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The Status of Safety Culture at Louisiana State University

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THE STATUS OF SAFETY CULTURE
AT LOUISIANA STATE UNIVERSITY

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by
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B.S., Oklahoma Baptist University, 1971
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For my wife and children,

Connie, Caty, and Jenna

Well, 'tis no matter; honour pricks me on.

Shakespeare, *Henry IV, Part 1*

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ABSTRACT

This work accesses the nature of and level of safety culture in the academic research community at Louisiana State University and Agricultural and Mechanical College (LSU). After serious chemical related accidents in academic research laboratories the National Academies of Science has made recommendations to improve safety within academic research by encouraging researchers to go beyond simple compliance with regulations and work toward fostering a strong, positive safety culture. The term, "safety culture" is used to describe workplace safety in various efforts to improve it. Researchers have studied these concepts from technical, social, and psychological viewpoints leading to the general consensus that a positive safety culture improves job safety. The concept of safety culture utilizes the concepts of organization theory that is directly related to safety such as safety attitude, values, and behavior. The safety attitude, values, and behavior at LSU are analyzed in reference to current thinking regarding safety culture.

A quantitative survey of the safety climate at LSU is presented to provide insight regarding the level of safety culture. The relative value of the safety climate at LSU was found to be 3.72 on a scale of 5 which is comparable to the published values of other universities and considered to be good. A confirmatory factor analysis (CFA) of a linear model for safety culture model based on inputs of safety climate, safety attitudes, and safety behaviors. CFA is a technique used in structural equation modeling (SEM) to determine if a certain model is valid. The goodness of fit values indicated that the model's overall structure of the culture model provided a reasonable fit of the data and confirmed the conceptual model.

CHAPTER 1. INTRODUCTION

The purpose of this work is to access the nature of and level of safety culture in the academic research community at Louisiana State University and Agricultural and Mechanical College (LSU). Across the nation, several serious chemical related accidents in academic research laboratories have generated discussion regarding methodologies that researchers can utilize to improve safety in academic laboratories. A recent report from the National Academies of Science has made recommendations to improve safety within academic research by encouraging researchers to go beyond simple compliance with regulations and work toward fostering a strong, positive safety culture. The NRC report defines "safety culture as an organization's shared values, assumptions, and beliefs specific to workplace safety". Universities must integrate safety as an essential element in the daily work of laboratory researchers and strive toward a constant commitment to safety (NRC 2014).

The renowned agricultural chemist and teacher, Justus von Liebig (1803-1873), was quoted in an 1890 address by August Kekulé as saying that "you have to ruin your health to get anywhere in chemistry" (Purchase 1994). Although researchers of von Liebig's day may have sacrificed their health for science, work conditions for the modern researchers have greatly improved thanks to increased safety awareness and technological advances in exposure control. Universities provide basic engineering controls, such as fume hoods and biological safety cabinets, to reduce researchers' levels of exposure, while the Occupational Safety and Health Administration (OSHA) rules requires education of laboratory personnel in exposure control (OSHA 1990). Regulatory requirements often drive safety initiatives at most universities and most universities are still in the command and control mode practiced by the Environmental Protection Agency in the 1970's. A

majority of universities do not have the same level of laboratory safety rules as required for industry (Backus at el.). For example, use of reactive chemical reviews and standard operating procedures are basic safety requirements in industry, however, these basic chemical safety tools are often unused at the university level. Instead, the level and enforcement of safety requirements are at the discretion of the principal investigator in academic laboratories. The general consensus is that this relaxed approach toward safety makes academic laboratories more dangerous than those in industry (Peplow & Marris).

The terms, “safety climate” and “safety culture”, are used to describe workplace safety in various efforts to improve it. Researchers have studied these concepts from technical, social, and psychological viewpoints leading to the general consensus that a positive safety culture improves job safety and a safety climate survey can be used as a metric to assess safety performance. The concepts of safety climate and culture utilize the basic concepts of organization theory that is directly related to safety such as safety attitude, values, and behavior (Reiman). The definitions of both safety climate and culture tend to be global in nature and ill-defined. The relationship between the two is unclear but even so, safety culture is an established key concept and a beloved buzz word of safety professionals.

Literature reviews of existing safety culture models conclude that most of the definitions of safety culture are very similar and the differences focus on the way people think and/or behave in relationship to safety (Guldenmund 2000/Choudhry). The concept is holistic in nature and safety culture is something an organization ‘is’ rather than something an organization ‘has’ (Reason 1998). Safety culture results from a combination of positive attitudes, good management practices established by organizations, and assigning the highest priority to safety. However, it is

difficult to quantify (Choudhry 2007). Aside from general consensus that a positive safety culture is necessary for safe work conditions, there is neither an accepted model for safety culture nor a clear-cut definition.

In practice, researchers tend to use safety culture and safety climate interchangeably. Safety climate studies often focus on the way that people perceive safety without addressing the actual attitudes or behavioral aspects of safety. Safety climate should not be viewed as an alternative or synonym to safety culture. Rather, safety climate is an aspect of safety culture and it is dependent on the overall prevailing safety culture (Gadd, 2002). Put simply, safety climate can be considered as a "snapshot" view of the organizations safety culture. Safety climate is measured via semi-quantitate method using questionnaires (Zohar, 2010).

While safety climate can be measured, safety culture is an abstract concept that considers safety in a holistic manner. Most models for improvement of safety culture have been qualitative in nature and consider safety culture as being the end achievement of various inputs such as attitude, behavior, shared beliefs, training, communications, management support, and leadership. While these studies offer goals to promote a better safety culture, they do not offer a straight forward manual of "How to Improve". However, the Association of Public and Land-grant Universities (APLU) recently published a report that provides a clear-cut methodology to improve safety culture (APLU).

Figure 1 presents an onion model of safety culture to demonstrate its complexity. Safety Culture is at the center of concentric circles of actions, attitudes, and behaviors that have influence an organization's overall safety. The outer layer provides the fundamental cornerstones of any organizational culture system. There needs to be strong support on the level of policy and the

related policy documents must provide the underlying principles of the organization. Without strong management support these policies will not be acted upon and the culture is weak. Individual commitment to safety is required for these policies to have meaning and effect. Finally, and perhaps most importantly, leadership provides the direction support the whole system. Without these, the process of improving safety culture cannot succeed.

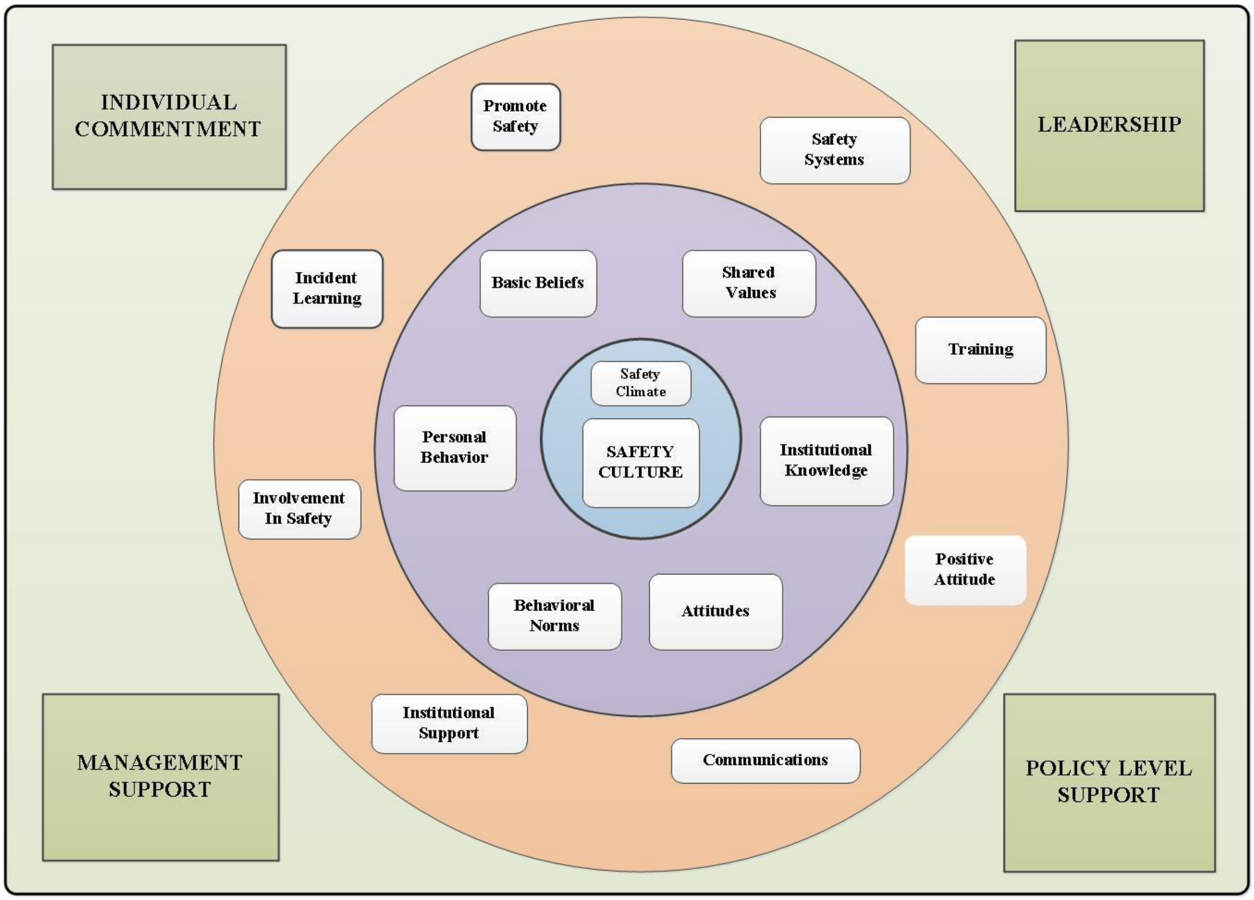

Figure 1.1. Safety Culture Inputs

The second layer of the onion model is comprised of action items that can aid in strengthening safety culture. The development of safety systems and institutional support provide the processes that improve safety. A positive attitude helps in promoting safety and staying involved in it. Incident learning and training provides employees and supervisors with the

necessary knowledge to improve. Altogether, these actions items are tied by honest communications within the group.

The third layer takes into account the psychological aspects that help build the culture of the organization. Every organization has institutional knowledge, shared values, and behavioral norms that determine how the overall system operates. Every employee has basic beliefs and attitudes that shape their personal behavior and their part in a safety culture. These factors merge together to form the safety culture of academic labs, including those at LSU. If the overall goal is to improve safety culture at LSU, then it is necessary to improve safety attitudes and behaviors using the action tools that are available. In this study, aspects of the onion model are reviewed to determine the overall status of safety culture at LSU.

1.1. Thesis Overview

Chapter two presents the general background information to understand the nature of safety culture at LSU. LSU is the flagship university and the major educational and research center for the state of Louisiana. It is a major research center with several hundred research laboratories and research expenditures in 2013-14 at $144 million (LSU). The biological, chemical and physical hazards found in a research laboratory are detailed to stress the potential for an exposure to a laboratory worker. While all hazards are reviewed, the primary focus is on chemistry. Simply because chemists are leading the effort to improve safety culture (Bertozz). The engineering, administrative, and personal controls used at LSU to prevent employee exposures are reviewed. Universities are required to comply with state and federal regulations. While safety culture is a holistic goal, the impact of government regulations drives most aspects of LSU's safety program.

Chapter three examines the events that initiated the current level of concern to improve safety culture. The Laboratory Safety Institute maintains a memorial which lists all the known laboratory accidents that resulted in death for the last hundred years. Over 50 researchers have died in lab accidents around the world since 1990 (LSI). The first incident in the United States to draw national attention to lab safety was the death of Dartmouth researcher, Karen Wetter Hahn (NRC 2014). A qualified researcher working in her field of expertise was exposed to a dimethyl mercury. She was wearing improper gloves for the task at hand and died after 18 months due to mercury poisoning.

In 2008, a researcher at University of California at Los Angles (UCLA) died as the results of an accident that involved the use of pyrophoric compound. While the internal UCLA investigation was closed, CAL/OSHA cited UCLA for safety violations and fined them $30,000. At the insistence of the researcher’s family, civil and criminal charges were brought again the principle investor (PI) and UCLA. After years of legal battle, UCLA settled and the PI was fined and given community service. This case is important because an individual PI was held accountable for an accident and the settlement resulted in a new level of safety requirements for the UC system (Torrice 2014).

A lab was destroyed and a graduate student was injured in an explosion at Texas Tech University in 2010. The student was scaling up an explosive compound when it detonated. This incident is significant because it was the first time that an academic accident was investigated by the Chemical Safety Board (CBS). The CBS is a federally mandated organization whose mission

is to investigate chemical accidents. The investigation standards used in industry were applied and deficiencies were found from the lab worker all the way to the upper management of the university (CSB).

In 2016, another significate incident occurred at the University of Hawaii (UH) when a tank containing hydrogen exploded injuring a lab worker. The University of California Center for Laboratory Safety (CLS) was contracted to investigate the incident as an independent third party reviewer. The CLS issued a detailed technical report concerning the explosion and the immediate cause. The immediate cause of the accident was the ignition of a hydrogen and oxygen gas mixture contained within pressure tank by a static charge (CLS/Tech). Recommendations to improve research safety operations were made in a second report (CLS/Rec). Known historical laboratory incidents at LSU are reviewed (EHS). The LSU incident at Choppin Hall is compared to the UH incident using the CLS recommendation report as a templet to consider potential risks for LSU.

Chapter four takes a deeper look at safety culture and safety climate in terms of organization theory. Organization climate is commonly considered as the generalized perceptions about the organization's items of concern. Organizational culture tends to reflect how people behave, how things are done, and the underlying values and beliefs of the organization (Ali at el.). The perception of the resulting attitudes and behavior help to establish the culture of the organization. Personal, team, and institution attitudes are considered as the primary components that influence a person's attitude about safety (Cheyne). Situational behaviors are also a component of the safety culture of an organization. Planning, practice, and negligence are considered as the primary components of safe behavior in a research laboratory (Jorgensen). The relationships between safety culture, climate, attitudes, and behaviors can be complex and

confusing but the concepts are useful tools for understanding the dynamics of institutional culture and to foster organization improvement (Peterson and Spencer).

Chapter five reviews the general structure of academic research in terms of the systemic impact of safety culture. Every university is different, but many universities, including LSU, places the primary responsibility of laboratory safety on the PI. The PI generally has significant authority in the determination of safety policy for the laboratory (Backus at el.). Research conducted by PI's are usually conducted in an autonomous manner with minimal administrative oversight. The expected duties of research faculty have exponentially increased. In addition, the primary mission of research, the PI is expected to write grants, mentor students, teach, administrate those grants, and serve on various committees. It is not surprising that the typical researcher sees safety as just another troublesome requirement that distracts from their real work (Kroll 2013).

In 2012, the American Chemical Society (ACS) issued a significant report on improving the culture of laboratory safety, *Creating Safety Cultures in Academic Institutions*. The report recognizes that most scientific researchers do not have strong safety skills and calls for changes in the academic safety educational process to promote and improve safety culture. This report identifies the best practices of a good safety culture and provides specific recommendations to strengthen their safety culture (ACS, 2012). The National Research Council (NRC) published *Safe Science: Promoting a Culture of Safety in Academic Chemical Research* in 2014. Due to the number of significant events in laboratories, the NRC was asked to look at instilling stronger safety practices in chemical research. A distinguished panel reviewed the ideas and methodologies of safety culture from the industrial and academic sectors and made recommendations for making

laboratory science safer. The goal of the project was to move chemical research beyond simple compliance to the adoption of a culture of safety in academic laboratories (NRC 2014).

A task force formed by the Association of Public and Land-grant Universities (APUL) utilized both of the reports above and additional sources to produce a roadmap for universities to enhance safety culture, *A Guide to Implementing a Safety Culture in Our Universities*. The guidance document that provides recommendations and guidance on the most appropriate strategies in a clear and concise bullet point format. Each facet of the university from the president down to student body have clearly defined action items and responsibilities to improve safety culture. Additionally, the APUL directly contacted the leadership of all its member universities and called on them to implement the recommendations to improve laboratory safety (APUL).

Chapter six provides the results of a quantitative survey of the safety climate at LSU, which may also provide insight regarding the level of safety culture. The data set for this exercise utilized a laboratory safety survey preformed in 2011 originally designed with the purpose of supporting a Hazard Mitigation Plan. The survey provides a measure of perceptions of laboratory safety among university personnel. The data was collected via individual interviews and statistically analyzed. The relative value of the safety climate at LSU was found to be 3.72 on a scale of 5. This value is comparable to the published values of other universities and considered to be good (Steward at el.).

Chapter seven presents the results of a confirmatory factor analysis (CFA) of a linear model for safety culture. CFA is a technique used in structural equation modeling (SEM) which utilizes cross-sectional statistical modeling techniques that includes factor analysis, path analysis and regression analysis. CFA is used to determine if a certain model is valid (O'Rourke & Hatcher).

A linear model of safety culture is proposed based on inputs of safety climate, safety attitudes, and safety behaviors (Figure 1.2). Data to confirm the model was based on an electronic survey that was sent to 1000 research personnel consisting of LSU faculty, research staff, and graduate students.

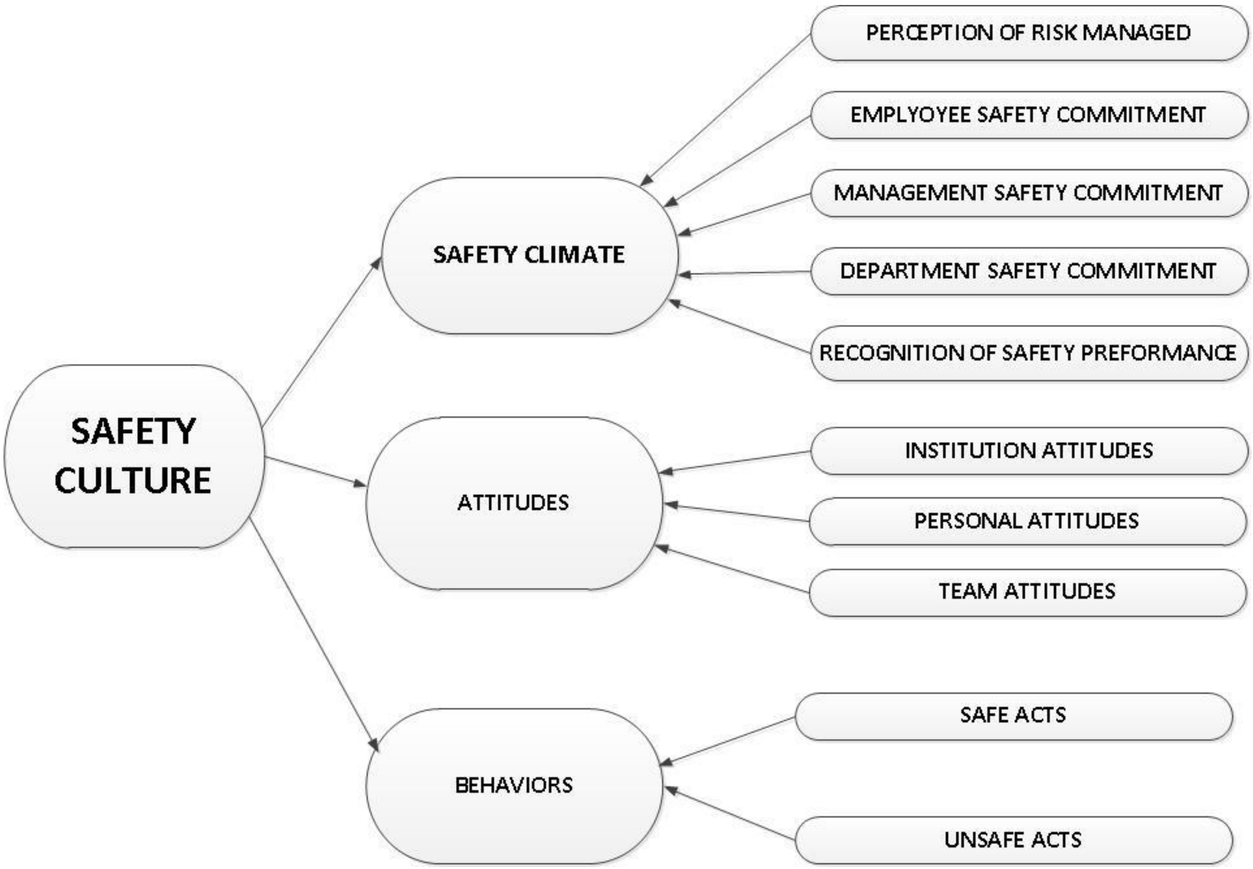

Figure 1.2. Safety Culture Conceptual Model

Approximately 300 responded and the data was tabulated and statically analyzed using structural equation modeling techniques. A linear model for Safety Culture at LSU was compared to the conceptual model using PRO CALIS in SAS 9.4. The Standardized Root Mean Residual (SRMR) of the model is 0.053. The Bentler Comparative Fit Index is 0.895. Root Mean Residual (RMR)

is 0.058. The goodness of fit values indicate that the model's overall structure of the culture model provides a reasonable fit of the data and confirms the conceptacle model.

In the conclusion section, the overall safety program and level of safety culture at LSU is summarized and evaluated. The existing lab safety program at LSU is reviewed in comparison to the APUL recommendations that help define safety culture. In general, the perception of LSU personnel is that the safety culture is good. However, that perception can easily and quickly change with one incident.

CHAPTER 2. HAZARDS AND APPLICABLE REGULATIONS

2.1. University Background

Louisiana State University is the flagship institution of the state of Louisiana. The university is located on more than 2,000 acres in the southern part of Baton Rouge on the east bank of the Mississippi River. The main part of the campus contains over 250 principal buildings grouped on a 650-acre plateau. In 2011, this university enrolled nearly 24,000 under-graduate and over 5,000 graduate students in 14 schools and colleges. The university has over 6,000 full-time and 9,000 part-time employees which include over 1,400 faculty members. The university is designated as a land-grant, sea-grant, and space-grant institution (LSU). The Office of Environmental Health and Safety (EHS) has a staff of ten safety professionals that provides regulatory compliance assistance, training programs, program development and implementation, technical support, inspections, and emergency response services for the Baton Rouge campus of Louisiana State University.

The primary goals of a university are to promote educational learning and research. LSU consistently ranks among the top 30 universities in total federal, state and private expenditures. LSU's instructional programs include 193 under-graduate and graduate professional degrees. In addition to the colleges, schools, centers for advanced study, and specialized units headquartered at this university, various state and federal governmental agencies maintain offices and laboratories on campus. At any given time, more than 1,200 sponsored research projects are in progress. Faculty, staff members, and graduate students also pursue numerous research projects that are not funded by outside agencies. Research expenditures at LSU in 2013-14 were $144 million. LSU's

awarded grants and contracts from federal, state, and private sources provide a significant boost to the Louisiana economy (LSU).

2.2. Hazards in Laboratories

University research laboratories are unique workplaces due to the number and type of potential hazards. Commonly university laboratories harbor the potential for acute and chronic exposure to a wide range of toxic agents. Every major university has the potential to utilize biological, chemical, mechanical, electrical, physical, and radiological agents in research settings (Prudent 2011).

2.2.1. Biological Hazards

Biological agents can pose a threat to workers and the general population depending on their potency and mechanism of release. Since the initial printing in 1984, Biosafety in Microbiological and Biomedical Laboratories (BMBL) has become the minimum standard of practice for biosafety. The BMBL addresses the safe handling and containment of infectious microorganisms and hazardous biological materials. Biological agents such as bacteria and fungi are living organisms while as viruses and prions are non-living biological agents. Toxins produced by biological agents are also items of concern. Through a risk based assessment process, biological agents are assigned to Biosafety Levels 1 through 4 with specific handling procedures and controls for each biosafety levels (BMBL 2009).

Modern biological research has grown exponentially in the last thirty years and is highly regulated in certain areas. Creation or research with biological agents that include recombinant DNA or synthetic nucleic acid molecules require additional scrutiny and handling procedures. Detailed safety practices, containment procedures, and training requirements are found in the

National Institute Health (NIH) Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules. To insure compliance with the NIH Guidelines, all applicable institutions are required to establish an Institutional Biosafety Committee (IBC) to review and approve protocols for working with Recombinant or Synthetic Nucleic Acid Molecules, Pathogens, potential Infectious Agents, Biological Toxins, and Human Clinical Trials (NIH 2016). Biological Safety Committee's look at all levels of biological projects to ensure safe protocols. The Inter-Institutional Biological Recombinant DNA Safety Committee (IBRDSC) serves this function for both LSU and Agricultural Center (IBRDSC).

Working with laboratory animals also pose numerous safety issues. Any biological agent, hazardous chemical, radiation source that has a potential to impact the animal also has the potential to impact the corresponding laboratory worker. Another risk is the fact that sometimes the animals spit, kick, scratch, or bite the handler. Institutions that work with animals and receive Federal funding must establish an Institutional Animal Care and Use Committee (IACUC) to review and approve protocols for all research-related animal work (NRC 2009). The mission of the LSU IACUC is to review teaching and research protocols to ensure the humane treatment of the animals and the safety of the research (IACUC).

2.2.2. Chemical Hazards

Chemicals have inherent physical, chemical and toxicological properties that require laboratory personnel to have a good understanding of the related health and safety hazards. The main types of chemical hazards include flammability, corrosively, reactivity/ instability, gases/cryogenic liquids, and toxicity. Laboratory personnel must understand the major hazard classes of chemicals, the types of toxicity, and recognize the potential routes of exposure. The most

important single generalization regarding laboratory research is to treat all compounds as potentially harmful, and work with them under conditions to minimize exposure by skin contact and inhalation (Prudent).

Flammable materials are simply materials that burn readily and are found in almost every research lab as some form of solvent or reactant. Flammable and combustible liquids are classified according to their flash point, with flammable liquids having a flash point of less than 100 °F and combustible liquids having a flash point between 100-200 °F. Both flammable and combustible liquids are considered fire hazards. Care must be taken during laboratory work to prevent ignition of flammable materials (CHP).

Corrosive chemicals are those which can cause damage to living tissue at the site of contact by chemical reaction. Major classes of corrosive substances include strong acids (e.g., sulfuric, nitric, hydrochloric, and hydrofluoric acids), strong bases (sodium hydroxide, potassium hydroxide, and ammonium hydroxide), dehydrating agents (sulfuric acid, sodium hydroxide, phosphorus pentoxide, and calcium oxide), and oxidizing agents (hydrogen peroxide, chlorine, and bromine). Corrosive substances pose a danger not only to skin and eyes, but also to respiratory tracts and sometimes to digestive tracts. Corrosive chemicals also have the potential to corrode other materials which might result in failure of a piece of equipment (CHP).

Highly reactive materials are those that have the potential to vigorously polymerize, decompose, condense, or become self-reactive under conditions of shock, pressure, temperature, light, or contact with another material. Anytime there is a runaway reaction there is a potential for an explosion. Compounds that contain high energy bonds such as azides, organic nitrates, nitro compounds, azo compounds, perchlorates, and peroxides that can violently destabilize when

exposed to light, mechanical shock, heat, or catalysts. Reactive metals such as sodium, lithium and potassium react with water or alcohols to produce flammable hydrogen gas. Air-reactive chemicals are also called pyrophorics; they react with oxygen or water in the air immediately upon exposure and ignite, sometimes violently. Organometallic reagents are often used in reactions that produce flammables as products or are carried out in flammable solvents and require special attention (CHP).

Oxidizing agents are chemicals that can remove electrons from other compounds often resulting in a violent reaction when they come in contact with reducing materials, trace metals, and sometimes ordinary combustibles. These compounds include the halogens, oxyhalogens, peroxyhalogens, permanganates, nitrates, chromates, and persulfates, as well as peroxides. Organic peroxides are a special class of compounds with unusually low stability and are among the most hazardous substances found in a laboratory. Common solvents, such as diethyl ether and tetrahydrofuran, can form peroxides on exposure to oxygen in air and become concentrated as the solvent evaporates. Although they are low-power explosives, they are hazardous because of their extreme sensitivity to shock, sparks, and other forms of accidental detonation. Any sample of a highly reactive material may be dangerous. The greatest risk is due to the remarkably high rate of a detonation reaction rather than the total energy released. A high-order explosion of even milligram quantities can drive small fragments of glass or other matter deep into the body. It is important to use even minimum amounts of hazardous materials with adequate shielding and personal protection (CHP).

A compressed gas is defined as a material in a container with an absolute pressure greater than 40 psi at 21 °C and cylinder of compressed gas are common laboratory supplies. Along with

the hazard associated with the high pressure, the compressed gas retains any hazard associated with the material in its gaseous form (CHP). The U.S. Department of Transportation (DOT) has established codes that specify the materials to be used for the construction and the capacities, test procedures, and service pressures of the cylinders in which compressed gases are transported. The Compressed Gas Institute has published a useful guide to safe handling and storage procedures for compressed gases (OSHA 1965). Cylinders must be restrained or secured from tipping or falling to prevent damage to the valve. Damaged valves may fail, resulting in catastrophic release of energy. [Prudent] Storage and use of flammable gases, like acetylene or hydrogen, are strictly regulated by local fire authorities (OSHA 1965).

Cryogenic liquids are agents or processes that deal with very low temperatures and are defined as materials with boiling points of less than −130 °F to differentiate them from standard refrigeration processes. Cryogens are often used in cold traps to condense volatile vapors from a gas stream and storage of biological samples. Cryogenic conditions are often achieved by using liquefied gases, particularly liquid nitrogen and helium. Rapid vaporization of cryogenic can displace oxygen from the atmosphere and asphyxiate lab personal. Cryogens have the ability to liquefy other gases, including oxygen and air, which can present addition hazards. The primary hazards of cryogenic liquids are frostbite, asphyxiation, fire or explosion, pressure buildup (either slowly or due to rapid conversion of the liquid to the gaseous state), and embrittlement of structural materials (CHP).

The Occupational Safety and Health Administration (OSHA) Laboratory Standard defines a hazardous chemical as a chemical for which there is statistically significant scientific evidence that acute or chronic health effects may occur in exposed personnel. The term 'health hazard'

includes chemicals which are corrosive, carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, sensitizers, and agents which damage specific organs (OSHA 1990).

Carcinogens are chemicals which are or may be associated with the development of carcinoma in humans. Generally, they are chronically toxic substances which cause damage after repeated or long-duration exposure. Their effects may only become evident after a long latency period and are particularly insidious because they may have no immediate apparent harmful effects (Prudent). Numerous national and international agencies issue lists of known or suspected human carcinogens. The International Agency for Research on Cancer (IARC) uses a classification system which divides agents into one of five groups. Group 1 agents are definitely carcinogenic to humans; Group 2A agents are probably carcinogenic to humans; Group 28 agents are possibly carcinogenic to humans; Group 3 agents cannot be classifiable as to carcinogenicity; and Group 4 agents are probably not carcinogenic to humans (Boyle & Levin, 2008). Whereas, the National Toxicology Program (U.S. Public Health Service) issues a biennial report to Congress with a classification system that uses only two groups: agents which are known to be human carcinogens, and agents which are reasonably anticipated to be human carcinogens (NTP). Not to succumb to logical chemical classification, one can refer to California's Proposition 65 which lists numerous chemicals believed by the state of California to cause cancer or reproductive toxicity regardless of scientific evidence.

