Between Subjects Effects

Source	Type III sum of squares	*df*	Mean square	*F*	Significance
Groups*Pre	.049	1	.049	.006	.930

Homogeneity of Variances and Equality of Covariance

ANCOVA required that the variances of the posttest scores between the control and experimental groups be nonsignificantly different. Levene's test of homogeneity, $p=.289$ was used to verify that the null hypothesis (no difference in the error variance between the two groups) was accepted. These results are shown in Table 3 below.

Table 3

Levene's Test of Equality of Error Variances

Dependent variable	*F*	*df*1	*df*2	Significance
Post	1.141	1	80	.289

Assumption of Homoscedasticity

The assumption was that the variance of the residuals was equal for all predicted values. To test for this assumption, a scatterplot, Figure 2, showed the standardized residuals against the predicted values. The graph showed that the residuals are randomly distributed and have approximately the same variance for all values of the predicted scores. There was homoscedasticity as assessed by visual inspection of the scatter plot (Figure 3). Therefore the assumption of homoscedasticity was not violated.

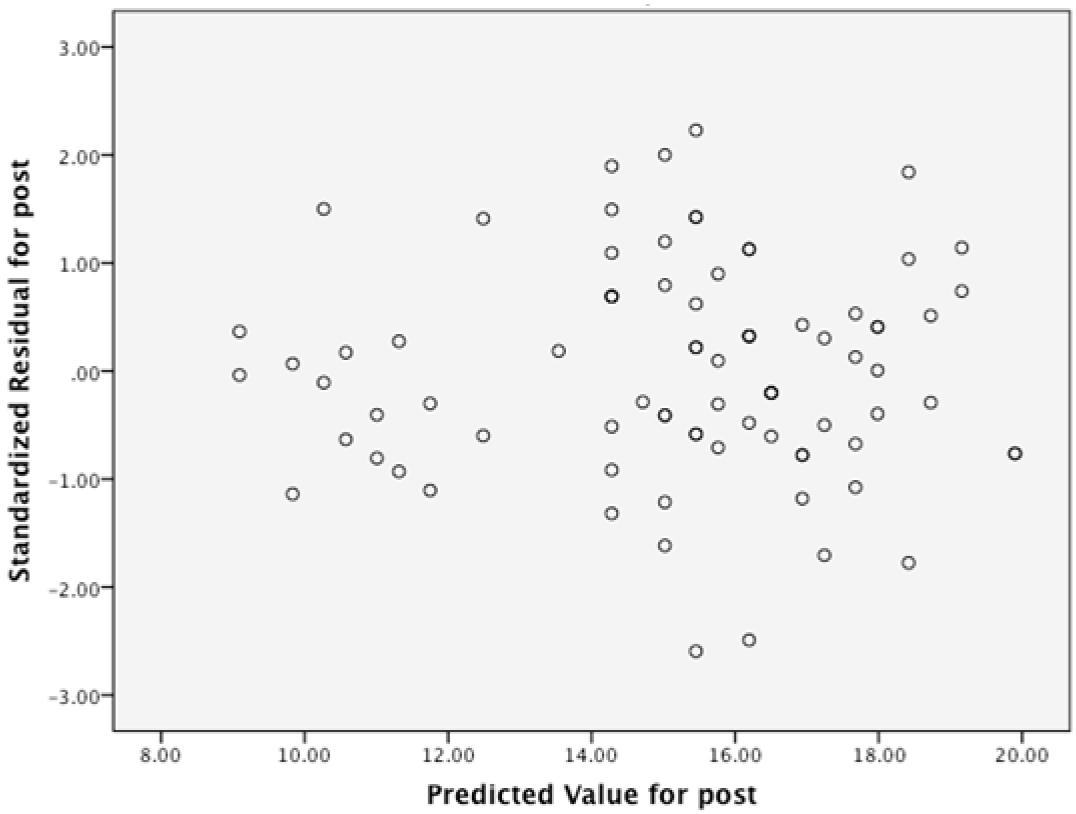

Figure 3. Scatter graph comparing the Predicted Value to the Standardized Residual for post scores.

Outliers

There are no outliers in the data, as assessed by no cases with standardized residuals greater than ±3 standard deviations (Figure 2).

ANCOVA Adjustment

After adjustment for pretest scores, shown in Table 4, there was a statistically significant difference in the post CAOS test scores between the control and experimental groups $F(1,79)=4.559$, $p<.05$, partial $\eta^2 = .055$.

Table 4

Univariate Tests

	Sum squares	*df*	Mean square	*F*	Sig	Partial η^2
Contrast	28.222	1	28.222	4.559	.036	.055
Error	489.048	79	6.190			

Note. Dependent variable: Post.

Descriptive Statistics

The descriptive statistics table (Table 5) presents the descriptive statistics (mean, standard deviation and number of participants) on the dependent variable, posttest, for the two levels. This table also included the adjustments made by the covariate analysis. This adjustment was used to equalize the differences on the posttest results that may have been due to the difference in the ability of the groups at the start.

Table 5

Adjusted and Unadjusted Intervention Means and Variability for Posttest with Pretest as a Covariate

		Unadjusted			Adjusted	
	Number	Mean	Mean %	Std deviation	Mean	Std error
Control	42	14.74	36.85%	3.41	14.66	.384
Experimental	40	15.75	39.38%	3.77	15.83	.393

Limitations of Research Findings

It was important to understand the limitations of ANCOVA because the estimates made by ANCOVA may be unrealistic. In this research, the difference in the original and adjusted scores were very small. In addition, the classes using the intervention were randomly assigned. It is important to guarantee that in assigning a variable to be a covariate, that the variable itself maybe essential and should not be held constant (Miller & Chapman, 2001). The data in this research met all the assumptions required to perform an ANCOVA test. The importance of these assumptions, if overlooked, would result in mistakes related to interaction terms in linear models (Engqvist, 2005).

Summary of Findings

An Analysis of Covariates (ANCOVA) was run to determine the effect of implementing an interactive component in the hypothesis testing unit of a first year statistics course compared to the control group without the intervention after controlling for differences in the two groups. All assumptions for ANCOVA, linear relationship between pre- and posttest, homogeneity of regression slopes, residuals for both groups normally distributed, homoscedasticity and homogeneity of variances, no outliers, were satisfied.

The purpose of using the pretest scores as a covariate in ANCOVA is to reduce the error variance and eliminate systematic variance. Since in this study the groups were intact and not randomly assigned, the main purpose of ANCOVA was to adjust the posttest means for differences among groups on the pretest. ANCOVA provides a way of statistically controlling the linear effect of variables not in the study. ANOCOVA removed the covariate, pretest score, by using regression to partial out the effects of the covariate (Green, & Salkind, 2003). The ANCOVA F test evaluated whether the population means on the dependent variable, adjusted for differences on the covariate, differed across the two groups. To bring about the desired control, ANCOVA adjusted each group's mean on the dependent variable using a complicated formula. The degree to which a group's mean score was adjusted depended on how far away that group stood on the mean of the pre-test score. Using this adjustment, ANCOVA provided the best estimates of how the groups would have performed if they had all possessed statistically equivalent means on the pretest. The adjusted means are shown in Table 5. After adjustment for the difference in pretest scores, there was a statistically significant difference in posttest scores between the experimental group and the control group, $F(1,79)=4.559$, $p<.05$, partial $\eta^2= .055$. Since there were two groups, partial η^2 is the same as η^2, indicating that 5.5% of the variance in the scores was due to the independent variable, group assignment. This is considered a medium effect with alpha=.05, $\eta^2= .055$, and a sample size of 80. The power of this test, the probability of detecting differences between the groups when such a difference exists is .80. The null hypothesis is rejected.

There is a difference in CAOS scores between students who learned with the interactive component on hypothesis testing and the students who did not.

Conclusion

The purpose of this study was to determine the effectiveness of a pilot interactive component, designed following western guidelines, in improving students' conceptual understanding of hypothesis testing. For this study, statistical tests were conducted to determine whether participation in the interactive intervention caused students to increase conceptual understanding demonstrated by the results of the CAOS scores. After postscores were adjusted using covariate techniques, the interactive component group performed significantly higher than students in the control group (Laerd Statistics, 2015). This study suggests that students demonstrated greater conceptual understanding of the hypothesis testing unit in first year statistics when engaged in the interactive unit. Although student achievement in the intervention group was statistically higher, the overall grades in the CAOS test for both groups were below the mean score of students taking CAOS in the United States, calculated by the professors at the University of Minnesota. The trend of the mean was around 50% correct on the CAOS test from 2005 to 2013 (delMas, 2014).

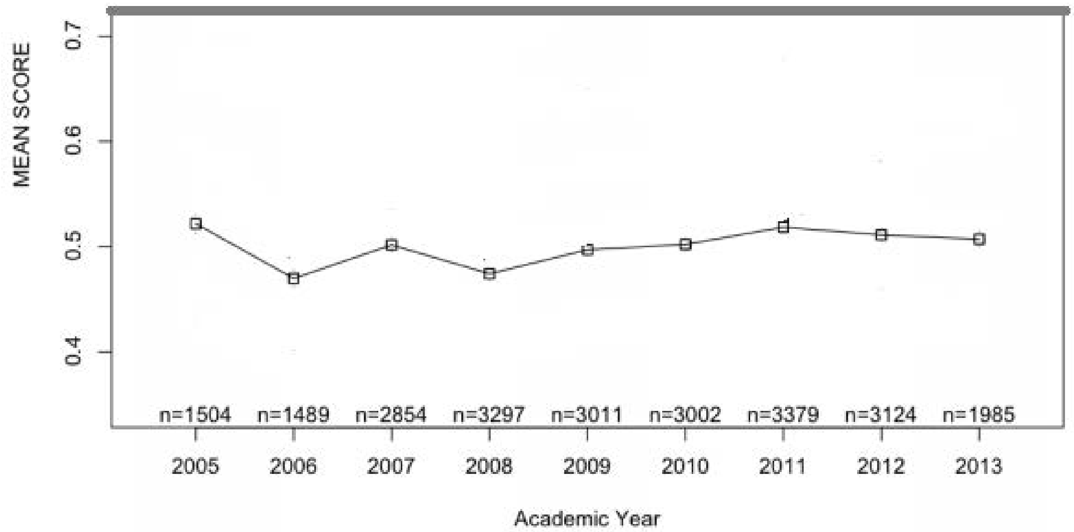

Figure 4. Mean scores on the CAOS test in the United States.

Discussion

As an instructor of statistics at PTC-Qatar, I had the opportunity to review the results from the unit test on hypothesis testing administered to all students enrolled in Math 1670. Since the college has 100% English as foreign language learners, there is an emphasis on level appropriate learning and assessment material. PTC-Q scans their tests and assignments using the Flesch-Kincaid Grade Level Readability Test to obtain an acceptable reading and comprehension level for EFL learners. The readability consensus from the 7 popular reading formulas for the CAOS test was grade 8 level with reading level fairly difficult to read. This was above the grade level of comprehension required to register at the college.

The results from the hypothesis unit test, regulated for level appropriate English, are shown in Table 6, below, revealing a significant difference in the mean of the experimental group (65.26±18.54) compared to the control group (53.44±30.72), a statistically significant difference of 11.82, $t(80)=-2.09$, $p=.04$.

Table 6

Comparing Unit Test Administered by College With Reading Level Appropriateness

	Control group	Experimental group
Mean	53.44	65.26
Variance	943.70	343.93
Observations	42	40
t statistic	-2.09	
p-value	.04	

The results of the CAOS test reinforced the need to create material that was appropriate for the audience. The cultural differences coupled with language differences challenged the EFL learners at the college to understand the material in the CAOS test. However, when the 4 main strategies for effective learning for EFL learners were applied in the intervention, the students performed better. To integrate the strategies into the complete statistics course required the use of multimedia, enhancement of students' thinking skills and student-centered instruction. In addition, project work as seen in this unit, especially group work dealing with cross cultural differences, helped improve understanding among the EFL students. The hands-on interactive component that was designed for students to work collaboratively on researching problems of interest to Qatari students is a model for teaching statistics to EFL adult learners. To extend the results of this study, a reconceptualizing workshop for statistics instructors at PCT-Qatar was recommended.

Section 3: The Project

Introduction

The problem described in this study was whether a hands-on, concept-based learning intervention implemented in a college-level statistics course improved the conceptual understanding of EFL learners who were accustomed to attending lectures in more traditional classrooms. Results of the study indicated that the hands-on, concept-based intervention was effective in raising students’ conceptual understanding of statistics concepts. The basis of the intervention was constructivist theory, and adult learning theory and EFL best practices were implemented wherever appropriate. The project design of a reconceptualization workshop for statistics instructors was based on the same theories as the intervention, providing a learner-centered environment experience designed using an appreciative inquiry framework. To allow instructors to implement the intervention and obtain similar effects for their students, a series of professional development workshops serve as the genre for this project.

The workshop will provide the opportunity for instructors to re-experience learning activities that build on their conceptual background knowledge and develop critical thinking skills based on statistical educational guidelines (Jones, Jones, & Vermette, 2011). This section presents an overview of the goals and a description of the project, including the rationale. A thorough literature review addresses professional development, adult learners, guided learning, and effective use of technologies based on these frameworks. This section also includes a discussion of implications for social change, strategies for implementation, and an evaluation plan.

Description and Goals

The reconceptualizing workshop, Instructors as Adult Learners, will be designed to reflect principles of adult learning and of EFL learning. The aims of the workshop are to help educators (a) reflect on their practice in statistics education, (b) develop collaborative relationships, and (c) construct professional knowledge through appreciative inquiry guidelines. Appreciative inquiry (AI) is a way to find the positive core of the participants, providing a source of energy for both personal and organizational change. This search and change are achieved through the five generic processes of AI: definition, discovery, dream, design, and destiny. The changes in content delivery, classroom activities, and integration of technology within a collaborative learning environment suggested by the results of this study require instructors, especially statistics instructors, to rethink their beliefs about teaching and practices in the classroom.

Because all students at PTC-Q are EFL learners, it is important for instructors to understand the needs of EFL adult learners. To meet these needs, the instructors will participate in workshops that illustrate the interdependency between the activity and the learning process with student-centered instruction (Watson, 2004). They need to experience the design of learning activities that aid conceptualization through well-defined, interrelated tasks. The instructors need to work with the interactive component and learn how to accomplish conceptual understanding through these instructional tasks and activities. The aim of the workshop is to promote the design of components that are based on adult learning theory, guided discovery learning theories, learning styles, and EFL best practices. In addition, instructors will have the opportunity to experiment, investigate, discuss, reflect, and collaborate with other instructors to change their practice and experience how their students engage in learning.

Rationale

When educators understand that learning is the construction of knowledge, they think differently about curriculum, instruction, and assessment and the integration of technology (Casquero, Portillo, Ovelar, Benito, & Romor, 2010). However, creating learning experiences that encourage students to (a) be engaged; (b) focus on the critical thinking process; and (c) explore, discover, discuss, and collaborate in context challenges is new for many instructors (Rice Doran, 2014; Ridgeway et al., 2013). In response to this challenge, the purpose of the reconceptualizing workshop (Instructors as Adult Learners) is to encourage faculty to examine their current practice and take advantage of an opportunity to learn new instructional strategies linked to effective practice.

The purpose of the quasi-experimental, quantitative study was to determine the effect of an interactive component on students' conceptual understanding of hypothesis testing. The results were significant, suggesting that learning environments that reflect adult learning theories and EFL learning theories are conducive to conceptual understanding of hypothesis testing. I propose that, by reproducing a learning environment suited for adult learners and EFL learners as described in the study, a reconceptualizing workshop will provide meaningful learning experiences for instructors in the context of their own classrooms. Using the innovations in this study as a basis, the workshop will offer a myriad of practical applications to enable participants to practice, collaborate, and apply what they have learned about the innovation so that they may become transformational educators with a new frame of reference for teaching adult learners and EFL learners. I believe that this project will have a positive effect on the learning environment at PTC-Qatar.

Review of the Literature

A thorough search of the literature was conducted using electronic education databases including Education Research Complete, ERIC, and Sage Education. Search terms included *teacher education*, *mathematics reconceptualizing, statistics education professional development, collaborative professional learning, adult learning theory, English as a foreign language theory, educational technology,* and *learning trajectories.* The articles cited were peer reviewed and, where possible, were published within the past 5 years.

In this literature review, I examine current theory and practice in adult learning theories, appreciative inquiry frameworks and applications, statistics and mathematics reconceptualizing, educational technologies, and EFL theories and best practices. Adult learning theories, EFL best practices, and educational technologies were the framework for designing the intervention in the study. A professional development workshop that reconceptualizes the learning process for mathematics instructors, especially those teaching statistics, is appropriate in helping to solve the problem of a high failure rate in a college-level statistics course offered in the Middle East. The framework for the workshop is appreciative inquiry, with adult learning theories, place-based learning concepts, learning trajectories, and EFL practices being addressed in each module.

Constructivism is the theoretical framework of the intervention. The learning environment for the workshop uses the same framework because it is considered to be the empowering framework for teacher education (Abdal-Haqq, 1998). In this workshop, the underlying criteria for activities are that learning occurs when the learners, math instructors, have the chance to interact with the content and collaborate with other teachers as well as reference the broader context in which the student learns (Bieler, 2012). Research on professional development for educators emphasizes that learner engagement and reflective practices are the most effective, relevant, and comprehensive (Casteel & Ballantyne, 2010; Cochran-Smith, 2011). The workshop environment draws on theories of andragogy, providing a learning experience that is learner centered, experiential, collaborative, and job relevant (Knowles et al., 2005). Learner engagement and peer interaction are important factors for EFL learners (Davis & Berland, 2013). Although the workshop will not be specialized for EFL instructors, it will examine issues of linguistics as well as cultural and cognitive diversity as they relate to the activities (Rice Doran, 2010).

In this environment, instructors' own learning experiences will be created by the instructors themselves as they interact with content and technology, mediated through the cultural experiences of the learner and the instructor, and will be responsible for the developmental needs of adult learners and EFL learners. In addition, participants will be encouraged to share their attitudes regarding the use of technology and its effects on learning. During the workshop, instructors will be exposed to multicultural education coupled with appropriate technology. If greater exposure to technology designed for multicultural classrooms is achieved, teachers and multicultural students will benefit from its use, and the classroom atmosphere will be enhanced academically (Williams, 2012). All of the perspectives that were reflected in the intervention will also be reflected in the reconceptualization workshop.

Appreciative Inquiry

The principles of appreciative inquiry (AI) best meld with the aims of the workshop. Appreciative inquiry, a social-constructivist framework, had its beginnings as a defined philosophy in the mid-eighties (Cooperinder & Srivastva, 1987). AI is described as a theory for approaching change by encouraging participants to uncover creative images that reside in their positive core. Proust (cited in Bushe & Kassam, 2005) explained that the real voyage of discovery consists not in seeking new landscapes, but in having new eyes. Through the appreciative inquiry framework, participants are encouraged to engage in re-imaging through dialogue (Thibodeau, 2011). Implementing the appreciative inquiry cycle: define (the topic), discovery (identify and appreciate the best of “what is”), dream (images of the future emerge from grounded examples), design (creating the ideal), and destiny (ongoing creation of an “appreciative learning culture”), enable the rediscovery of one’s true voice in an educator’s professional practice (Giles & Kung, 2010).

Appreciative inquiry framework is based on creating an environment that invites the voices of all people who are relevant to engage in the conversation (Whitney, Trosten-Bloom, & Rader, 2010). At this first workshop, EFL instructors and graduates will be guests during the first cycle to add their experiences in the classroom. Through the AI cycle, all participants will engage in a holistic workshop on diversity by reflecting on personal feelings and experiences related to cultural differences between themselves and their students (Alston-Mills, 2011). The opportunity for the instructors to work in an inclusive environment will give them the experience necessary to add diversity and inclusion to their classroom. The participants will be encouraged to listen to everyone’s perspectives, examining both divergent and convergent ideas, including self-exploration (Assudani & Kilbourne, 2015).

Inclusion involves recognizing and appreciating diversity especially in students of different cultural settings to work together productively and, when possible, use the differences for the common good (Ferdman, 2010). Since all students at PTC-Q are English as foreign language (EFL) students with approximately 12 mother tongues and the faculty are Canadian, inclusion is essential for students to succeed. Introducing place-based learning activities that are designed to give exposure to multiple perspectives is one method of facilitating inclusion (Blecker, & Boates, 2010). Providing students with opportunities for repeated practice and different ways of presenting information helps negotiate language barriers (Van Driel & Berry, 2012). The advantages identified in the research intervention matched the advantages identified in inquiry-based learning. The workshop will include small group collaboration, hands-on activities, opportunities to construct statistical understanding, and multiple paths to correct solutions, all based on authentic tasks (Davis & Berland., 2013).

Participants will be cognizant of these requirements and will reflect on how these factors may affect the success of the diverse student population (Porchea, Allen, Robbins, & Phelps, 2010).

Constructivism

The principal theory used to frame the content development of this workshop is constructivism. In the workshop, instructors will use their own understanding of statistics to make sense of students' understanding, thus constructing a theoretical model to relate and infer students' understanding (Wilson, Lee, & Hollegrands, 2011). Although constructivism usually emphasizes constructing one's own knowledge from past experiences, this use of model building will help educators to create models of students' thinking or conceptual understanding of statistics. The literature identifies four processes teachers use to help build the model: (a) describing, (b) comparing, (c) inferring, and (d) restructuring (Wilson, Sztajn, & Edgington, 2013). The first three focus on students' work while the fourth, restructuring, is the process by which the teachers change their own thinking about student learning. One of the aims of the workshop is to assist teachers in building models of students' thinking by helping them reveal particular behaviors and language used by the students.

Discussion of the Project

The project consists of a three-day workshop using an appreciative inquiry framework to (a) create a learning environment for statistics and mathematics instructors to re-conceptualize learning and teaching statistics, and (b) support the implementation of a change to delivery, classroom practices, and assessment of statistics education. College instructors will have the opportunity to create learning trajectories, to learn new technologies, and to collaborate while engaging in self-reflection. Collaborative professional learning will take place in an educational community that reflects the learning environment created for the study during the implementation of the hands-on statistics module. A hospitable space, both psychological and physical, is important to engage participants in constructive learning, and to impact team engagement and creative outputs (Assudani et al., 2015). The workshop will have a safe learning climate that enhances participants' autonomy and involvement in the learning process, and provides authentic learning experiences to encourage learning (Naude, van den Bergh, & Kruger, 2014). The workshop aims to build a strong classroom community by including pairwork, small group work and whole workshop activities from day one to provide opportunities for the participants to form connections. In addition, the first cycle in AI encourages the participants to share their background and culture. Throughout the workshop, participants are encouraged to be active learners by doing, making, writing and designing, creating, and solving. This process aids in motivating the participants and in understanding how to create a safe learning environment for adult learners.

The initial stage of the process is to define or create the inquiry process by clarifying the aims of the workshop, based on the results of the research. In the discovery cycle, the participants examine past good practices. Experts agree that one of the most effective forms of professional development is the sharing of good practice (Killion & Roy, 2009; Theoharis & Causton-Theoharis, 2010). In addition, adult learning theory teaches that engaging learners in this manner allows for the relevancy of the learning to be illustrated, thus increasing the likelihood of success. The workshop facilitator will draw on a multiplicity of voices, present or not, to ensure that best practices outside the scope of the participants but within the scope of the students will be heard (Alston-Mills, 2012). During sessions on the first day, participants will be asked to work in groups of four or five. By allowing the participants to create their own teams, maximum comfort level is achieved.

The dream cycle pushes instructors to think beyond the traditional boundaries. To aid instructors to think beyond their own boundaries, a diversity of learning opportunities from EFL best practices, including integrating educational technology, will be included.

Since the instructors are all English speaking, mathematics instructors, their experience with EFL best practices are limited.

In the design cycle, the facilitator will have the opportunity to demonstrate the usefulness and applicability of the statistics intervention, which in turn will promote the active participation of learners (Masuda, Ebersole, & Barrett, 2013). It has been observed that a myriad of collaborative learning experiences ensure the active engagement of learners in the professional development program .For example, the experiences include small group discussions, expert presentations mentorship and individual, face-to-face instruction (Masuda et al., 2013).

The typical fundamentals of professional development include content and pedagogy, data analysis, and individualized coaching support. Workshops based on the appreciative inquiry framework, in contrast, emphasize reflections that promote teachers' personal conceptual connections with the new initiative or practice (Aronson, 2010). In this last section, the destiny cycle, success is based on teachers' motivation and reflection. The reconceptualizing workshop is designed to have instructors apply new professional learning in the classroom and encourage positive change (Carter, 2009).

Potential Resources and Existing Supports

In the 2008 report, "The Road not Traveled – Education in the Middle East and North Africa (MENA)," the World Bank stated that approximately 20% of university students in MENA are enrolled in mathematics, science, and engineering (World Bank, 2008). In order to address the pillars in the Qatar National Vision 2030 (Qatar National Vision, 2010), Qatar wishes to move towards a knowledge-based society, which requires mathematics, science and research. To increase students' interest and success in these areas, students need to be motivated, experience hands-on activities related to their culture, and engage in authentic research. The Supreme Education Council and National Research Council are potential supporters of this initiative as they realize the requirement of high quality research as a prerequisite to the attainment of the Qatari goals. The General Secretariat of Development Planning, GSDP, 2012, in identifying a growing gap between graduate readiness and expectations of industry and research, have begun incentives for college and university graduates entering science and research fields. Some of the incentives include attractive salaries and allowances, and opportunities for training and professional development. This professional development workshop could be used to train graduates in the field of research, filling any identified gap in knowledge. A commitment from students and faculty, with the support of the administration is needed to achieve an increase in the conceptualization of statistics.

Potential Barriers

A change in the learning environment that shifts from lecture based to collaboratively based learning requires an evolution in both educators' practices and institutional focus (Cullen, Kullman, & Wild, 2013). It may be difficult to build time into the schedules of the instructors for ongoing professional development required to complete the visions created in the workshop. Assessment of the students will be both formative and summative to reflect the new approach. This change will require a revamping of the course, tools, and assessment by College of the North Atlantic advisory board in Newfoundland, Canada. The success of the workshop rests on trusting in the affirmative inquiry process. I believe this barrier has been addressed by engaging a trained facilitator in appreciative inquiry, in both the design and implementation of the workshop. In addition, I joined the appreciative inquiry learning community.

Role and Responsibility of Students and Others

The responsibility for the development and implementation of the project is the student/researcher. I created the activities in the intervention used in the study and I will facilitate creation of all the training materials and activities related to conceptualizing statistics. To maintain the principles of appreciative inquiry, the workshop will be led by a colleague at PTC-Q trained as an AI facilitator.

It will be the responsibility of the participants to engage in all aspects of the AI cycles. In addition, participation and collaboration are necessary in developing and sharing hands-on activities, creating units that are place-based, and integrating appropriate technology used in the research. College administrators are required to promote and facilitate collaborative self-reflective learning opportunities for statistics instructors.

Project Evaluation

The goal of the re conceptualizing workshop is to introduce faculty to a different approach to teaching statistics and to equip the participants with self-reflective, collaborative professional development through the AI cycle. To measure the effectiveness, an outcome-based evaluation will be used to find evidence of the usefulness of the workshop. I propose using the interventions designed in the workshop as one of the artifacts to be examined for success of the project. Also, built into the workshop is formative evaluation in the form of the facilitator conducting an informal walk-around in classrooms of the participants during the following semester to assess levels of implementation. The third level of assessment would be the grades received from the students who were in the new learning environments. The purpose of the assessment is twofold. First, the assessment will determine the effectiveness of the interventions in statistics courses taught at PTC-Q. Second, the assessment will determine whether the workshop changed faculty members' approach to teaching and whether the interventions were implemented. I recommend a brief questionnaire at the end of each day of the workshop for teacher participants to give feedback.

Implications, Including Social Change

Qatar is a growing scientific research community, motivated by scientific research initiatives sponsored by Qatar National Research Fund (QNRF). Among these initiatives is the Undergraduate Research Experience Program (UREP) designed to improve education through research at the postsecondary level. The program is intended to enhance collaboration between instructors and students, to give students the opportunity to gain experience in inquiry-based learning and problem solving, to engage in research, and interact with a wide range of stakeholders. Since QNRF is funding research projects at many levels, and the Supreme Education Council is promoting tools such as "Learning by Doing" and "Hands-on" research activities, it is essential that Qatari nationals have conceptual understanding of statistics and research. This project is intended to engage instructors in aligning practical activities with curriculum standards.

The results of the workshop could be noteworthy for the PTC-Q community. By increasing the number of graduates, the problem of unqualified researchers would be met. From the students' perspective and their sponsor, increasing students' conceptual knowledge in statistics would lower the failure rate and lead to an earlier graduation date.

In addition, more funding from grants proposed by students and faculty involved in research would be successful and produce more qualified student researchers. Faculty members could increase the effectiveness of delivering the statistics course with place-based examples and hands-on activities that reflect the skills required to be a successful researcher. This would be a major benefit to Qatar, as graduates would be able to fill the shortage of trained researchers.

Conclusion

The preceding section described the goals, supporting literature, implementation, and implications for social change of the project in this study. The proposed project that resulted from the study findings is a three-day workshop, a conceptualization workshop for statistics instructors to support the implementation of a change to delivery, classroom practices and assessment of statistics education. The framework for the workshop is appreciative inquiry with adult learning theories, place-based learning concepts, learning trajectories, and EFL practices being discussed in each module. The aim of the workshop is to create a learning community amongst the statistics instructors to help solve the problem of a high failure rate in a college statistics course offered in the Middle East.

This resource is based on the same theories as the intervention, providing a learner-centered environment experience that supports reflective, collaborative professional learning. One objective is to promote social change through the development of a curriculum that mirrors the work and skills required to be a successful researcher in Qatar. From the study results it is clear that the addition of hands-on activities, based on sound pedagogical theories in adult learning and EFL learning, increase conceptual understanding of statistics. Full implementation of a complete new curriculum with summative and formative assessment may increase the participation of students and faculty in the research grants available.

Reflections on the project study: The conclusions will be discussed in the following section. Recommendations for future research, including the possible weaknesses and strength of the project, will be discussed. Section Four concludes with a discussion of the possible social impact of the project.

Section 4: Reflections and Conclusions

The study tested whether or not a hands-on interactive component introduced in the hypothesis module of a statistics course improved students' conceptual understanding of statistics concepts. This reflects findings from North America and the United Kingdom, where teaching initiatives that encourage the active participation of students have been found to reduce failure rates (Freeman, 2014). This section includes reflection on the proposed workshop that resulted from my research study. The literature review examined EFL theories, learning styles, integration of technology, place-based examples, and hands-on activities in statistics education. This section includes the project's strengths and limitations, as well as a discussion of the researcher as a scholar, practitioner, and project developer. The conclusion includes a discussion of implications, applications, and directions for future research.

Project Strengths

The research study indicated that creating a learning environment based on EFL best practices and adult learning theories improved students' conceptual understanding of descriptive and inferential statistics (Abdelbasit, 2010). The change in the learning environment requires professional development training for instructors (Batanero et al., 2010). Research suggests that professional development, learning communities, and collaboration are effective means of improving instructors' effectiveness (Devlin-Scherer & Sardone, 2013; Linder, Post, & Calabrese, 2012). Because this project is designed to improve professional learning through collaboration while melding theory and practice, instructors will have the opportunity to experience the reconceptualization of statistical concepts in a learning environment that reflects the student learning environment. Such an experience could increase instructors' ability to develop and integrate a curriculum that mirrors the work and skills required to be a successful researcher. In turn, with this approach to learning and interacting with statistics, students will gain the experience necessary to work as researchers in the State of Qatar.

The foremost strength of the workshop is the creation of a learning community among statistics instructors and the positive results that may occur. Through professional sharing and collaboration, instructors could facilitate the implementation of new learning activities. This may result in the increased participation of students and faculty in research grants, a higher pass rate in statistics, and a learning environment showcased as a model for other subject areas in the Middle East.

Recommendations for Remediation of Limitations

The main limitation of this project is that participation is not mandatory and there is no certification for completing the course. Implementing the shift from lecture to collaboratively based delivery that is envisioned in the workshop would require ongoing collaboration and professional development for instructors. There needs to be a time commitment from the educators and the institution, as well as understanding of EFL learners from the advisory board in Newfoundland, Canada.

My recommendation for the remediation of these limitations is a pilot project that reflects the changes initiated by the intervention in the study. After one semester, a roundtable discussion with all of the stakeholders could be convened to evaluate the success of the project and the requirements necessary to implement the change. This would include a comprehensive professional development cycle for all participants.

Scholarship

Scholarship refers to high-level thinking and the skills needed to analyze theories and data. Engaged scholarship includes high-level thinking and academic service learning but extends to community-based research. The concepts of scholar practitioner and community-based research have been interwoven and reflected throughout my studies at Walden. Educational change is brought about by well-written, well-documented scientifically based research. To this end, I have learned how to search for literature, to be selective, to appreciate the content in peer-reviewed articles, to discriminate, and to remain focused on the main issue. I have also learned to trust in the process of affirmative inquiry, giving participants the opportunity to be agents of change.

For me, scholarship involves promoting collaboration, developing academic knowledge, and stimulating critical thinking for educators and students, with the goal of creating and maintaining learning communities that promote positive social change. By designing a workshop, I have learned the importance of having a vision and then sharing that vision in a clear, well-organized event. The scholarship of integration, as defined by Boyer (1990), involves applying theory and connections to a study across disciplines. I have learned that teaching and research should be well integrated to guarantee expanding the knowledge base and attaining high-level thinking skills. In tandem with integration, Boyer’s definition of scholarship of application refers to using the knowledge or results to help society solve problems. By definition, the results of the study demonstrate the scholarship of integration, creating learning activities to enhance the statistics curriculum at PTC-Q. The scholarship of application is the result of the project, which aims to create new learning environments in Middle Eastern and North African postsecondary institutions where the majority of students are adult EFL learners. Using these definitions of scholarship, the knowledge gained from the study is intended to encourage others to participate in the workshop, interact with the learning activities, and thus promote social change in the delivery and assessment of statistics education at the postsecondary level.