Toxicity is a characteristic of many substances from the poisons used by the ancient Greek to the waste from Love Canal. A toxin can be defined as a chemical which in small doses can cause adverse health effects (Gallo). Modern toxically is based on risk assessment methods which are often expressed in terms dependent upon the dose to which one is exposed, the amount of time

of exposure, and the route of exposure. A common measure of toxicity of a material is the LD 50, the concentration of exposure that will result in the death of fifty percent of a given population. The evaluation of hazards associated with working with toxic substances is complex and it is important to note that a number of factors influence the response of individuals to exposure to toxic compounds (Eaton and Gilbert).

Reproductive toxins can affect the reproductive health of both male and female personnel if proper procedures and controls are not used. For women, exposure to reproductive toxins during pregnancy can cause adverse effects on the fetus and postnatal functional defects. In men, various effects chemicals can impact sperm and male fertility. Chemicals that that cause local, short-term adverse effects, either from short-term or chronic use are defined as irritants. They are generally classified as noncorrosive agents for which inflammatory effects are reversible. Sensitizer (allergen) is a substance that causes exposed people to develop an allergic reaction in normal tissue after repeated exposure to the substance. Often initial exposure causes little or no effect, but upon repeated exposure may elicit strong reactions (CHP).

2.2.3. Physical Hazards

Electrical and magnetic hazards are common in laboratories with hazards associated with electrical shock or the ignition of flammables. Common electrical equipment found in laboratories includes fluid and vacuum pumps, lasers, electrophoresis and electrochemical power supplies, x-ray equipment, stirrers, hot plates heating mantles, microwave ovens and sonication devices. It is the responsibility for lab personal to regularly inspect electrical equipment to ensure that it is properly grounded and all wiring is intact (Prudent).

High and low pressure systems are also found in LSU research labs. Vacuum pumps are often used in conjunction with glass reaction vessels and rotary evaporators. High pressure vessels can be used for chemical reactions. However, the most common high pressure vessel is the steam autoclave. Autoclaves are used to destroy biological materials via high pressure and high temperature. Failure of the containment vessel is the primary danger associated with work at high or low pressure and the subsequent implosion or explosion which can result in injury and destruction (Prudent).

Many laboratories at LSU have some form of mechanical equipment that have the potential to be a safety hazard. For example, gas turbines for combustion research, polymer extruder, concrete pressers, various pumps, and rotating equipment. Additionally, there are several machine shops on campus. Many biological labs use high speed centrifuges which operate at high speed at and have great potential for injuring users if rotors are unbalanced. Even sample container breakage can generate aerosols that may be harmful if inhaled (OSHA 2010).

2.2.4. Radiation Hazards

Radioactive materials are found in research laboratories and LSU is no exception. A radioisotope is a chemical element with an unstable nucleus that undergo spontaneous decay to a more stable form and has the potential to release radiation that can be damaging to living tissue. Radioisotopes are commonly used in the life sciences research laboratories to trace biological energy pathways. Nuclear medicine is on the forefront of scientific medical research. Radioisotopes are used both in the diagnosis and treatment of certain diseases. Radioactive sealed sources are also found in various laboratory settings. Analytical instruments used sealed source as powers sources and detection units. X-ray machines and lasers are also sometimes referred to

as sealed sources. Acquisition, use and disposal of radioisotopes are heavily regulated by state agencies under the authority of the Nuclear Regulatory Commission (NRC). Nonionizing radiation also poses a hazard to laboratory workers. The primary hazard is to eyesight and nonionizing radiation includes ultraviolet, visible, and near-infrared radiation from lamps and lasers, and radiofrequency and microwave radiation from ovens, heaters and inductive furnaces (Prudent). There are claims that cancer is caused by electric and magnetic fields from cell phones and power lines. Despite denial from the NIH Cancer Institute there are still people out there wearing cone shaped aluminum hats (NIH).

2.3. Methods for Control of Laboratory Hazards

A hierarchy of hazard control is mandated by OSHA to protect workers from hazards. The preference of order for hazard control is engineering controls, administrative controls, and as a last resort the use of personal protective equipment. The four standard routes of exposure to a chemical or biological agent are inhalation, absorption, ingestion, and injection and the exact nature of the control depends on the exposure path (Prudent).

Equipment use to remove or reduce the hazard in the workplace are considered as an engineering control. Protection from inhalation hazards in laboratories consist primarily of ventilation devices like chemical fume hoods, biosafety cabinets, and local ventilation devices like snorkels. Chemical fume hoods are intended for work with flammable and corrosive chemicals by removing fumes from the breathing zone of workers via air flow. Biosafety cabinets are intended for work with bacteria, viruses, cell lines by keeping a sterile environment inside the cabinet and protect personnel in the laboratory by confining microbes. Microorganisms are removed by filtering air through a particulate filter and a carbon filter. Snorkels simply remove air from the

room via a hose over the process of concern (Prudent). LSU has a strong program for ventilation controls. Chemical fume hoods are maintained by Faculties Services and flow rates are checked yearly. Biological safety cabinets are also checked yearly by outside contractors. EHS has a dedicated Industrialist Hygienist to oversee ventilation control.

Engineering control for other exposure routes are dependent on the situation and if there is an engineering solution. Safety showers and eyewash stations are fundamental pieces of laboratory safety equipment that could be considered as engineering controls (OSHA, 2010). Safety showers are uses to quickly wash off hazardous materials off of the body and eyewash stations are used to rinse eyes after an exposure (Prudent). LSU provides laboratories with access to safety showers and eye wash stations.

The next level of controls to reduce exposure to hazardous material is administrative controls. Administrative controls are basically consisting of good laboratory practices as outlined in Prudent Practices and the BLMB. Some of these items fall into the common sense range like using smallest amount needed of the hazardous material, good handling technique, no food or drink in the lab, proper clothing and shoes, and wearing proper personal protective equipment. Administrative controls also contain items that are more proactive in nature. Hazardous material should be inventoried and tracked to minimize storage usage levels. Chemicals should be stored by a defined plan that prevents the mixing of incompatible material. The development and use of standard operating procedures (SOP) provides guidance to the lab worker. Safety reviews and hazard analysis can often help determine problems before they happen (Prudent, BLMB). At LSU, EHS provides these types of tools for the researcher use via the EHS Assistant. However, there is

no mandate to use these particular administrative control tools, but it left to the discretion individual PI.

Mandating the use of Personal protective equipment (PPE) in the lab is a significant administrative control. PPE against absorption and injection include protective laboratory coats or gowns, gloves, and eye protection. Unfortunately, the enforcement of the PPE use varies from lab to lab depending on the PI. Lab coats can protect workers against skin and clothing contact with hazardous materials. Different lab coats provide different protections and lab coat selection should be part of a hazardous analysis. Eye protection can include impact-resistant safety glasses; safety goggles or full-face shields depending on the level of hazard. Nobody should enter any lab containing hazardous material without basic eye protection and a lab coat. Lab personnel handling hazardous materials should wear gloves. It is important to select the right type of glove to use and these needs to be part of the hazard analysis. Also very important, lab workers need to be taught the proper techniques for glove use. For example, how and when to take gloves off to prevent contamination (Prudent).

When engineering and administrative controls cannot reduce risk of inhalation to acceptable levels, employees may wear respirators. Use of respirators is considered to be the last line of defense against exposure and a separate OSHA respiratory standard controls use of respirators. This standard requires that respirator users must have medical approval; be fit-tested annually, and have appropriate style of respirator for the task. LSU prefers to use administrative and engineer controls whenever possible, but has a respiratory protection program.

2.4. Regulations with Potential to Impact Laboratory Safety

Numerous federal, state, and local regulations have a potential to impact laboratory safety at a university to varying degrees. Perhaps the most relevant regulatory requirements for laboratory safety come from OSHA. The OSHA standards of the 1970's were aimed at industry and did not translate very well to laboratories; however, these OSHA general duty clauses do require the employer to provide a workplace free from recognized hazards (Prudent). The Hazard Communication Standard was initially established in 1983 for chemical manufacturers but was expanded to all industries (universities included) in 1987. The Hazard Communication Standard mandated improved chemical labeling, material safety data sheets (MSDS), and chemical training for workers. The overall impact of the Hazard Communication Standard was to increase access to information about hazardous materials (OSHA 1987). The Hazard Communication Standard was recently updated to become compliant with the Globally Harmonized System endorsed by the United Nations. The format for Safety Data Sheets (SDS) was standardized and a more coherent system of international warning words and symbols has been adopted (OSHA 2000). Louisiana has a State Right-to-Know law that mimics the federal hazardous communication regulation (LAC 33).

The 1990 OSHA Laboratory Standard "Occupational Exposure to Hazardous Chemicals in Laboratories" required laboratories to develop a chemical hygiene plan to reduce the potential for chemical exposure.to workers, determine potential exposure levels for workers, and provide training. The lab standard is one of the earliest performance standards issued by the federal government and the major objectives of the standard are outlined in Appendix A of the standard. The standard requires development of a chemical hygiene plan (CHP) consisting of good chemical

hygiene practices as recommended by the National Research Council's 1981 edition of Prudent Practices. The standard also requires employee training and defines special requirements for work with particularly hazardous substances and acute toxins. Based on the requirements of the OSHA Lab Standard, LSU has a CHP which can be accessed online, The CHP discusses the general principles of lab safety; responsibilities; laboratory design and maintenance, applicable standard operating procedures, general procedures for working with chemicals; and safety recommendations (CHP).

Other OSHA regulations have the potential to apply to laboratory settings such as the Respiratory Protection Standard (use of masks and respirators); the Blood borne Pathogens Standard (control the biologic hazards of human blood) and a number of standards found in 29 CFR 1910.1000 (OSHA 2010). In Louisiana, the OSHA program is administrated by the federal government and public employees including LSU employees are exempt from the OSHA requirements. LSU Policy Statement 19 (PS-19), "Environmental Health and Safety", states that all University activities shall be conducted in accordance with applicable safety codes, and governmental safety and environmental standards, which includes OSHA standards (PS-19). Unfortunately, at this university, compliance with OSHA regulations is policy and not a legal requirement.

The Environmental Protection Agency (EPA) regulates safe handling, storage and disposal of hazardous chemical waste through the Resource Conservation and Recovery Act (RCRA). Prior to passage of the initial RDRA regulations, disposal of hazardous chemical waste was largely unregulated. It was a common practice to dispose of hazardous chemical waste in uncontrolled landfills or directly to the sanitary sewer. The end result was the contamination of soil and water

with toxic chemicals (EPA). While the regulations are aimed at industry, that are applicable to university laboratories in full force. In Louisiana, the RCRA program is administered by the Department of Environmental Quality (DEQ) and LSU is subject to federal and state Hazardous Waste regulations. EHS is responsible for the hazardous program at LSU. LSU is a large quantity waste generator which means that it generates over 1000 kilograms of waste per month. EHS operates a 90-day waste facility which is permitted for storage only and no treatment or disposal is allowed on site. Chemical and biological waste are collected, categorized, and stored by EHS. Outside vendors collect the waste and it is incinerated at an approved facility.

A tremendous amount of effort is expended in training personnel in proper methods of waste disposal, but often a nonchalant attitude regarding following the rules prevails among the waste generators. Not unexpectedly, there is a flurry of activity to "make things right" following a federal or state waste handling citation similar to response to a serious accident (CEN). LSU provides an example of reactive handling of regulatory citation. On May 21, 2003, RCRA personnel conducted an inspection of waste handling on the Baton Rouge Campus and numerous citations were issued. In lieu of a large fine, LSU agreed to a Consent Agreement with the EPA to complete a Supplemental Environmental Project. The SEP required installation of a chemical inventory system, personnel to manage chemical inventory, review the use of alternate fuels, and provide training for other schools in Louisiana. At the completion of the program a total of $206,000.00 had been spent on SEP implementation activities (SEP).

The Chemical Facility Anti-Terrorism Standards (CFATS) are intended to enhance the security of US chemical plants against terrorist attacks. The US Department of Homeland Security (DHS) also applied the CFATS rule to academic universities. The regulation required any facility

holding a quantity equal or greater to the target level of a defined chemical (Appendix A list) to register, complete, and submit a preliminary screening assessment (Top-Screen). DHS would determine the associated level of risk which in turn would require the facility to perform site vulnerabilities assessments (SVA) and implement site security plans (SSP) to thwart terrorist attacks. LSU completed an extensive inventory of the CFATS chemicals and determined that it was below any of the chemical threshold levels (Homeland).

Biological Safety is rapidly becoming inundated with rules and regulations. The select agent program (42 CFR Part 73) is a maze of strict requirements and inspections enforced through the Center for Disease Control and Prevention (CDC). Outside of the select agent program, there are few federal regulations to reference. National Institutes Health (NIH) has issued strong biosafety requirements for projects involving DNA and RNA. Enforcement is through the threat to withhold grant funds and by reference to standard code for the practice for biosafety (BMBL). As such it us the responsibility of the university to guide researchers and monitor biological safety. At LSU, the Inter-Institutional Biological and Recombinant DNA Safety Committee (IBRDSC) has assumed this role through the registration and review of biological projects (IBRDSC).

Radiation Safety is a long established program that is highly regulated with specific requirements and consequences for the receipt, possession, use, transfer, and disposal of radioactive materials (NRC). LSU's Radiation Safety Office works with the Department of Environmental Quality to obtain licenses for each researcher using radioactive materials. Each license clearly defines the specific use and purpose of the radioactive materials. Prudent practices for working with radioactive materials are similar to those needed to reduce the risk of exposure to toxic chemicals. The Radiation Safety Office monitors the use of radioactive materials at LSU (RAD).

CHAPTER 3. SIGNIFICANT SAFETY EVENTS

Concerns about safety in academic laboratories has increased in the past few years as demonstrated by numerous editorials in chemistry related journals such as Chemical and Engineering News (an American Chemical Society publication) and chemistry related blogs such as such as ChemJobber and ChemBark. The rise in concern is partly because of recognition of the necessary to improve safety culture, partly of regulatory requirements, and partly due to several significant incidents that have brought attrition to the issue (NRC 2014). Adverse laboratory incidents occur more frequently in teaching and research when compared to industrial laboratories. Estimates of the frequency of these incidents in school and college laboratories have been reported to be 100 to 1,000 times greater than the frequency seen in industrial laboratories (LSI).m Scientists learn and establish safety practices during their years of study at post-secondary institutions, and carry those safety habits into their professional careers. Improving ways in which laboratory safety is taught s important to the future health and safety of society (ASC 2012). Reports that review these significant incidents in an effort to help the academic community to emphasize safety in research laboratories have been published by such noteworthy organizations such as the American Chemical Society, National Research Council, and The Association of Public and Land Grant Universities (APLU). These reports will be reviewed later in Chapter Five. This chapter looks at several of these significant events, describes some known incidents at LSU, and compares an accident at the University of Hawaii to a similar incident at LSU.

3.1. Dartmouth Incident

The death of Karen Wetterhahn is the first significant events that started increasing the awareness of safety culture. Dr. Wetterhahn, a professor of chemistry at Dartmouth College and director of the Toxic Metals Research Program, died on June 8, 1997 of mercury poisoning. Her death was attributed to a single exposure of dimethyl mercury in August, 1996. During a transfer of dimethyl mercury between containers, Wetterhahn spilled several drops of the compound onto her gloved hand. The spill was considered as only a minor incident at the time because it was done under the standard safety protocol at the time, conducting the transfer in a fume hood, wearing eye goggles, and disposable latex gloves. Approximately five months later, Wetterhahn began experiencing physical difficulties and was diagnosed with acute mercury poisoning. Her condition continued to deteriorate and in February 1997, Wetterhahn went into a coma. Within ten months of the initial exposure she was dead (Dartmouth).

Dr. Wetterhahn was considered as a specialist in metal toxicology, but was not aware of all the potential hazards associated with dimethyl mercury. The dimethyl mercury transfer was carried out using the best safety precautions known at the time. The Material Safety Data Sheets (MSDS) for dimethyl mercury recommended the use of chemically impervious gloves when handling the compound, but provided no additional details on the subject. Permeation testing after Dr. Wetterhahn's death indicated that dimethyl mercury permeates all standard gloves used in a research lab. OSHA safety guidelines were modified to discourage the of dimethyl mercury as an after fact of recognition of the high handling risk. An OSHA memorandum called for research organizations to produce a "protective chemical hygiene plan, which includes adequate guidance on the appropriate selection of personal protective equipment and engineering controls" (OSHA

DMM). The significant factor of this incident was that it surprised the academic community that a researcher would not know the hazards in their field of study and demonstrated the need for collaborative relationships between university researchers and health and safety professionals in to determine potential laboratory hazards and creating safe handling protocols.

3.2. University of California Los Angeles Death

The death of a chemistry research assistant, Sheharbano (Sheri) Sangji, from a chemical fire has brought significant attention to the general status of the safety culture in academic laboratories. On December 29, 2008, Ms. Sangji was working in the laboratory of Dr. Patrick Harran in the Department of Chemistry and Biochemistry at University of California, Los Angeles (UCLA) to scale up a reaction that had been previously completed. While drawing tert-butyl lithium in pentane into a syringe when an undetermined amount of the liquid splashed onto her hands, arms, and torso, and immediately ignited her clothing. Ms. Sangji was not wearing a lab coat and was burned over 43% of her body. She died from her burns on January 16, 2009 (Kemsley 2009).

The incident was investigated by the UCLA Fire Department, UCLA Police Department, UCLA Environmental Health & Safety Office (EH&S), Los Angeles (LA) City Fire Department, and California Division of Occupational Safety & Health (Cal/OSHA). The information collected by UCLA fire marshal investigators was reviewed by the California State Fire Marshal Arson Bomb Investigation Division and concluded that the incident was an accident and closed the case. Cal/OSHA investigated the incident due to Sangji's status as an employee rather than a graduate student and as a result of the investigation Cal/OSHA fined the university $31,875. Cal/OSHA cited UCLA due to the lack safety training and training documentation; failing to ensure employees

wore appropriate personal protective equipment (PPE), and failing to correct unsafe conditions and work practices identified in a previous laboratory safety inspection. Sangji's family publically expressed their belief that the investigations were inadequate and pressed to take the matter to the Los Angeles district attorney's (LA DA) office. Cal/OSHA forwarded its findings to the LA DA's office for evaluation (Kemsley 2011).

On December 27, 2011, the LA DA's Office filed charges against the University of California (UC) Reagents and UCLA chemistry professor Patrick Harran for felony violations of California labor laws. California labor code that makes it a crime for any employer or employee manager to willfully violate any occupational safety or health standard in a way that causes death or prolonged injury to an employee. The term "willfully" means that the employer's actions were not accidental but it does not imply that the employer intended to break the law or injure an employee. The specific charges cite regulations involving failure to correct unsafe workplace conditions and procedures in a timely manner, failure to require work-appropriate clothing and personal protective equipment, and failure to provide chemical safety training to employees. Convection on the charges had the potential for a four-and-a-half years in state prison term for Dr. Harran and the university faced fines of as much as $4.5 million (Kemsley 2011).

UCLA did not contest the findings or appeal the fine but began working to enhance the university's lab safety programs. In a summary report, Gibson's reports improved operations of the Office of Environment, Health and Safety (EH&S). They instituted mandatory laboratory safety training of researchers and enhanced overall inspection procedures. Implementation of a Laboratory Hazard Assessment Tool (LHAT) that helps researchers in the identification of hazards

and track laboratory space and personnel. Use of personal protective equipment (PPE) improved and the LHAT helps guide lab groups in compliance with PPE policies (Gibson).

On July 27, 2012 a settlement agreement between the UC board of reagents and the LA DA's office was signed which dropped the felony charges against UC. The agreement did not include Dr. Harran and the charges against him were not dropped. The Regents accepted responsibility for the laboratory conditions that led to Sangji's death and establish an environmental law scholarship in Sangji's name at UC Berkeley. They also agreed to maintain a laboratory safety program for laboratories at all of its campuses (Torrice 2012).

The safety program requires specific safety training for principal investigators and laboratory personnel. Written standard operating procedures for hazardous chemicals had be developed and reviewed by the PI before that chemical can be used in their lab. PI's are required to outline minimal personal protective equipment their laboratories and enforce the use of PPE. Additionally, ULCA is required to formally document and evict any laboratory personnel who fails to wear the proper PPE (PEA).

On Sept. 5, 2012, Dr. Harran was arraigned and testimony heard during a preliminary hearing in November and December, 2012. Dr. Harran was ordered to stand trial on April 26, 2013. Dr. Harran's defense team filed a motion to dismiss the case based on the credibility of the chief Cal/OSHA investigator of the case. The investigator had a sealed juvenile record for murder of man during a failed methamphetamine deal. The motion contended that the failure to disclose the conviction brings into question his creditability and that the incident report. The judge denied the defense motion to dismiss the case. The motion was appealed to the California Court of Appeal and the motion was dismissed on Oct. 24, 2013 (Torrice 2014).

On June 20, 2014, an agreement to defer Dr. Harran's prosecution of on felony charges was approved. The charges were not dismissed, but the case was effectively placed on hold until his completion of the terms of the agreement. Dr. Harran is required to pay a $10,000 fine and complete multiple forms of community service over a five-year period. The professor must complete 800 hours of community service in the UCLA hospital system in a non-teaching role. He is also required to develop and teach an organic chemistry preparatory course for Los Angeles inner-city high school students. He is required to lecture all incoming UCLA chemistry and biology students about laboratory safety. Any violation of the California labor code over the five-year term will nullify the terms of the agreement. The L.A. DA's office, Cal/OSHA, and the court will monitor compliance with the terms of the agreement. Assuming full compliance, the DA's office will move to dismiss all charges against him and will not pursue any further prosecution at the end of the five-year term (DPA).

Dr. Harran was selected as a fellow of the American Association for the Advancement of Science in 2015. In theory, the AAAS selection process is based only on scientific achievement and not behavior or other issues. However, in response to numerous comments, the AAS reconsidered his election as fellow. Based on the fact that several members of the nomination committee were unaware of the accident, the AAS rescinded the election of Patrick Harran as a fellow (Kemsley 2015).

This incident and court case is very significant in the world of academic laboratory safety culture. The safety programs developed for the UC schools provide a "gold" standard for laboratory safety requirements. The additional UCLA requirements reintroduced the concept of EHS as safety cops. However, the most significant aspect is the knowledge that individual

researchers are really responsible for their people and that they cannot count on full University support in case of a serious incident.

3.3. Texas Tech University Laboratory Explosion

A laboratory explosion at Texas Tech University (Texas Tech) is another pressing example of the need to improve the culture of safety in academic research. On January 7, 2010, a graduate student within the Chemistry and Biochemistry Department was severely injured when a chemical that he was working with detonated. While there have been numerous academic incidents, this one is significant because it was formally investigated by the U.S. Chemical Safety and Hazard Investigation Board (CSB). While the report noted that academic research laboratories have a unique cultural and dynamic nature, the CSB found systemic deficiencies within Texas Tech that contributed to the incident (CBS).

The CSB is a scientific investigative organization established by the Clean Air Act Amendments of 1990. Its mission is the investigation of chemical incidents to determine root causes and to issue recommendations in an effort to prevent future events. Texas Tech was the first academic incident that was investigated using the same standards and techniques as an industrial chemical accident (CBS).

Texas Tech was a subcontractor in a U.S. Department of Homeland Security (DHS) program titled “Awareness and Localization of Explosive-Related Threats” (ALERT). The focus of Texas Tech’s research included synthesizing and characterizing new potentially energetic materials. Graduate students were synthesizing a nickel hydrazine perchlorate (NHP) derivative on the order of 300 milligrams. In order to have a uniform sample for analytical testing the reaction was scaled up to 10 grams. The scale up was done without written procedures, consulting the PI,

or formal hazard analysis. The product was placed in mortar with hexane to grind to a uniform size. When it exploded, the worker was not wearing safety goggles. After the incident, all partners in the ALERT program implemented a voluntary stop-work order in the laboratories working with energetic materials which lasted four months (CBS).

Often an accident investigation tends to focus on the actions and decisions of the individuals involved in the immediate activities preceding the event. For example, it is likely that an in house investigation of the Texas Tech incident would have focused on the actions of the student and the inquiry ended at that point. This is a limited form of inquiry that tends to overlook the underlying causes of the incident. The CSB applied modern accident causation methods in the form of in the James Reason's "Swiss cheese model" to the Texas Tech explosion. [Reason] The CSB concluded that each layer of safety management within the university had deficiencies that contributed to the incident (CBS).

Texas Tech's laboratory safety management plan was modeled after OSHA's Laboratory Standard (29 CFR 1910.1450) which primarily addresses chemical health hazards and does not consider potential physicals hazards in the laboratory. Practices and procedures were not in place to effectively assess and control the hazards of the energetic materials research work. Guidance for research laboratory hazard evaluation did not exist. Texas Tech did not have a comprehensive system to document and communicate near-miss and previous incidents. The principal investigators, the department, and university administration at Texas Tech provided insufficient safety accountability and oversight (CBS).

The CBS report notes that generally academic laboratories have not utilized the vast number of references, standards and guidelines developed to promote different types of hazard

evaluation methodologies in industrial settings. The CSB calls for all academic institutions to use the lessons learned from the Texas Tech incident as an opportunity to compare their own policies and practices for laboratory safety (CBS).

3.4. University of Hawaii Incident

On March 16, 2016, a postdoctoral researcher lost her arm, sustained burns to her face, and temporary loss of hearing in hydrogen/oxygen explosion at the University of Hawaii at Manoa campus (UH). She was working in a laboratory at the Hawaii Natural Energy Institute (HNEI) in the Pacific Ocean Science and Technology (POST) building. The University of California Center for Laboratory Safety (CLS) was contracted to investigate the incident as an independent third party reviewer. The CLS issued a detailed technical report concerning the explosion and the immediate cause. The immediate cause of the accident was the ignition of a hydrogen and oxygen gas mixture contained within pressure tank by a static charge (Merlic 1). Recommendations to improve research safety operations were made in a second report (Merlic 2).

The primary goal of the research at HNEI is renewable energy sources and energy integration into the grid system. The specific lab's primary research involved green production of bioplastics and biofuels using open continuous gas flow bioreactors. Knallgas bacteria captures the energy from the reaction between hydrogen and oxygen to fix carbon dioxide into cellular components. Individual gas flows were metered into a gas proportioner and then through the bioreactor with the excess gas vented into a laboratory fume hood. This type of process had been used in the lab since 2013 using various types of bioreactors (Merlic 1).

The postdoctoral researcher had joined the research group in October 2015 with the assignment of developing a closed gas system bioreactor for elimination of gas waste. She came

from a university with a strong safety program and had inquired into the safety procedures required from the university. She completed her required safety training before starting to work in the lab. Her training also the use of the existing reaction system (1gallon pressure vessel) and preparation of the reaction gas mixture (70% H_2/20% O_2/10% CO_2). This reaction system had been used for about 8 months without incident. Experimental protocol changes and any necessary changes were discussed in weekly group meetings. It was determined to scale-up the experimental procedure by pre-mixing the three gases in a thirteen-gallon gas storage tank (Merlic 1). A tank was ordered and leaked checked upon arrival. Between February until March 16, 2016 the gas storage tank was filled eleven times with varying explosive mixtures (H_2/O_2 /CO_2) and pressures (37- 117 psig). The experiments were reviewed on a weekly basis with the primary concern being improvements of the bacterial culture conditions. Researchers assumed that the process was safe if they stayed well below the maximum pressure of the rated gas storage pressure (140 psig). It is of significance to note that the lab was subjected to a laboratory safety inspection in January 2016. The use of the gas storage tank was not questioned because the inspector used a typical checklist focusing on storage of chemicals, waste handling, gas cylinder storage, laboratory fume hood certification, and documentation of training (Merlic 1).

A “near miss” incident with the small pressure reactor occurred the day before the accident. Upon touching the on/off button of the vessel’s digital gauge, the researcher heard a “cracking sound”. When the vessel was opened, the petri dishes inside were singed and cracked. A pressure gauge had been added to the experimental setup the month before to allow better measurement of gas consumption, but the gauge was not rated as intrinsically safe. Upon reporting the incident, the PI advised the researcher not to use the vessel again (Merlic 1).

The next day, she proceeded to set up a run using the bioreactor and the thirteen gallon mixed gas storage tank. The tank had the same type of pressure gauge as the one-gallon tank and it was the eleventh time that it has been filled with a hydrogen/oxygen mixture. When she pushed the On/Off button of the pressure gauge on the tank, it exploded. The resulting explosion caused severe injuries to the postdoctoral researcher and devastating the lab and adjoining areas (Merlic 1).

The actual cause of the accident was discharge of a static charge to an explosive mixture. There were several safety errors related to the explosion. The researchers were not familiar with the fundamental principles of working with extremely explosive gases. Instrumentation was not intensively safe and the tank was not grounded. Previous incidents of static shocks were ignored. Blast barriers were not in place and the researcher was not wearing PPE (Merlic 1).

3.5. Louisiana State University Incidents

Documentation on historical incidents at LSU is poor. This is largely due to a lack of a methodology for record keeping in the Office of Environmental Health and Safety who is normally the responsible party for laboratory accident investigation. Almost all the mature professors in the chemistry department have stories of the “good old times” involving fires and explosions. Without records, these incidents do not exist and are not useful as learning tools.

3.5.1 Life Science Annex Incident

The available documentation for this event consists of a one-page accident report and historical knowledge from the professor involved. In 2002, a postdoctoral researcher was running an experiment in a chemical fume hood when there was an explosion. He lost an eye and was admitted to a hospital for treatment. The professor was out of town when the accident happened

and there is no information as to the reaction being run. Although, the professor indicated that there was a good amount of damage in the lab. The post doc recovered and returned home. As a learning/punishment lesson, the professor was made the safety officer of the department and served in that role for several years. It should be noted, that an accident of that magnitude at this point in time would warrant a full investigation by an outside party.

3.5.2 Choppin Hall Incident

On March 10, 2011 in the 6^{th} Floor Hallway of Choppin Hall; a chemistry graduate student was carrying a pressurized stainless steel one-liter cylinder with a pressure gage and valve assemblies between rooms when the gas mixture inside the tank exploded in the hall. The cylinder had been prepared for an offsite chemistry demonstration as part of the chemistry department's educational program. The purpose of the demonstration to produce small scale fires and explosions in balloons under controlled conditions. The balloons are filled from separate pressure cylinders containing either hydrogen or oxygen. Balloons are filled by mixing hydrogen and oxygen in balloons. This was a standard part of the graduate student's job function. The root cause of the incident was that an unpurged cylinder containing one gas was filled with the other gas which resulted in an explosive mixture (LSU EHS).

The graduate student was carrying the cylinder by the pressure gage. Inspection of the cylinder reviled that the explosion caused the bottom valve assembly on the tank to blow out completely. The hot pressurized gas mixture blew the tank completely out of his hand and flashed part of his long sleeve cotton shirt away, particularly on the lower part of his left arm. The bottom valve assembly disintegrated causing shrapnel wounds to the student's left hand. He was taken to Baton Rouge General emergency room for treatment. Doctors found first and second degree burns

to his left arm and hand. The student also required an operation to remove the metal fragments from his arm and hand. Some metal was left in his hand and the large laceration to his hand was left open to heal properly. There was no nerve or tendon damage. The student was released that night and made a full recovery (LSU EHS).