Project Development and Evaluation

The project study culminated in the development of a three day workshop designed for the participants to experience a learning environment where they interact with content and technology while developing an understanding of how the cultural differences and developmental needs of both adult learners and EFL learners affect learning. Developing this workshop required committing long hours and hard work, thinking and rethinking ideas, experimenting with different approaches, and studying various workshop theories. After an exhaustive search and numerous interviews, I concluded that the appreciative inquiry approach best suited the clientele and the subject matter and was the best vehicle to promote change. From the onset of developing a learning community in my classroom, I have tried to share my experiences with other instructors. I realize now that change requires an organized approach with ample space for discussion. Trust in the process was the most difficult part of the cycle.

During project development, I learned that I needed to be precise and focused. I needed to keep the needs of the participants, such as the learners, in the forefront. I had to be sure that I was not so biased in my approach that the atmosphere was not conducive to sharing and debating. I was careful to consider the theories of adult learners and EFL learners by including a variety of learning experiences that take into account diverse learning styles.

Leadership and Change

I have learned that educational leadership involves taking responsibility for what takes place. It requires flexibility to appreciate other points of view coupled with a communication style that is inclusive across multiple cultures. In other words, a variety of strategies are required to gain the confidence of others and to share knowledge.

I have learned from appreciative inquiry facilitator training that it is easier to encourage collaboration through respectful communication and active inquiry. I believe that as a leader, I am a catalyst for change and must find appropriate avenues to achieve this goal. I also realize that good leaders recognize challenges and develop systematic plans to remedy problems. I believe that I am a leader who takes responsibility and believes in collective need and positive change.

Analysis of Self as Scholar, Practitioner, and Project Developer

As a scholar, I have learned the importance of technology, of research, and of reflection. I have increased my skill in the areas of research, analysis, and application. The project has required me to be precise, scholarly, focused, and reflective. Through self-discovery, I have come to understand my educational style and the educational style of others. Through reflection, I have strived to include activities and examples that may be more in tune with the learner. I have experienced the value of collaboration in academic environments and have tried to extend the experience to other areas of my life.

I have been an educational practitioner for many years. However, most of that developmental time was spent in isolation. The project study has reinforced my understanding of the importance of collaboration and the community of learners. I realize that I am most alive when I am studying. I believe that during my doctoral journey, I have become a better educator, employee, and learner. I realize that as a facilitator of learning, I have the means to encourage, excite, and create lifelong learners. In all of this, I am appreciative of the power of research. I realize that change requires hard work, being respectful of participants, and being vigilant and aware of positive learning environments.

As a project developer, I was outside of my comfort zone. I enjoy developing learning materials, integrating technologies, creating hands-on activities for my students but sharing my approach to teaching with others was a challenge. By studying the research on appreciative inquiry and understanding the basic principles of collaboration and respect, I was able to begin my work as a project developer. I understand that education and training programs are tailored to the audience with the underlying principles of adult education always at the forefront. In this area, I have room to grow.

The Project's Potential Impact on Social Change

The project will impact social change if it empowers educators to collaborate, implement technology, and reflect on effective EFL learner and adult learner theories. This work is important, as Qatar strives to be a knowledge society. It is vital that this approach to teaching statistics expands to include research projects as a requirement for all university graduates in Qatar. By creating an opportunity for math and statistics educators to meet and share ideas, instructors would have access to the best practice methods in math teaching, skills expected of educators, and the latest advances and drastic changes in teaching math knowledge and skills at postsecondary institutions, especially in MENA.

The project's impact on social change would include using the strategies developed in this study to assist EFL learners in MENA to develop conceptual understanding in statistics and in other areas. By meeting the needs of the learner and being cognizant of different cultures, instructors are able to transform their students into active learners. In addition, real world scenarios improve students' problem solving and critical thinking skills (Fini, 2010). The workshop strength is in sharing experiences and ideas through professional development, instructor collaboration, and technology to ensure an effective integrated learning environment.

Implications, Applications, and Directions for Future Research

The research tested the effects of an intervention in one module of the statistics course. On a larger scale, the strategies developed in this study could also achieve increased conceptual understanding in other modules and be designed to be transferable to other courses. One of the important implications of developing new material that changes the learning environment is the responsibility of introducing the concept to its target audience. In order to accomplish this, I will be a speaker at educational conferences here in MENA and in North America. I will also work with the Supreme Council of Education, Qatar to develop a pilot project and discuss funding for further research involving approaches to teaching EFL learners at the postsecondary level.

Future research could include collaboration with the developers of CAOS, University of Minnesota, to address conceptual understanding of statistics for students outside of the United States, especially EFL learners. Organizers of professional development workshops could conduct research to assess the extent to which concepts are implemented and teaching techniques applied. Ongoing research in teaching statistics might uncover other strategies to assist in educating EFL learners.

Conclusion

In this section, I reflected on the project, my growth, and my doctoral program journey. I reflected on my growth as an educator and a leader responsible for educating learners and promoting social change. I reflected on myself as a scholar, project developer, and practitioner. I included my thoughts on the qualities of a good leader and the requirements to lead an appreciative inquiry workshop.

The positive results of the study encouraged development of more hands-on activities to aid the conceptual understanding of statistics. The project, a professional development workshop, was designed to encourage instructors to experience learning activities that build on their conceptual background knowledge and develop critical thinking skills based on statistical educational guidelines. These initiatives were expected to bring about collaborative learning environments, to encourage stakeholders to participate, to improve the success rate in first year statistics, and to provide support for statistics instructors.

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Appendix A: Professional Development Curriculum and Materials

Purpose:

This professional development workshop has been developed to familiarize instructors with best practices for teaching statistics to EFL learners and adult learners. The framework for this workshop is affirmative inquiry (AI) to help facilitate collaboration among the instructors, while using past experiences to reflect and create a positive learning environment. Participants will have the opportunity to develop and share successful teaching and learning activities especially in teaching statistics.

Goals:

1. To introduce affirmative inquiry (AI) and help the participants construct professional knowledge through the AI guidelines.
2. To provide the participants with the opportunity to reflect on their teaching and learning skills in statistics education for their own personal growth.
3. To provide the participants with the skills to develop learning artifacts that have been shown to be effective in teaching statistics.
4. To provide the participants with the opportunity to experiment, investigate, discuss, reflect, and collaborate with other instructors.

Learning Outcomes:

Participants will be proficient at designing hands-on components for beginning statistics, creating formative and summative assessments, integrating appropriate technologies, and developing place-based activities that are founded on adult learning theory, guided discovery learning theories, learning styles, and EFL best practices. The learner target of this workshop is the development of a learning environment in statistics that reflects the attributes of the best practices initiated in the AI cycle through the use of collaborative planning and reflection. The results of instructors having the opportunity to experiment, investigate, and discuss will be reflected in a transformed curriculum, assessment, and activities. After completion of this workshop, participants will:

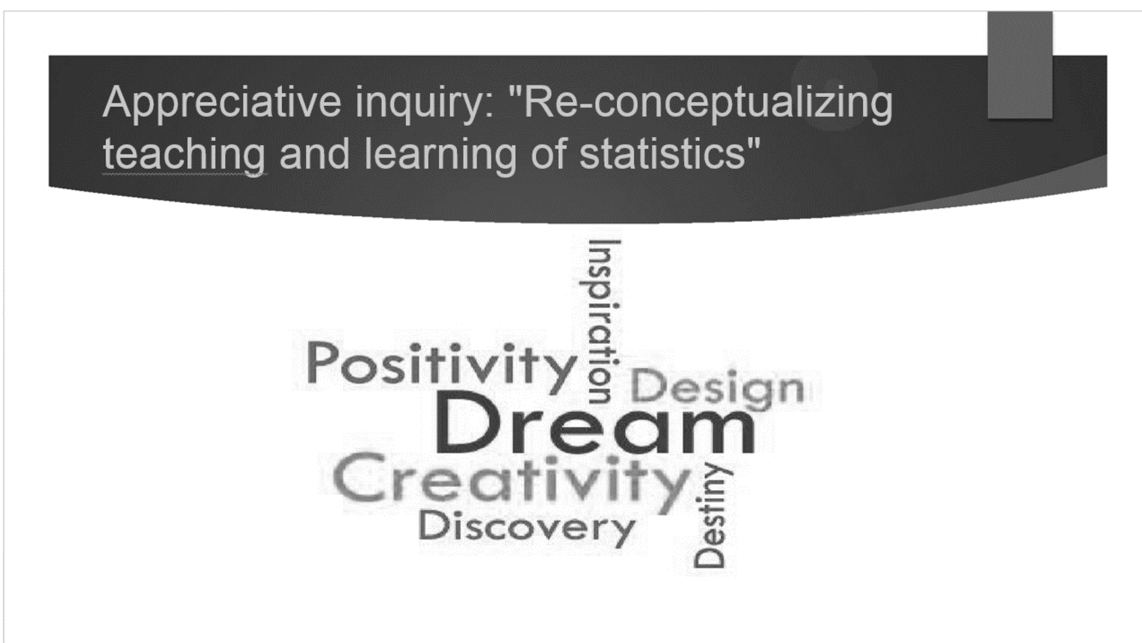
- Be familiar with AI, collaboration, and reflection
- Understand the learning needs of adults and EFL learners
- Create place-based hands-on activities

Intended Audience:

Statistics and mathematics instructors in postsecondary institutions in the Middle East and North Africa (MENA). English as foreign language instructors as guests

Professional Development Power Point

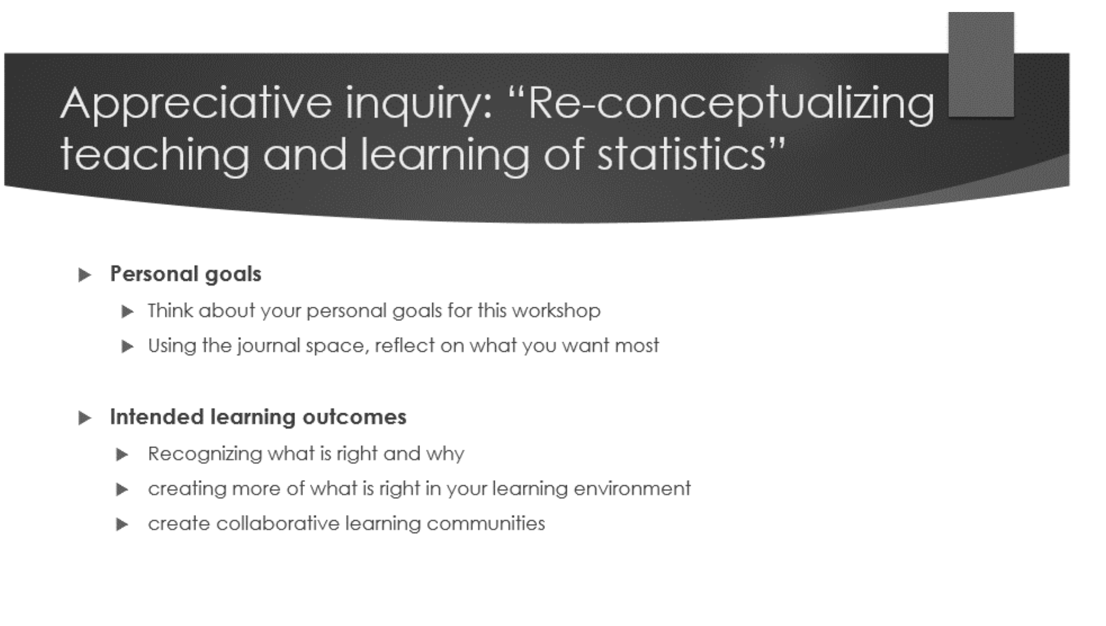
Slide 1



Slide 2

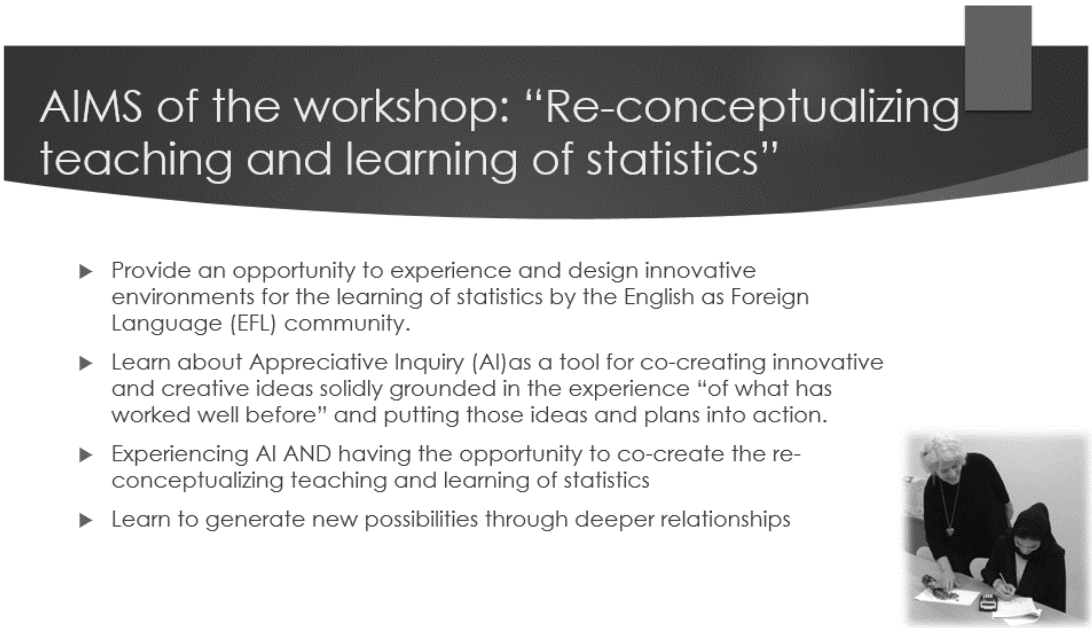

Session Overview
Day 1: Affirmative Inquiry ….Discovery and Dream Cycle
Day 2: Affirmative Inquiry …..Design and Destiny Cycle
Day 3: Resources and Follow up
Daily Schedule
7:30-8:00 Continental Breakfast
Morning Break
Lunch
Afternoon Break
2:00 Session Ends

Slide 3


Appreciative inquiry: "Re-conceptualizing teaching and learning of statistics"
Personal goals
Think about your personal goals for this workshop
Using the journal space, reflect on what you want most
Intended learning outcomes
Recognizing what is right and why
creating more of what is right in your learning environment
create collaborative learning communities

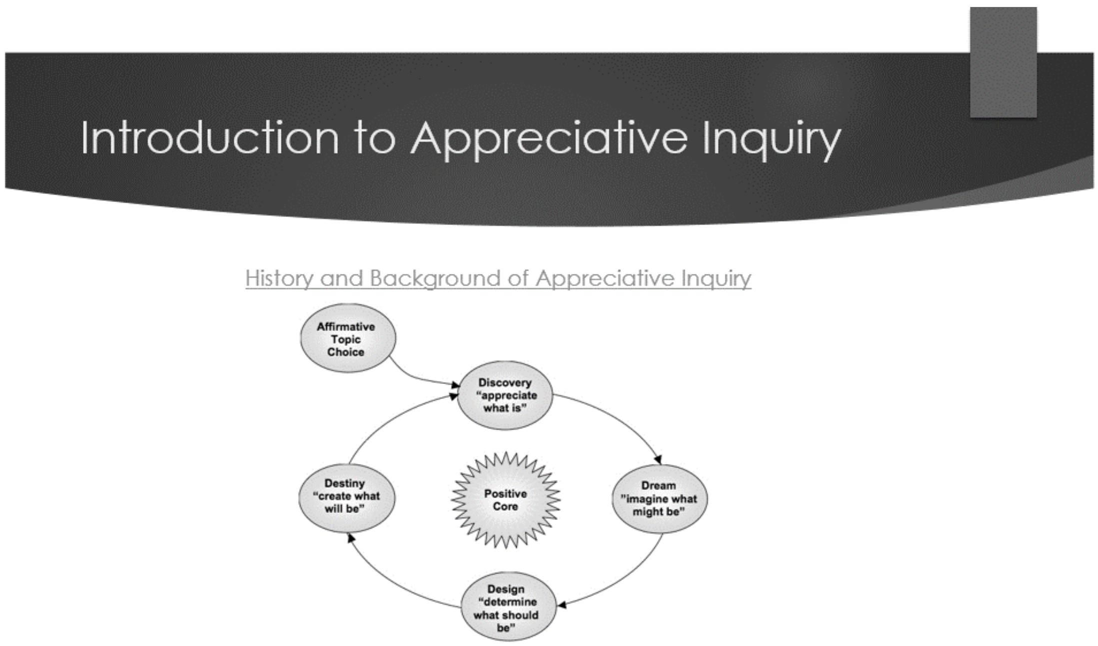
The initial stage of the process is to define, or create the inquiry process by clarifying the aims of the workshop

Slide 4



In the define cycle, it is important that the aims of the workshop are made clear. The facilitators will re-iterate the importance and instruct participants to put the aims in their journal.

Slide 5

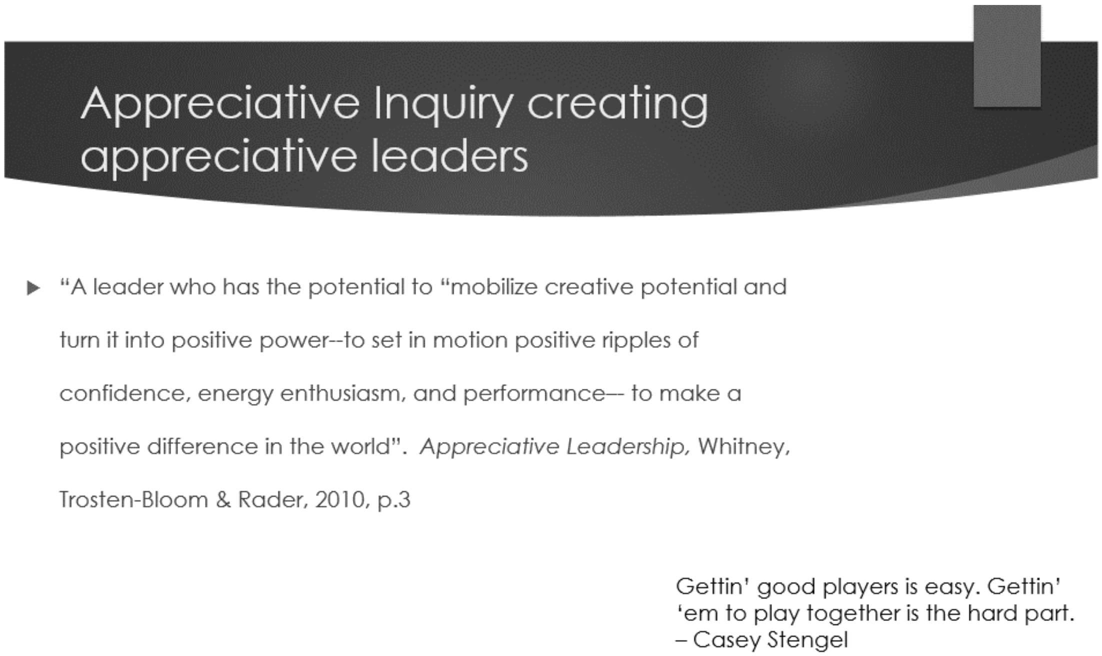


Learning from moments of excellence is the basis of AI. The following slides will elaborate on the history and background of AI and the cycles.

Slide 6

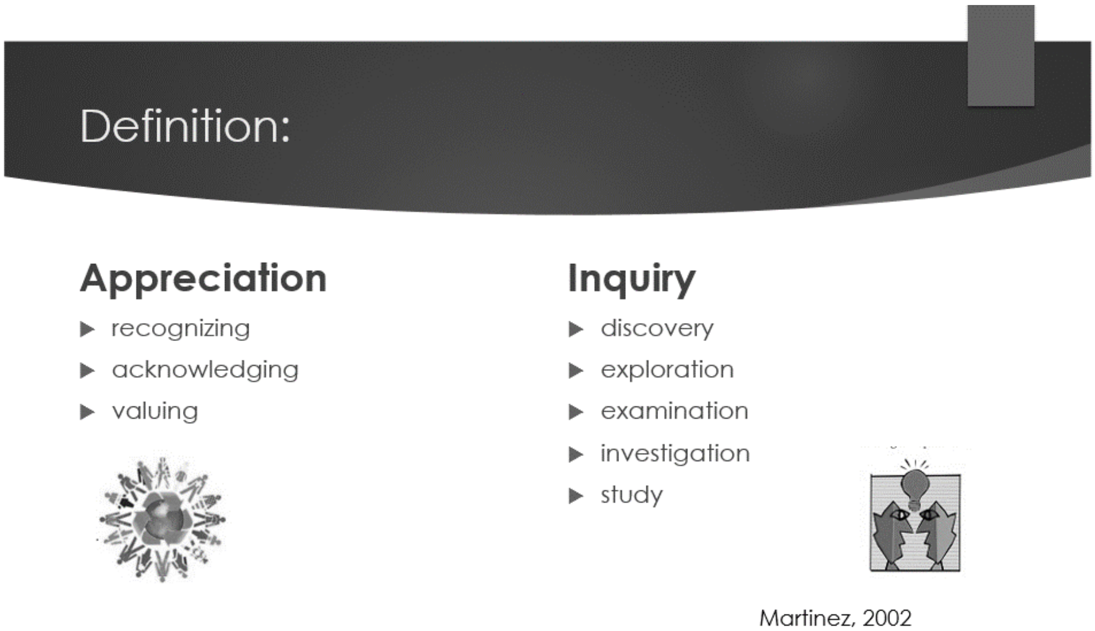
Appreciative Inquiry facilitator will address the philosophy and process. Through widespread inquiry participants perceive the need for change, explore the possibilities and contribute to solutions.

Slide 7



Facilitator will re-establish the role of instructors as leaders and identify how this workshop with appreciative inquiry as its framework will help faculty assume that role.

Slide 8



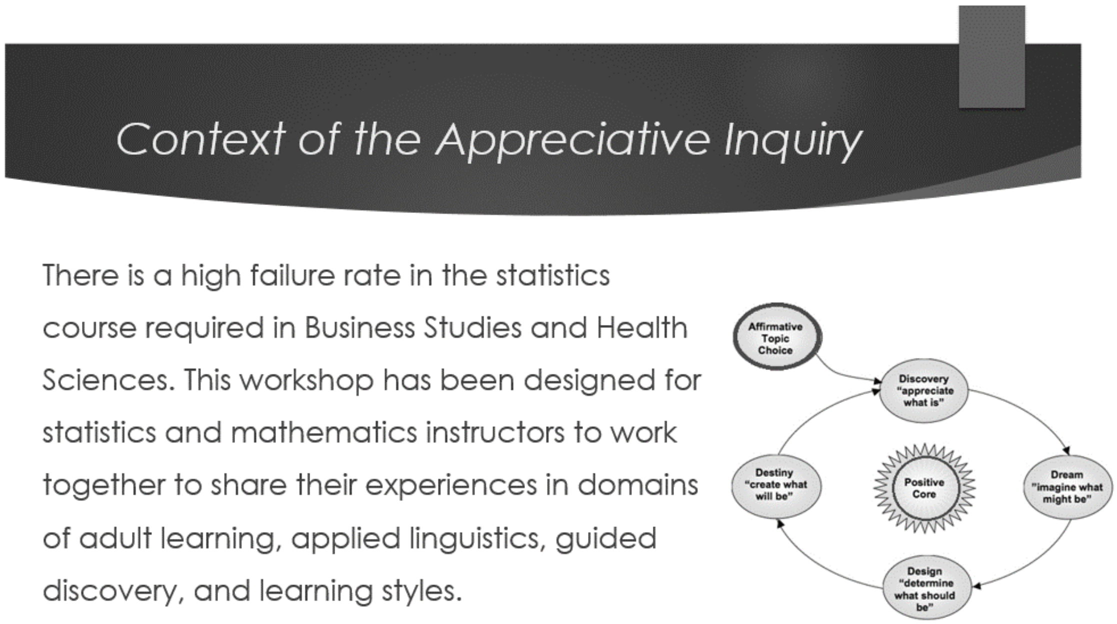
By identifying the dictionary meaning of Appreciation and Inquiry, the meaning of Appreciative Inquiry is illuminated.

Slide 9

The video is important to be sure that all participants are aware and comfortable with the process.

https://www.youtube.com/watch?v=ZwGNZ63hj5k

Slide 10

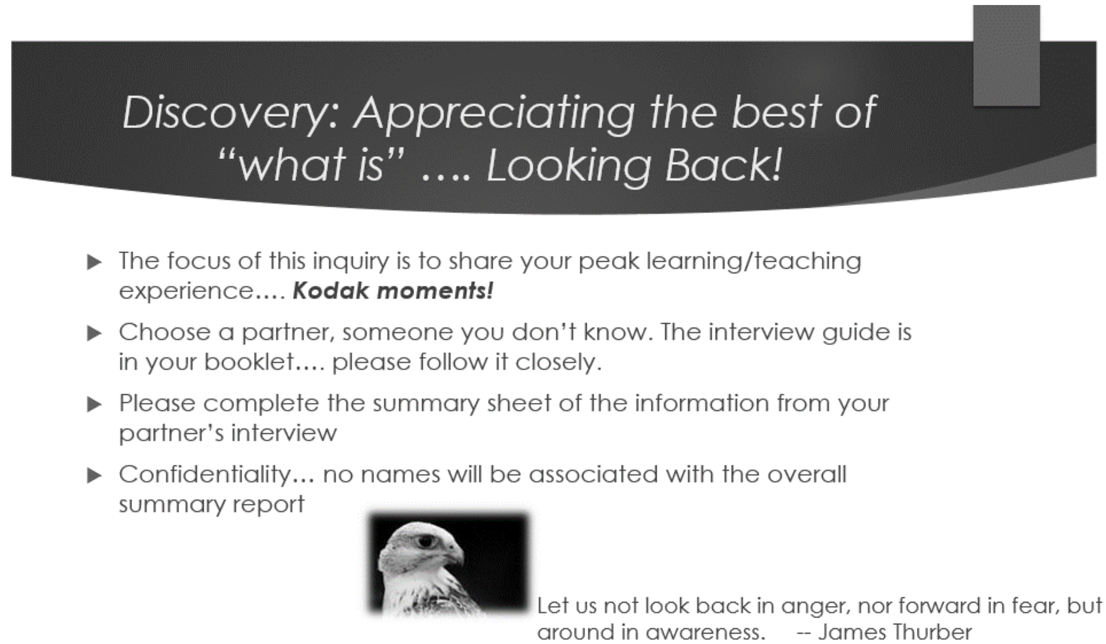


Defining the problem is important. The facilitators will identify the problem, lead a short discussion and field any questions. The problem will be posted throughout the meeting room.

Slide 11

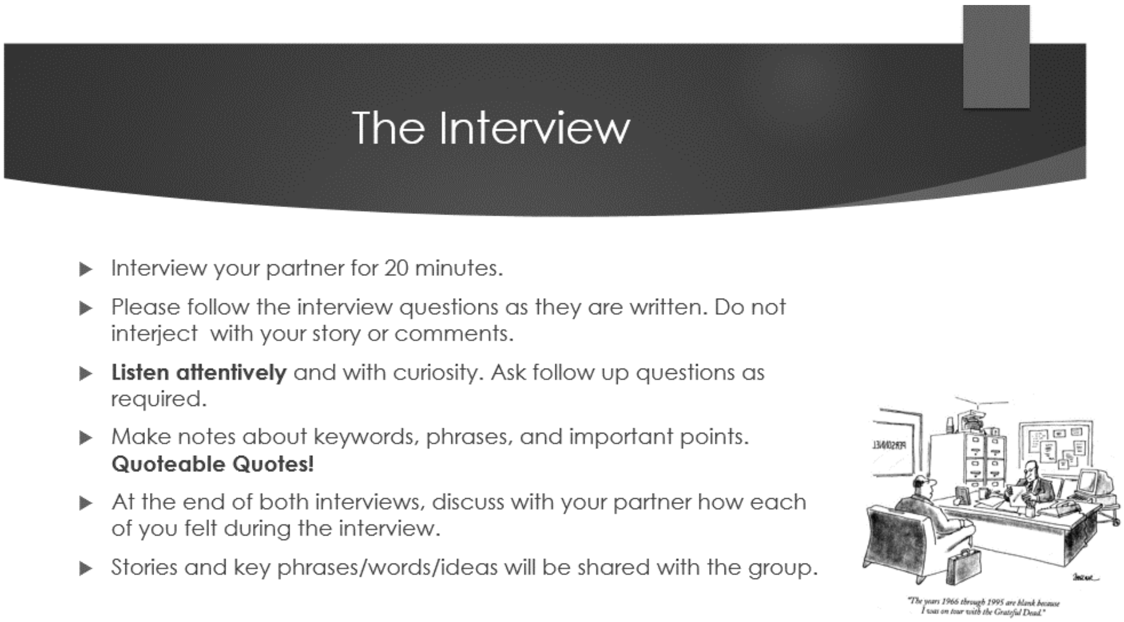
In the discovery cycle the participants focus on past good practices. The task in this cycle is to focus on peak times, seeking to understand unique factors such as leadership, technologies, learning processes, planning methods, learning environments. Experts agree that one of the most effective forms of professional development is the sharing of good practice.). In addition, adult learning theory teaches that engaging learners in this manner allows for the relevancy of the learning to be illustrated, increasing the likelihood of success. The workshop facilitator will draw on a multiplicity of voices, present or not, to ensure best practices outside of the scope of the participants but within the scope of the students will be heard.

Slide 12



Through customized interview guides included in the participant's notebooks, moments of high performance will be identified. Participants are encouraged to let go of negative thoughts and experiences and seek to learn from even small wins. Participants will choose a partner. By allowing the participants to create their own teams, maximum comfort level is achieved.

Slide 13

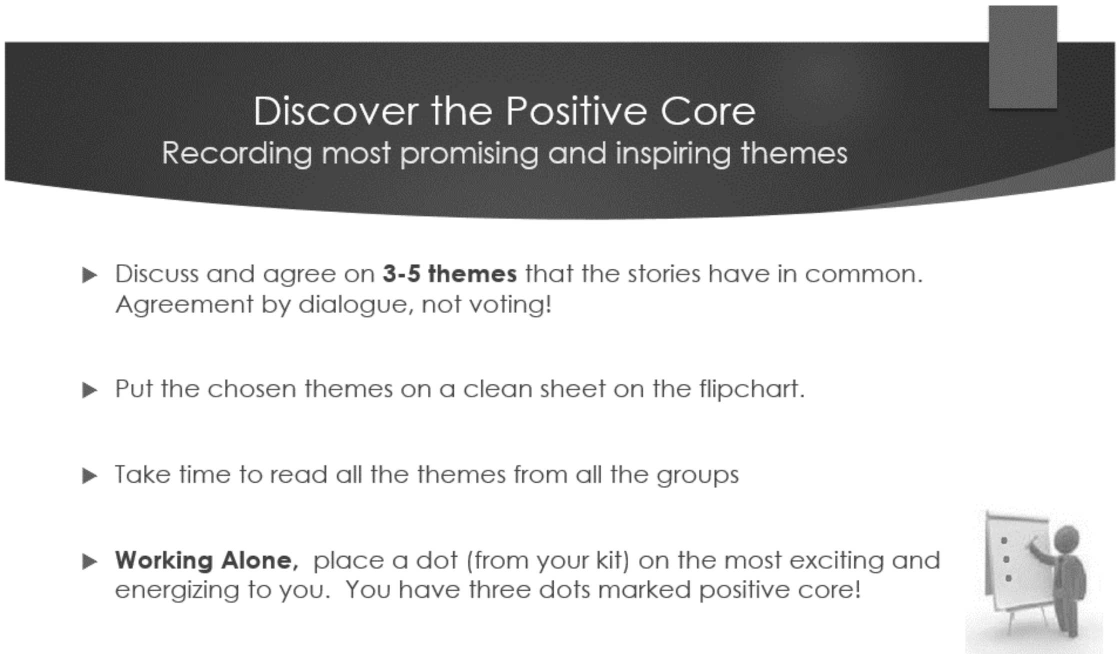


This process will be timed. There will be an hour allotted for the interviews. Emphasize the importance of following the guidelines and keeping notes.

Slide 14

Each group member will share the highlights of the interview with their group. Choose a facilitator and recorder to create a list of high energy themes obtained in the interviews. Remind participants this is a collaborative learning activity.

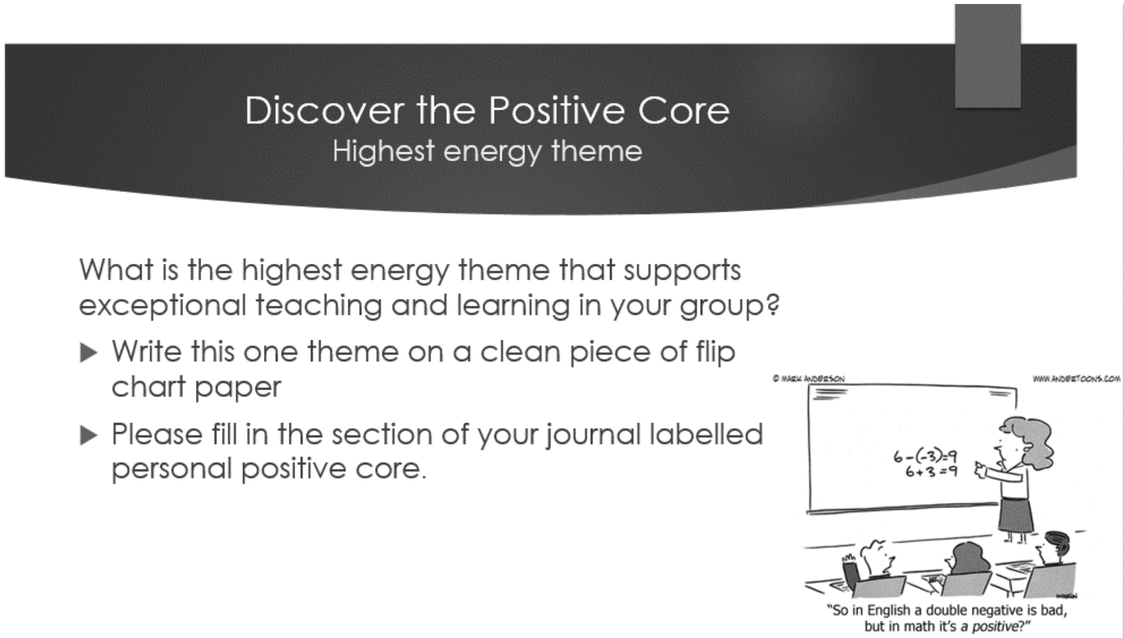
Slide 15



The culmination of the interview is a list of common themes. The key here is collaboration. Use dialogue to create the list. Each group will list their three to five main themes.