There was no active fire aside from the initial detonation, although the smoke from his shirt set off the fire alarm. LSU Police, Baton Rouge Fire, & LSU EHS responded to the alarm. A Baton Rouge Arson Investigator also responded (LSU EHS) After interviews with the principle investigator and graduate student and inspection of the cylinder, it is believed that there was an accidental mixing of hydrogen and oxygen gas in the pressure cylinder. The detonation could have been triggered by the compressive heating that took place on recharging the pressure cylinder. The pressure cylinder was labeled as containing oxygen and had a partial pressure of gas already in it. The graduate student recharged it without releasing the existing gas and flushing the tank out. Although the pressure cylinder was labeled for oxygen it may have had a partial pressure of hydrogen (LSU EHS).

EHS recommend development of a procedure that addressed cylinder labeling, filling, and emptying. All personal were required to document that they understood the procedure before working with the project. Additional signage was required for the primary fill tanks. The PI was also asked to review the process to see if lower pressures could be used in the procedure (LSU EHS).

3.5.3 Dairy Science Incident

On April 10, 2014, an international undergraduate intern (Honduras) was working on an undergraduate research project in the Dairy Foods Research and Teaching Lab. The student was

heating a bottle of media in order to pour some agar plates. She had placed a screw top Pyrex bottle on a hot plate to heat the media. The media began to boil and exploded when it was picked up. The student has failed to follow operating procedures and loosen the screw top so that excess pressure would not build up in the bottle. One large piece of glass from the bottle severely cut the top side of her wrist just above her left hand. She also received some minor cuts on the forearm of her right arm. While the hot media did spray onto her hair, she received no burns on her face or arms (LSU EHS).

LSU Campus Police, Baton Rouge Police, Baton Rouge Fire Department, and EMT officers responded. The student was treated by EMT and taken to the emergency room at Our Lady of the Lake Hospital. She was treated at the emergency room and released. The next day she underwent successful surgery to repair damaged tendons in her left wrist. She returned to Honduras at the end of the semester.

The lab was closed off and EHS responded to examine the lab. EHS confirmed the events as described above, checked the lab for hazardous materials, and cleaned up the blood. Since Dairy Science was an academic unit of the Ag Center, the official accident report was completed by the Department Head. The report states that the student had received careful safety instructions in all lab procedures and had been supervised by graduate students through the first replication of her experiments. The base cause of the accident was deviation from standard lab procedures by the student. In a follow-up report by EHS, some questions were raised about training documentation and written standard operating procedures. There was no official response from the Ag Center and the incident was considered closed.

3.6. Comparison of UH and Choppin Hall Event

This section is to compares of the safety programs between the University of Hawaii and Louisiana State University. After a thorough review by The University of California Center for Laboratory Safety (CLS) of the UH safety program after a major accident found several deficiencies in their safety program. The safety program at LSU operates in a similar fashion and had a similar type of accident. In general, both universities provide the base level of compliance while a great deal of responsibility pushed to the principle investigators.

UH at Manoa has approximately 19,000 total students (undergraduate and graduate students) and is a public research university. The campus is home to over 300 principal investigators with over 500 laboratory rooms. There are 20 colleges and professional schools including the Hawaii Natural Energy Institute (HNEI) which conducts research on renewable energy sources. The explosion occurred within a HNEI laboratory. The Environmental Health and Safety Office (EHSO) consists of 22 individuals and manages the laboratory safety program under the direction of the Vice Chancellor of Research (Merlic 2).

Louisiana State University has approximately 24,000 undergraduates and over 5,000 graduate students in 14 schools and colleges. This university has over 6,000 full-time and 9,000 part-time employees which include over 1,400 faculty members. LSU has approximately 500 principal investigators with over 800 laboratory rooms. The Office of Environmental Health and Safety (EHS) have a staff of ten safety professionals. EHS is in the Facility and Property Oversite Division and directly reports to the Assistant Vice President of Real Estate, Public Partnerships, & Compliance.

While the level of injury and property damage was much lower at LSU, there are similarities between the two incidents. Both were repetitive tasks that involved a hydrogen/oxygen gas mixture. Consider the level of scrutiny if an outside agency had completed the LSU investigation. Internal investigations tend to focus on the actual incident and make recommendations prevent reoccurrence. Outside agencies tend to look beyond root causes of the incident using techniques developed for industry to address fundamental safety issues (Merlic 2). Clearly, the UH laboratory is not alone in having safety problems. In fact, overall the safety problems found in UH and LSU laboratories are remarkably similar due to size and structure of their respective safety programs and culture. Both are public universities with a large research base and a relatively small EHS unit with very little real enforcement power. It extremely challenging to incorporate safety into research. PIs are driven by the real and perceived pressures to produce results and to publish to get and maintain funding. Safety is not perceived as a factor in the advancement of their carriers while invocation and scientific discoveries are core considerations. When the constant modification of experimental procedures is part of the fundamental research process, stopping to complete a safety review can be seen as a determent to forward progress. Additionally, with the current predominance of interdisciplinary, often researchers are not qualified to work with highly hazardous materials and do not recognize the potential hazards. As long as researchers tend to place higher value on results than on safety and physical hazards are loosely regulated, there is a high potential for catastrophic incidents (Merlic 2).

3.7. Potential Impacts of CLS Recommendations to LSU

The CLS report found serious deficiencies in UH's laboratory safety program. The accident is attributed to a lack of effective safety oversight program and the general state of the existing safety culture. Some of the recommendations in the CSL report are specifically aimed at the underlying safety problems at UH while others are directed toward all at all institutions of higher education that conduct research (Merlic 2).

UCSL Recommendation: Role of Campus Leadership in changing safety practices

All improvements in the culture of safety must come from Senior Campus Leadership. Without Statements from the highest level within the University that reinforce the importance of conducting all research safely there will not be any fundamental improvement in the culture of safety. The CLS report also emphasis the need for campus leadership to be familiar with the similarity in the institutional issues cited in CLS report and CBS report on the Texas Tech laboratory explosion. Another recommendation is that campus administrative and EHSO leaders review and determine how the APLU report "*Guide for Implementing a Safety Culture in Our Universities*" could be utilized to improve the research safety. Perhaps the most important recommendation is the formation a faculty–led safety committee be formed to address safety needs relating to chemical and physical hazards (Merlic 2).

LSU: The APLU report has been reviewed by LSU leadership. An existing committee, the Research Safety Committee, has been requested to review the report and make recommendations to improve the overall culture of safety at LSU.

UCSL Recommendation: Active Role of Faculty in changing safety practices.

The CLS report stresses the need for faculty to be engaged with both the campus administration and EHSO to guide safety changes via leadership of a Chemical and Physical Safety Committee. Faculty must work to ensure that the necessary resources are provided and that safety is a collaborative effort to improve safety culture (Merlic 2).

LSU: Facility safety attitudes range from extremely pro-active to non-existent. Some faculty expect EHS handle all safety matters for their lab. The repurpose of the Research Safety Committee is a right step in the involvement of LSU faculty because the committee has requested more facility join the committee. However, faculty tend to feel overwhelmed with their current duties and do not care to be involved in another "worthless" committee. As such, upper leadership needs to encourage faculty to become involved by confirming the importance of safety.

UCSL Recommendation: Formulate a unified Research Safety Program.

The CLS report recommended that UH form a single operating unit to support to support research operations. They pointed out the need for additional staff and addition of a Learning Management System to integrate researcher training. Another conclusion was that EHSO lacked IT support to upkeep their website with pertinent safety information. The report also suggested that the qualifications of personal be upgraded (Merlic 2).

LSU: With the exception of Radiation Safety, LSU EHS is a single operating unit. EHS chemical, biological, industrial hygiene, and waste personal work together to support the research community. Of the ten professionals on staff, there are three PhD's and five certified professionals. When compared to peer institutions, additional EHS people are needed for

a research facility the size of LSU. The Campus Safety, Health, and Environmental Management Association (CSHEMA) has developed equations that estimate EHS staffing and budget based on the ratio of research/non-research floor space. Based on these equations, LSU should have a staff of 22 safety personnel and an operating budget of 1.5 million (CSHEMA).

LSU EHS has provided researchers with a database tool, Environmental Health and Safety Assistant (EHS Assistant), to document on-line training, complete chemical and biological inventories, inspection response, and risk assessments. While the EHS Assistant is an excellent tool, it has proven to be a challenge to convince researchers to utilize the database tools.

Communication and outreach was a significant issue at UH which was attributed to their web site and LSU has a similar issue with their web site. As such, a needed resource of LSU EHS is an IT person to support the maintenance of the Safety Web site and the EHS Assistant.

UCSL Recommendation: Laboratory inspection Program

The CLS report suggested several modifications of the UH inspection program. The inspection process was not rigorous and recommended that the "Lab Inspection Checklist" be modified to cover additional hazards and the questions be grouped by hazards. Inspections need to be carried out with researchers present while there is active research ongoing. Collaborative inspections need to be used as an educational experience for both researchers and inspectors. The report suggested that each lab have a designated Laboratory Safety Officer as the point of contact for EHSO (Merlic 2).

LSU: LSU has taken a collaborative approach to inspections. The general approach is for the EHS inspector to take a consultant approach and talk to researchers about our services. The base inspection process consists an informal walkthroughs and review of the documentation associated with the EHS Assistant database. Compliance inspections ae schedule as needed.

UCSL Recommendation: Revise the Chemical Hygiene Plan and Laboratory Safety Manual

The CLS report recommends a complete revision of the UH Chemical Hygiene Plan (CHP) and Campus Laboratory Safety Manual to move away from compliance documents in an effort to move the campus towards a more comprehensive culture of safety where safety is an integral part of research. The documents should be revised by a joint team of EHSO and research faculty to achieve these goals (Merlic 2).

LSU: LSU revised the CHP to include physical hazards and links to standard operating procedures after the Texas Tech incident, but it remains a basic compliance document. The LSU safety manual is also a compliance document and outdated. LSU has taken the approach that safety information is available on the Safety Web site and hard copies are not required. However, the web site is hard to navigate and does not provide a free flow of information. Modification and updating the web is dependent on part time graduate students. However, none of the professional staff has the expertise or time to modify the web site to make a living document.

UCSL Recommendation: Develop effective SOPs.

The report recommends that UH ESHO revise all aspects of SOP program. The CLS report finds a generalized approach to campus-wide safety training and states the lab-specific safety

training should be a mandatory requirement. An important part of this requirement is the use of Standard Operating Procedures (SOPs) to ensure that safe practices are followed where there are hazardous materials or conditions. Laboratory SOPs were inadequate, incomplete, or absent entirely and researchers need better guidance on SOP development, content, and use (Merlic 2).

LSU: LSU has provided some general SOP's on the web site. The SOP's are linked in the Chemical Hygiene Program plan. These examples use an industrial format that address safety, background, the procedure, and waste disposal. However, research labs do not generally utilize SOP's, let alone a standard format.

UCSL Recommendation: Develop a mechanism to address risk assessments.

The report recommends that UH EHSO development a mechanism to address risk assessments. Since the root cause of UH incident was a failure to recognize the extreme hazards presented by a gas tank filled with an explosive gas mixture, UH EHSO should provide researchers with technical assistance for development of and implementation of risk assessments. A Research Safety Committee approval should be required before such conducting experiments (Merlic 2).

LSU: LSU has an electronic tool through the EHS Assistant that is a basic risk assessment, Laboratory Assessment Tool (LAT). Researchers complete an assessment of the hazards in their lab by answering yes/no questions relating to chemical, biological, radiation, mechanical, hazards. The LAT is submitted to EHS for review. Upon approval, a report is generated for the research lab that describes the potential hazards and the required mediation actions. While not a formal risk assessment, it allows EHS to recognize potential sources of hazards and investigate as needed.

UCSL Recommendation: Safety Training

While the CSL report did not make specific reconditions on UH Safety education program, it did note that the basic UH in-class "Lab Safety Training" courses only cover general safety principles and act as a starting point for researchers. The report stated that lab-specific safety education is critical to ensure that researchers know their own research and that UH need to ensure that policies and procedures are in place to ensure that such training occurs (Merlic 2).

LSU: LSU has developed a series of power point training courses that provide basic training. This training is required yearly and reminders of training due are sent out monthly. The level of compliance with the training has increased since the program was started, but remains about 70% compliance level which is below desired levels.

The on-line training only provides the basic level of safety training. EHS does offer hand-on lab training on a demand basis, specifically incoming chemistry graduate students and BL3 personnel. Those sessions are documented in the EHS Assistant, but lab based training is not currently documented by EHS

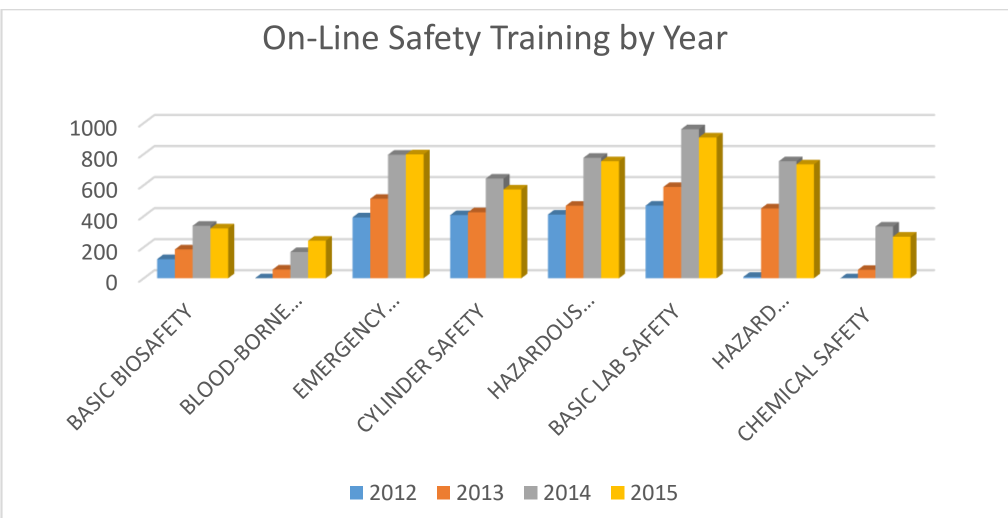

Figure 3.1. On-Line Safety Training by Year

UCSL Recommendation: Personal Protective Equipment

Personal Protective Equipment (PPE) is the lowest level in the hierarchy of hazard controls, but wearing the proper PPE can be a lifesaving act. However, wearing PPE is often at the discretion of the principle investigator. The CSL report noted that researchers did not consistently wear appropriate PPE in the laboratory where the accident occurred. The report also noted that the level of PPE is often underestimated simply researchers do not understand the potential hazards (Merlic 2).

LSU: Use of PPE in LSU research labs is not consistent and depends of the level of enforcement by the PI. Like UH, LSU has researchers that underestimate PPE requirements or feel that it is not necessary. Proper PPE has to be provided by the employer. PPE use requires a culture of safety to encourage workers to consistently wear their safety equipment. EHS has initiated a pilot Nomex lab coat program for high hazard chemistry workers. The program was funded by RISK/EHS and the results indicate that it improved the safety culture and encouraged worker to wear all their PPE in a consistent basis. However, the program has not generated enough upper level support to ensure future funding.

UCSL Recommendation: Gas Cylinder Use

The CSL report detailed several examples of improper gas and gas cylinder usage at UH since gas use was integral to the UH accident (Merlic 2).

LSU: LSU has provided training on the use of gas cylinders. However, constant violations of gas cylinder handling and use have been noted in research labs. Further education on the topic is required.

UCSL Recommendation: Near Miss Events in Research Laboratories

A near miss event is an unplanned and unexpected event that does not result in any injury, illness or property damage, however could have had the potential to do so. A near miss event is a warning that something is wrong and should result in a shutdown of operations and trigger a thorough investigation of all procedures. This did not happen at UH because of the way that researchers generally perceive risk. Either they do not recognize the hazard or it became a routine part of their work and they consider themselves as experts in the field (Merlic 2).

The CLS report recommended that UH develop a process by which all near-misses and accidents are promptly reported and investigated. In order to be effective, near miss reporting must not result in punitive actions. This was also a recommendation of the CSB to following the incident at Texas Tech University (Merlic 2).

LSU: LSU has an effective program of accident reporting and investigation. Like most other universities, LSU does not have a near miss reporting system. There is no data as to how many near misses there have been and if their investigation would prevent a future accident.

Conclusion

Investigating near miss incidents, the UH incident, and all the other recent lab accidents provide LSU an opportunity to take a hard look at the lab safety program. It is a chance to improve the safety culture before being forced to do so as the result of a catastrophic incident.

CHAPTER 4. SAFETY CLIMATE AND SAFETY CULTURE

Workplace safety has been studied from technical and psychological viewpoints and has led to the general consensus that a positive safety culture improves job safety. Aside from the general consensus, there is neither an accepted model for safety culture nor a clear cut definition. The term "safety culture" was first used in reference to the Chernobyl accident in April 1986 in International Atomic Energy Agency (IAEA) reports. The term culture was borrowed from anthropology and refers to a generalized description of personal decisions of the individual engaged in activities that impact safety (Sorensen). Today, safety culture is an established key concept and buzz word of safety professionals (Choudhry). The concepts of organizational culture and climate have provided the basis for many of the definitions and measures proposed for safety culture and climate (Cox and Flin). A review of safety climate or safety culture is not complete without a review of the relevant aspects of organizational culture and climate.

4.1. Organization Culture

Organizational culture can be described as a phenomenon that involves beliefs, values and behaviors and exists at a variety of different levels. It manifests itself in a wide range of artefacts within any particular organization. Organizational culture helps define the environment of the organization which in turn allows workers to comprehend, interpret, accept, and control their work environment to enhance performance. Organizational culture can be considered to be defined by the following characteristics. It is a holistic construct, relatively stable, and multidimensional. Organizational culture is shared by groups of people so that culture is a synergistic aggregate of various sub-cultures such as national culture, corporate culture, organizational culture, departmental culture, group culture and psychological climate. Organizational culture constitutes

practices such norms, values, ritual, heroes, and symbols in a manner of multiple layers not unlike an onion. It is also functional in the sense that it supplies a frame of reference for behavior, i.e. the way we do things around here (Guldenmund 2000).

There are two main lines of research in respect to organizational culture, one considers it as an entity and the other as an aspect. In cultural assessment, the perspective from which the culture in question is viewed influences which aspects of an organization are considered important (Choudhry), Reiman and Oedewald (2004) claim “organizational culture refers to values, norms and underlying assumptions forming over time during the company history and affecting all the company’s activities and are in turn affected by them” (Reiman and Oedewald). This depicts the cultural overlap within an organizational setting and is representative of the entity view. The aspect view suggest that culture analysis must be context-specific and related to a central issue or object. The nature of organizational culture has been a vigorous debate for almost 40 years. There is universal agreement that it exists, and that it plays a crucial role in shaping behavior in organizations. However, there is little consensus on what organizational culture actually is, how it influences behavior, and whether it is something leaders can change (Guldenmund 2000).

Organizational culture tends to reflect how people behave, how things are done, and the underlying values and beliefs of the organization (Ali at el.). The perception of the resulting attitudes and behavior help to establish the climate of the organization. The relationship between culture and climate can be complex and confusing but the concepts are useful tools for understanding the dynamics of institutional behavior and to foster organization improvement (Peterson and Spencer).

4.2. Organizational Climate

The antecedent of organizational culture is organizational climate. In the 1970s, much research was undertaken under the title of organizational climate. Gradually, during the 1980s, the term culture replaced the term climate in this type of research. The development of these concepts has been successive rather than in parallel. While related, they currently represent different concepts (Guldenmund 2000). Organizational climate can be viewed as a collective subjective construct in which there are multiple subsystem climates that can be referenced to criteria such as structure, effectiveness, and safety. Climate can be analyzed across levels over time and considered to be the individual descriptions of the social setting or context of which the person is part (Falcione et al). Climate as has been defined as the enduring quality of the total organization that is experienced by the occupants, influences further behavior, and can be described in terms of the values of a particular set of characteristics of the organization (Tagore). Research on organizational climate requires the measurement of both objective organizational conditions and the individual perceptions of those conditions. Climate can be considered as a shared perception, a shared set of conditions, or a combination of both (Denison).

4.3. Culture versus Climate

The relationship between organizational culture and climate has been a point of discussion for over forty years and many authors have addressed the relationship between culture and climate. For example, Denison (1996) has claims there is a clear distinction between the two. Climate refers to a situation and how it links to the attitudes and behaviors of organizational members. Climate is subject to direct manipulation by people with power and influence because of its temporal and subjective nature. Culture is an evolved context that is rooted in history, collectively

held, and sufficiently complex to resist many attempts at direct manipulation (Denison). Another distinguish between culture from climate is the way that they can be measured. Climate research tends to use quantitative techniques to describe phenomena at a given time from an external perspective (Glick). Climate can be viewed as a 'mood' indicator which reflects the perceptions of the organization at a discrete point in time (Cox and Flin).

Culture research is holistic on nature and employs qualitative techniques and an appreciation for the unique aspects of individual social settings to explain the dynamic processes within the organization (Glick). A culture study is concerned with uncovering unit values and beliefs through on-going observations of the individuals in their group. Climate research can be characterized by surveys of members' attitudes about their organization (Cheyne).

Culture and climate are now often used as interchangeable terms, however there are differences (Denison). Climate generally focus on individual or 'group' perceptions of the prevailing structures and culture measures generally focus on the patterns of values and beliefs that lead to the emergence of these structures (Cooke and Szumal). Culture and climate both are learned through socialization and interaction and deal with the ways by which members of an organization make sense of their environment (Reichers and Schneider). Climate as describes shorter-term characteristics of the organization which indicate how it treats its members. Culture reflects longer-term characteristics which describe the types of people that the organization employs (Vereke). Culture and climate provide different interpretations of the same phenomenon in that that climate can most accurately be understood as a manifestation of culture. As such, a 'positive' culture will be promoted and maintained by a 'positive' climate and vice versa. Culture and climate can be viewed as reciprocal processes in a cyclic relationship (Shein).

4.4. Safety Culture

Safety culture is an organizational culture which emphasizes safety. As such, it will exhibit the same, or similar, characteristics and relationships with other phenomena as its parent concept. The concept of safety culture is important for the understanding of occupational health and safety management and can be utilized to determine how to focus safety management efforts by assessing its safety culture (Cheyne).

After the Chernobyl incident, the concept of safety culture became an over-riding priority in the nuclear industry. The main element of safety culture as defined by International Nuclear Safety Advisory Group (INSAG) was that safety was a priority commitment in policy, management and individual levels. Individual awareness, responsibility and control are to be supported within the immediate work group and the resulting safety behaviors are also reinforced through the organizational safety management process and the communication lines within the organization. In 1993, the Advisory Committee on Safety in Nuclear Installations (ACSNI) Human Factors Study Group provided an updated definition of safety culture that offered a breakdown of the elements required to achieve a good, or positive, safety culture and specify their inter-relationships. Like other definitions of safety culture, the ACSNI definition emphasize shared values and beliefs that interact with an organization's safety structures and control systems to produce behavioral norms (Reason 1998). The notion that safety culture is a shared and social phenomenon is central to many of its definitions (Cheyne).

Most of the widely-quoted definitions of Safety Culture treat it as an entity in itself. The concept is holistic in nature and safety culture is something an organization 'is' rather than

something an organization 'has'. Safety culture results from a combination of good safety attitudes, good safety management established by organizations, and assigning the highest priority

Table 4.1 Definitions of Safety Culture

Reference	Definition of safety culture
Pidgeon (1991)	The set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious.
IAEA (1991)	That assembly of characteristics and attitudes in organizations, which establishes that, as an over-riding priority, nuclear plant safety issues receives the attention warranted by their significance.
ACSNI HSC (1993)	The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management. Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures.
Kennedy and Kirwan (1998)	An abstract concept, which is underpinned by the amalgamation of individual and group perceptions, thought processes, feelings and behaviors, which in turn gives rise to the particular way of doing things in the organization. It is a sub-element of the overall organizational culture
Hale (2000)	Refers to 'the attitudes, beliefs and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems'
Glendon and Stanton (2000)	Comprises attitudes, behaviors, norms and values, personal responsibilities as well as human resources features such as training and development
Guldenmund (2000)	Those aspects of the organizational culture which will impact on attitudes and behavior related to increasing or decreasing risk
Cooper (2000)	Culture is 'the product of multiple goal-directed interactions between people (psychological), jobs (behavioral) and the organization (situational); while safety culture is 'that observable degree of effort by which all organizational members directs their attention and actions toward improving safety on a daily basis'
Mohamed (2003)	A sub-facet of organizational culture, which affects workers' attitudes and behavior in relation to an organization's on-going safety performance

(Cont.)

Table 4.1 (Cont.)

Reference	Definition of safety culture
Richter and Koch (2004)	Shared and learned meanings, experiences and interpretations of work and safety - expressed partially symbolically – which guide people's actions towards risk, accidents and prevention
Fang et al. (2006)	A set of prevailing indicators, beliefs and values that the organization owns in safety
Zhang et al. (2007)	The enduring value and priority placed on worker and public safety by everyone in every group at every level of an organization. It refers to the extent to which individuals and groups will commit to personal responsibility for safety; act to preserve, enhance and communicate safety concerns; strive to actively learn, adapt and modify (both individual and organizational) behavior based on lessons learned from mistakes; and be rewarded in a manner consistent with these values.
Edwards et al. (2013)	Can be viewed as the assembly of underlying assumptions, beliefs, values and attitudes shared by members of an organization, which interact with an organization's structures and systems and the broader contextual setting to result in those external, readily-visible, practices that influence safety.
ACS (2012)	A reflection of the actions, attitudes, and behaviors of its members concerning safety—these members include the managers, supervisors, and employees in the industrial and governmental communities; and the administration, faculty, staff, and students in the academic community
NRC (2014)	Safety culture refers to an organization's shared values, assumptions, and beliefs specific to workplace safety or, more simply, the importance of safety within the organization relative to other priorities. A strong, positive safety culture arises not because of a set of rules, but because of a commitment to safety throughout an organization.
Stuart, R. (2017) CSHEMA Culture COP	Safety culture are informal aspects of the organizational operations related to environmental health and safety issues. In higher education, the organizational mission is teaching, research and service and safety culture supports success in those aspects of the institution.

to safety (Cooper). However, a different view presented by Guldenmund that organizational culture should be considered as the central theme. Safety culture is an aspect of organizational culture and researchers should focus on how to measure it (Guldenmund 2000).

Numerous definitions of safety culture exist in the academic literature as demonstrated in Table 4.1. The definitions are similar in the perspective of beliefs, with each focusing, to varying degrees, on the way people think and/or behave in relation to safety. These definitions tend to reflect the view that safety culture is something an organization 'is' rather than something an organization 'has'. The safety culture of an organization to be one in which safety is regarded by everyone as being an issue that concerns everyone (Choudhry).

It has been observed that a positive safety culture implies that the whole is more than the sum of the parts. The various individual components and processes interact a synergistic effect where all the people involved share similar perceptions and adopt the same positive attitudes to safety producing a collective commitment. The converse is true in that organizations with a poor safety culture, the resulting whole is less than the sum of its parts (Booth and Lee).

A model for safety culture presented by Cooper proposes that interactive and reciprocal relationships exist between psychological, situational and behavioral factors in safety culture as well as in organizational culture (Cooper). Safety culture can be considered a product of multiple goal-directed interactions between people (psychological), jobs (behavioral), and the organization (situational). There is perpetual dynamic interplay among people and their environments (Davis). People's attitudes and perceptions about safety can be assessed through safety climate questionnaires to provide a measure of the psychological dimension. The behavioral aspects of safety culture can be measured through self-reporting procedures. An alternate is the use of observational safety behavioral checklists and trained personnel to observe, quantify, and provide feedback. Audits and inspections that look at the structure of the organization, policies, working procedures, and management systems can be utilized to assess the situational aspects of safety

culture. These components can be measured independently or in combination to quantify safety culture (Cooper).

The definitions suggested by the American Chemical Society (2012), the National Research Council (2014), and the CSHEMA (2017) can be considered as functional definitions of safety culture aimed at academic research laboratories. The ACS and NRC definitions are part of reports that provide a specific frame work to improve safety culture. The CSHEMA definition is the baseline for a working group on improving safety culture. Zhang provides an excellent summary of the properties found in the various definitions of safety culture. There are several common features which are detailed below:

- Safety culture is a concept defined at group level or higher, which refers to the shared values among all the group or organization members
- Safety culture is concerned with formal safety issues in an organization, and closely related to, but not restricted to, the management and supervisory systems.
- Safety culture emphasizes the contribution from everyone at every level of an organization. The safety culture of an organization has an impact on its members' behavior at work.
- Safety culture is usually reflected in the contingency between reward system and safety performance. Safety culture is reflected in an organization's willingness to develop and learn from errors, incidents, and accidents.
- Safety culture is relatively enduring, stable and resistant to change (Zhang et al).

Aside from general consensus that a positive safety culture is necessary for safe work conditions, there is neither an accepted model for safety culture nor a clear-cut definition.

Literature reviews by Choudhry, Dongping, and Mohamed (2007) and Guldenmund (2000) of academic papers concerning safety culture models concluded that most of the definitions of safety culture are very similar and the differences focus on the way people think and/or behave in relationship to safety (Choudhry et al., Guldenmund 2000) Safety culture results from a combination of good safety attitudes, good safety management established by organizations, and assigning the highest priority to safety.

4.5. Safety Climate

Like the concepts of organizational culture and climate are linked, the definitions, conceptualizations, and models of safety culture are linked throughout the literature with the concept of safety climate. The definitions of both safety climate and safety culture tend to be global and are often based on the objectives of the researcher. In general, safety climate looks at the perceptions of the group members while safety culture also considers the groups beliefs and attitudes (Guldenmund 2000).

Researchers tend to use safety culture and safety climate interchangeably but safety climate studies tend to focus on the way that people perceive safety and does not address actual behavioral or situational aspects of safety. Safety climate should not be viewed as an alternative to safety culture because safety climate is an aspect of safety culture and is dependent on the overall prevailing safety culture Safety climate is the more appropriate term for the output from questionnaire based surveys. Climate surveys are only capable of sensing surface features discerned from the workforce's attitudes and perceptions at a given point in time. Likewise, methodology is one of the main differences between organizational culture and climate (Denison).

There are as many definitions of safety climate as there are researchers. Normally, the research uses the definition that best fits their research (Guldenmund 2000). However, the majority of definitions differ from safety culture in common ways. As summarized by Zhang, the commonalities of safety climate definitions include:

- Safety climate is a psychological phenomenon, which is usually defined as the perceptions of the state of safety at a particular time.
- Safety climate is closely concerned with intangible issues such as situational and environment factors.
- Safety climate is a temporal phenomenon, a "snapshot" of safety culture, relatively unstable and subject to change (Zhang).