During the next half hour and if necessary break time, participants will read all the themes. Important! Working alone identify the most exciting themes for you personally. Record them in your notebook and vote with the sticker dots.

Slide 16



The facilitator will encourage conversation and dialogue, to guide individual vision into a shared vision for the group. The sharing of ideals helps create a positive climate where social bonding flourishes. Remind participants to fill in their personal journals.

Slide 17

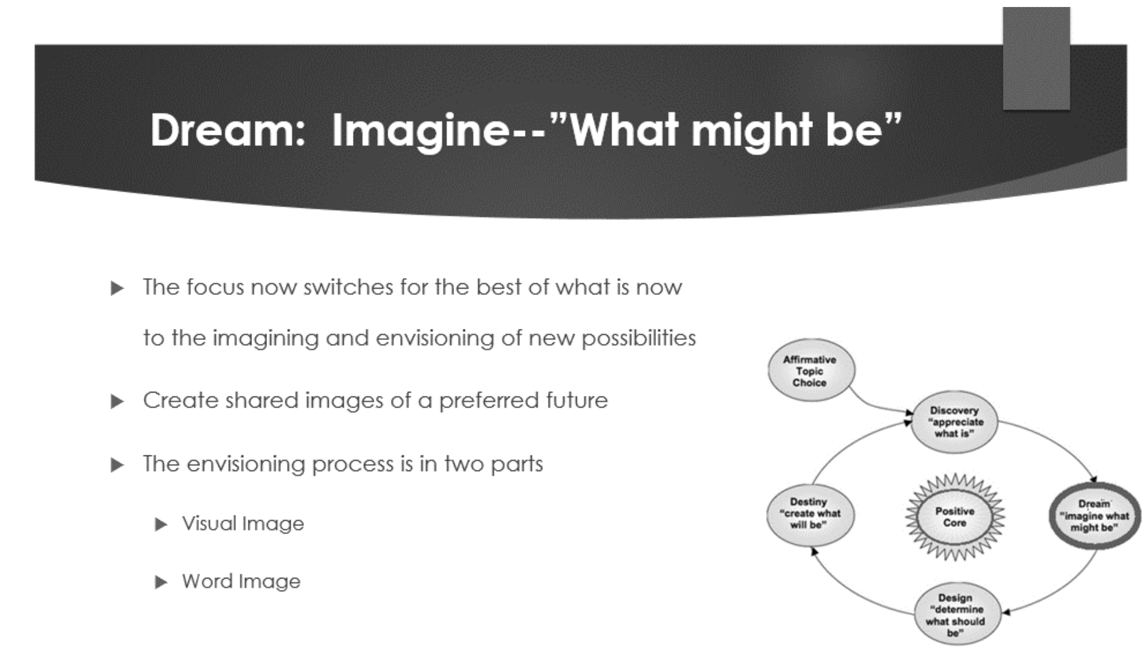
Dream: Imagine--"What might be"

"If you can imagine it,
you can achieve it;
if you can dream it,
you can become it

….nothing expands possibilities like unleashed imagination."

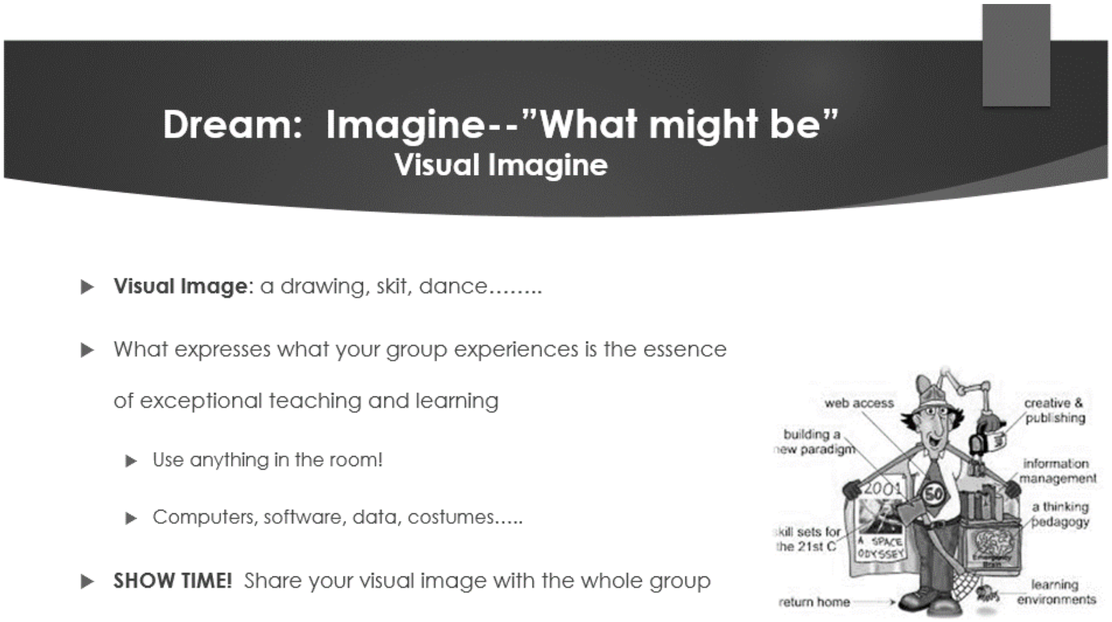
Fountains of Faith: The Words of
William Arthur Ward

Slide 18



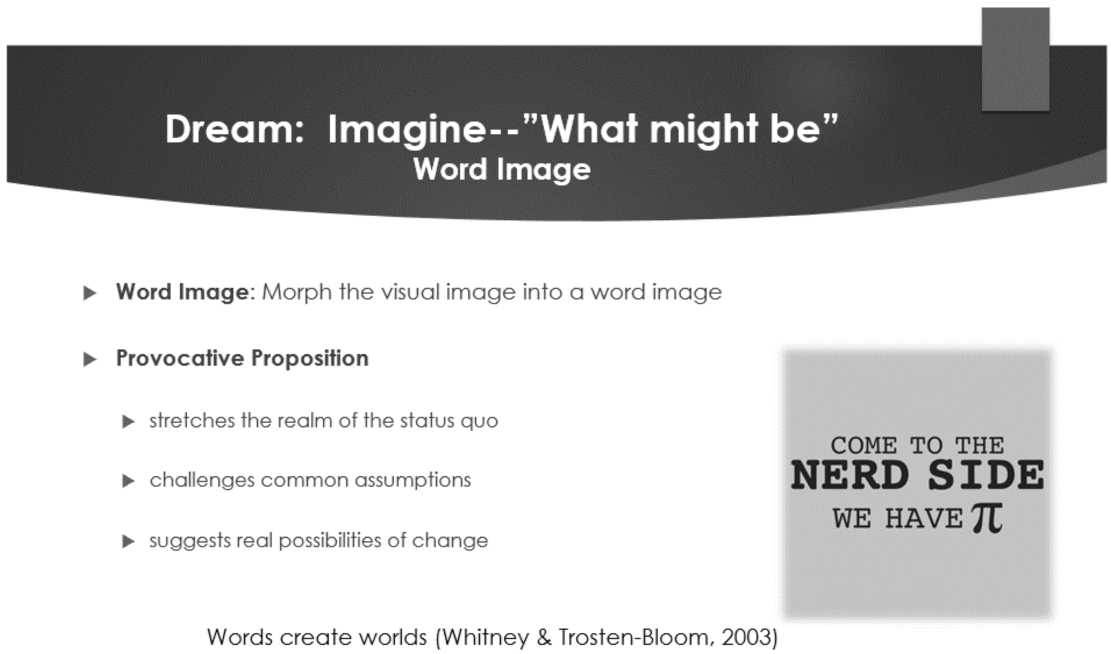
To aid instructors to think beyond their own boundaries, a diversity of learning opportunities from EFL best practices, including integrating educational technology will be included. Since the instructors are all English speaking mathematics instructors, their experience with EFL best practices are limited.

Slide 19



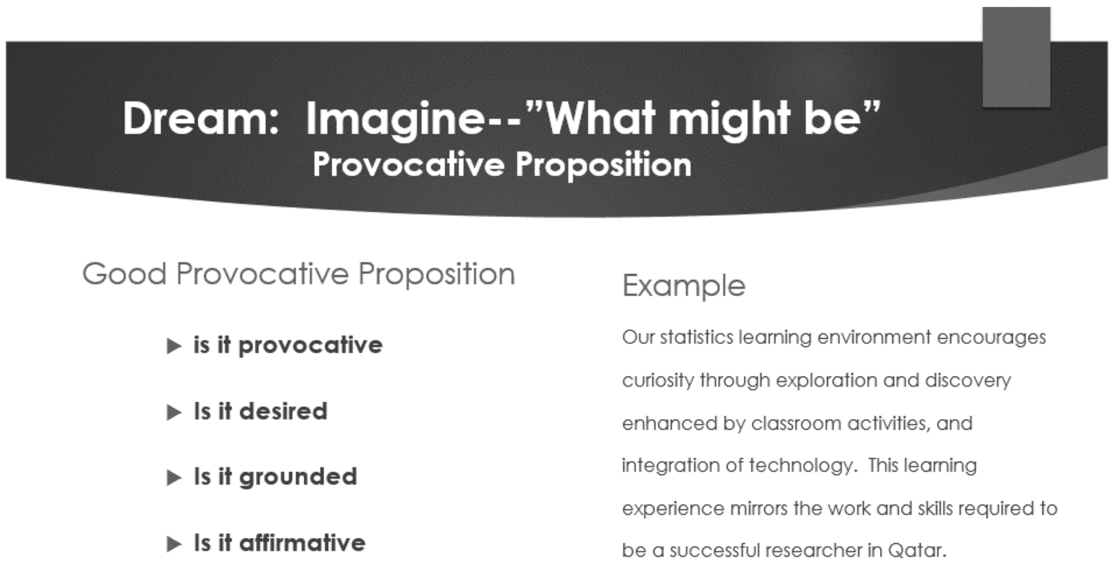
- 45 minutes to create the visual image. Room contains math props, statistics props, computers, printers, and a full complement of crafts.
- 45 minutes for each group to perform/explain

Slide 20



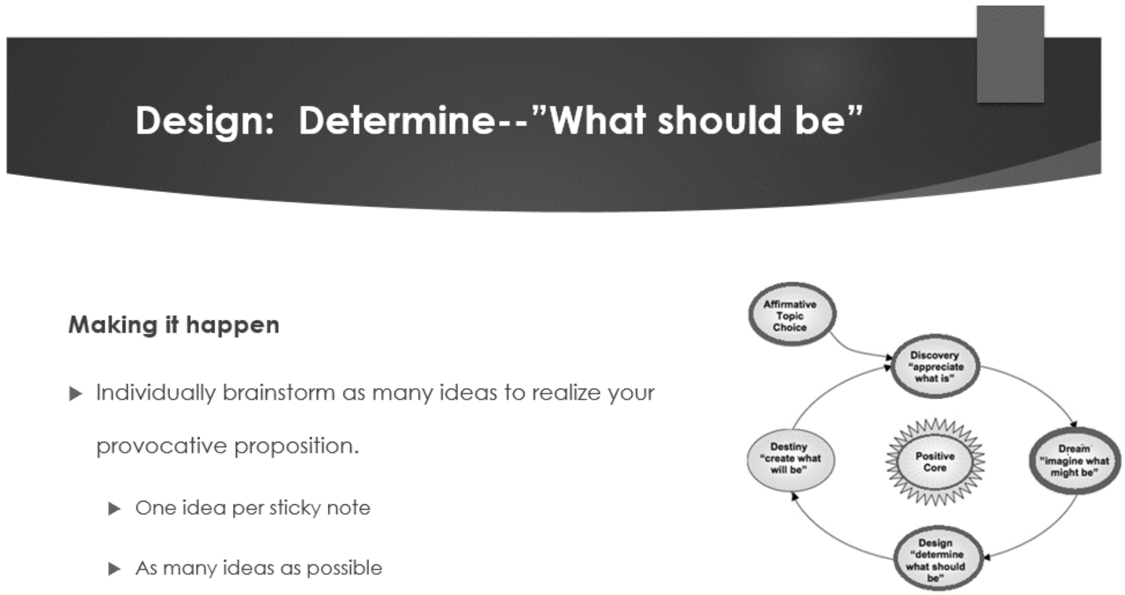
45 minutes to create the Word image

Slide 21



Dream: Imagine--”What might be”
Provocative Proposition
Good Provocative Proposition
is it provocative
Is it desired
Is it grounded
Is it affirmative
Example
Our statistics learning environment encourages curiosity through exploration and discovery enhanced by classroom activities, and integration of technology. This learning experience mirrors the work and skills required to be a successful researcher in Qatar.

Slide 22



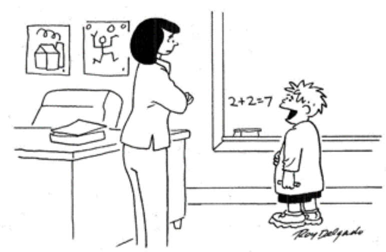
The facilitator will create an opportunity to explicitly demonstrate the usefulness and applicability of the statistic's intervention which in turn will promote the active participation of learners.

Slide 23

Design: Determine--"What should be"
Making it happen

Making it happen: Teams

- Review all the ideas and group into similar themes
- List the action ideas on your flip chart
- Review all the action ideas and pick one
  - Pick a leader
- **ACTION PLAN**
  - Design group report



" Haven't you ever heard of ***statistical manipulation*** ? "

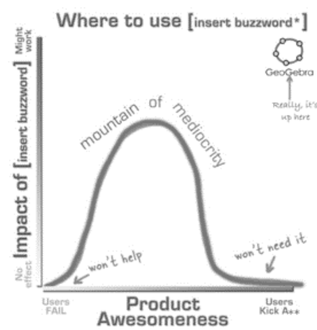
Slide 24

Design: Determine--"What should be"
Making it happen

Making it happen: Individual

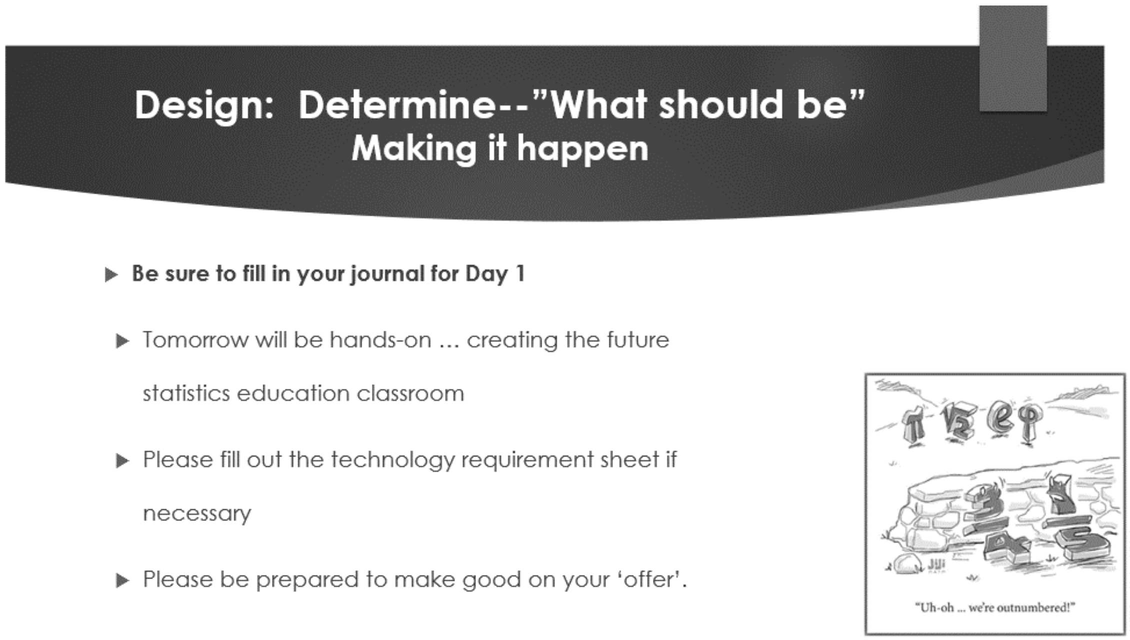
- Make a commitment … *I commit to discuss project ideas with someone from another department for example!*
- Make an offer … *I offer to help other colleagues prepare and upload their e learning materials. Perhaps?*
- Make a request … *I request that our team have a future planning session once each semester. Other Ideas?*

- **What can you do individually to make it happen**
  - Write it on a sticky note



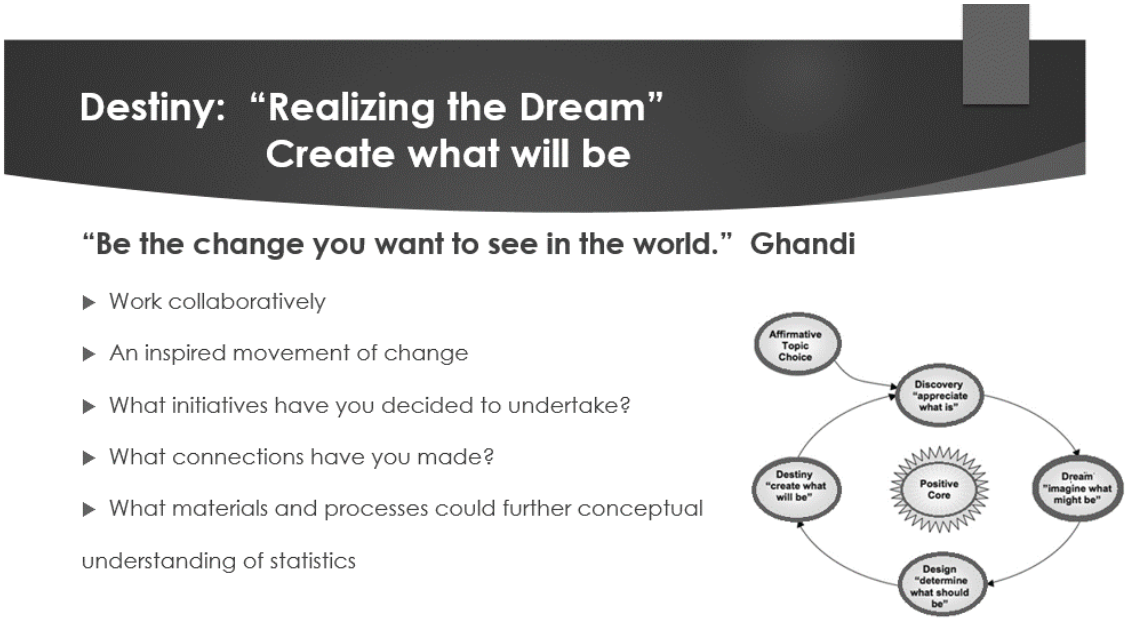
Facilitator will encourage active engagement of learners in this professional development program. Creating a myriad of collaborative learning opportunities, for example small group discussions, expert presentations mentorship, and individual, face-to-face instruction.

Slide 25



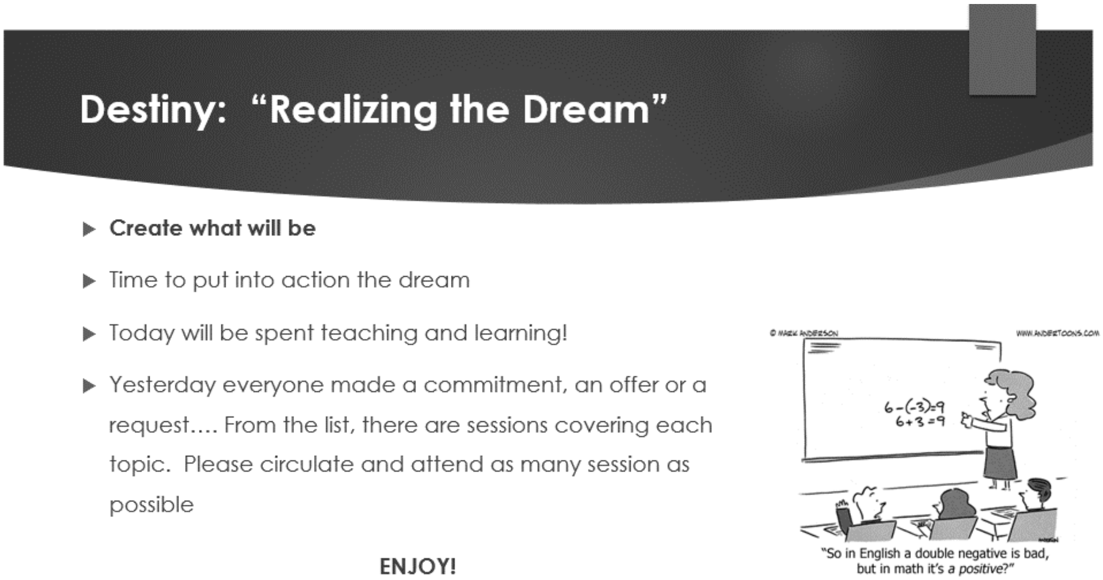
Facilitator reemphasis that unlike the typical fundamentals of professional development, content and pedagogy, data analysis, and individualized, and follow-up coaching support, workshops based on the Affirmative Inquiry framework emphasis reflections which promote teachers' personal conceptual connections with the new initiative or practice…..reminding the participants the importance of journal entries.

Slide 26



This section the facilitator reminds the participants that it is designed to have instructors apply new professional learning in the classroom and encourage positive change.

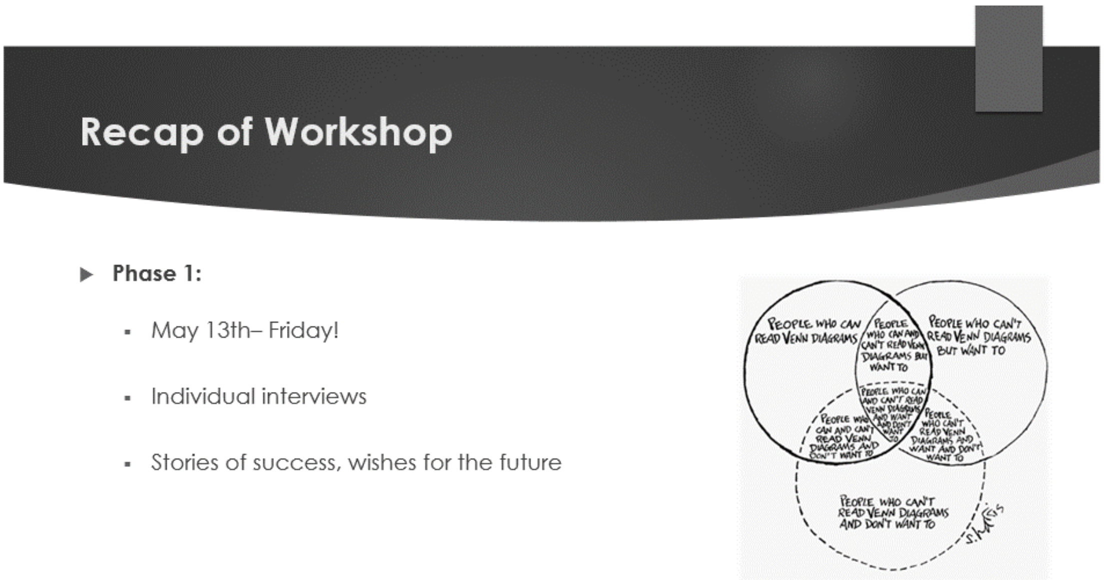
Slide 27



Active participation is required. Interact with as many of the presentations as possible.

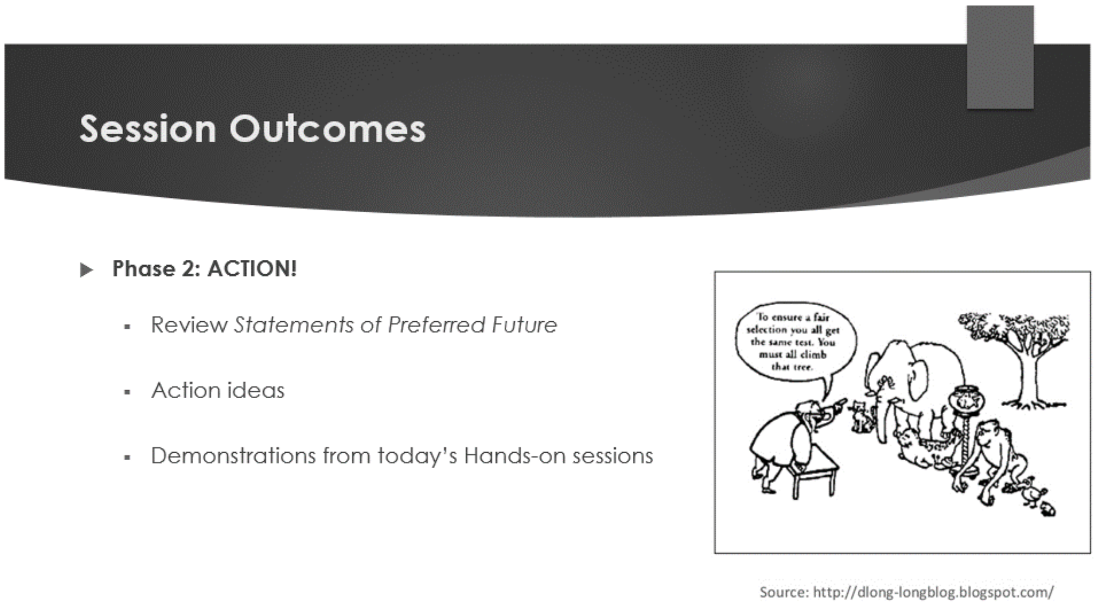
Collaborate with colleagues. Create communities of practice.

Slide 28



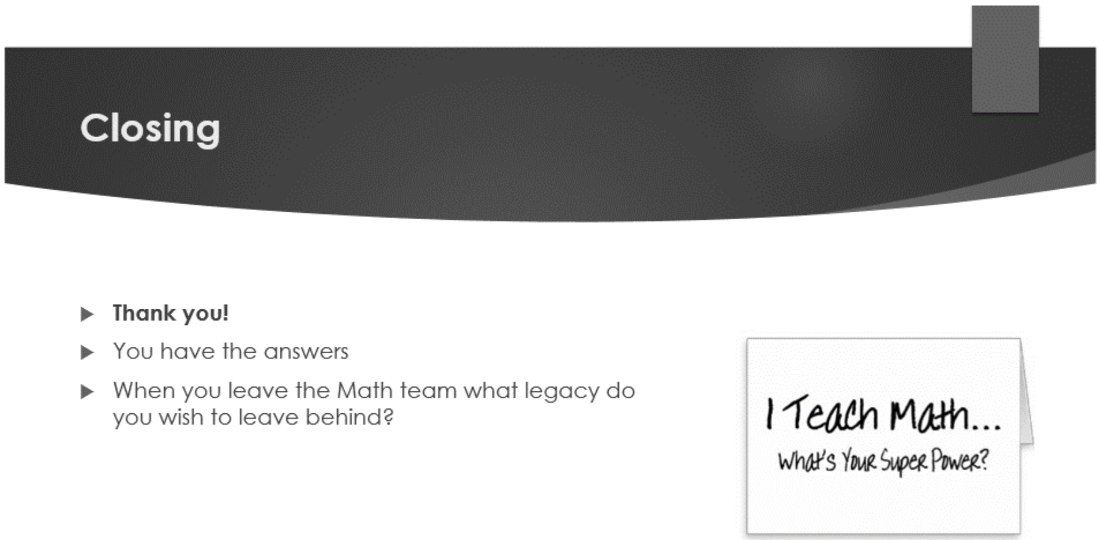
In this last session, please be sure you have used the booklet as expected and have journal entries completed.

Slide 29



In this wrap up sessions, short demonstrations of the hands-on activities and technology use, best practices, communication, collaborative ideas will be reviewed.

Slide 30



Thank the participants for the time and active involvement. Thank them also for sharing and creating new learning communities.

Participants' Handbook

The Art of Teaching and Learning Statistics: An Appreciative Inquiry Approach!

Participants' Notebook

Workshop Dates: May 13th, 2016 – May 15th, 2016

Training Location: Premier Technical College – Qatar

Facilitator: Sarah Inkpen

Instructor: Premier Technical College – Qatar Phone: 974 4495 2435

sarah.inkpen@cna-qatar.edu.qa

Name ____

Interview Questions

"Human systems grow toward what they persistently ask questions about."

- *David Cooperrider and Diana Whitney*

DISCOVERY

Recall a time when you participated in **a powerful teaching/learning experience**—a time when learning was inspiring, energizing, challenging, and exciting. Tell me that story.

- What made it exceptional?
- Who was involved?
- What was your contribution?
- What made it important to you?
- How did it change you as a learner or an educator?
- What do you consider the core factor that makes for excellence in education?

What was the most **quotable quote?**

What was the most compelling story?

As a listener what was the most exciting moment?

Did an innovative example of powerful teaching or learning emerge? What did you learn?

What three themes stood out in this interview?

1.
2.
3.

Individual Activity

Working alone, take time to look at the themes posted on the walls by all the groups. Decide which of the themes you find most exciting and energizing. This is a theme you would like to include in your vision of powerful learning or teaching.

List your themes here:

List your conditions, factors or forces required for a powerful learning or teaching experience:

List what you want to create in order to support your powerful learning or teaching experience:

"The ability to express a vision in metaphors, to articulate it in such a way that it is understood and embraced by all, is an essential quality of leadership."

- Capra (2002)

DREAM

Having discovered best practices from the past and identified what made them work, we now look at the future. How can we recreate these good experiences and build them into a learning community?

Imagine a time in the future when people look to our Statistics Department as an exceptional example of a learning community where students of all backgrounds, all ages, and all mother tongues engage as learners to conceptualize and understand statistics.

- In this exciting future, how are students engaged in the learning community?
- What is true of teachers in this learning community?
- What kinds of systems and structures are most encouraging in student and teacher engagement?

Provocative Proposition

Journal

Take a moment to think about your personal goals for the workshop. Write down or reflect on what you most want from these three days.

Reflection

What was the most important thing you learned each day?

The Pygmalion Effect: "When we expect certain behaviors of others, we are likely to act in ways that make the expected behavior more likely to occur."

- Rosenthal and Babad (1985)

Design:

What are the areas where you feel more student engagement could have the most impact on improving the conceptual understanding of statistics?

As you reflect on successful teaching and learning experiences, what initiatives stand out as being exceptionally promising in creating a statistics learning community?

References

Capra, F. (2002). *The hidden connections: A science for sustainable living*. New York, NY: Harper Collins.

Rosenthal, R., & Babad, E. Y. (1985). Pygmalion in the gymnasium. *Educational Leadership, 43*(1), 36–39.

Appendix B: Comprehensive Assessment of Outcomes for a First Course in Statistics

Comprehensive Assessment of Outcomes for a first course in Statistics (CAOS)

CAOS 4

Developed by the Web ARTIST Project https://app.gen.umn.edu/artist/

Funded by a grant from the National Science Foundation NSF CCLI ASA-0206571

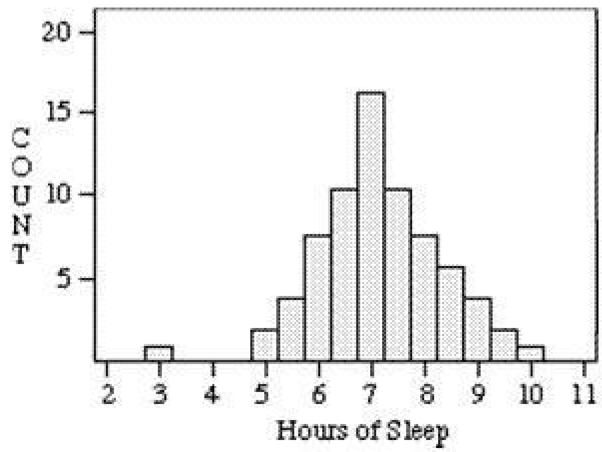
Principal Investigators:
Joan Garfield and Bob delMas, University of Minnesota Beth Chance,
Cal Poly – San Luis Obispo Post-doctoral Research Assistant;
Ann Ooms, University of Minnesota

Version 31

September 8, 2005

ARTIST CAOS 4 POSTTEST

The following graph shows a distribution of hours slept last night by a group of college students.



1. Select the statement below that gives the most complete description of the graph in a way that demonstrates an understanding of how to statistically describe and interpret the distribution of a variable.