Various researchers have proposed to use safety climate as an alternative performance indicator by correlating their results to the established safety performance indicators like safety management audits, accidents and incidents and near-misses. The first reported measure of safety climate using a questionnaire was completed in 1980 for employees in industrial organizations in Israel. Since safety climate studies measure perception of the group's overall safety level, some researchers have suggested that determination of safety climate can be used as a safety performance indicator much like safety management audits and accidents, incidents, and near-misses reporting (Guldenmund 2000). For example, Cabrera reports a relationship between certain audited management areas and attitudinal measures. Also, the modification factors resulting from their audit and a self-reported accident measure are highly correlated in their study (Cabrera et al.). Zohar (2010) reviewed and summarized numerous safety climate studies performed for industry that used various types and numbers of questions (Zohar 2010).

There are indications that safety climate has a positive effect of safety behavior, but studies showing direct correlations have not resulted in clear cut conclusions (Cooper). Safety climate research has focused on the methodology to improve measurement scales and predictive validity with regard to a variety of safety outcomes. Guldenmund suggested that climate research should focus on the validity of the construct and whether it indeed yields a robust indication of an organization's safety performance and not on the development of new measurement tools (Guldenmund 2000). In agreement, Zohar states that "Safety climate perceptions should thus focus on the nature of relationships between safety policies, procedures, and practices, taking into account that oftentimes rules and procedures associated with safety compete with those associated with other domains (e.g. safety vs. productivity or efficiency)". He also claims that research has validated safety climate as a robust leading indicator or predictor of safety outcomes and calls for the research to approach safety climate in a theoretical manner (Zohar 2010).

Guldenmund (2000) raises the question of what to do with a given safety culture or climate has assessment. Most safety climate research reports some type of scores on certain dimensions, but since most researchers work with their own dimensions or scales there are not any acceptable benchmarks He also suggests that an integrative framework be developed that merges safety climate with safety culture and delivers categories for both safety attitudes and basic assumptions that are open to investigation (Guldenmund 2000). CSHEMA is offering a standard climate survey to its members in an effort to build a database for benchmarking. The relationship between culture and climate can be complex and confusing but the concepts are useful tools for understanding the dynamics of institutional behavior and to foster organization improvement (Peterson and Spencer).

4.6 Safety Attitudes

Historically, the most prominent framework for the study of attitudes has been the tripartite. Attitude is an unobservable psychological construct which manifests itself in relevant beliefs, feeling, and behavioral components (Fazio). A fairly simple attitude model is the ABC model of attitude which describes its structure in terms of three components. The Affective component which involves a person's feelings/emotions about the attitude object. The Behavioral (or conative) component which is the way the attitude we have influences how we act or behave. The cognitive component involves a person's belief / knowledge about an attitude object. One of the underlying assumptions about the link between attitudes and behavior is that of consistency. The principle of consistency is when the behavior of a person to be consistent with the attitudes that they hold. In theory, this reflects the idea that people are rational and attempt to behave rationally at all times and that a person's behavior should be consistent with their attitude(s). However, even though the principle may be a sound one, it is clear that people do not always follow it and often behave in seemingly quite illogical ways. Attitude strength is often a good predictor of behavior in that the stronger the attitude the more likely it should affect behavior. Attitude strength involves importance and personal relevance and refers to how significant the attitude is for the person and how relates to self-interest, social identification and value. If an attitude has a high self-interest for a person, it is going to be extremely important and have a very strong influence upon a person's behavior. By contrast, an attitude will not be important to a person if it does not relate in any way to their life. The knowledge aspect of attitude strength covers how much a person knows about the attitude object. People are generally more knowledgeable about topics that interest them and are likely to hold strong attitudes (positive or negative) as a consequence. Attitudes based on direct

experience are more strongly held and influence behavior more than attitudes formed indirectly (McLeod).

Employee attitudes play a significant role in an organization's safety culture. The factors that influence safety culture are norms and rules for effectively handling hazards, positive attitudes towards safety, and the capacity for reflection on safety practice (reflexivity). Along with the addition of senior management commitment, these factors have been described as idealized organizational objectives. The measurement of employee attitudes towards safety and their perceptions of workplace hazards can thus provide some indication of whether these objectives are being met and, in turn, the nature of an organization's safety climate and underpinning safety culture (Pidgeon). In fact, employee attitudes are one of the most important indices of safety culture since these attitudes are often framed as a result of all other contributory features of the working environment (Cox and Cox, 1991). The idea that attitudes can be indicative of culture is further substantiated in light of the three component description of attitude. Shared values and basic assumptions influence the affective and cognitive aspects, while the cultural behavioral norms and organizational practices influence the behavioral intention component (Cheyne). The application of the ABC model to attitude and potential behavior change, has been described as the "winning of hearts and minds" (Cox and Cox, 1996) where both emotions (hearts) and cognitions (minds) should be targeted to alter behavior (Cox and Cox, 1996).

Much research into the assessment and quantification of culture and climate for safety has centered on the use of surveys to determine attitudes and their potential impact on behaviors. Studies have used attitude and perception measurement techniques in relation to safety issues in

different organizational settings such as industrial gas manufacturing, chemical sector, construction, mining, aviation, nuclear, offshore oil production, and metal processing (Cheyne).

Additionally, there is widespread interest in measuring healthcare provider attitudes about issues relevant to patient safety (safety culture). A standardized Safety Attitudes Questionnaire was developed by the University of Texas Center of excellence for Patient Safety Research and Practice to establish benchmarking data. The model demonstrated good psychometric properties and it is open access. The Healthcare industry has embraced it use in several different areas to improve patient safety. The survey measures caregiver attitudes in six patient safety related domains. It allows direct comparison with other organizations, to prompt interventions to improve safety attitudes, and to measure the effectiveness of these interventions (Sexton).

Development of safety attitudes is a complex process involving mindfulness, situational awareness, and sense-making (Klein 2006). The process of acquisition, reflection and action is the desired pathway for the development of positive attitudes for a strong culture of safety. Awareness, recognition, evaluation, and control are considered as the individual aspects of attitude toward safety (NRC 2014; Grau 2002; Hamaideh 2004; Chenyl 2000).

Lab personnel need to be aware of their surroundings and act accordingly. There are numerous hazards and risks associated with working in a research in the laboratory. Researchers often work on the cutting edge of science and do not see the potential hazards. There are federal, state and local regulations covering research laboratory safety that need to be considered. Lab personnel must be aware of the resources that are available to lab personnel, like the EHS Assistant and web page, and utilize these tools. While the university, laboratory directors, and co-workers

should take every precaution to assure the safety of an individual, the individual lab worker must be aware that their safety is ultimately their own responsibility.

The need to recognize the risks and hazards associated with working in a research laboratory is a critical aspect of developing a strong safety attitude. Institutional procedures are in place to protect researchers and lab personnel must recognize the need to follow the safety rules of their lab. Training is a key aspect so that lab workers are able to recognize the chemical and physical hazards in research laboratories and the specific risks associated with their laboratory. The goal is to develop lab worker with an understanding that it is possible to work safely in a research laboratory if proper policies and procedures are implemented and followed.

The need to identify and evaluate potential hazards of an experiment throughout the life of a study is another cornerstone of any culture of safety. Related safety information should be reviewed before an experiment is attempted and utilized to make educated predictions about the potential hazards inherent in the experiment. It is necessary for a researcher to look beyond the experiment and consider potential worst case scenarios. A hazard analysis be completed with each procedural change to ensure the continuing safety of the project.

Institution wide administrative protocols and engineered safety features are the first line of experimental risk control. Based on the evaluation step, the next level of control are the specific risk controls that are necessary for the planned experiment. The researcher must consider what can be done to do this experiment safe to complete and put those controls in place.

However, the three validated studies identified in the literature did not find that these four aspects were related to the factors extracted during factor analysis (Grau, 2002; Hamaideh, 2004; Chenye, 2000). The factor extractions of the three reviewed studies varied slightly with the focus

of the individual instrument, but were generally divided into three sub-factors; personal responsibility, involvement as part of a team, and institutional responsibilities. The structural model proposed in Chapter Seven utilize sub-factors, Personal, Team and Institution, to describe the attitude component of the model.

4.7. Safety Behavior

Historically, safety professionals have centered on controlling the physical work environment and work procedures of employees in an effort to prevent errors and accidents, such as use of standard operating procedures and use of proper personal protective equipment. A complementary approach to safety improvement focuses on the human factors in work accidents. Given the inevitability of human error, it is necessary contextualize behavior for greater understanding. Fogarty utilizes the Theory of Planned Behavior (TPB) to examine the human factors that contributed to violations in aviation maintenance (Fogarty).

TPB appears to provide a link between climate and types of workplace behaviors that are intentional but unsafe acts. An unsafe act results from the deliberate deviation from the safe method of performing a particular task or job or from slips, lapses and mistakes made by individuals (Reason 2000). An individual's behavior is a direct function of behavior intention and perceived behavioral control. Intentions are themselves shaped by attitudes, subjective norms, and perceived behavioral control, which in turn are each based on an underlying belief structure. A person's attitude towards a behavior is determined by their salient beliefs about the consequence of the behavior and the desirability of the outcome for each. Behavior is also influenced by the subjective norms which refer to an individual's perceptions of the beliefs and behaviors of significant others also influence behavior. Perceived behavioral control (PBC) refers to a person's perception of the

ease or difficulty of performing the behavior and is another determinant of behavior intention. People often intend to perform certain behaviors, yet fail because of factors that fall outside their control (Ajzen 1991).

The vignette survey method had demonstrated validity in measuring both socially sensitive issues and highly complex constructs. The general method of using vignettes in psychological studies involves the presentation of a situation where participants are asked to declare the likelihood of reacting to the situation with a given set of possible options reflecting the range of the latent trait being studied. This method has been used successfully in determining a person's perceptions, values and norms in studies of culturally sensitive subjects. Based on the success of vignette use in identifying traits in sensitive situations, they may be a very good option for self-reporting behaviors addressing safety in the research laboratory (Alexanda).

A series of vignettes was written reflecting real-life incidents occurring in research laboratories over the past five years. Each of these incidents resulted in injuries or damages. The option selected in the actual incident that resulted in injuries or damages was included as a possible solution along with alternative options ranging from very safe to very unsafe. Multiple vignettes were developed to address each of the three aspects of safe behavior in a research laboratory (Planning, Practice and Negligence) proposed in the structural model in Chapter seven (Jorgensen).

CHAPTER 5. SAFETY CULTURE DEVELOPMENT IN LABORATORY RESEARCH

5.1. Laboratory Safety in Academia

Most universities do not have strict laboratory safety rules similar to those found in industry (Backus at el.). The general consensus is that this relaxed approach toward safety makes academic laboratories more dangerous than those in industry (Peplow & Marris). A 2011 editorial in Nature contends that academic research laboratories only deal with safety and environmental concerns after a substantial accident (Nature). After the accident, there is a flurry of activity focusing on whether the university or principle investigator (PI) could have taken more precautions to prevent the accident. A significant portion of this activity is related to damage control and public perception. Most researchers are well aware of the safety deficiencies in their laboratories, but historically too many researchers have a poor attitude in regard to safety and fail to address the issues. This is further complicated by the fact that researchers often see the safety professional as a “Safety Cop” whose role is to enforce those “trivial” rules (Elston).

In an industrial setting, safety is a significant concern and directly linked to job performance standards. Safety is reviewed in the perspective of being a system management priority where accidents arise from casual factors that reside at multiple levels within complex socio-technological economic systems. Accidents can result from actions of a frontline worker (active failure) but can often be traced to a decision made at higher level of the organization (latent failure). Analytical tools such as risk assessment methodologies are utilized to find potential system failures and correct them. Industrial units tend to be well-defined structures with strong management organizations that have the authority to make necessary changes at various levels to impact safety (Reason). Ashbrook (2013) contends that universities are governed in a manner

similar to small cities where all concerned parties have a voice. This concept of rule by committee makes the application of any system perspective tool difficult because the general structure finds the concept of latent failures unacceptable (Ashbrook).

The PI generally has significant authority over their 'fiefdoms' and determines safety policy for the laboratory (Backas el at.) Research conducted by PIs is usually conducted in an autonomous manner with minimal administrative oversight as long as the researcher continues to bring in money. Universities are putting increasing pressure on researchers to obtain grant monies with significant overhead charges. Universities take anywhere between 30 to 50 percent of the grant for administrative and indirect costs. Researchers are expected to pay their salaries and the salaries of their staff from the grant funds. Additionally, federal funding is at all-time low and the competition for grant money is extremely high. Most research faculty also has teaching responsibilities. Depending on the university, a teaching load is between two and four courses per year which includes class time, preparation time, office hours, and grading. Schools are admitting students with inadequate preparation and demanding that more students pass. Additionally, faculty is required to serve on various committees. It is not surprising that the typical researcher sees safety as just another troublesome requirement (Kroll).

University research laboratories are unique workplaces due to the number and type of potential hazards. Commonly university laboratories harbor the potential for acute and chronic exposure to a wide range of toxic agents. Every major university has the potential to utilize biological, chemical, corrosive, explosive, flammable, physical, and radiological agents in research settings (Emery). Researchers tend to follow the money and apply for grants in "hot" areas of research. This often results in the performance of research outside the researcher's

particular area of expertise. For example, what qualifies an electrical engineer to do human cell tissue culture? Additionally, the rise of cross-discipline incubator projects has helped to stretch and challenge the breadth of expertise of many faculty members. The scope of operations at universities is often increasing in complexity due to further collaboration with individuals at other institutions. Therefore, increased organizational complexity and an independent mode of operation create a situation where it is especially difficult to build a strong safety culture in academia (Askbrook).

Ashbrook (2013) contends that the underlying reason for the lack of safety culture in academia is due to the decentralized nature of academic culture and the general lack of accountability. Laboratories in industry normally have strong lines of management which can define a safety strategy and enforce its implementation. Universities function through the concept of shared governance between the Board of Trustees, the administration, the faculty, and unofficially, the staff. Without consensus from all the involved parties, it is challenging to implement any program, not just laboratory safety programs. University administration is responsible for developing, publicizing, and monitoring university safety policies. Faculty should be involved in making these policies and have the primary responsibility for their implementation. Faculty is also responsible for the primary training of their personnel, be it informal on the job training or a formal introduction to the laboratory and its respective safety procedures. The EHS department serves to promote the administration's policies and act as reference sources for faculty. Each party in a positive safety culture has clearly defined roles and must be held accountable (Askbrook). The NRC promotes improved safety culture throughout academic by a commitment to safety throughout each university that supports the free exchange of safety information,

emphasizes learning and improvement, and assigns greater importance to identifying and solving problems rather than placing blame (NRC 2014).

Improvement in laboratory safety via application of safety culture concepts to an academic organization is feasible. A strong positive safety culture is not a set of rules, but a commitment to safety throughout an organization. The largest challenge to improve safety and regulatory compliance in the research laboratory is to instill a mindset change at the university. University administration must make safety a priority and assume responsibility for developing, publicizing, and monitoring university safety policies. Faculty should be involved in making these policies and have the primary responsibility for their implementation. Research leaders must realize that they are responsible for the safety of their people and for the primary training of their personnel, be it informal on the job training or a formal introduction to the laboratory and its respective safety procedures. The environmental health and safety (EHS) department serves to promote the administration's policies and acts as reference sources for faculty. EHS professionals must work with administrators, faculty, and researchers to help establish a strong, positive safety culture. Each party in a positive safety culture has clearly defined roles and must be held accountable (NRC 2014, Ashbrook).

5.2. American Chemical Society Safety Culture Report

The American Chemical Society assembled a Safety Culture task force to develop guidance, suggestions, and recommendations that can help strengthen the safety culture in two- and four-year undergraduate, graduate, and postdoctoral programs. The task force goals were to identify the best elements and best practices of a good safety culture and make recommendations that could be used by universities and colleges to strengthen their safety culture. Another goal was

to identify tools and resources that would be beneficial to these efforts. *Creating Safety Cultures in Academic Institutions: A Report of the Safety Culture Task Force of the ACS Committee on Chemical Safety* was published in 2012 (ACS 2012).

Creating Safety Cultures defines safety culture as "a reflection of the actions, attitudes, and behaviors of its members toward safety" and suggests seven characteristics of a strong safety culture: (1) strong leadership and management for safety; (2) continuous learning about safety; (3) strong safety attitudes, awareness, and ethics; (4) learning from incidents; (5) collaborative efforts to build safety culture; (6) promoting and communicating safety; (7) institutional support for funding safety. Based on these seven characteristics, *Creating Safety Cultures* makes seventeen

Table 5.1 ACS Recommendations to Improve Safety Culture

Number / Recommendation	
Recommendations Concerning Leadership and Management	
1	Establish the lines of authority for safety; develop a safety policy that includes laboratory safety, and includes safety responsibilities in the job descriptions and performance plans of all employees.
2	Encourage every leader to become a proponent of safety and safety education, and to demonstrate this care for safety in their actions with other staff members and students.
3	Establish a strong, effective safety management system and safety program for the institution, including laboratory safety.
Recommendations Concerning Teaching Laboratory Safety	
4	Ensure graduating chemistry undergraduate students have strong skills in laboratory safety and strong safety ethics by teaching safety lessons in each laboratory session, and by evaluating and testing these skills throughout the educational process (table 1).
5	Ensure all faculty, staff, and graduate and undergraduate students involved in teaching, managing, or overseeing students in laboratory courses and sessions have successfully completed a course in lab safety.
6	Implement hazards analysis procedures in all new lab work, especially laboratory research.

(Cont.)

Table 5.1 (cont.)

Number / Recommendation	
Recommendations Concerning Safety Attitudes, Safety Awareness, and Safety Ethics	
7	Build awareness and caring for safety by emphasizing safety throughout the chemistry curricula.
8	Include safety education and training (for undergraduate students, graduate students, and postdoctoral scholars participating in proposed research) in research grant proposals, and oversight of research for safety.
9	Adopt a personal credo: the "Safety ethic"—value safety, work safely, prevent at-risk behavior, promote safety, and accept responsibility for safety.
Recommendations Concerning Learning from Incidents	
10	Establish and maintain an incident reporting System, an incident investigation System, and an incident Database that should include, not only employees, but also graduate students, postdoctoral scholars, and other nonemployees.
11	Establish an internal review process of incidents and corrective actions with the Departmental Safety Committee (faculty, staff, students, graduate students, and postdoctoral scholars), and provide periodic safety seminars on lessons learned from incidents.
12	Publish or share the stories of incidents and the lessons learned (case studies) to your institution's Web site, a public Web site, or an appropriate journal where students and colleagues from other institutions may also use these as case studies for learning more about safety.
Recommendations Concerning Collaborative Interactions	
13	Establish a series of safety councils and safety committees from the highest level of management to the departmental level or lower. Each of these committees reports, in turn, to a committee that is higher in the hierarchy of the institution.
14	Establish a close working relationship with EHS personnel at every departmental level, seeking their advice and experience in safety, and offering departmental and faculty advice to EHS based upon their experience and knowledge of chemistry.
15	Establish a close working relationship with local emergency responders, so they are prepared to respond to emergencies in laboratories.
Recommendations Concerning Promoting Safety	
16	Establish a system to promote safety in an institution or department that encompasses: electronic communications; printed materials; special seminars or events discussing or promoting safety; a recognition system for good safety performance; and a process to solicit, review, and act on suggestions for improving safety and identifying safety issues.
Recommendations Concerning Institutional Support	
17	Identify the ongoing need to support a strong safety culture and work with administrators and department chairs to establish a baseline budget to support safety activities on an annual basis.

recommendations for academic institutions attempting to improve safety culture. (Table 5.1) Each recommendation aims to help institutions more strongly demonstrate the seven characteristics of safety culture that the report identifies.

Creating Safety Cultures emphasizes the importance of safety education in undergraduate teaching laboratories. The expectation is that strong safety education during undergraduate studies will translate to graduate students with stronger safety ethics and will lead to stronger safety culture in academic labs. In turn, the overall quality of safety in research will increase. Like the responses to the ULCA and Texas Tech incidents, *Creating Safety Cultures* emphasizes the need for reporting systems, investigation systems, and a database of safety incidents with the belief that incident reporting supports continuous learning about safety. In addition to its broader recommendations about strengthening safety culture, the *Creating Safety Cultures* offers suggestions for the duties that the entire hierarchy of academic laboratories, from university presidents, to principal investigators and faculty, to laboratory staff, might undertake to improve safety culture.

5.3. National Research Council Safety Culture Report

In response to the wave chemical incidents, the National Research Council formed the Committee on Establishing and Promoting a Culture of Safety in Academic Research Laboratories. Its purpose was to look at ways to look at instilling stronger safety practices in chemical research. The committee consisted of university academic leadership and safety and health administrators, highly distinguished chemistry faculty members, and experts in the field of safety culture and human systems integration. The goal was to move chemical research beyond simple compliance to the adoption of a culture of safety in academic laboratories. *Safe Science: Promoting A Culture*

of Safety in Academic Chemical Research was published in 2014. *Safe Science* presents a series of findings, conclusions, and recommendations as described in Table 5.2. The contention is that if followed, these recommendations can assist institutions in establishing and promoting a culture of safety in academic chemistry research (NRC 2014).

Table 5.2. NRC Recommendations to Improve Safety Culture

Consideration	Comment
Institution-Wide Dynamics and Resources	
Finding 1	Safety is emerging as a priority and a core value of many academic institutions and of individual laboratories. A strong, positive safety culture is more beneficial than a compliance-only culture.
Finding 2	A strong, positive safety culture is a core element in the responsible conduct of research.
Conclusion 1	If laboratory safety is an unquestioned core value and operational priority for the institution, then safety will never be traded for research productivity.
Recommendation 1	The president and other institutional leaders must actively demonstrate that safety is a core value of the institution and show an ongoing commitment to it.
Finding 3	The availability and commitment of university resources to laboratory safety vary across institutions.
Finding 4	Universities often do not provide sufficient incentives to promote a strong, positive safety culture. In some cases they may create barriers or disincentives.
Conclusion 2	University policies and resource allocations have a strong impact on a department’s ability and willingness to help provide for a strong, positive safety culture. If an institution or individual laboratory wants to develop and sustain a safe and successful research program, then it must consider the resources it has available for safety and explore research options and requirements accordingly.
Recommendation 2	The provost or chief academic officer, in collaboration with faculty governance, should incorporate fostering a strong, positive safety culture as an element in the criteria for promotion, tenure, and salary decisions for faculty.
Recommendation 3	All institutions face a challenge of limited resources. Within this constraint, institutional head(s) of research and department chairs should consider the resources they have available for safety when considering or designing programs, and identify types of research that can be done safely with available and projected resources and infrastructure.

(Cont.)

Table 5.2 (cont.)

Consideration	Comment
Finding 5	There is a lack of clarity and consistency about safety roles and responsibilities across the university, particularly among faculty, researchers, and environmental health and safety personnel.
Recommendation 4	University presidents and chancellors should establish policy and deploy resources to maximize a strong, positive safety culture. Each institution should have a comprehensive risk management plan for laboratory safety that addresses prevention, mitigation, and emergency response. These leaders should develop risk management plans and mechanisms with input from faculty, students, environmental health and safety staff, and administrative stakeholders and ensure that other university leaders, including provosts, vice presidents for research, deans, chief administrative officers, and department chairs, do so as well.
Research Group Dynamics	
Finding 6:	There is variability across academia with regard to the involvement of researchers at all levels in establishing and sustaining a strong, positive laboratory safety culture.
Finding 7:	The deeply rooted hierarchy and highly competitive nature of academic research can inhibit the advancement of a strong, positive safety culture.
Finding 8	Students and postdocs are dependent on the principal investigator for their professional advancement. The power differential in this relationship may affect group members' willingness to raise safety concerns.
Finding 9	Most researchers in academia are still in the early phases of their professional development. As such, they may not have the requisite knowledge and skills to recognize and understand the risks associated with their work.
Finding 10	Research is regularly performed independently (including during off-hours and alone) and may be carried out with limited or no oversight or feedback.
Conclusion 3	Contribution and engagement by both principal investigators and by researchers through an open and ongoing dialogue are critical to creating a strong, positive safety culture. Safety culture is more likely to be sustained when safety issues are discussed broadly and frequently as an integral part of the research training and development process.

(Cont.)

Table 5.2 (cont.)

Consideration	Comment
Conclusion 4	There are several key attributes related to research group dynamics that contribute to the advancement of the laboratory safety culture. A strong, positive safety culture: includes open communication about safety as a key element that is sought out, valued, and acted upon; values learning and continuous improvement with respect to safety; includes regular safety communication, for example, “safety moments,” in academic research events (e.g., seminars, group meetings, doctoral defenses, and teaching); and empowers student and research trainees to have a “voice” and maintain an environment that encourages raising safety concerns freely without fear of repercussions.
Conclusion 5	A research group with a strong, positive safety culture engages with environmental health and safety personnel collaboratively.
Recommendation 5	Department chairs and principal investigators should make greater use of teams, groups, and other engagement strategies and institutional support organizations (e.g., environmental health and safety, facilities), to establish and promote a strong, positive, safety culture.
Recommendation 6	Department chairs should provide a mechanism for creating a robust safety collaboration between researchers, principal investigators, and environmental health and safety personnel.
Data, Hazard Identification, and Analysis	
Finding 11	Leading indicators from hazard analysis, risk mitigation, and best practices are not being widely used in laboratory safety planning. Often these data are not being collected for academic and non-industrial laboratories.
Finding 12	Incident and near-miss data are important sources of information for driving improved safety performance and for monitoring progress. Such key data are often repressed or distorted when there is a punitive approach in response to incidents.
Conclusion 6	Information is a key input to establishing and promoting a strong, positive safety culture. Incident and near-miss reports are important learning tools for laboratory safety, but presently are not effectively reported, compiled, analyzed, and disseminated within the research community. To ensure that useful data are available, a change in reporting and the availability and sharing of information is necessary.

(Cont.)

Table 5.2 (cont.)

Consideration	Comment
Finding 13	Researchers may not understand or appreciate the hazards of chemical materials and procedures in their work. This may be especially relevant for departments in which researchers typically have less training in chemistry (e.g., molecular biology, biochemistry, and engineering), yet often work with potentially hazardous materials or procedures
Recommendation 7	Organizations should incorporate non-punitive incident and near-miss reporting as part of their safety cultures. The American Chemical Society, Association of American Universities, Association of Public and Land-grant Universities, and American Council on Education should work together to establish and maintain an anonymous reporting system, building on industry efforts, for centralizing the collection of information about and lessons learned from incidents and near misses in academic laboratories, and linking these data to the scientific literature. Department chairs and university leadership should incorporate the use of this system into their safety planning. Principal investigators should require their students to utilize this system.
Finding 14	Hazard analysis is not routinely incorporated into experimental designs, procedures, and records in academia.
Conclusion 7	Routine hazard analysis is a critical component in research planning and execution. It represents an element of a strong, positive safety culture. Comprehensive hazard analysis and the use of engineering controls are especially important for experiments that are new to the individual and/or are being scaled-up.
Recommendation 8	The researcher and principal investigator should incorporate hazard analysis into laboratory notebooks prior to experiments, integrate hazard analysis into the research process, and ensure that it is specific to the laboratory and research topic area.
Training and Learning	
Finding 15	Laboratory safety training is highly variable across institutions, departments, and research groups.
Conclusion 8	A high-quality training program is an important element of a strong, positive safety culture.
Finding 16	There is a lack of comprehensive, early, and individual-laboratory-centric training and education for researchers, principal investigators, and in some cases, environmental health and safety staff. Many researchers arrive at a new institution or in a new laboratory without proper training or appreciation for appropriate safe laboratory practice.

(Cont).

Table 5.2 (cont.)

Consideration	Comment
Conclusion 9	Classroom and online training is necessary but not sufficient to ensure knowledge, skills, qualifications, and abilities to perform safely in a laboratory environment and to establish a strong, positive safety culture.
Recommendation 9	Department leaders and principal investigators, in partnership with environmental health and safety personnel, should develop and implement actions and activities to complement initial, ongoing, and periodic refresher training. This training should ensure understanding and the ability to execute proper protective measures to mitigate potential hazards and associated risks.

Safe Science is an academic-like document that was the first to have development of a safety culture as it primary concern. *Safe Science* examines safety systems and culture outside of academic chemical research to identify key themes, principles, and methods that are relevant to laboratory safety. Three stages of safety systems and cultures are described. The technology period was where safety was addressed in terms of engineering and administrative controls. The systems perspective is based on the concept of human–systems integration (HSI) that reside at multiple levels within complex sociotechnical systems. Safety Culture represent the third epoch of modern safety management (NRC 2014).

Safe Science addresses the current state of laboratory safety in chemical research in academic settings. Current practices and attitudes are reviewed in the context of the current hierarchy of actors involved in laboratory safety. After identifying the strengths and weaknesses of the actors, systems are identified that may be established to raise the overall safety performance of academic research labs to improve laboratory safety dynamics. Roles, responsibilities, authorities, and accountability for the conduct of safe science in academic research institutions is also considered.

5.4. APLU Guide to Implementing Safety Culture

The last publication to be considered is perhaps the most useful. A *Guide to Implementing a Safety Culture in Our Universities* was issued in April 2016 by the Association of Public and Land-grant Universities (APLU). APLU is a research, policy, and advocacy organization dedicated to strengthening and advancing the work of public universities in the U.S., Canada, and Mexico. APLU formed the Task Force on Laboratory Safety to provide research universities with recommendations and guidance on the most appropriate strategies to help enhance the culture of laboratory safety on each campus (APLU 2). The task force was created in coordination with the Association of American Universities (AAU), American Chemical Society (ACS), and Council on Governmental Relations (COGR), is comprised of senior research officers, environmental and health safety officers, faculty, and industry and national lab representatives (APUL 1). All universities are called to embrace a renewed commitment to improving the culture of safety for all academic research, scholarship, and teaching. APLU representatives made direct appeals to university presidents and Chancellors to utilize the guide and publicize their commitments and expectations within their institutions.

This document presents the roadmap for a university to improve safety culture. The guide distills years of thinking about lab safety by presenting 20 specific recommendations synthesized from the National Academies, the ACS, and the U.S. CSB. The attitudes, procedures, and administrative structures likely to reduce calamities in research labs and other facets of university are outlined (Beverly). Table 5.3 presents the APLU core values for building a culture of safety. (APLU)

Table 5.3. APLU Core Institutional Values Foundational to a Culture of Safety

Value	Description
1	Safety is everyone's responsibility. Each institution should commit to providing a campus environment that supports the health and safety practices of its community (faculty, students, staff, and visitors) and empowers the community to be responsible for the safety of others. A safe campus environment is a right of employment for all categories of employees. A safe campus learning environment is a right of all involved in education and research.
2	Good science is safe science. Safety is a critical component of scholarly excellence and responsible conduct of research.
3	Safety training and safety education are essential elements of research and education. They instill a culture of safety in the next generation of researchers and future faculty, and they are important for our students' career development and employability.
4	An improved culture of safety is necessary to truly reduce risk throughout the academic enterprise.
5	It is best to recognize that diverse methods and flexible approaches will be used by each institution to develop a strong culture of safety, unique to its situation.