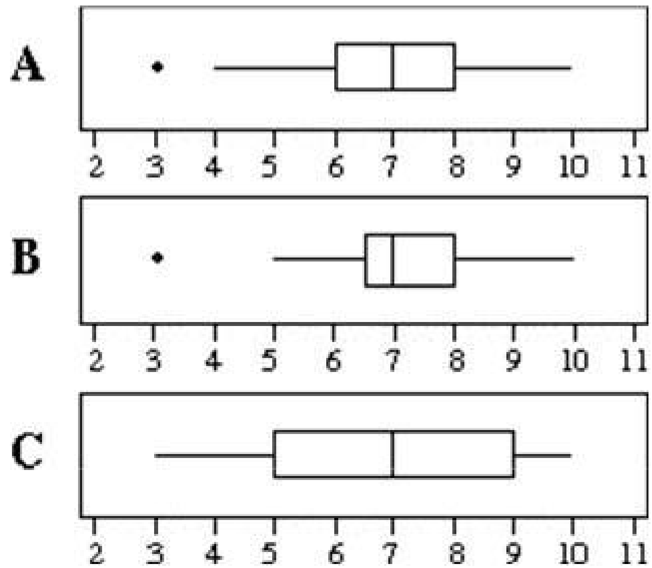
   a. The bars go from 3 to 10, increasing in height to 7, then decreasing to 10. The tallest bar is at 7. There is a gap between three and five.

   b. The distribution is normal, with a mean of about 7 and a standard deviation of about 1.

   c. Most students seem to be getting enough sleep at night, but some students slept more and some slept less. However, one student must have stayed up very late and got very few hours of sleep.

   d. The distribution of hours of sleep is somewhat symmetrical and bell-shaped, with an outlier at 3. The typical amount of sleep is about 7 hours and overall range is 7 hours.

2. Which box plot seems to be graphing the same data as the histogram in question 1?



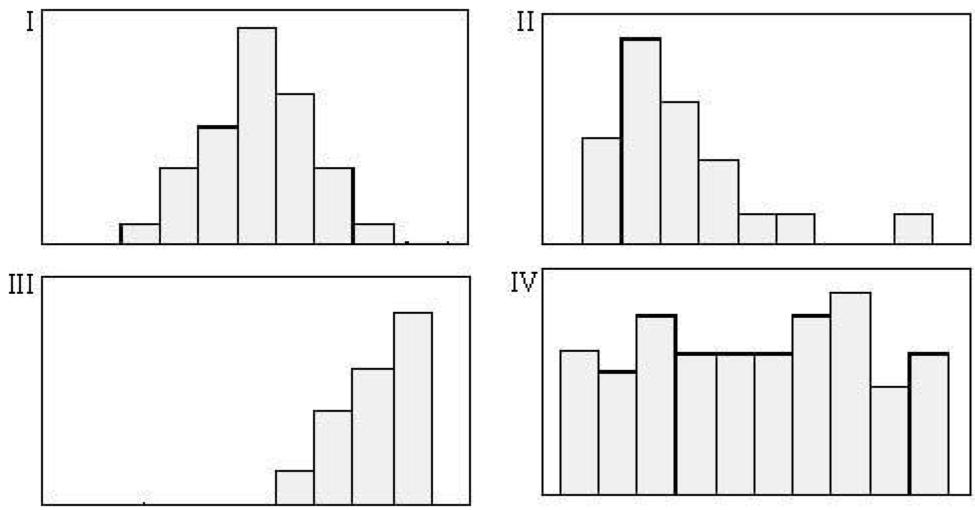
a. Boxplot A.

b. Boxplot B.

Boxplot C.

Items 3 to 5 refer to the following situation:

Four histograms are displayed below. For each item, match the description to the appropriate histogram.



3. A distribution for a set of quiz scores where the quiz was very easy is represented by:

   a. Histogram I

   b. Histogram II

   c. Histogram III

   d. Histogram IV

4. A distribution for a set of wrist circumferences (measured in centimeters) taken from the right wrist of a random sample of newborn female infants is represented by:

   a. Histogram I

   b. Histogram II

   c. Histogram III

   d. Histogram IV

5. A distribution for the last digit of phone numbers sampled from a phone book (i.e., for the phone number 968-9667, the last digit, 7, would be selected) is represented by:

   a. Histogram I

   b. Histogram II

   c. Histogram III

   d. Histogram IV

6. A baseball fan likes to keep track of statistics for the local high school baseball team. One of the statistics she recorded is the proportion of hits obtained by each player based on the number of times at bat as shown in the table below. Which of the following graphs gives the best display of the distribution of proportion of hits in that it allows the baseball fan to describe the shape, center and spread of the variable proportion of hits?

Player	Proportion of hits
BH	0.305
HA	0.229
JS	0.281
TC	0.097
MM	0.167
GV	0.333
RC	0.085

Player	Proportion of hits
SU	0.270
DH	0.136
TO	0.218
RL	0.267
JB	0.270
WG	0.054
MH	0.108

Player	Proportion of hits
BC	0.301
AA	0.143
HK	0.341
RS	0.261
CR	0.115
MD	0.125

A

B

C

D

7. A recent research study randomly divided participants into groups that were given different levels of Vitamin E to take daily. One group received only a placebo pill. The research study followed the participants for eight years to see how many developed a particular type of cancer during that time period. Which of the following responses gives the best explanation as to the purpose of randomization in this study?

   a. To increase the accuracy of the research results.

b. To ensure that all potential cancer patients had an equal chance of being selected for the study.

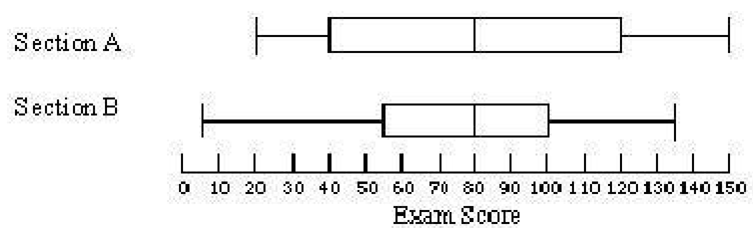
c. To reduce the amount of sampling error.

d. To produce treatment groups with similar characteristics.

e. To prevent a skew in the results.

Items 8 to 10 refer to the following situation:

The two box plots below display final exam scores for all students in two sections of the same course.



8. Which section would you expect to have a greater standard deviation in exam scores?

   a. Section A

   b. Section B

   c. Both sections are about equal.

   d. It is impossible to tell.

9. Which data set has a greater percentage of students with scores at or below 30?

   a. Section A

   b. Section B

   c. Both sections are about equal.

   d. It is impossible to tell.

10. Which section has a greater percentage of students with scores at or above 80?

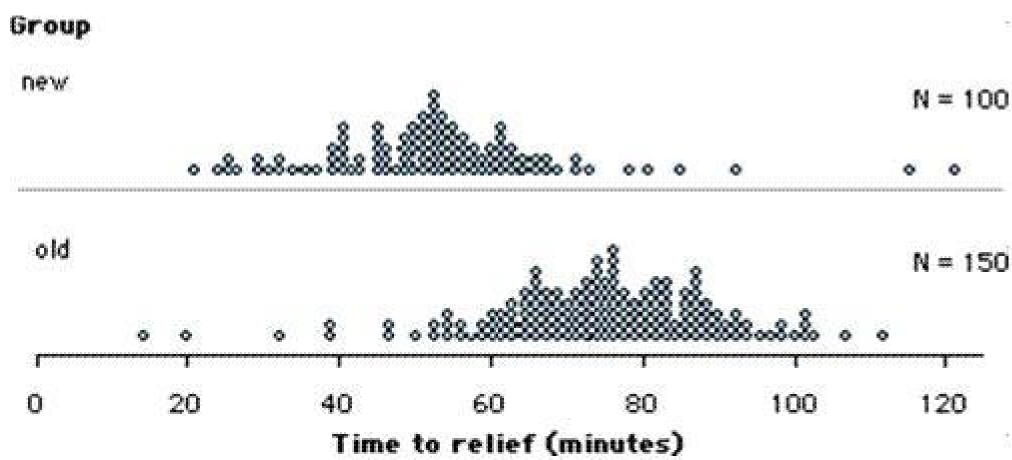
    a. Section A

b. Section B

c. Both sections are about equal.

Items 11 to 13 refer to the following situation:

A drug company developed a new formula for their headache medication. To test the effectiveness of this new formula, 250 people were randomly selected from a larger population of patients with headaches. Of these people, 100 were randomly assigned to receive the new formula medication when they had a headache, and the other 150 people received the old formula medication. The time it took, in minutes, for each patient to no longer have a headache was recorded. The results from both of these clinical trials are shown below. Items 11, 12, and 13 present statements made by three statistics students. For each statement, indicate whether you think the student's conclusion is valid.



11. The old formula works better. Two people who took the old formula felt relief in less than 20 minutes, compared to none who took the new formula. Also, the worst result—near 120 minutes—was with the new formula.

    a. Valid.

    b. Not valid.

12. The average time for the new formula to relieve a headache is lower than the average time for the old formula. I would conclude that people taking the new formula would tend to feel relief about 20 minutes sooner than those taking the old formula.

    a. Valid.

    b. Not valid.

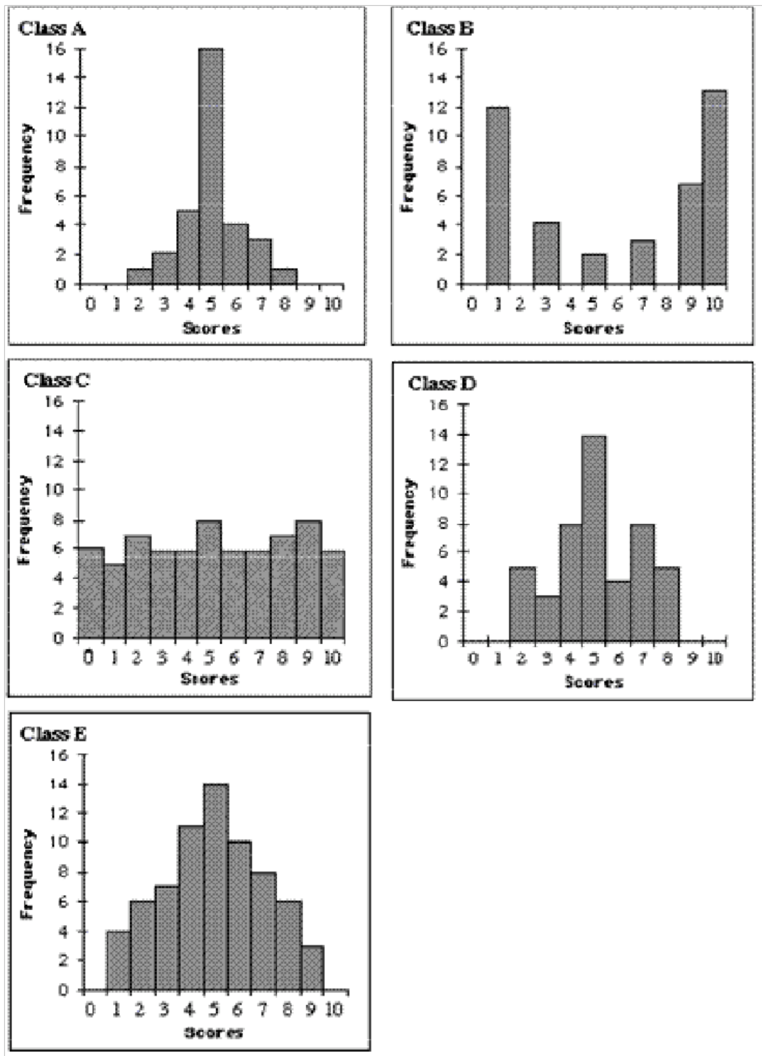
13. I would not conclude anything from these data. The number of patients in the two groups is not the same so there is no fair way to compare the two formulas.

    a. Valid.

    b. Not valid.

Items 14 and 15 refer to the following situation:

Five histograms are presented below. Each histogram displays test scores on a scale of 0 to 10 for one of five different statistics classes.



14. Which of the classes would you expect to have the lowest standard deviation, and why?

    a. Class A, because it has the most values close to the mean.

    b. Class B, because it has the smallest number of distinct scores.

    c. Class C, because there is no change in scores.

    d. Class A and Class D, because they both have the smallest range.

e. Class E, because it looks the most normal.

15. Which of the classes would you expect to have the highest standard deviation, and why?

a. Class A, because it has the largest difference between the heights of the bars.

b. Class B, because more of its scores are far from the mean.

c. Class C, because it has the largest number of different scores.

d. Class D, because the distribution is very bumpy and irregular.

e. Class E, because it has a large range and looks normal.

16. A certain manufacturer claims that they produce 50% brown candies. Sam plans to buy a large family sized bag of these candies and Kerry plans to buy a small fun sized bag. Which bag is more likely to have more than 70% brown candies?

a. Sam, because there are more candies, so his bag can have more brown candies.

b. Sam, because there is more variability in the proportion of browns among larger samples.

c. Kerry, because there is more variability in the proportion of browns among smaller samples.

d. Kerry, because most small bags will have more than 50% brown candies.

e. Both have the same chance because they are both random samples.

17. Imagine you have a barrel that contains thousands of candies with several different colors. We know that the manufacturer produces 35% yellow candies. Five students each take a random sample of 20 candies, one at a time, and record the percentage

of yellow candies in their sample. Which sequence below is the most plausible for the percent of yellow candies obtained in these five samples?

a. 30 %, 35%, 15%, 40%, 50%.

b. 35 %, 35%, 35%, 35%, 35%.

c. 5%, 60%, 10%, 50%, 95%.

d. Any of the above.

18. Jean lives about 10 miles from the college where she plans to attend a 10-week summer class. There are two main routes she can take to the school, one through the city and one through the countryside. The city route is shorter in miles, but has more stoplights. The country route is longer in miles, but has only a few stop signs and stoplights. Jean sets up a randomized experiment where each day she tosses a coin to decide which route to take that day. She records the following data for five days of travel on each route.

Country Route - 17, 15, 17, 16, 18

City Route - 18, 13, 20, 10, 16

It is important to Jean to arrive on time for her classes, but she does not want to arrive too early because that would increase her parking fees. Based on the data gathered, which route would you advise her to choose?

a. The Country Route, because the times are consistently between 15 and 18 minutes.

b. The City Route, because she can get there in 10 minutes on a good day and the average time is less than for the Country Route.

c. Because the times on the two routes have so much overlap, neither route is better than the other. She might as well flip a coin.

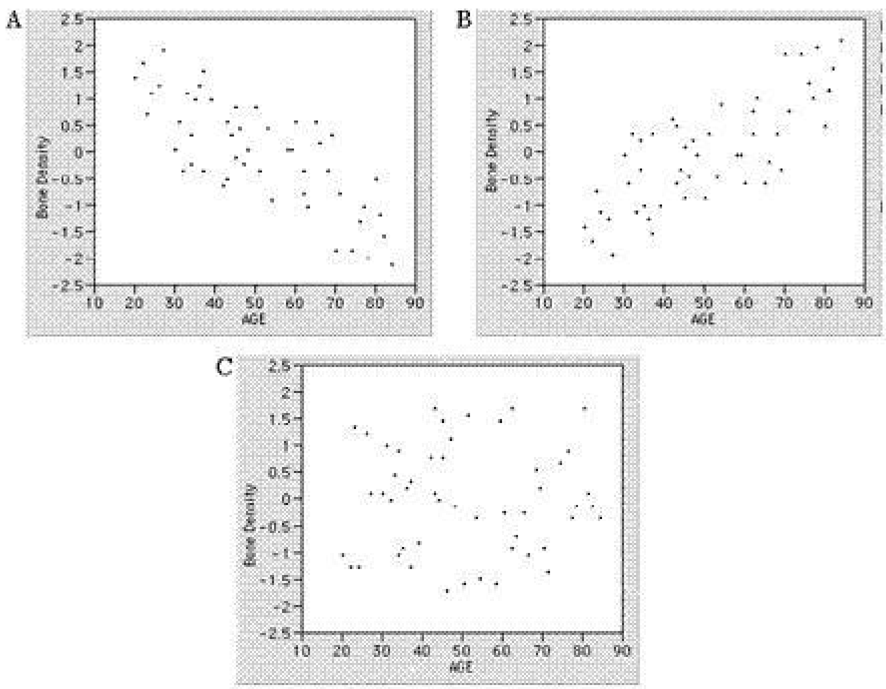
19. A graduate student is designing a research study. She is hoping to show that the results of an experiment are statistically significant. What type of *p*- value would she want to obtain?

a. A large *p*- value.

b. A small *p*- value.

c. The magnitude of a *p*- value has no impact on statistical significance.

20. Bone density is typically measured as a standardized score with a mean of 0 and a standard deviation of 1. Lower scores correspond to lower bone density. Which of the following graphs shows that as women grow older they tend to have lower bone density?