Strong, consistent, and credible commitment from the organization's top leadership is required for any effective safety regime. Leaders must communicate with and gain buy-in from university members at every level, from top administrators, researchers, staff, faculty, and all students ranging from advanced Ph.D. candidates to the newest undergraduates. The guide urges making safety an explicit, prominent, and consistent institutional priority; providing and requiring effective and thorough training; and establishing clear and unified processes for assessing risks and reporting incidents and near-misses to allow learning from mistakes. To ensure that such learning takes place, postdocs, graduate students, undergraduates, and staff members all need to be explicitly empowered "to voice safety questions and concerns to their faculty supervisors, EHS offices, and/or safety committee" without fear of reprisal (APLU).

Table 5.4. APLU Guidelines to Improve Safety Culture

Value	Consideration
INSTITUTION-WIDE DYNAMICS AND RESOURCES	
President/chancellor	
1	Renews commitment to improve the culture of safety for all academic research, scholarship, and teaching.
2	Designates a campus lead and leadership team to begin the process. Considers appropriate committees to help implement a culture of safety, including a safety committee of faculty, Environmental Health and Safety (EH&S) officers, and other representatives who can provide formative feedback to researchers, educators, and staff.
The campus lead and leadership team	
3	Conduct campus dialogues with stakeholders to develop a shared vision of safety that aligns with the institutional mission and to develop an action plan.
4	Develop effective safety policies, procedures, and management systems, and identify the resources necessary for implementation. Establish recognition and reward systems and integrate these into tenure and promotion, hiring, and annual performance reviews.
5	Clearly articulate the roles and responsibilities of all stakeholders.
6	With the faculty, embed safety communication in laboratories, classes, departments and throughout the wider campus.
7	With the faculty, work to create a trusting and safe culture. Encourage the development of a generative culture based on open dialogue, reporting, and learning from near misses, as described by the National Academy of Sciences.
Institution	
8	Develops a risk assessment process for laboratory safety that is integral to all activities conducted in the laboratory or the field.
9	Establishes a unified administrative reporting model that connects responsibility for development and implementation of academic safety policies. The model should fall under one administrative pillar in the institution and should include faculty, EH&S officers, and administrative leaders.
10	Empowers undergraduate students, graduate students, postdoctoral fellows, and staff to voice safety questions and concerns to their faculty supervisors, EH&S offices, and/or safety committee.
11	Works to strengthen collegial and collaborative relationships between faculty and EH&S staff.
12	Works to enhance effective working relationships with first responders.

(cont.)

Table 5.4 (cont.)

Value	Consideration
Data, hazard identification, and analysis	
Institution	
13	Implements routine hazard analyses and includes them as integral components of undergraduate and graduate education; thesis, dissertation, and funding proposals; and experimental design for all experiments.
14	Implements a process to report incidents and near misses so that the campus community can learn from these incidents.
Training and learning	
Institution	
15	Provides laboratory safety education and training for students, faculty, EH&S staff, and department heads.
16	Ensures undergraduate and graduate science and engineering curricula include an emphasis on safe practices.
Continuous improvement	
Institution	
17	Conducts self-assessment and bench-marking using measures that can provide feedback on whether it is moving to a safer culture.
18	Develops a continuous improvement system that provides feedback, reassessment, and on-going training and learning opportunities.
19	Develops a system of accountability, including peer-to-peer accountability.
20	Promotes academic and industrial/government partnerships that allow academic researchers to learn from strong and well-developed safety cultures in industrial and government laboratories.

The recommendations are organized in four overarching categories: institution-wide dynamics and resources; data, hazard identification, and analysis; training and learning; and continuous improvement. (Table 5.4) The guide includes an analysis showing the alignment of the 20 recommendations with foundational reports. For each recommendation, the task force has provided reading lists, tools, strategies, illustrative examples, and/ or best practices drawn from a community of stakeholders for implementing these recommendations. These resources were

selected to help an appointed campus team navigate the process of strengthening their culture of safety. The task force has provided some actions that university community members can take to advance a culture of safety. These delineate the roles and responsibilities of presidents, other senior administrators, faculty, deans, department chairs, staff, and students.

5.5. Values for a Culture of Safety

The way people think and behave in relation to safety defines Safety Culture. To reduce risk throughout the academic enterprise an improved culture of safety is necessary throughout the academic enterprise. Safety culture is reflected by numerous inputs such as attitude, behavior, shared beliefs, training, communications, management support, and leadership. These common themes run through the reports reviewed above.

They all provide information about and methodology to improve safety culture at a university level. *Creating Safety Cultures in Academic Institutions* stresses teaching of safety laboratory practices to ensure that students have the necessary tools to work safety. *Safe Science* is an academic white paper to ensure that the community is aware of the issues. In a format where a problem is described, an overall conclusion is offered, and finally a recommended course of action. *Guide to Implementing a Safety Culture* offers a straight direct manual for how to build a strong viable safety culture.

The basic conclusion is that safety is everyone’s responsibility. If the goal is to have a strong culture of safety, LSU must provide a campus environment that supports and empowers the health and safety practices of their community. The flat structural organization, the concept of academic freedom, and a general laissez-faire attitude toward safety makes this a difficult process. This process must start at upper management with strong commitment and supporting actions to

improve safety. The process also needs to be approached in the lab level. Students must have the proper safety tools, training, and the support of their principle investigator and his management personnel. In short, to improve Safety Culture, there needs to be a renewed commitment to make safety a core value for all academic research, scholarship, and teaching.

CHAPTER 6. LOUISIANA STATE UNIVERSITY SAFETY CLIMATE SURVEY

The purpose of this chapter is to estimate the safety climate at Louisiana State University utilizing data from an existing survey. LSU suffered a natural disaster from hurricane Gustav making landfall in 2008 (LPB). This event resulted in the Federal Emergency Management Agency (FEMA) providing funding for the university to develop a Hazard Mitigation Plan. Hazard mitigation planning is a systematic process to identify natural and man-made hazards threatening communities and to reduce potential adverse impacts through strategies that reduce risks and vulnerabilities. This university developed a Disaster Resistant University (DRU) plan pursuant to the requirements of the Disaster Mitigation Act of 2000 (Gail). Several surveys, including a survey of research personnel about laboratory safety, were conducted in 2011 to support the development of the Hazard Mitigation Plan.

6.1 Introduction

Both of the terms, safety climate and safety culture have been used to describe workplace safety in efforts to improve safety. Reviews from technical, social, and psychological viewpoints have led to the general consensus that a positive safety culture improves job safety, and a safety climate survey can be used as a metric to assess safety performance (Ali el at.). Safety climate is a “snapshot” measurement of employees’ perceptions, attitudes, and beliefs about risk and safety. Methods to quantitatively measure safety climate have been developed and are considered as one of the best indicators of general workplace safety. Safety climate has also been considered as a manifestation of the more broadly defined safety culture (Shein).

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Zohar (2010) reviewed and summarized numerous safety climate studies performed for industry that used various types and numbers of questions (Zohar 2010). Since safety climate studies measure perception of the group's overall safety level, some researchers have suggested that determination of safety climate can be used as a safety performance indicator. There are indications that safety climate has a positive effect of safety behavior, but studies showing direct correlations have not resulted in clear cut conclusions Cooper). Safety climate research has focused on the methodology to improve measurement scales and predictive validity with regard to a variety of safety outcomes. Zohar (2010) claims that research has validated safety climate as a robust leading indicator or predictor of safety outcomes (Zohar 2010).

Wu, Liu, and Lu (2007) published a quantitative scaling system to estimate the safety climate at several university and college laboratories in Taiwan. A questionnaire was utilized to rank safety concerns on a scale of one to five and the estimation of safety climate was the mean of the rankings. A score of five indicated a high perception of the organization's safety climate while a one indicated a low safety climate. Items measured included the employee's perception of safety climate, chief executive officer's safety commitment and action, manager's safety commitment and action, employee's safety commitment, perceived risk, and emergency response (Wu at el.). Gutierrez, Emery, Whitehead, and Felknor (2013) completed similar study using five dimensions of safety perception to measure safety climate at five major universities in the United States. The five dimensions included perceptions of risks being managed, employee's safety commitment, department and supervisor's commitment, recognition of safety performance, and administration's safety commitment (Gutierrez at el.)..

In practice, researchers tend to use safety culture and safety climate interchangeably but safety climate studies tend to focus on the way that people perceive safety and does not address actual behavioral or situational aspects of safety. Safety climate should not be viewed as an alternative to safety culture because safety climate is an aspect of safety culture and is dependent on the overall prevailing safety culture (Gadd). However, in the case of academia, safety climate may be the only indicator that is readily available due to the lack of resources for determination of metrics for behavioral and management studies in academia (Copper) The results of a safety climate study for LSU utilizing a 2011 laboratory safety survey for the Hazard Mitigation Plan is presented.

6.2. Climate Survey Methodology

A survey of laboratory personnel was conducted in 2011 by students in a graduate level environmental science course as part of supporting data for the Hazard Mitigation Plan development. The original intent of the laboratory questions was aimed at estimating the impact of a hurricane on research laboratories and preparing for future events. In an effort to quantify the safety climate at this university, the survey data was compared to the concepts previously utilized for universities to put numerical values on safety climate (Wu at el.). The initial survey data was reviewed and culled to 26 questions relating to laboratory safety concerns in an effort to estimate safety climate levels.

The surveyed group consisted of principal investigators, researchers (post degree positions), staff (non-academia researchers), and graduate students that worked within research laboratories. A list of known laboratory personnel was generated using a random sorting method. Approximately 150 people were contacted and 85 responded. The participants were asked fifty

questions about their perception of their laboratory including training, facilities, safety equipment, hazards, chemical and waste handling, previous events, overall feeling of safety, and areas for improvement.

The survey was conducted via personal interviews. While extremely time consuming, this method allows for elaboration of questions and personal insight regarding the questions. However, the open-ended format also increases the difficulty of coding the questions for accurate statistical analysis. For example, the initial survey contained three questions concerning the use of personnel protective equipment (PPE). The important question about what PPE was being used could not be coded and was not used in the climate survey. Another important question regarding individuals feeling unsafe had a negative answer and had to be coded differently. The data was coded by assigning a numerical value to the responses. Multi response questions were scored using on a Likert-type scale of 1–5, with "no response" assigned a neutral value of three. Dichotomous questions that were answered with "yes" or "no" were also assigned a Likert-type scale of one for the negative response and five for the positive response. The assigned scores ranging from one to five were aggregated to reveal strengths and weaknesses linked to the level of safety perception. A measure of one represents a very poor safety climate, while five represents an excellent safety climate.

The questions were divided into three groups that correspond to the existing safety climate studies performed at other universities. The primary demographics collected consisted of university rank, time of service, building, and department. Perception of safety was determined by answers to questions concerning potential hazards, hazardous events, feeling unsafe, emergency response, and security. The commitment of direct supervision to safety was determined by

answers to questions concerning PPE use, enforcement of PPE use, training, inspections, housekeeping, standard operating procedure (SOP) use, and access to material safety data sheets (MSDS). Upper management commitment to safety was indicated by the existence of practices that support safety such as fire drills, fire extinguisher inspections, and chemical inventory. Providing physical safety equipment for the laboratory was also considered in the evaluation of the commitment of upper management to safety.

The data was analyzed using SAS 9.3. Each question was analyzed separately to determine overall mean and the mean by both rank and time of service in the laboratory. Total frequency and two-way frequency were completed by rank and time of service. ANOVA was completed for each question to determine if there were significant differences between rank and time of service on each question. An initial estimate of the safety climate parameter of each safety commitment group was provided by the mean of each group assuming equal weight for each question. Since the data contained only two applicable demographic variables, a multivariate regression was not performed. The Cronbach alpha coefficient was determined as a reliability analysis to assess the internal consistency of each group. A factor analysis was performed for each group of questions to determine the principle components (questions that are significant in the estimation of safety climate). The safety climate rating of each group was re-estimated using only the principle components. The mean of each safety dimension group was determined assuming equal weight for each of the principle components. The overall safety climate value was estimated from the mean of all the principle components assuming equal weight for each component.

6.3. Climate Survey Results

Demographic information collected from the survey is displayed below in the pie graphs. Figure 6.1 shows the academic position of the laboratory personnel who responded to the questionnaire and Figure 6.2 demonstrates the length of service in the respective laboratory. The survey participants were identified as graduate students (35%), faculty (24%), researchers (35%), and staff (6%). The length of service demographic indicates that 15% of those surveyed had been

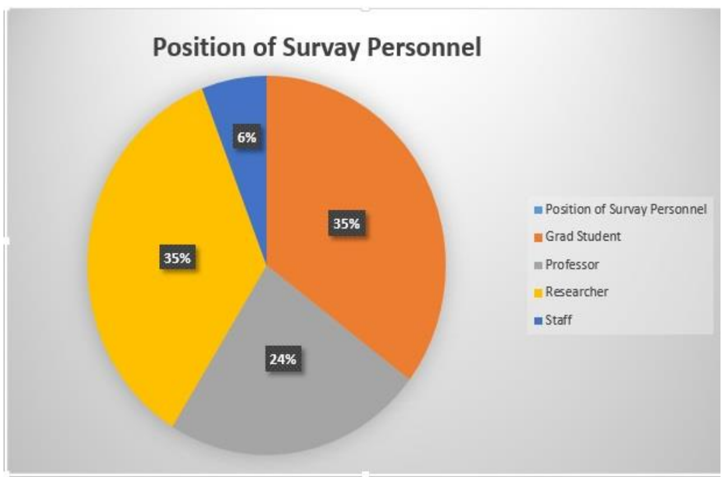

Figure 6.1. Position of Survey Personnel

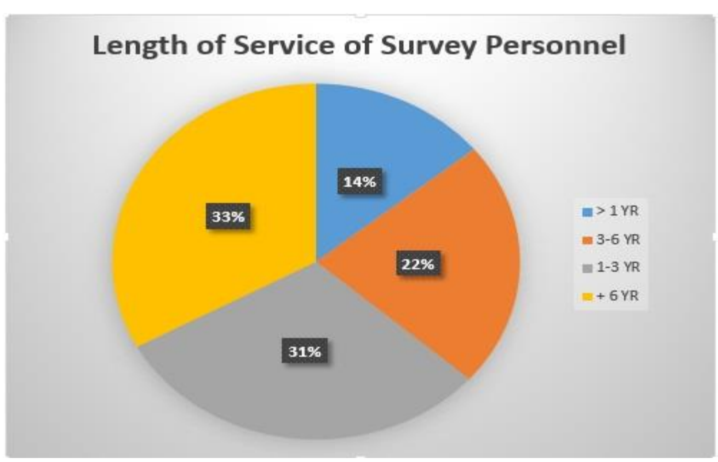

Figure 6.2. Length of Service of Survey Personnel

in the laboratory for over 6 years, 27% with 3 to 6 years of service, 40% with 1 to 3 years of service, and 18% had less than a year of research experience in the laboratory. Figure 6.3 shows the length of service in the laboratory for each ranking.

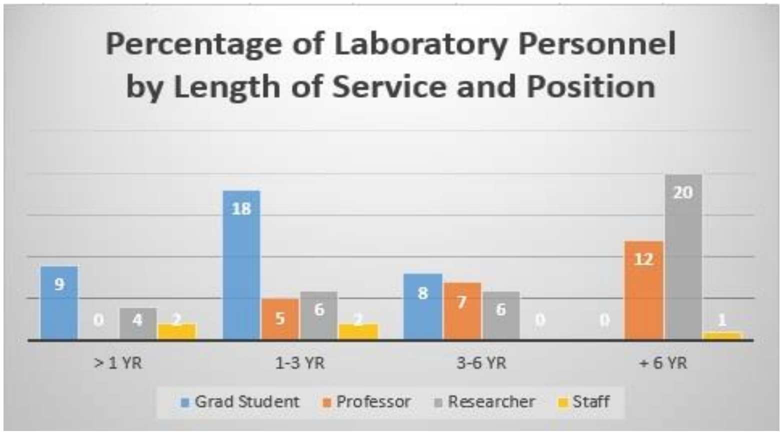

Figure 6.3. Percentage of Laboratory Personnel by Length of Service and Position

A goal of the survey was to obtain a representative sample of the whole university to determine overall safety and emergency response readiness. Figure 6.4 gives an indication of the

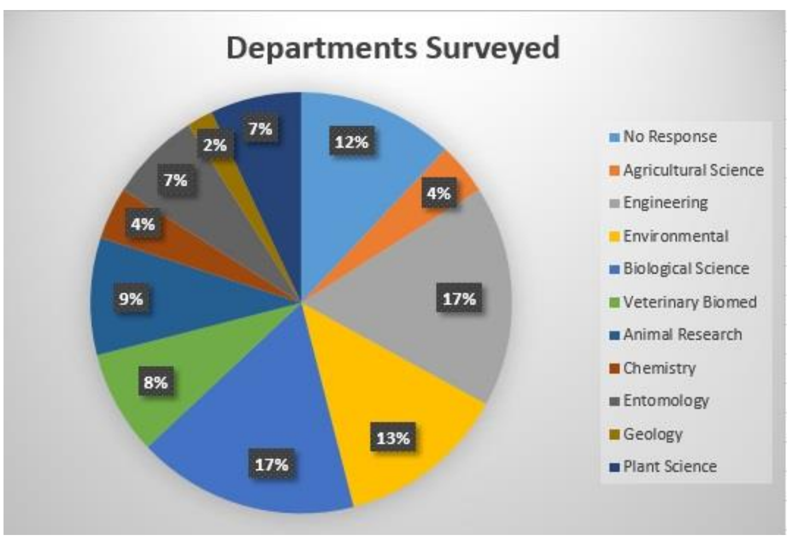

Figure 6.4. Departments Surveyed

departments utilized in the laboratory survey. The Biological Sciences and Engineering Departments, each represented 17% of the total responders. Agricultural Sciences represented 13% of the total. Almost 12% of the responders did not indicate the department in which they worked. Overall, the survey provided a good representation of LSU demographics.

Table 6.1. Upper Management Commitment to Safety

Analysis Group	Number	Question	Analysis Label	N	Mean	Std Dev	Cronbach Alpha	Eigen Value
PHY	Q.9	Are fire drills performed?	DRILL	85	3.56	1.76	0.28	1.57
PHY	Q.11	Does the lab have functioning emergency showers?	SHOWER	85	3.63	1.81	0.32	1.39
PHY	Q.12	Does the lab have emergency eye wash stations?	EYE	85	4.13	1.62	0.12	1.13
PHY	Q.13	Does the lab have hood vents?	HOOD	85	4.72	1.03	0.31	1.06
PHY	Q.16	Are there fire detectors suppression equipment in the lab?	F_DETECT	85	4.01	1.53	0.19	0.91
PHY	Q.17	Are the fire extinguishers regularly inspected?	EXTIN	85	4.11	1.22	0.25	0.8
PHY	Q.20	Are chemicals inventoried?	CHEM	85	4.48	1.2	0.35	0.41
PHY	Summary	Total Components		595	3.99	1.57	0.29	---
PHY	Summary	Principle Components		340	4.01	1.64	---	---

Table 6.1 lists the survey questions that were used to represent upper management's commitment to safety as well as the results of the statistical analysis. These questions where grouped together under the PHY (physical) term for analysis. Upper management provides the

physical safety equipment for the laboratory. The upper management safety support is also indicated by practices that support safety such as fire drills, fire extinguisher inspections, and chemical inventory. There were no significant ANOVA differences in the PHY group. The mean of the PHY group assuming an equal weight for all the questions is 3.99 ± 1.57. Considering only the principle components, the mean of the PHY group is 4.01 ± 1.64.

The Department (DEPT) group represents the commitment of direct supervision to safety and includes questions concerning PPE use, training, inspections, housekeeping, SOP use, and MSDS access. (Table 6.2) There were no significant ANOVA differences in the DEPT group. The mean of the DEPT commitment to safety group assuming an equal weight to every question is 3.67 ± 1.66. Considering only the principle components, the mean of the DEPT commitments to safety group is 3.48 ± 1.74.

Perception (PREC) of safety included questions concerning potential hazards, hazardous events, feeling unsafe, response, and security (Table 6.3). The only significant ANOVA difference in the PREC group was between time of service and the number of hazard events. Responders with over 6 years of service saw a significant increase in hazardous events. The mean of the PREC group assuming an equal weight to every question is 3.51 ± 1.45. Considering only the principle components, the mean of the PREC group is 3.74 ± 1.71.

Multivariate regression was not performed because there were only two applicable demographic parameters, length of service and rank. Additionally, the only significant difference in the ANOVA analysis was length of service and number of accidents.

Table 6.2. Direct Supervision Commitment to Safety

Analysis Group	Number	Question	Analysis Label	N	Mean	Std Dev	Cronbach Alpha	Eigen Value
DEPT	Q.14.1	Is PPE required to work in lab?	PPE	85	4.74	0.97	0.49	2.32
DEPT	Q.14.1	Is the PPE requirement strictly enforced?	ENFORCE	85	3.94	1.65	0.41	1.32
DEPT	Q.18	Has the lab staff been trained on the proper use of extinguishers?	EX_TRAIN	85	3.31	1.73	0.46	1.1
DEPT	Q.22	Are there general safety inspections?	GEN	85	3.52	1.55	0.42	1.09
DEPT	Q.23	How would you rate the labs overall housekeeping measures?	HK	85	1.92	1.36	0.58	1.03
DEPT	Q.30	Are there written standard operating procedures (SOPs)?	SOP	85	4.27	1.3	0.43	0.77
DEPT	Q.30.1	Are there written emergency SOPs?	WRITTEN	85	3.44	1.61	0.41	0.74
DEPT	Q.33	Are these emergency procedures easily accessible?	ACCESS	85	3.94	1.14	0.44	0.64
DEPT	Q.34	Are material safety data sheets (MSDS) available on demand?	MSDS	85	4.79	0.82	0.5	0.54
DEPT	Q.6	Were you required to complete a safety training course prior to working in the lab?	TRAIN	85	2.85	1.97	0.49	0.45
DEPT	Summary	Total Components		850	3.67	1.66	0.49	---
DEPT	Summary	Principle Components		425	3.48	1.74	---	---

Table 6.3. Worker Perception of Safety

Analysis Group	Number	Question	Analysis Label	N	Mean	Std Dev	Cronbach Alpha	Eigen Value
PREC	Q.15	Does the lab have potential for fires or explosions?	FIRE	85	2.69	1.91	0.02	1.86
PREC	Q.24	During your employment, have any hazardous events have occurred which jeopardized the lab or its staff?	EVENTS	85	4.36	1.45	-0.03	1.1
PREC	Q.26	Have you ever felt unsafe in your lab due to a hazardous event?	FEEL	85	4.15	1.17	0.15	1.03
PREC	Q.27	How would you rate your lab's response to potential hazards in the past?	RATE	85	3.91	0.78	0.23	0.97
PREC	Q.28	How well do you feel/think your lab was for prepared for the hurricane?	HURR	85	3.62	1.03	0.21	0.82
PREC	Q.42	What is the general security of the lab?	SECUR	85	2.11	0.66	0.11	0.69
PREC	Q.44	Are you aware of the potential for adjoining areas that would pose a significant risk during a lab emergency?	RISK	85	2.86	1.53	0.14	0.56
PREC	Summary	Total Components		595	3.51	1.45	0.15	---
PREC	Summary	Principle Components		255	3.74	1.71	---	---

To assess the internal consistency within each group, the Cronbach alpha coefficient was determined for each group via SAS reliability analysis. The Cronbach alpha coefficient is the average value of the reliability coefficients that can be obtained from all the possible combinations when split into two half tests. The raw values and not the normalize values of Cronbach alpha coefficient are presented in this paper. The Cronbach alpha value reported for each question is the coefficient for the group if that individual item is removed. The sets of questions used to determine the departmental commitment (DEPT) to safety had a Cronbach alpha coefficient of 0.49. While the perception of safety (PREC) and the commitment management (PHY) have even lower values of 0.15 and 0.29, respectively. Since guidelines set a value of 0.7 as minimally acceptable, these values indicate that the internal consistencies between questions are very poor and would need to be reworded for any future survey (O'Rourke & Hatcher).

Table 6.4. Summary Values of Safety Climate

Analysis Group	Number	Components	N	Mean	Std Dev	Cronbach Alpha
PHY	Summary	Total Components	595	3.99	1.57	0.29
PHY	Summary	Principle Components	340	4.01	1.64	---
PREC	Summary	Total Components	595	3.51	1.45	0.15
PREC	Summary	Principle Components	255	3.74	1.71	---
DEPT	Summary	Total Components	850	3.67	1.66	0.49
DEPT	Summary	Principle Components	425	3.48	1.74	---
Estimated Safety Climate from Principle Components			1020	3.72	1.71	---

To complete a construct validity analysis, a factor analysis was performed for each group of questions to determine the principle components of the group. Based on the Kaiser Guttman rule, only the questions that had Eigen-values over one are significant in the estimation of the indicators for safety climate. (O'Rourke & Hatcher).

The estimation for the PHY group utilized four of the seven questions. The estimation for the PREC group utilized three of the seven questions. The estimation for the DEPT group utilized five of the ten questions. Assuming an equal weight of all the significant questions, the values of the perceived safety climate at this University are 3.72 ± 1.71 (Table 6.4). Although the mean of all significant questions was used as an estimate of safety climate, the factor analysis also indicated that a significate portion of the survey questions should be reworded.

6.4. Climate Surrey Discussion

The values of the safety climate survey for LSU are similar to the American universities described in Gutierrez's publication (Gutierrez at el.). LSU is also comparable to those universities in terms of facility, staff, student size, and amount of research dollars spent. Tables 6.1-6.3 describe the mean value of each question and the mean value of each safety group, both with and without consideration of component significance. Table 6.4 is a summary of each safety climate group and the overall safety climate value.

Based on the present study, the safety climate rating for LSU is estimated at 3.72 ± 1.71, on a scale of 1–5, with 5 indicating very high perception of safety. The average safety climate value presented for the Taiwanese universities by Wu et al. (2007) was approximately 4.0, which was reported as representing a "high" value for safety climate. This study concentrated on defining

the different types of factors that can influence a safety climate value. Additionally, the study utilized a 46 question survey and included over 100 universities (Wu at el.). Gutierrez, et al. (2013) looked at five universities in the United States utilizing a 26 question survey administrated through CSHEMA (Campus Safety Health and Environmental Management Association). Safety climate values for the five universities ranged from 3.57 ± 0.92 to 4.16 ± 0.60. These results are reported as indicative of an overall "high" perception of safety on these campuses. Thus, it appears that LSU also displays a high perception of the safety climate based on the present literature.

While the scales were normalized and questions partially duplicated, direct comparison to the safety climate values in the work of Wu et al. (2007) and Gutierrez et al. (2013) is problematic. There are differences in the survey questions and methods which relates back to the concerns posed by Guldenmund about comparison of climate safety data and Zohar's call to develop better model for safety climate studies (Guldenmung, Zohar 2010). The survey at LSU was conducted via personal interviews. While extremely time consuming, this method allows for expansion of questions and personal insight regarding the questions. However, the open-ended format also increases the difficulty of coding the questions for accurate statistical analysis. This study lacks the level of detail of the Taiwanese study due to fewer questions about safety concerns and parameters. This study only duplicates three of the five safety dimensions used in the American study. The PREC section of this study closely duplicates perceptions of risks being managed in the American study. The DEPT section of this study duplicates department and supervisor's commitment to safety in the American study. The PHY section mimics the administration's safety commitment. Recognition of safety performance and employee's safety commitment parameters found in the American study were not included in this study.

The significant numerical factors used in determination of the managerial level of safety commitment (PHY) at this University were related to providing physical safety items in the laboratory like fire suppression, chemical vent hoods, and safety showers which are required under building codes. Likewise, the inspection of fire extinguishers and fire drill are items required by local fire codes. At best, the answers in the PHY section provide an estimated indication of the actual safety commitment of management. The level of perceived management safety support in the American study ranged from 3.72 to 4.14 while the value of management safety support level at this University was 4.01 ± 1.64.

The significant numerical factors for estimation of the perception of safety in the laboratory were the potential for fire, past hazardous events, and feeling unsafe in the laboratory. Approximately half of the people interviewed believe that there was potential for fire in their laboratory. The number of hazardous events was skewed toward longer length of service and showed the only significant ANOVA parameter. The results of the survey indicate that most people feel safe in their laboratory. Survey responses also indicate that laboratory personnel feel that they were relatively prepared for emergencies. However, the questions about laboratory security and potential hazards from other labs indicate the belief that outside hazards have a potential to impact their laboratory. While security was not normally considered as a function of safety professionals, its importance increases as regulatory oversight increases. In some cases, possible concerns about outside forces could distract from internal safety issues. The level of perceived safety management of risks in the American study ranged from 4.45 to 4.68 while the perception level at this University was only 3.74 ± 1.71.

In the present study, the significant numerical factors used in determination of the departmental level of safety commitment were related to PPE, safety inspections, and housekeeping. Almost all interviewees responded that PPE is required in their laboratory, but the scores dropped on the questions concerning enforcement and training for use of PPE. The survey indicated that safety inspections were being conducted, but the types of inspections were not covered. In general, laboratory personnel have the perception that general laboratory housekeeping is a problem. A reasonable number of the responses indicated the existence of SOP's in the laboratory, but the survey did not address additional details concerning formats or enforced use. Approximately half of the responders indicated that no form of safety training was required before beginning work in the laboratory. The level of perceived departmental safety support in the American study ranged from 3.31 to 4.19 while the value of departmental safety support level at this University was 3.48 ± 1.74.

Based on careful evaluation of this safety climate survey, both the reliability analysis and the factor analysis indicated that the survey could be designed better to quantify safety climate for LSU. In a repeat of the survey, questions also need to be reworked to address the conceptual aspects of safety climate. All dichotomous questions should be converted to multilevel questions and use the Likert scale.

The relative merit of a safety climate study should be considered. While a valuable safety measurement tool, climate surveys only measure one part of safety culture. Their value as a tool increases when the survey is done on a yearly basis and yearly changes can be noted. Additionally, the academia community needs to develop a database from several universities so that baseline values are established. Researches have to recognize the limitations of safety climate surveys.

The values of the reported studies at universities indicate that there is a perceived high level of safety which almost seems intuitive in nature. People take pride in their work and become accustomed to their daily work environment. Unless there is a workplace problem or event, they feel safe and would tend to perceive their safety in a positive manner. Actually, they are only one event away from losing that perception of safety. It is a duty of an EHS professional to help maintain a positive outlook and strive to increase researcher's attitudes toward increased safety levels.

6.5. Climate Survey Conclusion

The determination of metrics to estimate a safety level at a university is not an easy task and these metrics are hard to define and often difficult to collect. The goal to quantitatively estimate the safety climate at this LSU based on an existing survey was achieved. Professionals on the EHS staff found the results to match their intuitive perceptions of the safety at their university and the values correspond with published values at other universities. However, the question of the relative merit of safety climate studies to measure safety culture remains open to debate. Behavioral and situational aspects of safety culture have not been fully considered in academia. Methods to address these concerns at an academic setting need to be furthered developed and validated. Until then, the recommendations presented by the National Research Council to improve safety culture should be considered as the best opportunity to actually enhance safety culture at an academic level (NRC 014).

CHAPTER 7. CONFIRMATORY FACTOR ANALYSIS OF SAFETY CULTURE AT LOUISIANNA STATE UNIVERSITY\

The overall purpose of my dissertation research is to determine the nature of and level of safety culture in the research community at Louisiana State University. Safety culture focuses on the way people think and/or behave in relation to safety. Safety culture is an abstract concept that considers safety in a holistic manner. Most models for improvement consider safety culture as being the end achievement of various inputs such as attitude, behavior, shared beliefs, training, communications, management support, and leadership.

A shortcoming with most safety culture models is the lack of their integration into general models of organizational culture. A model for safety culture presented by Cooper (2000) proposes that interactive and reciprocal relationships exist between psychological, situational and behavioral factors in safety culture as well as in organizational culture (Cooper). Safety culture can be considered a product of multiple goal-directed interactions between people (psychological), jobs (behavioral), and the organization (situational). There is perpetual dynamic interplay among people and their environments (Davies). -People's perceptions about safety can be assessed through safety climate questionnaires to provide a measure of the psychological dimension. The behavioral aspects of safety culture can be measured through self-reporting procedures or the use of observational safety behavioral checklists and trained personnel to observe, quantify, and provide feedback. However, there honesty concerns with the self-reporting procedures and the observational procedures tend to be highly time consuming and not cost effective (Cooper).

A three component model consisting of Safety Climate, Safety Attitudes, and Safety Behavior is proposed to define Safety Culture. (Figure 7.1) A questionnaire was utilized to

measure the proposed model. The Climate sections provides the situational aspect by looking at the perception of safety and the overall commitments to safety. The Attitude section provides insight into the psychological nature of safety culture. The Behavior section provides insight into how people behave in a research situation.

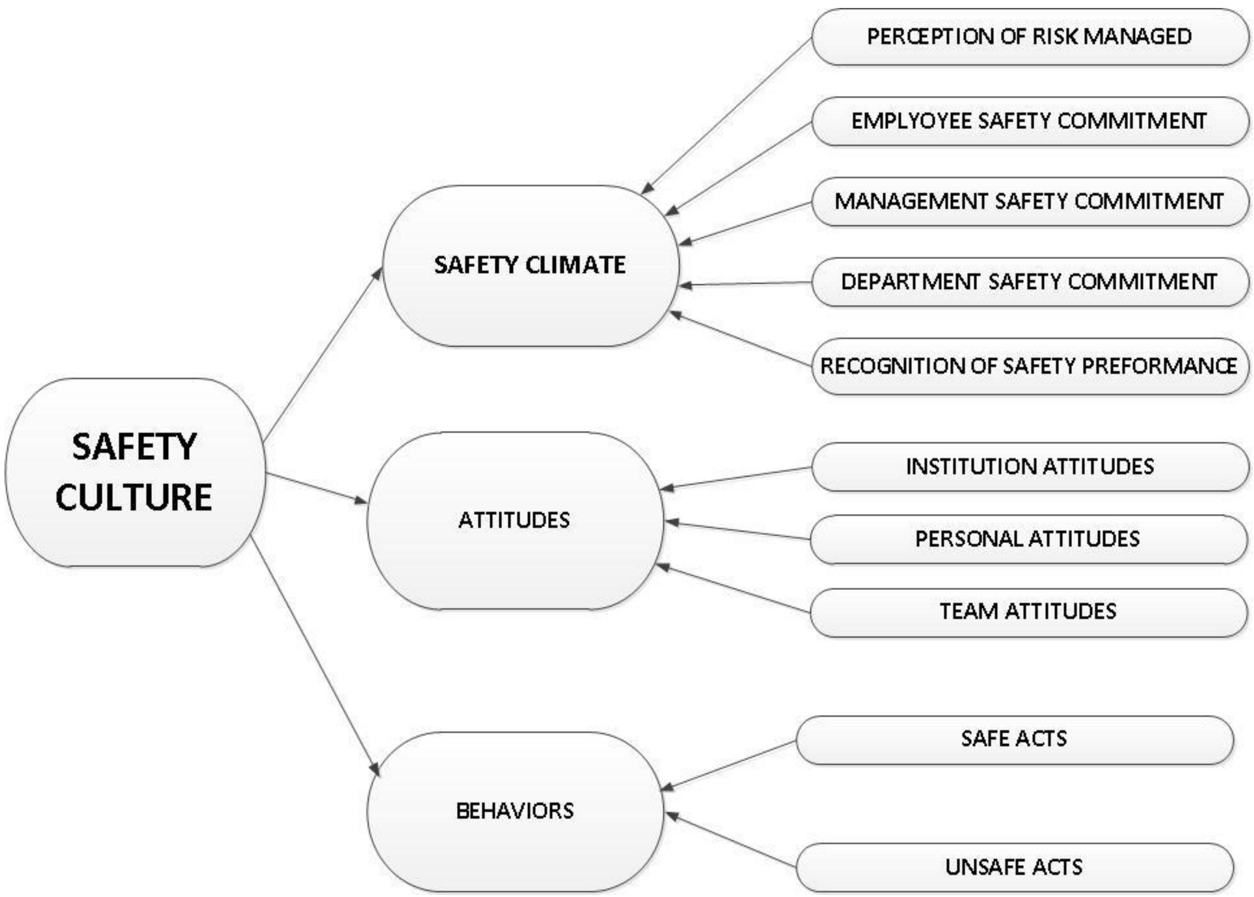

Figure 7.1. Safety Culture Conceptual Model

The general concept of structural equation modeling (SEM) is to develop a model based on a conceptual overview of the process and then use statistical techniques to determine if the model fits. Safety culture is an abstract concept that is hard to measure. Safety climate studies

have been used to provide a snapshot picture of safety culture but fail because they do not address the psychological and behavioral aspects of safety culture. Structural equation modeling (SEM) is a general linear and cross-sectional statistical modeling technique used to determine whether a certain model is valid In this case, the primary interest is focused on the latent constructs which are psychological variables like Safety Climate, Safety Attitude, and Safety Behavior rather than on the manifest variables used to measure these constructs. Measurement of these latent constructs is recognized as difficult and error-prone. The SEM technique explicitly models measurement error to derive unbiased estimates for the relations between latent constructs. To this end, SEM allows multiple measures to be associated with a single latent construct. The model assumes a structure of the covariance matrix of the measures. Once the model's parameters have been estimated, the resulting model-implied covariance matrix can then be compared to an empirical or data-based covariance matrix. If the two matrices are consistent with one another, then the structural equation model can be considered a plausible explanation for relations between the measures (Rigdon).

7.1. Data Collection Method for CFA

In September, 2015, a peer from Utah State University contacted me for help with a dissertation project. He was trying to develop a model linking training, attitudes, and behavior to Safety Culture. The model would then be confirmed using structural equation modeling. I was happy to help since I was interested in similar research. The EHS Assistant database was used to find LSU researchers that had recently completed the three basic on-line training courses (Basic Lab Safety, Hazard Communication, and Emergency Response). The EHS Assistant is a commercial database that LSU utilizes to maintain chemical/biological inventories, on-line safety

training, and compliance issues. It a permit based system where each Principle Investigator is assigned a permit and in turn laboratory space and personnel are assigned to that permit. Approximately 120 researchers representing a mix of faculty, staff, graduate student, and undergraduates received a hard copy of the Utah State Survey. EHS collected the surveys and forwarded them to Utah State. Several additional schools were included in the Utah State survey effort. In January 2016, an electronic copy of the LSU data already coded for use in preliminary analysis was received (Jorgenson). The attitude and behavior sections of the Utah/LSU data was subjected to exploratory factor analysis to determine potential factor loadings for a LSU Safety Culture Survey. The principles factor method was used to extract the factors, which was followed by a varimax (oblique) rotation. Two, three and four factor loadings were considered. All statistical work was completed using SAS 9.4.

A questionnaire was developed to measure safety culture at LSU. The survey and contact process was approved by the LSU Institutional Review Board. The first section of the survey covered basic demographics, including position at the university, gender, associated school or college, location, and length of time in research. The level of training and accident experience were also included in the first part of the survey. The second section was based on the CSHEMA safety climate survey that was originally presented by Gutiérrez in 2013 (Gutiérrez at el.). The climate survey looks at management support for safety, department support for safety, personal support for safety, perception of safety, and recognition of safety actions. CHEMSA is currently assisting universities in determination of their safety climates and is collecting the metrics to build a bench marking database for reference. However, to date, no psychometric properties analysis has been published on the CHEMSA survey. The Climate sections provides the situational aspect

as a latent construct for Safety Culture by looking at the perception of safety and the overall commitments to safety.

The third section comprises an attitude survey to define another latent construct for safety culture. It is loosely based on the "Safety Attitude Questioner" used in the medical field to improve hospital performance by measuring caregiver's attitudes in patient safety related domains (Sexton). The attitude section was modified to consider attitudes of researchers in academic labs by Utah State personnel (Jorgensen 1). The Utah State Attitude questions were used in the LSU Survey with only minor changes. With the exception of CSHEMA, there are very few safety standards that can be used as bench marks. The rational for using the Utah State attitude survey is that the data can be used in benchmarking efforts and the preliminary data could be used in an exploratory factors analysis. Using the same data in the exploratory factor analysis and then in a corresponding confirmatory factor analysis is a poor statistical practice because in that case the CFA does not confirm a theoretical model, it just validates the EFA. Based on literature reviews and EFA analysis of the Utah/LSU data, there are three factors that represent overall safety attitude which are institution, team, and personal attitudes.

The fourth section focuses on behavior as the third part of the model for safety culture. Initially the survey was designed using vignette (matrix) methods, which have been used in psychological studies (Alexander). The general method involves the presentation of a situation where participants are asked to declare the likelihood of reacting to the situation with a given set of possible options ranging from safe to unsafe. The scenarios used in the survey were based on actual incidents from Utah State University. Again the questions used in the LSU Survey were the Utah State questions with minor changes.

The people who were requested to complete the LSU survey were determined using the EHS Assistant. An excel spreadsheet was generated containing each lab worker's name, worker designation, department, principle investigator, email, and lab position. The initial list contained approximately 2,400 names. People with incomplete information and undergraduate workers were removed from the list. Since the target group are scientific "wet" lab researchers all departments not doing "wet" lab work was eliminated as potential recipients of the survey. A final pass was made to remove personnel with special circumstance such as retired, recently deceased, or indicted for criminal charges. On March 29, 2016, a cover email containing the links to the survey was sent to 1088 researchers at LSU via mail merge. The email was successfully received by 1033 people. After a week, there were 126 survey money responses. A reminder Email was sent to the same group on April 7, 2016 which resulted in an additional 106 responses. On April 18th, a third email was sent. The survey was closed an April 28th with a total of 306 responses. Survey monkey was set up so that all responses were confidential. Accepting that the survey precipitants were "cherry picked", there was still only a 30% response to the survey. In general, the responses tended to be very positive.

The data was downloaded from survey monkey in the form of a PDF file, Power Point Presentation, and a comma delineated file (CVS). The CVS file for the climate and attitude sections was coded using a seven point Likert scale with the assumption that the scale is linear. Both positive and negative questions were included in the questioner to look at relative bias. On the positive questions a value of seven corresponded to the highest positive question while on the negative questions, a value of one corresponded to the most positive result. Missing data was replaced with the average Likert scale value for that question.

In the behavior section, the initial concept was that each scenario would represent planning, practice, and negligence, respectively. The vignette based behavior data was initially coded using a weighted two scale axis. The vertical axis used a Likert scale from highly unlikely to highly likely. The neutral value was left out of the survey questionnaire. Additionally, each of the four proposed solutions to the problem was ranked from very safe to very unsafe which created a sliding scale and areas of reverse coding to account for the possible range of reactions. [Smith, 2012] However, the vignette data was not conducive to statistical analysis due to the matrix construction itself and poor wording of some of the questions. For example, in response to a container venting on a bench top, one option was to pick up the container and put it in the hood. While putting something in a hood to prevent exposure is good, picking up a reacting bottle is a bad idea. There was a great deal of feedback on the scenario questions that they were not realistic and they were chemical based. In the future, the existing scenarios and questions will need to be reworked and scenarios developed for other disciplines.

The behavior data was recoded using a much simpler approach. Industry have characterized actions as safe or unsafe for over forty years. Using a Likert scale, safe act answers were give a value of seven corresponding to highly likely. Unsafe act answers were given a value of one corresponding to highly likely. The recoded behavior data was reviewed for completeness. Several responders did not complete the section or did not understand that each question had to be answered. Where appropriate, an average value was inserted, otherwise the data was left blank. At this point, simple statistics were completed using the SAS Mean and FREQ procedures.

7.2. Result of Safety Culture Study

Demographic results are presented below alone with the graphical presentation. The distribution of personnel rank answering the survey is fairly balanced with faculty at 34%, graduate students at 40%, and researchers at 8% and staff at 18%. (Figure 7.2) There were slightly more males (56%) responding than females (44%).

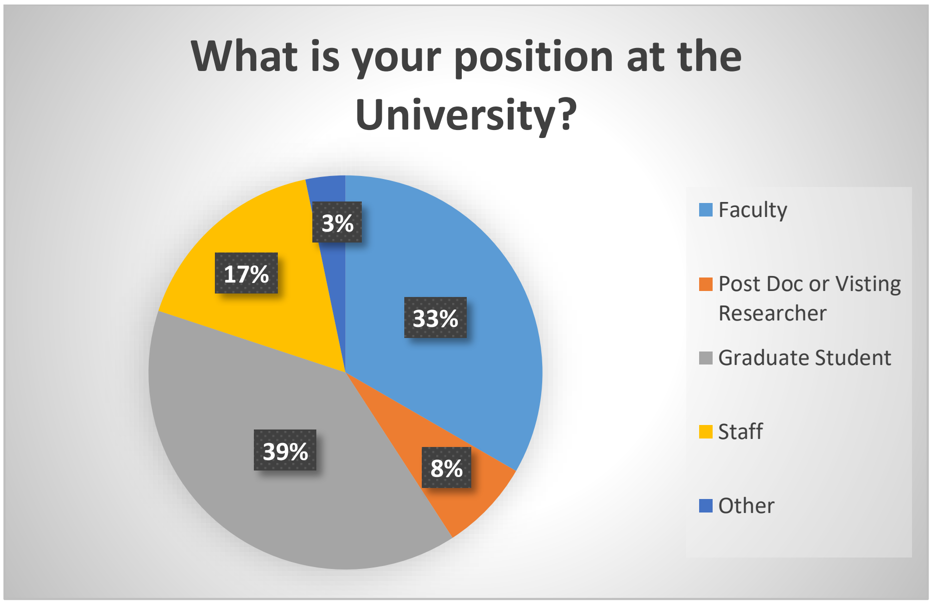

Figure 7.2. University Position

The major scientific work in the in the university are represented with the College of Science at 36%, the Agriculture Center with 25%, School of Veterinary Medicine at 14%, College of Engineering at 13%, and the College of Energy Coast and Environment at 13%. (Figure 7.3) Likewise, there is a good distribution of campus building with Animal Food Science /Vet Science at 4%, Choppin/ CMB at 20%, Energy Coastal Environmental at 11%, Howe Russell/ Nicholson at 2%, Life Sciences Complex at 25%, Miller/ Sturgis/ RNR at 9%, Patrick Taylor/ Chem E/ ERAD at 10%, and the Vet Medicine Complex at 12%. (Figure 7.4) The level

of experience of the personnel surveyed tended to be very high with 36% indicating that they had over 15 years of experience in the laboratory, 9% with 10 to 15 years, 12% with 6 to 10 years, 21% with 3 to 6 years, and only 21% with less than 3 years. (Figure 7.5)

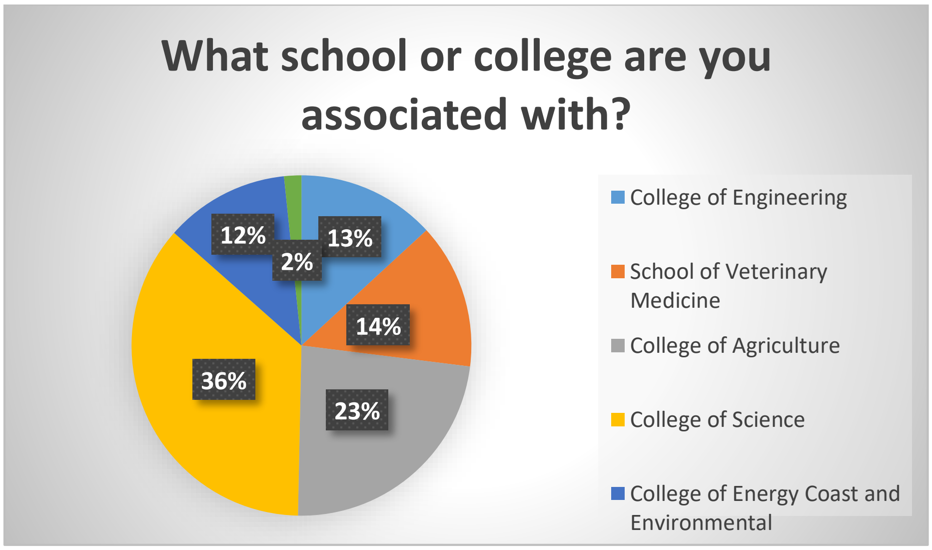

Figure 7.3. Associated School or College

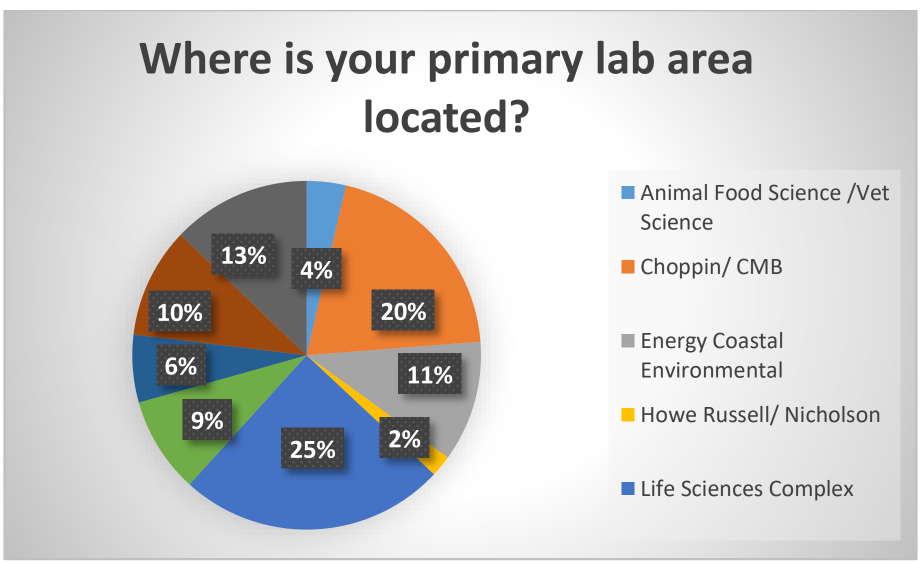

Figure 7.4. Primary Lab location

Russell/ Nicholson at 2%, Life Sciences Complex at 25%, Miller/ Sturgis/ RNR at 9%, Patrick Taylor/ Chem E/ ERAD at 10%, and the Vet Medicine Complex at 12%. (Figure 7.4) The level of experience of the personnel surveyed tended to be very high with 36% indicating that they had over 15 years of experience in the laboratory, 9% with 10 to 15 years, 12% with 6 to 10 years, 21% with 3 to 6 years, and only 21% with less than 3 years. (Figure 7.5)

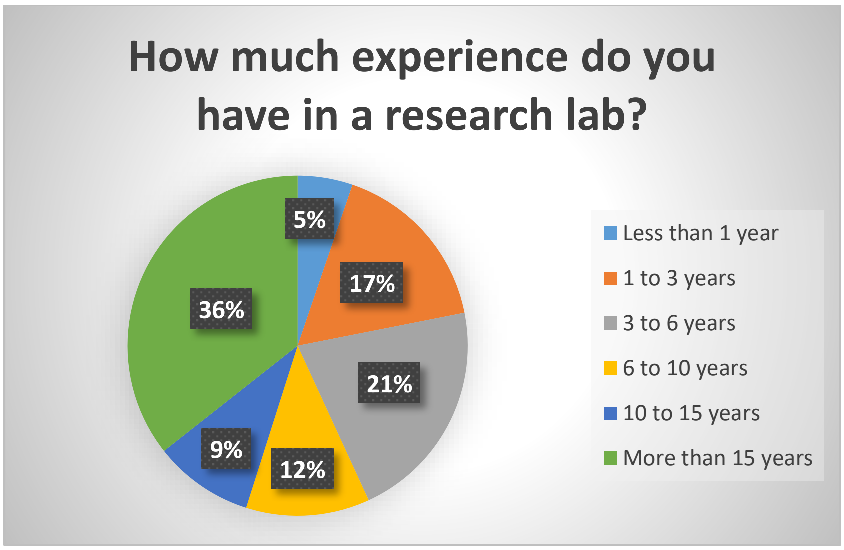

Figure 7.5. Experience Level

The safety training question allowed multiple answers and the largest category was On-line safety training provided by EHS at 79% responding, closely followed by on the job training in the laboratory at 62%, formal research laboratory safety training at 42%, other on-line safety training at 38%, as part of a college science course at 37%, and only 2% responded none. (Figure 7.6). The question concerning accidents in the laboratory also allowed multiple answers. Over 55% of the responders claimed to have never had any sort of incident while 40% stated that they had experience a minor incident. Less than 15% claimed to have had involvement with a severe incident.

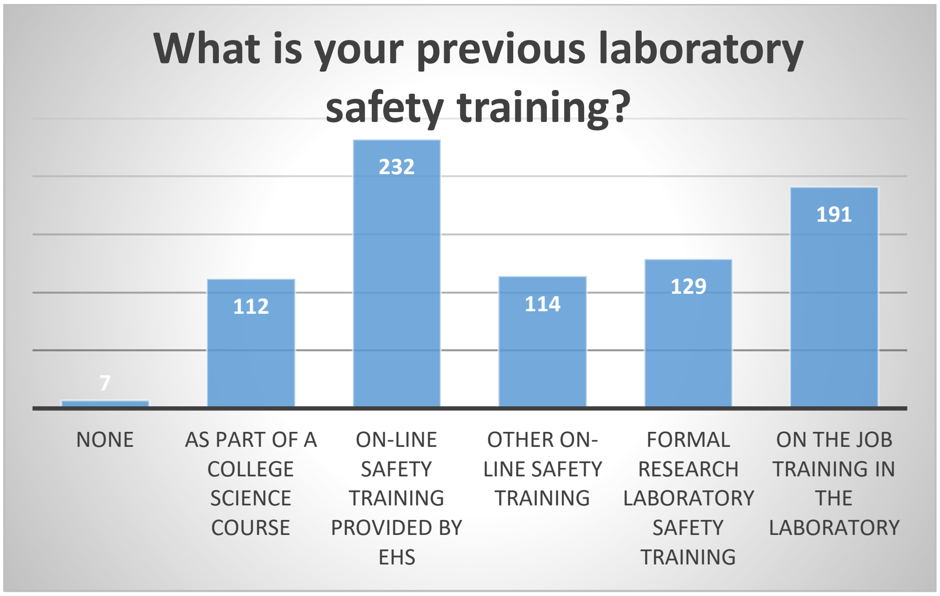

Figure 7.6. Laboratory Safety Training

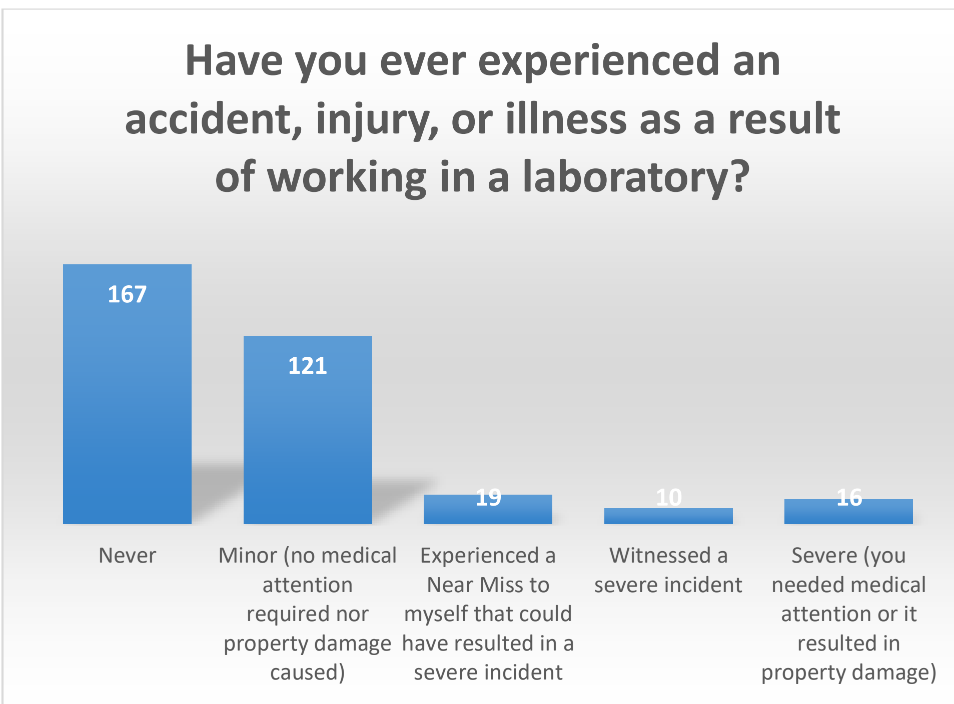

Figure 7.7. Laboratory Incidents

Table 7.1 provides a summary of the survey questions, their short name, how they were coded, the factor assigned, the mean, and standard deviation.

Table 7.1. Summary of Survey Questions

Number	Question	Name	Coding	Factor	Mean	SD
Climate Questions						
Q8	If or when I have had a work-related safety concern, my safety concern was adequately addressed.	RESPONSE	Positive	F1	5.8	1.11
Q9	I am aware of the ways that I can report incidents, hazards or near misses.	AWARNESS	Positive	F1	5.8	1.23
Q10	I feel free to report hazardous conditions, unsafe behaviors, or safety violations.	REPORTING	Positive	F1	6	1.01
Q11	The safety training I receive at work helps me stay safe on my job.	TRAINING	Positive	F2	5.8	1.08
Q12	My work unit is involved in the campus safety programs focused on my safety.	INVOLVEMENT	Positive	F2	5.5	1.25
Q13	My department or work unit has taken steps over the last 12 months to make my work place safe	PROMOTION	Positive	F2	5.5	1.34
Q14	Individuals in my work unit have access to the appropriate standard operating procedures, tools, and equipment to perform their duties.	SYSTEM	Positive	F3	6	0.94
Q15	Individuals in my work unit consistently utilize the appropriate standard operating procedures, tools, and equipment to perform their duties.	UTILIZE	Positive	F3	5.7	1.15
Q16	My department/work unit recognizes individual safety achievement through rewards and incentives.	RECONIZE	Positive	F4	3.4	1.77
Q17	I have a general sense that campus leadership promotes the importance of maintaining a safe working/learning environment.	LEADERSHIP	Positive	F4	5.2	1.34
Attitude Questions						
Q18	I look out for the safety of my colleagues.	CONCERN_1	Positive	F7	6.3	0.81

(Cont.)

Table 7.1. (Cont.)

Number	Question	Name	Coding	Factor	Mean	SD
Q19	When accidents or near misses occur, they are seldom reported to the Lab Manager, PI or the Department.	ACCEDENTS_2	Negative	F8	4.8	1.73
Q20	I feel that it is important that ALL safety measures are completed before starting an experiment.	MEASURES	Positive	F6	6.25	0.80
Q21	Wearing gloves and a lab coat is only necessary when working with hazardous materials.	PPE	Negative	F8	5	2.09
Q22	I have no responsibility for the health and safety of other persons in my lab.	CONCERN_2	Negative	F8	6.4	1.13
Q23	I am always provided what I need to ensure safety in the lab.	NEEDS	Positive	F6	5.8	1.25
Q24	Individuals in my lab would be hesitant to report behavior that is unsafe.	HESITANT	Negative	F6	5.3	1.67
Q25	Accidents, injuries, and near misses in my lab are seen by the group as opportunities for change.	REPORTING	Positive	F6	5	1.48
Q26	I feel it is important to review the literature for safety techniques about activities in my lab.	LITERATURE	Positive	F7	5.6	1.24
Q27	I feel that unless a chemical is really dangerous, it is acceptable to discard it down the drain or into the garbage.	DISCARD	Negative	F8	6.1	1.24
Behavior Questions						
Number	Question	Name	Coding	Factor	Mean	SD Dev
Scenario 1	You are working alone in your lab when you find a 4-L amber glass bottle labeled as Experiment 113b sitting on another person's lab bench. You hear and see that the container is venting gas from around the lid. Please review the following possible immediate responses and mark the likelihood of your attempting each of the given options					
B1A	Open the lid to relieve the pressure	OPEN	Negative	F10	6.1	1.42
B1B	Pick up the container, move it to the hood, and close the hood sash	PICKUP	Negative	F10	3.3	2.22
B1C	Close and lock the door, then go find the person responsible for the bottle and have them deal with it	LEAVE	Positive	F11	4.9	2.04

(Cont.)

Table 7.1. (Cont.)

Number	Question	Name	Coding	Factor	Mean	SD
B1D	Report the condition to your supervisor	REPORT	Positive	F11	6	1.43
Scenario 2	You are conducting an experiment that you have never done before (nor has anyone that you know personally), using chemicals that you are not familiar with. This experiment calls for heating a chemical that you know very little about, but believe that it is flammable and appears to have a high vapor pressure (it evaporates quickly). This procedure was meticulously detailed in a very well written study that you recently read in a highly respected and peer-reviewed journal. Based on this information what is the likelihood for your addressing this situation with the provided possible actions?					
B2A	Write up a step by step procedure and have it certified by the EH&S office	EHS	Positive	F11	4.1	2.12
B2B	Work with your PI or Department Head to develop an SOP	SOP	Positive	F11	5.4	1.7
B2C	Run the experiment using equipment and methods as close to those described in the paper as possible	RUN	Negative	F10	2.9	1.89
B2D	Conduct a literature review to determine the physical, chemical, and toxicological properties of the chemical before running the experiment	REVIEW	Negative	F10	6.2	1.27
Scenario 3	You are performing a time-sensitive procedure using a series of very expensive chemicals that includes a highly volatile and extremely toxic substance. Because of these recognized hazards, you are doing the experiment in a chemical fume hood. After about an hour, you begin to feel ill so you leave the lab to walk around and get a bit of "fresh air". After being out of the lab for a short time, you begin to feel better so you return to work. Almost immediately upon returning to the fume hood, you begin to feel ill again. Given this scenario, the time sensitivity of the experiment, and the amount of effort and expense to set up the experiment, how likely would you be to do each of the following options?					
B3A	Quench (stop) the reaction, close the fume hood, and call to have the fume hood evaluated and fixed	QUENCH	Positive	F11	5.8	1.53
B3B	You finish the experiment because the reaction is almost complete, therefore it will be OK to tough it out.	FINISH	Negative	F10	5.5	1.62
B3C	Ask a fellow lab mate to observe both the experiment and you for potential problems while you finish	CONTACT	Negative	F10	4.9	1.93
B3D	Leave the reaction and the laboratory immediately. Contact your PI and ask what you should do	OBSERVE	Positive	F11	5.7	1.61

An important advance in social science research has been the development of Structural equation modeling software in which prediction of latent or unobserved variables are

hypothesized. A latent variable is a hypothetical construct, a variable that cannot be directly observed. The existence of a latent variable can only be inferred by the way that it influences manifest variables that can be directly observed. The overall goal of Structural Equation Modeling is to predict specific relationships between latent variables. This is a two-part process where a measurement model is developed and tested using confirmatory factor analysis to verify that indicator variables effectively measure the underlying constructs of interest and that the measurement model demonstrates an acceptable fit to data. After optimizing the measurement model, it can be modified to predict specific relationships between latent variables allows the testing of hypotheses that certain latent constructs predict other latent constructs (O'Rourke & Hatcher).