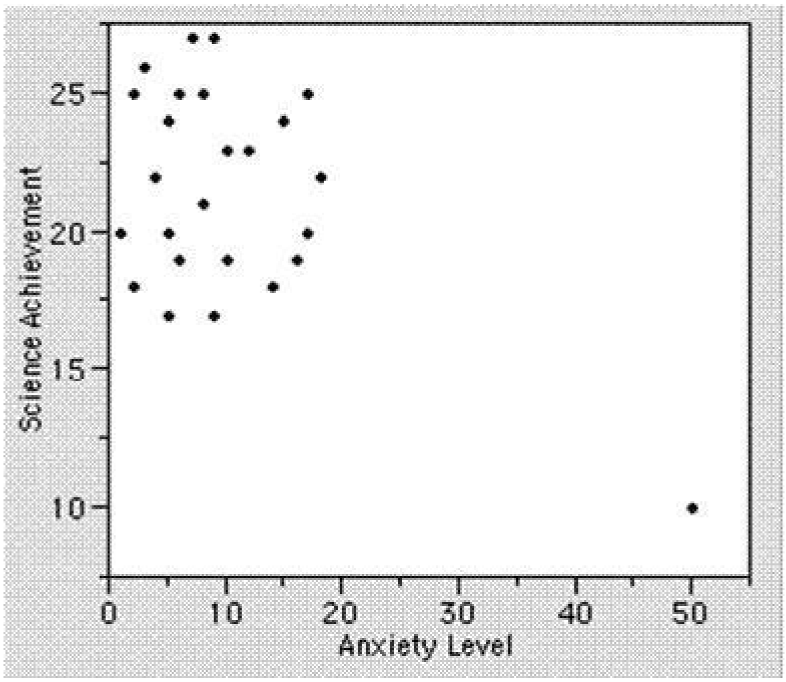
a. Graph A.

b. Graph B.

c. Graph C.

21. The following scatterplot shows the relationship between scores on an anxiety scale and an achievement test for science. Choose the best interpretation of the

relationship between anxiety level and science achievement based on the scatterplot.



a. This graph shows a strong negative linear relationship between anxiety and achievement in science.

b. This graph shows a moderate linear relationship between anxiety and achievement in science.

c. This graph shows very little, if any, linear relationship between anxiety and achievement in science.

22. Researchers surveyed 1,000 randomly selected adults in the U.S. A statistically significant, strong positive correlation was found between income level and the number of containers of recycling they typically collect in a week. Please select the best interpretation of this result.

a. We cannot conclude whether earning more money causes more recycling among U.S. adults because this type of design does not allow us to infer causation.

b. This sample is too small to draw any conclusions about the relationship between income level and amount of recycling for adults in the U.S.

c. This result indicates that earning more money influences people to recycle more than people who earn less money.

Items 23 and 24 refer to the following situation:

A researcher in environmental science is conducting a study to investigate the impact of a particular herbicide on fish. He has 60 healthy fish and randomly assigns each fish to either a treatment or a control group. The fish in the treatment group showed higher levels of the indicator enzyme.

23. Suppose a test of significance was correctly conducted and showed no statistically significant difference in average enzyme level between the fish that were exposed to the herbicide and those that were not. What conclusion can the graduate student draw from these results?

    a. The researcher must not be interpreting the results correctly; there should be a significant difference.

    b. The sample size may be too small to detect a statistically significant difference.

    c. It must be true that the herbicide does not cause higher levels of the enzyme.

24. Suppose a test of significance was correctly conducted and showed a statistically significant difference in average enzyme level between the fish that were exposed to the herbicide and those that were not. What conclusion can the graduate student draw from these results?

    a. There is evidence of association, but no causal effect of herbicide on enzyme levels.

    b. The sample size is too small to draw a valid conclusion.

    c. He has proven that the herbicide causes higher levels of the enzyme.

d. There is evidence that the herbicide causes higher levels of the enzyme for these fish.

Items 25 to 27 refer to the following situation:

A research article reports the results of a new drug test. The drug is to be used to decrease vision loss in people with Macular Degeneration. The article gives a *p*- value of .04 in the analysis section. Items 25, 26, and 27 present three interpretations of this *p*value. Indicate whether each interpretation is valid or invalid.

25. The probability of getting results as extreme as or more extreme than the ones in this study if the drug is actually not effective.
    a. Valid.
    b. Invalid.
26. The probability that the drug is not effective.
    a. Valid.
    b. Invalid.
27. The probability that the drug is effective.
    a. Valid.
    b. Invalid.

Items 28 to 31 refer to the following situation:

A high school statistics class wants to estimate the average number of chocolate chips in a generic brand of chocolate chip cookies. They collect a random sample of cookies, count the chips in each cookie, and calculate a 95% confidence interval for the average number of chips per cookie (18.6 to 21.3). Items 28, 29, and 30 present four interpretations of these results. Indicate whether each interpretation is valid or invalid.

28. We are 95% certain that each cookie for this brand has approximately 18.6 to 21.3 chocolate chips.

a. Valid.

b. Invalid.

29. We expect 95% of the cookies to have between 18.6 and 21.3 chocolate chips.

    a. Valid.

    b. Invalid.

30. We would expect about 95% of all possible sample means from this population to be between 18.6 and 21.3 chocolate chips.

    a. Valid.

    b. Invalid.

31. We are 95% certain that the confidence interval of 18.6 to 21.3 includes the true average number of chocolate chips per cookie.

    a. Valid.

    b. Invalid.

32. It has been established that under normal environmental conditions, adult largemouth bass in Silver Lake have an average length of 12.3 inches with a standard deviation of three inches. People who have been fishing Silver Lake for some time claim that this year they are catching smaller than usual largemouth bass. A research group from the Department of Natural Resources took a random sample of 100 adult largemouth bass from Silver Lake and found the mean of this sample to be 11.2 inches. Which of the following is the most appropriate statistical conclusion?

    a. The researchers cannot conclude that the fish are smaller than what is normal because 11.2 inches is less than one standard deviation from the established mean (12.3 inches) for this species.

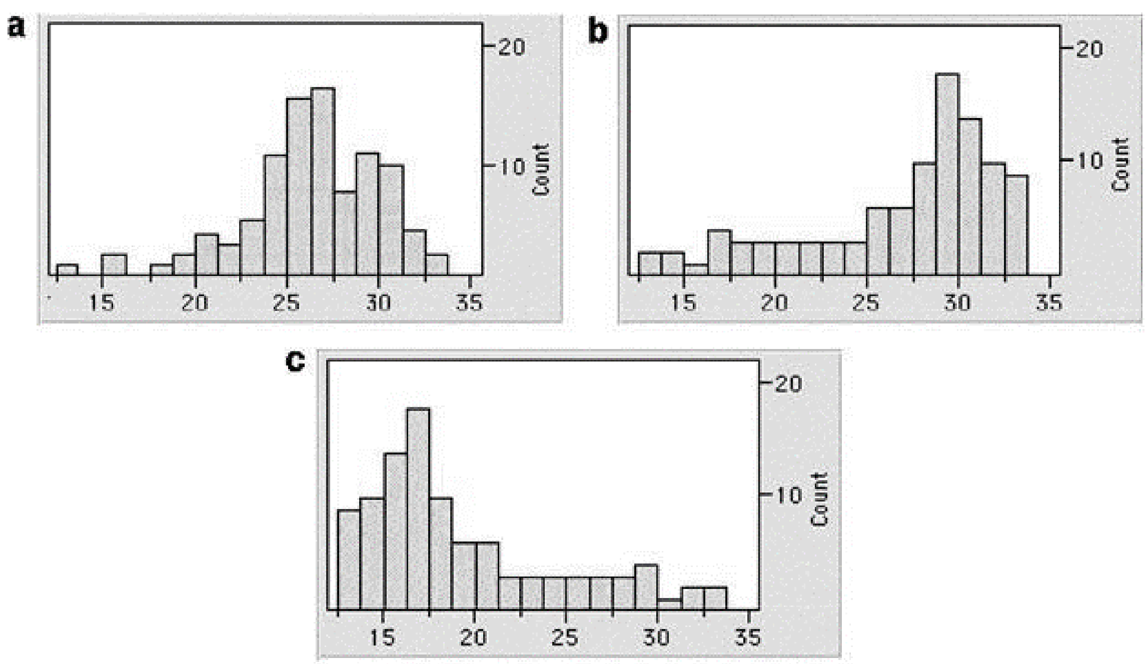
    b. The researchers can conclude that the fish are smaller than normal because the sample mean should be almost identical to the population mean with a large sample of 100 fish.

The researchers can conclude that the fish are smaller than what is normal because the difference between 12.3 inches and 11.2 inches is much larger than the expected sampling error.

A study examined the length of a certain species of fish from one lake. The plan was to take a random sample of 100 fish and examine the results. Numerical summaries on lengths of the fish measured in this study are given.

Mean	26.8 mm
Median	29.4 mm
Standard Deviation	5.0 mm
Minimum	12 mm
Maximum	33.4 mm

34. Which of the following histograms is most likely to be the one for these data?



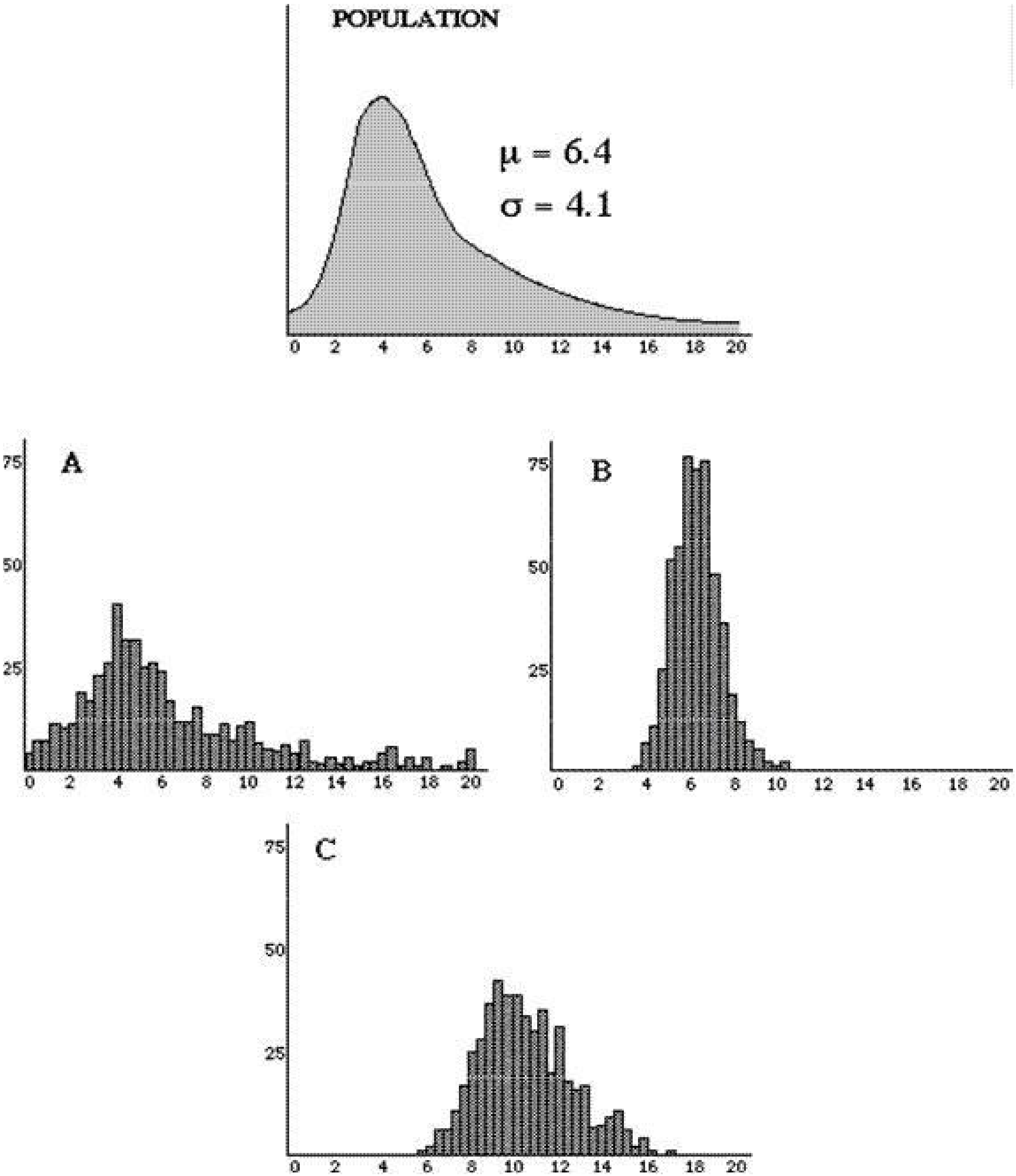
a. Histogram a.

b. Histogram b.

c. Histogram c.

Items 34 and 35 refer to the following situation:

Four graphs are presented below. The graph at the top is a distribution for a population of test scores. The mean score is 6.4 and the standard deviation is 4.1.



35. Which graph (A, B, or C) do you think represents a single random sample of 500 values from this population?

a. Graph A

b. Graph B

c. Graph C

36. Which graph (A, B, or C) do you think represents a distribution of 500 sample means from random samples each of size 9?

a. Graph A

b. Graph B

c. Graph C

37. This table is based on records of accidents compiled by a State Highway Safety and Motor Vehicles Office. The Office wants to decide whether people are less likely to have a fatal accident if they are wearing a seatbelt. Which of the following comparisons is most appropriate for supporting this conclusion?

Safety Equipment in Use	Injury		ROW TOTAL
	Nonfatal	Fatal	
Seat Belt	412,368	510	412,878
No Seat Belt	162,527	1,601	164,128
COLUMN TOTAL	574,895	2,111	577,006

a. Compare the ratios 510/412,878 and 1,601/164,128

b. Compare the ratios 510/577,006 and 1,601/577,006

c. Compare the numbers 510 and 1,601

38. A student participates in a Coke versus Pepsi taste test. She correctly identifies which soda is which four times out of six tries. She claims that this proves that she can reliably tell the difference between the two soft drinks. You have studied statistics and you want to determine the probability of anyone getting at least four right out of six tries just by chance alone. Which of the following would provide an accurate estimate of that probability?

   a. Have the student repeat this experiment many times and calculate the percentage time she correctly distinguishes between the brands.

   b. Simulate this on the computer with a 50% chance of guessing the correct soft drink on each try, and calculate the percent of times there are four or more correct guesses out of six trials.

   c. Repeat this experiment with a very large sample of people and calculate the percentage of people who make four correct guesses out of six tries.

   d. All of the methods listed above would provide an accurate estimate of the probability.

39. A college official conducted a survey to estimate the proportion of students currently living in dormitories about their preference for single rooms, double rooms, or multiple (more than two people) rooms in the dormitories on campus. Which of the following does NOT affect the college official's ability to generalize the survey results to all dormitory students?

   a. Five thousand students live in dormitories on campus. A random sample of only 500 were sent the survey.

   b. The survey was sent to only first-year students.

   c. Of the 500 students who were sent the survey, only 160 responded.

   d. All of the above present a problem for generalizing the results.

40. The number of people living on American farms has declined steadily in the last century. Data gathered on the U.S. farm population (millions of people) from 1910 to 2000 were used to generate the following regression equation: Predicted Farm Population = 1167 - .59 (YEAR). Which method is best to predict the number of people living on farms in 2050?

   a. Substitute the value of 2050 for YEAR in the regression equation, and compute the predicted farm population.

   b. Plot the regression line on a scatterplot, locate 2050 on the horizontal axis, and read off the corresponding value of population on the vertical axis.

   c. Neither method is appropriate for making a prediction for the year 2050 based on these data.

   d. Both methods are appropriate for making a prediction for the year 2050 based on these data.

41. The following situation models the logic of a hypothesis test. An electrician uses an instrument to test whether or not an electrical circuit is defective. The instrument sometimes fails to detect that a circuit is good and working. The null hypothesis is that the circuit is good (not defective). The alternative hypothesis is that the circuit is not good (defective). If the electrician rejects the null hypothesis, which of the following statements is true?

   a. The circuit is definitely not good and needs to be repaired.

   b. The electrician decides that the circuit is defective, but it could be good.

   c. The circuit is definitely good and does not need to be repaired.

The circuit is most likely good, but it could be defective.

CAOS 4 ANSWER KEY

1. D	11. B	21. C	31. A
2. B	12. A	22. A	32. C
3. C	13 B	23. B	33. B
4. A	14. A	24. D	34 A
5. D	15. B	25. A	35. B
6. C	16. C	26. B	36. A
7. D	17 A	27. B	37. B
8. A	18. A	28. B	38. A
9. D	19. B	29. B	39. C
10. C	20. A	30. B	40. B

Appendix C: Letter of Cooperation

COLLEGE OF THE NORTH ATLANTIC - QATAR

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[redacted]

October 27, 2014

Dear Sarah,

Re: Request to participate in Research Study
Sarah Inkpen – Doctoral Student, Walden University

Based on my review of your research proposal, I give permission for you to conduct the study outlined in, *The Effect of an Interactive Component on Student's Conceptual Understanding of Hypothesis Testing*, within the College of the North Atlantic – Qatar's mathematics department during the 2014 – 2015 academic year.

I understand that my organization's responsibilities include allowing access to statistics classes to conduct pre- and post-testing and to work with faculty implementing the identified intervention. We reserve the right to withdraw from the study at any time if our circumstances change. We will advise you in writing with our intent to withdraw.

I confirm that I am authorized to approve your research within my department as the Dean of the school and that you have sought, and received, permission from our institution's Manager of Applied Research who has thoroughly reviewed your research methodology.

I understand that the data collected will remain entirely confidential and may not be provided to anyone outside the research team without permission of Walden University's IRB.

Sincerely,

[redacted]

COLLEGE OF THE NORTH ATLANTIC QATAR

CNA-QATAR.COM