In the case of the climate section of the model, the general outline and divisions presented by Gutiérrez were used as the climate model (Gutiérrez at el.). The model depicted below is a second order latent variable model because the latent variables are a hypothetical construct that is not directly observed. The model has to be both linear and additive. Latent variables are identified by short names such as F1 and F2 (F for latent Factor). Each latent factor has a disturbance term (D) represents the effects on endogenous variables due to such things as omitted variables, measurement error, and misspecification of equations. The latent variable is inferred from its influence on manifest variables. Variables Q8 through Q10 measure the perception of how risk is managed (F1), Q11 through Q13 measure the employment commitment to safety (F2), Q14 and Q15 measure departmental commitment to safety (F4), and Q18 and Q17 measure management commitment to safety (F3). F1, F2, F3, and F4 define Safety Climate (F5). In the figure manifest variables (represented by rectangles) are the variables that were collected from questionnaires

completed by participants. Although the hypothetical constructs (represented by ovals) generally represent the variables of greatest interest, they are not directly measured. Error variance is separated from the core measurement of latent variables using a residual term (indicated by the symbol E for Error term) to each manifest variable. A unique path way coefficients were created for a given independent variable and the corresponding latent factor as indicated by an "L" term. All latent factors generally are allowed to covay which means that covariance estimates will be calculated for every pairing of F variables and represented by a "C" term. The equations used to describe the model are linear and additive relationships and the data is normally distributed. The sample size is acceptable and the model is over identified.

In the original climate model had five factors, the model below only has four. Manifest variables recognize and leadership were combined because each was associated with their own latent factor. It is recommended that each latent variable be assessed with at least three indicators. Technically, a latent factor may be assessed with just two indicators under certain conditions and is fairly common in the social sciences. However, a single variable representing a factor is not acceptable. (O'Rourke & Hatcher).

In the case of the attitude model, the factors and related variables were based on exploratory factor analysis of the attitude data produced in the UTAH survey. The three components of Institution, Team, and Personal were based on literature review (Cheyne). Institution Attitude (F8) is represented by Accents_2 (Q19), PPE (Q21), and Discard (Q27). Personal Attitude (F7) is represented by Concern_1 (Q18), Measures (Q20), and Literature (Q26). Team Attitude (F6) is represented by Concern_2 (Q22), Needs (Q23), Hesitant (Q24), and Reporting (Q25).

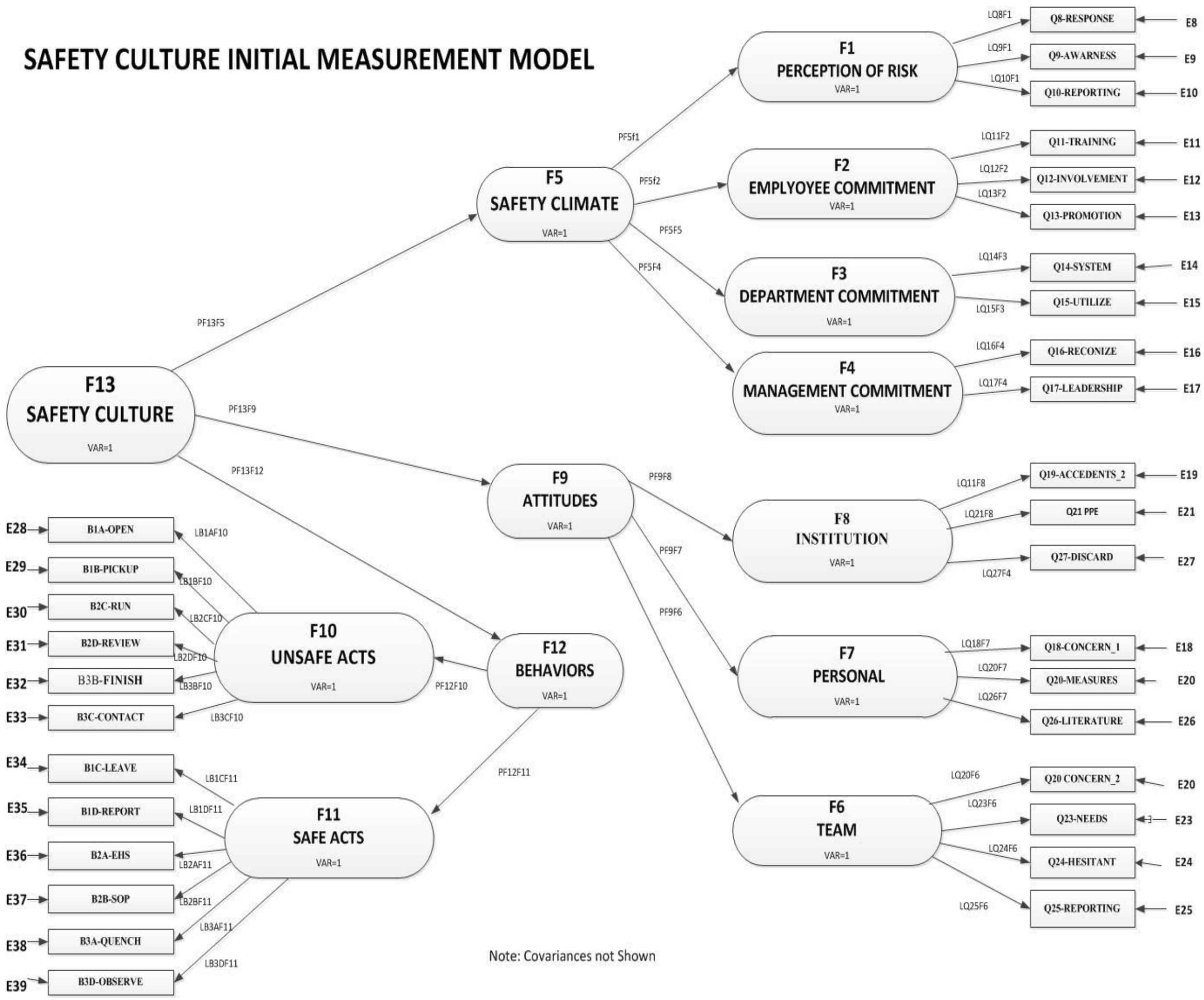

Figure 7.8. Safety Culture Initial Measurement Model

As stated above, the Behavior data had to be recoded to a simpler format. Each potential scenario action was reviewed to determine if it was safe or unsafe. Unsafe Acts (F10) is represented by Open (B1A), Pickup (B1B), Run (B2C), Review (B2D), Finish (B3B), and Contact (B3C). Safe Acts (F11) represented by Leave (B1C), Report (B1D), EHS (B2A), SOP (B2B), Quench (B3A), and Observe (B3D).

Internal Consistency is an issue when questionnaires are used in research. Indices of reliability are the most popular measures of internal consistency. Internal consistency is the extent to which the individual items that constitute a test correlate with one another or with the test total. In the social sciences, the most widely used index of internal consistency is the coefficient alpha, also known as Cronbach's alpha. The general rule of thumb is that the coefficient alpha values should be over 0.70. However, some social scientists report coefficient alphas under .70 and still utilize the data effectively (O'Rourke & Hatcher). Estimates of internal consistency as measured by Cronbach's alpha using SAS 9.4 PROC ALPHA COOR are within acceptable limits for all the culture study variables. The Cronbach Alpha Coefficient based the standardized data is 0.816.

7.3. CFA Measurement Model Run One

Based on the Figure 7.8 above, the initial culture model was run in SAS 9.4 using PROC CALIS with COV, RESIDUAL, and MODIFICATION options. The covariance option specifies that analyses will be performed on a covariance matrix (not a correlation matrix), the residual option requests that the absolute and normalized covariance matrix be printed, and the modification option requests Lagrange Multiplier and Wald test modification indices are calculated. These indices are useful when determining how the model might be modified if it does not demonstrate an adequate fit. The LINEQS statement was used to indicate which manifest variables load on which latent factors using a series of equations. The VARIANCE statement was used to specify which parameters are to be estimated and which are to be fixed. In a CFA the variances of latent factors are set at 1 to address the problem of scale indeterminacy. Since the latent factors are hypothetical constructs there is no established metric or scale which makes it impossible to distinguish what is actual relationship between factor variance and factor loading. The COV

statement is used to identify pairs of variables that are expected to covary. The parameter estimation is done by comparing the actual covariance matrices representing the relationships between variables and the estimated covariance matrices of the best fitting model. This is obtained through numerical maximization of a fit criterion as provided by maximum likelihood estimation (O'Rourke & Hatcher).

The initial model parameters were estimated via the McDonald method and default initial values. Then the Levenberg-Marquardt Optimization was utilized for optimization and a summary is provided above. The optimization technique used by CALIS requires the repeated computation of the function value (optimization criterion) and the gradient element (first-order partial derivatives) until both parameters meet the define requirements (O'Rourke & Hatcher). It took the program 168 iterations before the convergence criterion has been satisfied. It should be noted that SAS log file had a warning that while all predicted variances for the latent variables were positive, the corresponding predicted covariance matrix is not positive definite. It has one negative eigenvalue.

In a CFA, one proves that a data set will verify the proposed model. If the model provides a reasonably good approximation, it should do a good job of accounting for the observed relationships in the dataset. In other words, the model should provide a good fit to data. The process begins by reviewing significance tests for factor loadings, overall goodness-of-fit indices (e.g., SRMR, CFI, and RMSEA), and then proceeds to other indices such as R^2 values and modification indices (O'Rourke & Hatcher).

CFA models need to have a sufficient number of observations relative to degrees of freedom to minimize the likelihood of Type II errors. It is necessary for the model to possess

sufficient statistical power to reject poorly fitting model and have confidence in reported goodness-of-fit indices. (O'Rourke & Hatcher). Based on a sample size of 290 and 413 degrees of freedom the model's statistical power using the MacCallum method. The model has a statistical power of 1.0. This value is above the recommended power of 0.80 which indicates with the model acceptable statistical power. (O'Rourke & Hatcher).

It customary to examine the chi-square statistic to test of the null hypothesis that the model fits exactly in the population (i.e., $p > .05$). This statistic is generally significant when the model provides a good fit to data. However, CFA models tend to be more complex than path models and the chi-square statistic should not be seen as a bona fide goodness-of-fit index. Chi-square values are useful primarily when modifying models to ensure that changes are statistically significant. Since the chi-square is dependent on the degrees of freedom, the ration of the two is considered a fit index (O'Rourke & Hatcher). The chi-square/df of this model is 2.27 which is a little bit higher than the acceptable level of 2 which is based on a general rule of thumb.

There is no universal consensus as to which goodness-of-fit indices provide the best reflection of model fit, but it is common practice to report one absolute index (e.g., Standardized RMR), one parsimony index (e.g., RMSEA), and one incremental index (e.g., CFI). SRMR values less than .055 are ideal. In contrast, CFI values between .90 and .94 suggest adequate fit, but values greater than .94 are more ideal. Similar to the SRMR, smaller RMSEA values reflect good model fit. A RMSEA value above .10 is deemed to be poor; values between .08 and .10 are deemed to be mediocre, and values between .055 and .08 suggest fair model fit; whereas values less than .055 are viewed as most ideal. In addition, the range of RMSEA confidence limits should be relatively

narrow; 90% confidence limits between .090 ≥ RMSEA CL90 ≥ .000 are adequate whereas limits between .054 ≥ RMSEA CL90 ≥ .000 are ideal (O'Rourke & Hatcher).

Overall, these values provide a mixed indication that the overall structure of the culture model fits the data. The Bentler Comparative Fit Index of 0.720 suggests that the model does not fit. Standardized RMR of 0.0936 is considered as mediocre. However, the RMSEA Estimate of 0.0663 indicates a fair fit of the model and the 90% confidence limits of $\pm$ 0.0056 appear to relatively narrow.

A path analysis was conducted to identify the variables that determine variability in the dependent variables. The goodness of fit indices does not necessarily reflect the extent to which the independent variables in the model account for variability in the dependent variables. PROC CALIS also reports R^2 values for all endogenous variables included in the model. These R^2 values indicate the percent of variance in the endogenous variables accounted for by their antecedents. R^2 values may range from 0 to 1 with larger values indicating a greater percent of explained variance (O'Rourke & Hatcher). For example, the Perception of Risk Managed (F1) is the antecedent for three variables, Response (Q8), Awareness (Q9), and Reporting (Q9). Q8 accounts for 28%, Q9 accounts for 43%, and Q10 accounts for 47% of the estimated variance associated with F1.

The model's path coefficients from a latent factor to an indicator variable represents a factor loading term. If the factor loading term is nonsignificant, it indicates that the corresponding variable does not significantly contribute to measurement of the underlying factor and can be deleted from the model. It is general practice to interpret and report standardized path coefficients

and covariance estimates along with their respective t values instead of unstandardized estimates and standard errors. The t values represent large-sample t tests of the null hypothesis that factor loading are equal to zero in the population (O'Rourke & Hatcher).

In the case of the Culture section, the obtained t values in the output show that all factor loadings for the climate section are significant at $p < .0001$. All of obtained t values the attitude section with the exception of Q25 (reporting) are significant at $p < .0001$. Q25 ($p = .0056$), B1A ($p = .009$) and B2C ($p = 0.005$) also prove the null hypothesis because t values greater than 2.58 are significant at $p < .01$. B1B, B2D, and B1C fail to prove the null hypothesis and can be considered as insignificant factor loadings. The R2 values for endogenous variables B1B, B2D, and B1C account for 2%, 2%, and 0.1%, respectively, of the variance in the endogenous variables accounted for by their antecedents. The obtained t values in the output show that all the variances of the exogenous variables are significant at $p < .01$. However, the t values obtained for the standardized results for covariances among exogenous variables indicates that several pairings fail to prove the null hypothesis that covariances are equal to zero in the population. However, in the measurement model all latent variables are allowed to covay and none of the insignificant covariances will be removed (O'Rourke & Hatcher).

PROC CALLIS completes Wald tests to determine what parameters can be deleted from the model without negatively affecting goodness-of-fit indices. In a measurement model, factor loadings that can be dropped are the primary concern. The Wald test indicates that the factor loading between B1C and F11 could be dropped from the model without significantly affecting the chi-square statistic. The Wald testes also indicates that there are several covariances that could be dropped.

The deletion of nonsignificant paths is the most justifiable model revision especially when it can be justified on a theoretical basis. As discussed before the behavior survey was initially presented as vignettes where responses where based on a hazardous scenario. Some of the vignette responses were worded poorly and caused confusion with the potential answer. For example, in the B1B response to a container venting on a bench top, one option was to pick up the container and put it in the hood. While putting something in a hood to prevent exposure is good, picking up a reacting bottle is a bad idea. Response B1C also offers two optional actions. It is safe to leave the lab but going to find the responsible party is not the best course of action because there is no warning sign and the time frame is unknown. In B2D, the response is to conduct a literature review before running a new experiment is not unsafe in itself, it does not add anything. Journal publications tend to not stress hazards or include the numerous failures before success.

7.4. CFA Measurement Model Run Two

Based on statistical data and backed by theory, variables B1B, B1C and B2D and the associated path coefficients were removed from the model. The model was rerun as described above. It took the program 76 iterations before the convergence criterion was satisfied for the revised model. It should be noted that SAS log file still had the warning that the predicted covariance matrix is not positive definite because it had a negative eigenvalue.

The statistical power of the revised model was checked using the MacCallum method. Based on a sample size of 290 and 326 degrees of freedom the model's statistical power remained at 1. The chi-square/df of this model is at 2 which is acceptable based on a general rule of thumb. The goodness of fit values indicate that the revised model's overall structure of the culture model fits the data. The SRMR of the revised model is 0.064. The Bentler Comparative Fit Index of

0.812 is still below the acceptable level. Standardized RMR of 0.059 is considered as a fair fit and the 90% confidence limits of $\pm$ 0.0066 appear to relatively narrow.

The obtained t values in the output show that all factor loadings for the model are significant at $p < .0001$ with exception of Q25, B1A and B2C. Q25 and B2C factor loadings are still significant at $p < .01$ due to the size of their t values. At $p < 0.0276$, B1A fails to prove the null hypothesis. The obtained t values in the output for the revised model show that all the variances of the exogenous variables are significant at $p < .0001$.

7.5. CFA Measurement Model Run Three

In an effort to improve model fit, B1A and the associated path coefficient were removed from the model. The model was rerun as described above. It took the program 78 iterations before the convergence criterion was satisfied for the revised model. It should be noted that SAS log file still had the warning that the predicted covariance matrix is not positive definite because it had a negative eigenvalue.

There was no change in the Goodness of Fit parameters. The obtained t values in the output show that all factor loadings for the model are significant at $p < .0001$ with exception of Q25 and B2C. Q25 and B2C factor loadings are still significant at $p < .0008$ and $p < .0014$ due to the size of their t values. The obtained t values in the output for the revised model show that all the variances of the exogenous variables are significant at $p < .0001$, with the exception of E29 with $P < 0.0534$ and a t value of 1.93.

However, the t values obtained for the standardized results for covariances among exogenous variables in the revised model indicates that several pairings still fail to prove the null

hypothesis that covariances are equal to zero in the population. However, the number of significant covariances in the revised measurement model dropped to 10 from the initial model with 21 significant covariances.

The revised measurement model provides s fair fit to data as measured by the SRMR, CFI, and RMSEA, and narrow 90% confidence limits for the RMSEA. The revised model retains sufficient power to reduce the likelihood of Type II errors to less than 1 in 100. While these findings provide support for the revised measurement model, however, additional tests to be completed to assess the reliability and validity of the model.

Reliability refers to consistency of measurement in that a model is reliable if the scores upon repeated testing of the same participants. Validity, on the other hand, refers to the extent to which an instrument measures what it is intended to measure. PROC CALIS was be used to assess item reliability, composite reliability, variance extraction estimates, convergent validity, and discriminant validity. Combined, these procedures provide evidence concerning the extent to which responses to indicators measure what they are intended to measure.

Indicator reliability is defined as the square of the correlation between a latent factor and that indicator. Indicator reliability estimates are presented in PROC CALIS output in the squared multiple correlation values table. The R^2 ("R-square") values indicates the percent of variance in each indicator that is accounted for by the common factor to which it was assigned and are I indices of item reliability. When assessing the contribution to measurement by scale items upon their respective factors, R2 values greater than 0.39 are considered ideal (O'Rourke & Hatcher). In the revised measurement model Q8, Q19, Q27, Q21, Q18, Q20, Q25, Q26, Q22, Q23, B2C, B3C, B1D, B2A, B2B, B3A, and B3D have R2 values lower than 0.39. As such, their relevant

contribution to the respective latent factor is questionable. Reliability and validity results for Run 3 are summarized in Table 7.2.

Table 7.2 – Model Run Three Composite Reliability and Variance Extracted

Construct and Indicators		Standardized Loading	T Value * P <0001	Indicator Reliability	Error Variance	Composite Reliability	Variance Extracted
F1 = PRECEPTION	Q8	0.54	10.393	0.29	0.71	0.62	0.41
	Q9	0.65	13.7954	0.42	0.58		
	Q10	0.72	16.3087	0.51	0.49		
F2 = EMPLOYEE	Q11	0.64	15.0507	0.41	0.59	0.68	0.49
	Q12	0.73	20.2905	0.54	0.46		
	Q13	0.72	19.2735	0.51	0.49		
F3 = DEPARTMENT	Q14	0.66	15.9138	0.44	0.56	0.65	0.5
	Q15	0.75	19.5725	0.56	0.44		
F4 = MANAGEMENT	Q16	0.65	13.562	0.42	0.58	0.63	0.46
	Q17	0.71	15.0982	0.5	0.5		
F8 = INSTITUTION'	Q19	0.62	8.7907	0.38	0.62	0.48	0.23
	Q27	0.46	6.7723	0.21	0.79		
	Q21	0.33	4.6634	0.11	0.89		
F7 = PERSON	Q18	0.59	10.7579	0.34	0.66	0.51	0.26
	Q20	0.46	7.8678	0.21	0.79		
	Q26	0.47	8.1321	0.22	0.78		
F6 = TEAM	Q22	0.25	4.2335	0.06	0.94	0.46	0.21
	Q23	0.52	10.0037	0.27	0.73		
	Q24	0.68	14.4756	0.46	0.54		
	Q25	0.21	3.3579	0.04	0.96		
F10 = UNSAFE	B2C	0.23	3.204	0.05	0.95	0.51	0.31
	B3B	0.8	11.3502	0.75	0.25		
	B3C	0.47	3.204	0.21	0.79		
F11 = SAFE	B1D	0.47	7.2812	0.22	0.78	0.50	0.22
	B2A	0.59	9.7418	0.35	0.65		
	B2B	0.48	7.5193	0.23	0.77		
	B3A	0.4	6.2239	0.16	0.84		
	B3D	0.4	5.9912	0.16	0.84		

It is appropriate to compute a composite reliability index for each latent factor included in the model. The composite reliability index is analogous to the coefficient alpha, and reflects the internal consistency of indicators measuring a given factor. Like the Cronbach alpha coefficient, the composite reliability index values should generally be greater than 0.69 (O'Rourke & Hatcher). In this model, none of the composite reality index values meet the level of acceptable criteria. This indicates that the variables do not really describe the corresponding latent factor.

The variance extracted is estimated to assess the amount of variance captured by factors in relation to variance attributable to measurement error. An estimates value of greater the 0.50 is an acceptable level of the variance extracted estimates. An estimate less than 0.50 indicate that measurement error is larger than variance captured by the factor (O'Rourke & Hatcher). In this model the variance extracted estimates ranged from a low of 0.22 to a high of 0.50. This also calls into questions concerning the validity of the latent construct as well as its indicators.

7.6. CFA Measurement Model Run Four

Based on the Indicator Reliability I (IR), all variables with an IR value below 0.2 were removed from the model. Removing components Q21, Q22, Q25, B2C, B3A, and B3 should improve model fit and still leave at least two components per factor. The model was rerun as described above. It took the program 50 iterations before the convergence criterion was satisfied for the revised model. It should be noted that SAS log file still had the warning that the predicted covariance matrix is not positive definite because it had a negative eigenvalue.

The modifications to the model improved the Goodness of Fit parameters as seen in Table 7.3. The obtained t values in the output show that all factor loadings for the model are significant at $p < .0001$. The obtained t values in the output for the revised model show that all the variances of

the exogenous variables are significant at $p < .0001$, with the exception of E28 with $P < 0.0534$ and a t value of 1.93. The t values obtained for the standardized results for covariances among exogenous variables in the revised model indicates that 11 pairings still fail to prove the null hypothesis that covariances are equal to zero in the population.

Table 7.3. Model Improvement Summary

Fit Summary		Run 1	Run 2/3	Run 4
Modeling Info	Number of Observations	290	290	290
Absolute Index	Chi-Square	937.24	607.54	313.25
	Chi-Square DF	413	299	158
	Standardized RMR (SRMR)	0.094	0.064	0.053
Parsimony Index	RMSEA Estimate	0.066	0.06	0.058
	RMSEA Lower 90% Confidence Limit	0.061	0.053	0.048
	RMSEA Upper 90% Confidence Limit	0.072	0.067	0.068
Incremental Index	Bentler Comparative Fit Index	0.721	0.821	0.895

A composite reliability index and indicator reliability for each latent factor was calculated for the run four model. The values for indicator reliability range from 0.21 to 0.56. The R^2 values is an indication reliability of an indicator variable and values above 0.39 are considered as ideal. In the revised run four model Q8, Q19, Q27, Q18, Q20, Q26, Q23, B3C, B1D, B2A, and B2B, have R^2 values lower than 0.39. A composite reliability index and indicator reliability for each latent factor was calculated for the run four model. The composite reliability index estimates the reliability of scale responses and should generally be greater than 0.69. The composite reliability

index values for the run four model range from 0.50 to 0.68. The variance extracted is estimated to assess the amount of variance captured by factors in relation to variance attributable to measurement error. An estimates value of greater the 0.50 is an acceptable level of the variance extracted estimates. In run four of model the variance extracted estimates ranged from a low of 0.26 to a high of 0.50 as shown in Table 7.4.

Table 7.4. Model Run Four Composite Reliability and Variance Extracted

Construct and Indicators		Standardized Loading	T Value * P<0.001	Indicator Reliability	Error Variance	Composite Reliability	Variance Extracted
F1 = PRECEPTION	Q8	0.54	10.393	0.29	0.71	0.62	0.41
	Q9	0.65	13.7954	0.42	0.58		
	Q10	0.72	16.3087	0.51	0.49		
F2- = EMPLOYEE	Q11	0.64	15.0507	0.41	0.59	0.68	0.49
	Q12	0.73	20.2905	0.54	0.46		
	Q13	0.72	19.2735	0.51	0.49		
F3 = DEPARTMENT	Q14	0.66	15.9138	0.44	0.56		
	Q15	0.75	19.5725	0.56	0.44		
F4 = MANAGEMENT	Q16	0.65	13.562	0.42	0.58	0.63	0.46
	Q17	0.71	15.0982	0.5	0.5		
F8 = INSTITUTION'	Q19	0.62	8.7907	0.38	0.62	0.48	0.29
	Q27	0.46	6.7723	0.21	0.79		
F7 = PERSON	Q18	0.59	10.7579	0.34	0.66	0.5	0.26
	Q20	0.46	7.8678	0.21	0.79		
	Q26	0.47	8.1321	0.22	0.78		
F6 = TEAM	Q23	0.52	10.0037	0.27	0.73	0.56	0.36
	Q24	0.68	14.4756	0.46	0.54		
F10 = UNSAFE	B3B	0.8	11.3502	0.75	0.25	0.6	0.45
	B3C	0.47	3.204	0.21	0.79		
F11 = SAFE	B1D	0.47	7.2812	0.22	0.78	0.52	0.27
	B2A	0.59	9.7418	0.35	0.65		
	B2B	0.48	7.5193	0.23	0.77		

Removal of the variables with IR levels below 0.2 resulted in a greatly improved model fit, even so it can only be described as fair. It is not possible to remove any additional variables and retain the basic requirements of a CFA model. Therefore, run four model will be accepted as the final measurement model

Factor loading values are shown in Table 7.5, Standardized Effects in Linear Equations. The obtained t values in the output show that all factor loadings for the model are significant at p < .0001. The obtained t values in the output for the run four model show that all the variances of the exogenous variables are significant at p < .0001, with the exception of E28 with P < 0.0534 and a t value of 2.16

The t values obtained for the standardized results for covariances among exogenous variables in the revised model indicates that 11 pairings still fail to prove the null hypothesis that covariances are equal to zero in the population. As such they represent significant covariances.

Table 7.5. Standardized Effects in Linear Equations

Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Q8	F1	LQ8F1	-0.54368	0.052	-10.455	<.0001
Q9	F1	LQ9F1	-0.64464	0.04684	-13.763	<.0001
Q10	F1	LQ10F1	-0.71564	0.04387	-16.312	<.0001
Q11	F2	LQ11F2	-0.64371	0.04196	-15.339	<.0001
Q12	F2	LQ12F2	-0.73014	0.03645	-20.031	<.0001
Q13	F2	LQ13F2	-0.71551	0.03734	-19.162	<.0001
Q14	F3	LQ14F3	-0.66449	0.04122	-16.12	<.0001
Q15	F3	LQ15F3	-0.74146	0.03839	-19.312	<.0001
Q16	F4	LQ16F4	-0.64649	0.04819	-13.416	<.0001
Q17	F4	LQ17F4	-0.71394	0.04727	-15.105	<.0001

(Cont.,)

Table 7.5 (Cont.)

Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
F5	F1	PF5F1	0.06863	0.0000756	907.6	<.0001
F5	F2	PF5F2	0.06863	0.0000756	907.6	<.0001
F5	F3	PF5F3	0.06863	0.0000756	907.6	<.0001
F5	F4	PF5F4	0.06863	0.0000756	907.6	<.0001
Q19	F8	LQ19F8	-0.61216	0.08417	-7.2732	<.0001
F5	F1	PF5F1	0.06863	0.0000756	907.6	<.0001
Q27	F8	LQ27F8	-0.41041	0.07049	-5.8225	<.0001
Q18	F7	LQ18F7	-0.60184	0.05415	-11.115	<.0001
Q26	F7	LQ26F7	-0.45322	0.05775	-7.8481	<.0001
Q23	F6	LQ23F6	-0.54034	0.05281	-10.232	<.0001
Q24	F6	LQ24F6	-0.63429	0.05185	-12.233	<.0001
F9	F6	PF9F6	0.06959	0.0000826	842.4	<.0001
F9	F7	PF9F7	0.06951	0.0000825	842.4	<.0001
F9	F8	PF9F8	0.06954	0.0000825	842.4	<.0001
B3B	F10	LB3BF10	-0.82962	0.08676	-9.5624	<.0001
B3C	F10	LB3CF10	-0.46038	0.06605	-6.9703	<.0001
B1D	F11	LB1DF11	-0.56354	0.06717	-8.3897	<.0001
B2A	F11	LB2AF11	-0.5283	0.06704	-7.8802	<.0001
B2B	F11	LB2BF11	-0.56844	0.06721	-8.4575	<.0001
F12	F10	PF12F10	0.07033	0.0000319	2203.5	<.0001
F12	F11	PF12F7	0.07025	0.0000319	2203.5	<.0001
F13	F5	PF13F5	0.38335	0.0003918	978.4	<.0001
F13	F9	PF13F9	0.37881	0.0003621	1046.2	<.0001
F13	F12	P13F12	0.37433	0.0003073	1218.3	<.0001

Table 7.6. Standardized Results for Variances of Exogenous Variables

Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Error	E8	vare8	0.70441	0.05655	12.457	<.0001
	E9	vare9	0.58444	0.06039	9.6777	<.0001
	E10	vare10	0.48786	0.06279	7.7694	<.0001
	E11	vare11	0.58564	0.05403	10.8399	<.0001
	E12	vare12	0.46689	0.05323	8.7713	<.0001
	E13	vare13	0.48804	0.05343	9.1334	<.0001
	E14	vare14	0.55846	0.05478	10.1942	<.0001
	E15	vare15	0.45024	0.05694	7.9077	<.0001
	E16	vare16	0.58205	0.06231	9.3418	<.0001
	E17	vare17	0.49029	0.06749	7.2646	<.0001
	E18	vare18	0.63779	0.06517	9.7861	<.0001
	E20	vare20	0.79477	0.05233	15.1881	<.0001
	E21	vare21	0.68243	0.07571	9.0142	<.0001
	E22	vare22	0.7209	0.07084	10.1769	<.0001
	E23	vare23	0.70804	0.05707	12.4066	<.0001
	E24	vare24	0.59768	0.06578	9.0862	<.0001
	E25	vare25	0.67687	0.07641	8.8583	<.0001
	E26	vare26	0.79459	0.05235	15.1799	<.0001
	E27	vare27	0.83157	0.05786	14.3731	<.0001
	E28	vare28	0.31174	0.14395	2.1656	0.0303
	E29	vare29	0.78805	0.06081	12.9583	<.0001
Disturbance	D5	VARD5	0.94205	0.00208	453.8	<.0001
	D9	vard9	0.96629	0.00229	421.2	<.0001
	D12	vard12	0.98838	0.0008971	1101.8	<.0001
	D13	vard13	0.55404	0.0009166	604.4	<.0001

Table 7.7. Standardized Results for Covariances among Exogenous Variables

Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
F1	F11	CF1F11	0.20127	0.09184	2.1915	0.0284
F2	F10	CF2F10	0.05213	0.08054	0.6472	0.5175
F2	F11	CF2F11	0.31548	0.08529	3.6988	0.0002
F3	F10	CF3F10	0.1364	0.08495	1.6056	0.1084
F3	F11	CF3F11	0.28746	0.09145	3.1433	0.0017
F4	F8	CF4F8	0.28702	0.10943	2.6229	0.0087
F4	F10	CF4F10	-0.0333	0.08728	-0.3815	0.7029
F6	F11	CF6F11	0.37084	0.10278	3.6082	0.0003
F8	F10	CF8C10	0.35786	0.10671	3.3536	0.0008
F8	F11	CF8F11	0.08583	0.1166	0.7361	0.4617
F10	F11	CF10F11	0.1756	0.09185	1.9119	0.0559

7.7. CFA Model Discussion

The planned analysis was to follow a two-step procedure based on the approach described by Anderson and Gerbing (1988). In the first step, confirmatory factor analysis was used to develop a measurement model that demonstrated an acceptable fit to data. The initial model had a Bentler Comparative Fit Index of 0.720 and a standardized RMR of 0.0936. This model fit could only be considered as mediocre and could not be considered as validation of the conceptual safety culture model. Variables B1B, B2D, and B1C fail to prove the null hypothesis and can be considered as insignificant factor loadings. The deletion of nonsignificant paths is the most justifiable model revision. Pickup (B1B) and Review (B2D) were removed as indicators for Unsafe Acts (F10).

Leave (B1C) was removed from Safe Acts (F11). The removals also be justified on a theoretical basis due to poor wording in these vignettes responses that caused confusion with the potential answer.

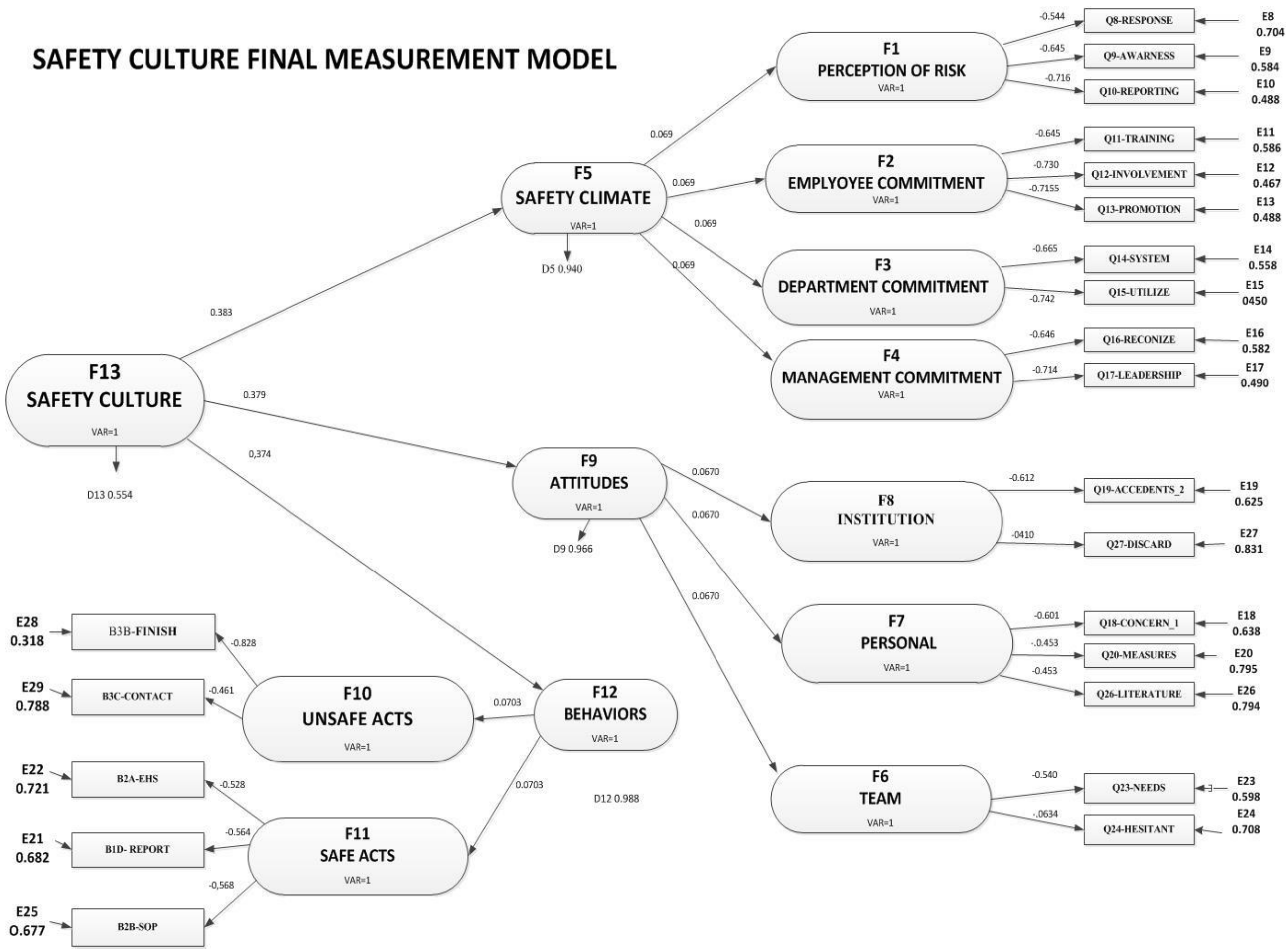

Figure 7.9. Final Safety Culture Measurement Model

In Model Run Two, the variables B1B, B1C and B2D and the associated path coefficients were removed and the model was rerun. The goodness of fit parameter for the second model improved with a Bentler Comparative Fit Index of 0.812 and a standardized RMR of 0.059.

However, at $p < 0.0276$, Open (B1A) fails to prove the null hypothesis and can be considered as insignificant factor loading.

In Model Run Three, B1A and the associated path coefficients were removed and the model was rerun. The goodness of fit parameters did not change, so indicator reliability and composite reliability of the model were calculated. Reliability refers to consistency of measurement and validity indicates the extent to which an instrument measures what it is intended to measure. The composite reliability index reflects the internal consistency of indicators measuring a given factor and should have a value greater than 0.69. In Model Run Three the composite reliability ranges from 0.48 to 0.68. As such, there are potential concerns the variables do not really describe the corresponding latent factor. Indicator reliability values greater than 0.39 are considered ideal. In Model Run Three Q8, Q19, Q27, Q21, Q18, Q20, Q25, Q26, Q22, Q23, B2C, B3C, B1D, B2A, B2B, B3A, and B3D have IR values lower than 0.39. As such, their relevant contribution to the respective latent factor is questionable.

In Model Four, variables Q21, Q22, Q25, B2C, B3A, and were removed and the model rerun. The removed variables have an IR value below 0.2 and were not impacting the associated factor. Their removal improved the goodness of fit parameters (Bentler Comparative Fit Index of 0.895 and a standardized RMR of 0.058) and still have at least two components per factor. The so indicator reliability and composite reliability of Model Run Four were recalculated without any significant improvement so the questions concerning reliability and validity remain. Even with greatly improved model fit, even so the model can only be described as fair. It is not possible to remove any additional variables and retain the basic requirements of a CFA model. Therefore, run four model will be accepted as the final measurement model. The final measurement model could

not be used a SEM model to determine the relations ships between the latent variables. The SEM model would not converge to a final matrix and additional calculations were not possible.

This work confirms that the conceptual safety culture model is valid and safety culture can be described in terms of safety climate, safety attitude, and safety behavior. The issue with the model are related to the initial survey questions. The safety climate section shows excellent psychometric properties. It was based on a CSHEMA survey that well established and gone through several revisions. The psychometric properties of the attitude and behavior survey sections were deficient. The pilot attitude data did not sync with the final attitude data. While an interesting concept the vignette data did not function well upon analysis due to the dual scaling and general confusion on the people taking the survey. While the concept was proved, there is a great deal of additional research required. Fine tuning of both the attitude and behavioral questionnaires is required. An additional consideration is to increase the number of variables used to describe the factors.

CHAPTER 8. CONCLUSIONS

The overall purpose of my dissertation research is to determine the nature of and level of safety culture in the research community at Louisiana State University. Safety culture focuses on the way people think and/or behave in relation to safety. Safety culture is an abstract concept that considers safety in a holistic manner. Most models for improvement consider safety culture as being the end achievement of various inputs such as attitude, behavior, shared beliefs, training, communications, management support, and leadership. All three major safety culture reports, *Creating Safety Cultures in Academic Institutions: a report of the Safety Culture Task Force of the ACS Committee on Chemical Safety, Safe Science: Promoting A Culture of Safety in Academic Chemical Research, and APLU Guide to Implementing a Safety Culture in Our Universities* expand on the individual roles of academic personnel in improving Safety Culture.

Upper management leadership is key to improving Safety Culture to the point that the process is in jeopardy of failing without that support. At LSU, the role of management support has been delegated to the Research Safety Committee (RSC) that has been developed in the last few years. It is already in existence and staffed with key decision makers from LSU and the Ag Center, facility, and EHS personal. The APLU report calls for the formation of an institutional lead and leadership team responsible for facilitating the building of a culture of safety. Although the LSU RSC should be responsible for this task, it is not clear if this was mandated in the establishment of the committee or the subsequent actions by the RSC committee.

The role of the RSC should be to provide the leadership to promote safety culture at the university by engaging all stakeholders to build and implement an inclusive, collaborative plan with the institution through effective dialogue. This process should develop a relationship with

departments and faculty to create a trusting and safe culture by encouraging the development of a generative culture based on open dialogue, reporting, and learning from near misses. The previous history of communications to the general campus has not achieved these goals. As a simple example, the zero drug tolerance policy has made graduate students warry of reporting incidents, let alone near misses. To date, only small steps have been made in the advancement to ensure that safety communication is embedded in laboratories, classes, departments and throughout the wider campus.

Deans and Department Heads/Chairs have a significant role in developing the safety culture. The level of support is as different as the individuals in that role ranging from safety first to a laissez faire approach toward safety. In theory, these academic units should work collaboratively with researchers, the RSC, and EHS toward the common goal of supporting a culture of safety as a bridge to effectively communicate the importance of a strong safety culture to all members of their department and/or college. As an example of both positive and negative aspects of safety commitment is the promotion of safety culture is the Nomex lab coat program for high hazard chemistry workers. A pilot program was funded by RISK/EHS and the results indicate that it improved the unit's safety culture and encouraged workers to wear all their PPE on a consistent basis. However, the program did not generate enough upper level support (College and ORED) to ensure future funding. The Chemistry Chair believed in the program to the point that program was expanded to the whole department and internally funded at a loss in departmental operating budget.

Faculty are fundamental in any process to improve safety culture because they manage their research area and ultimately are the responsible party for safety in their lab. Again there is a

wide range of safety attitudes among the faculty. Some facilitate open dialogues about safety, conduct a hazard analysis prior to conducting any experimental procedure, and act as a role model for good safety behavior. On the other hand, there are faculty who have poor safety awareness. For example, a professor who responded that training on the use of liquid nitrogen is not necessary because the process has been done a thousand times and nobody has ever been hurt. Another example is the assistant professor who states that his lab personnel do not need lab coats because they only do micro-chemistry. And even a chaired professor who ignored written standard operating procedures to move a full refrigerator with a biohazard sticker. Until upper management makes safety a higher priority, there will be faculty that hinder the development of a culture of safety.

Depending on the Principle Investigator, undergraduate and graduate students, postdoctoral scholars, and research personnel are generally not encouraged to voice safety questions and concerns to their faculty supervisors or EHS. Early in my Chemical Safety role, I was lecturing a young researcher about something she was doing wrong. Her reply was that “I do not have a green card and I am not afraid of you”. Hopefully, my mentoring has improved, but that one statement enlightened me to the general attitude of personnel in academic research, which has not changed much over the last twenty years at LSU. Undergraduate and graduate students are generally deficient in laboratory skills when they enter the research laboratory. Others, especially older generations, learned proper chemical techniques in the lab for a quantitative analysis course. Unfortunately, that course and similar courses are no longer taught on LSU campus and we have generations of chemists who learn safety in informal situations. These issues are not limited to chemistry laboratories, but display the situation in the majority of all laboratories

on campus in diverse fields of study. Most students, undergraduate and graduate, do not know enough to stop an unsafe procedure, how to report incidents, why standard operating procedures are useful, what or when to use the appropriate personal protective equipment (PPE), or conduct a hazard analysis prior to conducting any experimental procedure. Industry spends months with new hires from LSU and elsewhere to install the concept of safety. The University's mission is research and teaching. We are failing our students by not teaching them safety.

What is the role Environmental Health & Safety Personnel in promoting a culture of safety at LSU? *Safe Science* states the EHS should serve as safety consultants to the academic community and work collaboratively with research personnel to encourage open and ongoing dialogue about safety. EHS consist of ten safety professionals to support campus operations with over 800 research labs. CSHEMA has developed equations that estimate EHS staffing and budget based on the ratio of research/non-research floor space. Based on these equations, LSU should have a staff of 22 safety personnel and an operating budget of 1.5 million (CSHEMA). EHS does not have the staff and resources to mount an effective EHS program.

Historically, EHS has always been a small department. Every increase in staffing has come from as a direct response to a serious problem, to comply with a new ruling, or a disastrous event. Biological safety personnel were added to ensure compliance with the Select Agent program. Addition of chemical personnel and the purchase of the Environmental Health and Safety Management Database were conditions of the Supplemental Environmental Project that was part of a RCRA compliance agreement. The EHS department has not received a high enough priority by the LSU administration. Since the breakup of the Office of Public safety, EHS initially reported to the Office of Information Technology, and currently to Facility and Property Oversite, to

managers without a safety background. The education of management regarding the importance of the role of EHS in the University is an ongoing effort.

The unofficial mantra of the department is “do what you can, with what you have.” Given the lack of resources, EHS has done a remarkable job. Through the implementation of the EHS Assistant, compliance tools have been provided to researchers. Chemical and Biological inventory, on-line training, and lab hazard analysis are the primary tools. EHS and RISK have worked together to develop an accident reporting system and investigate all incidents. Perhaps the greatest good performed by the EHS department has been the outreach to the academic community to help educate lab personnel about safety.

What is the status of safety culture at LSU? LSU is firmly entrenched in culture of compliance and has not moved to the adoption of a culture of safety in academic laboratories. Safety efforts are aimed at compliance with regulations on radiation safety, bio-safety, and hazardous waste disposal. These regulations have enforcement provisions. LSU is exempt from OSHA regulations, although OSHA regulations are followed via Policy State PS-19, and there are no enforcement provisions for chemical research. Unfortunately, there is very little support at LSU to improve the culture of safety simplify because as shown by the climate survey analysis, most researchers perceive that their labs are safe without further training.

Institutes only change their culture in response to some type of failure or poor performance, and organizations seeking to change their safety culture are often doing so because of some significant safety-related problem or perceived vulnerability (Schein). In short, the only way LSU is going to improve safety culture is as the result of a significant laboratory accident.

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APPENDIX A. INSTITUTIONAL REVIEW BOARD EXEMPTION APPROVAL

ACTION ON EXEMPTION APPROVAL REQUEST

Institutional Review Board
Dr. Dennis Landin, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu | lsu.edu/irb

TO: Jerry Steward
Environmental Science

FROM: Dennis Landin
Chair, Institutional Review Board

DATE: March 2, 2016

RE: IRB# E9802

TITLE: Measure Safety Attitudes and Behaviors of LSU Researchers

New Protocol/Modification/Continuation: New Protocol

Review Date: 3/2/2016

Approved ___X___ **Disapproved** __________

Approval Date: 3/2/2016 **Approval Expiration Date:** 3/1/2019

Exemption Category/Paragraph: 2a

Signed Consent Waived?: Yes

Re-review frequency: (three years unless otherwise stated)

LSU Proposal Number (if applicable):

Protocol Matches Scope of Work in Grant proposal: (if applicable)

By: Dennis Landin, Chairman ____________________

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc. Approvals will automatically be closed by the IRB on the expiration date unless the PI requests a continuation.**

**All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb*

APPENDIX B. SAS PROC CALLIS MODELING RUNS

RUN 1 - CFA - MEASUREMENT MODEL CULTURE 8/3/17

LSU DATA

RUN 1 - CFA - MEASUREMENT MODEL CULTURE 8/3/17

The CONTENTS Procedure

Data Set Name	WORK.TEST_1	Observations	306
Member Type	DATA	Variables	39
Engine	V9	Indexes	0
Created	08/03/2017 12:14:55	Observation Length	368
Last Modified	08/03/2017 12:14:55	Deleted Observations	0
Protection		Compressed	NO
Data Set Type		Sorted	NO
Label			
Data Representation	WINDOWS_64		
Encoding	wlatin1 Western (Windows)		

Engine/Host Dependent Information	
Data Set Page Size	65536
Number of Data Set Pages	2
First Data Page	1
Max Obs per Page	177
Obs in First Data Page	164
Number of Data Set Repairs	0
ExtendObsCounter	YES
Filename	C:\Users\Machine\AppData\Local\Temp\SAS Temporary Files_TD12916_LAPTOP-OV06L7T4_\test_1.sas7bdat
Release Created	9.0401M2
Host Created	X64_8HOME

Alphabetic List of Variables and Attributes						
#	Variable	Type	Len	Format	Informat	Label
28	B1A	Num	8			OPEN
29	B1B	Num	8			PICKUP
30	B1C	Num	8			LEAVE

Alphabetic List of Variables and Attributes						
#	Variable	Type	Len	Format	Informat	Label
31	B1D	Num	8			REPORT
32	B2A	Num	8			EHS
33	B2B	Num	8			SOP
34	B2C	Num	8			RUN
35	B2D	Num	8			REVIEW
36	B3A	Num	8			QUENCH
37	B3B	Num	8			FINISH
38	B3C	Num	8			CONTACT
39	B3D	Num	8			OBSERVE
2	F2	Num	8			EMPLOYEE
3	Q1	Char	16	$16.	$16.	Q1
4	Q2	Char	6	$6.	$6.	Q2
5	Q3	Char	19	$19.	$19.	Q3
6	Q4	Char	35	$35.	$35.	Q4
7	Q5	Char	19	$19.	$19.	Q5
8	Q8	Num	8			RESPONSE
9	Q9	Num	8			AWARNESS
10	Q10	Num	8			REPORTING
11	Q11	Num	8			TRAINING
12	Q12	Num	8			INVOLVEMENT
13	Q13	Num	8			PROMOTION
14	Q14	Num	8			SYSTEM
15	Q15	Num	8			UTILIZE
16	Q16	Num	8			RECONIZE
17	Q17	Num	8			LEADERSHIP
18	Q18	Num	8			CONCERN_1
19	Q19	Num	8			ACCEDENTS_2
20	Q20	Num	8			MEASURES
21	Q21	Num	8			PPE
22	Q22	Num	8			CONCERN_2
23	Q23	Num	8			NEEDS
24	Q24	Num	8			HESITANT
25	Q25	Num	8			REPORTING
26	Q26	Num	8			LITERATURE

Alphabetic List of Variables and Attributes						
#	Variable	Type	Len	Format	Informat	Label
27	Q27	Num	8			DISCARD
1	_	Num	8			3

LSU DATA

RUN 1 - CFA - MEASUREMENT MODEL CULTURE 8/3/17

The Means Procedure

Variable	Label	N	Mean	Std Dev	Minimum	Maximum
_	3	306	158.5000000	88.4788110	6.0000000	311.0000000
F2	EMPLOYEE	306	4641360188	17856917.76	4620258107	4686241915
Q8	RESPONSE	306	5.7549020	1.1053041	1.0000000	7.0000000
Q9	AWARNESS	306	5.7516340	1.2269169	1.0000000	7.0000000
Q10	REPORTING	306	6.0032680	1.0097829	2.0000000	7.0000000
Q11	TRAINING	306	5.8398693	1.0790913	1.0000000	7.0000000
Q12	INVOLVEMENT	306	5.4901961	1.2472535	2.0000000	7.0000000
Q13	PROMOTION	306	5.4671242	1.3375670	1.0000000	7.0000000
Q14	SYSTEM	306	6.0197386	0.9441478	2.0000000	7.0000000
Q15	UTILIZE	306	5.6895425	1.1502053	1.0000000	7.0000000
Q16	RECONIZE	306	3.4242484	1.7725230	1.0000000	7.0000000
Q17	LEADERSHIP	306	5.2360784	1.3391988	1.0000000	7.0000000
Q18	CONCERN_1	306	6.2581699	0.8109993	3.0000000	7.0000000
Q19	ACCEDENTS_2	306	4.8158170	1.7270122	1.0000000	7.0000000
Q20	MEASURES	306	6.2532680	0.8006078	1.0000000	7.0000000
Q21	PPE	306	4.9477124	2.0891314	1.0000000	7.0000000
Q22	CONCERN_2	306	6.4360784	1.1293452	1.0000000	7.0000000
Q23	NEEDS	306	5.7475490	1.2539259	1.0000000	7.0000000
Q24	HESITANT	306	5.3366013	1.6697208	1.0000000	7.0000000
Q25	REPORTING	306	4.9901961	1.4787795	1.0000000	7.0000000
Q26	LITERATURE	306	5.6405229	1.2393249	1.0000000	7.0000000
Q27	DISCARD	306	6.1311438	1.2449954	1.0000000	7.0000000
B1A	OPEN	290	6.0596516	1.4190779	1.0000000	7.0000000
B1B	PICKUP	290	3.2867609	2.2216998	1.0000000	7.0000000
B1C	LEAVE	290	4.9268640	2.0372512	1.0000000	7.0000000
B1D	REPORT	290	6.0279009	1.4285485	1.0000000	7.0000000
B2A	EHS	290	4.1275862	2.1227710	1.0000000	7.0000000
B2B	SOP	290	5.4413793	1.7043639	1.0000000	7.0000000
B2C	RUN	290	2.8650690	1.8949368	1.0000000	7.0000000
B2D	REVIEW	290	6.1586207	1.2707835	1.0000000	7.0000000
B3A	QUENCH	290	5.7500000	1.5339300	1.0000000	7.0000000
B3B	FINISH	290	5.4513448	1.6187906	1.0000000	7.0000000
B3C	CONTACT	290	4.9094138	1.9292365	1.0000000	7.0000000
B3D	OBSERVE	290	5.6562759	1.6076900	1.0000000	7.0000000

LSU DATA

RUN 1 - CFA - MEASUREMENT MODEL CULTURE 8/3/17

The COOR Procedure

30 Variables:	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18
	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	B1A	B1B
	B1D	B2A	B2B	B2C	B3A	B3B	B3C	B3D			

Simple Statistics							
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum	Label
Q8	290	5.75862	1.11160	1670	1.00000	7.00000	RESPONSE
Q9	290	5.72069	1.24836	1659	1.00000	7.00000	AWARNESS
Q10	290	5.99310	1.02222	1738	2.00000	7.00000	REPORTING
Q11	290	5.83793	1.09003	1693	1.00000	7.00000	TRAINING
Q12	290	5.48621	1.25398	1591	2.00000	7.00000	INVOLVEMENT
Q13	290	5.46876	1.32806	1586	1.00000	7.00000	PROMOTION
Q14	290	6.02772	0.92967	1748	2.00000	7.00000	SYSTEM
Q15	290	5.69655	1.13652	1652	1.00000	7.00000	UTILIZE
Q16	290	3.40628	1.77006	987.82000	1.00000	7.00000	RECONIZE
Q17	290	5.22497	1.34959	1515	1.00000	7.00000	LEADERSHIP
Q18	290	6.27931	0.79002	1821	3.00000	7.00000	CONCERN_1
Q19	290	4.80221	1.73277	1393	1.00000	7.00000	ACCEDENTS_2
Q20	290	6.25690	0.80006	1815	1.00000	7.00000	MEASURES
Q21	290	4.97241	2.08950	1442	1.00000	7.00000	PPE
Q22	290	6.43448	1.13646	1866	1.00000	7.00000	CONCERN_2
Q23	290	5.72672	1.27174	1661	1.00000	7.00000	NEEDS
Q24	290	5.36207	1.66272	1555	1.00000	7.00000	HESITANT
Q25	290	4.99310	1.49044	1448	1.00000	7.00000	REPORTING
Q26	290	5.65172	1.22238	1639	1.00000	7.00000	LITERATURE
Q27	290	6.10734	1.25292	1771	1.00000	7.00000	DISCARD
B1A	290	6.05965	1.41908	1757	1.00000	7.00000	OPEN
B1B	290	3.28676	2.22170	953.16066	1.00000	7.00000	PICKUP
B1D	290	6.02790	1.42855	1748	1.00000	7.00000	REPORT
B2A	290	4.12759	2.12277	1197	1.00000	7.00000	EHS
B2B	290	5.44138	1.70436	1578	1.00000	7.00000	SOP
B2C	290	2.86507	1.89494	830.87000	1.00000	7.00000	RUN
B3A	290	5.75000	1.53393	1668	1.00000	7.00000	QUENCH
B3B	290	5.45134	1.61879	1581	1.00000	7.00000	FINISH
B3C	290	4.90941	1.92924	1424	1.00000	7.00000	CONTACT
B3D	290	5.65628	1.60769	1640	1.00000	7.00000	OBSERVE

Cronbach Coefficient Alpha	
Variables	Alpha
Raw	0.776895
Standardized	0.815506

Cronbach Coefficient Alpha with Deleted Variable					
	Raw Variables		Standardized Variables		
Deleted Variable	Correlation with Total	Alpha	Correlation with Total	Alpha	Label
Q8	0.387199	0.767643	0.414071	0.806850	RESPONSE
Q9	0.399739	0.766378	0.432494	0.806138	AWARNESS
Q10	0.511471	0.763991	0.529809	0.802344	REPORTING
Q11	0.418709	0.766639	0.462172	0.804988	TRAINING
Q12	0.420164	0.765498	0.474449	0.804510	INVOLVEMENT
Q13	0.430631	0.764600	0.471873	0.804610	PROMOTION
Q14	0.371583	0.769292	0.429974	0.806236	SYSTEM
Q15	0.533314	0.761974	0.576996	0.800482	UTILIZE
Q16	0.323905	0.768873	0.354775	0.809125	RECONIZE
Q17	0.385856	0.766478	0.421756	0.806553	LEADERSHIP
Q18	0.409564	0.769278	0.449896	0.805464	CONCERN_1
Q19	0.292450	0.770642	0.304038	0.811055	ACCEDENTS_2
Q20	0.354875	0.770619	0.366486	0.808678	MEASURES
Q21	0.153871	0.780854	0.139948	0.817183	PPE
Q22	0.155973	0.776016	0.177956	0.815779	CONCERN_2
Q23	0.416744	0.765535	0.453046	0.805342	NEEDS
Q24	0.489944	0.759628	0.510017	0.803121	HESITANT
Q25	0.162270	0.776767	0.181360	0.815652	REPORTING
Q26	0.405263	0.766298	0.403557	0.807255	LITERATURE
Q27	0.327180	0.769344	0.314540	0.810657	DISCARD
B1A	0.136251	0.777680	0.104101	0.818500	OPEN
B1B	0.026714	0.790711	0.008890	0.821959	PICKUP
B1D	0.287542	0.770771	0.268687	0.812389	REPORT
B2A	0.345046	0.768045	0.316055	0.810599	EHS
B2B	0.266145	0.772065	0.265444	0.812511	SOP
B2C	0.051465	0.785454	0.013525	0.821792	RUN
B3A	0.207175	0.774741	0.193149	0.815215	QUENCH
B3B	0.382281	0.765743	0.358329	0.808990	FINISH

Cronbach Coefficient Alpha with Deleted Variable					
	Raw Variables		Standardized Variables		
Deleted Variable	Correlation with Total	Alpha	Correlation with Total	Alpha	Label
B3C	0.173043	0.778458	0.165948	0.816223	CONTACT
B3D	0.193526	0.775666	0.172610	0.815977	OBSERVE

LSU DATA

RUN 1 - CFA - MEASUREMENT MODEL CULTURE 8/3/17

The CALIS Procedure

Covariance Structure Analysis: Model and Initial Values

Modeling Information	
Maximum Likelihood Estimation	
Data Set	WORK.TEST_1
N Records Read	306
N Records Used	290
N Obs	290
Model Type	LINEQS
Analysis	Covariances

Variables in the Model		
Endogenous	Manifest	B1A B1B B1C B1D B2A B2B B2C B2D B3A B3B B3C B3D Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19 Q20 Q21 Q22 Q23 Q24 Q25 Q26 Q27 Q8 Q9
	Latent	f12 f13 f5 f9
Exogenous	Manifest	
	Latent	F1 f10 F11 f2 f3 f4 f6 f7 f8
	Error	e28 E29 E34 E35 E36 E37 E31 E30 E38 E32 E33 E39 e10 e11 e12 e13 e14 e15 e16 e17 e18 e19 e20 e21 e22 e23 e24 e25 e26 e27 e8 e9 D12 d13 D5 D9
Number of Endogenous Variables = 36 Number of Exogenous Variables = 45		

Initial Estimates for Linear Equations

```
Q8  =  LQ8f1   (.) F1  +        1  e8
Q9  =  LQ9F1   (.) F1  +        1  e9
Q10 =  lq10f1  (.) F1  +        1  e10
```

```
                    Initial Estimates for Linear Equations
Q11 =  LQ11F2  (.) f2  +         1  e11
Q12 =  lq12f2  (.) f2  +         1  e12
Q13 =  LQ13F2  (.) f2  +         1  e13
Q14 =  LQ14F3  (.) f3  +         1  e14
Q15 =  LQ15F3  (.) f3  +         1  e15
Q16 =  LQ16F4  (.) f4  +         1  e16
Q17 =  lq17f4  (.) f4  +         1  e17
f5  =  PF5F1   (.) F1  + PF5F2  (.) f2  + PF5F3  (.) f3  + PF5F4 (.) f4  +  1 D5
Q19 =  LQ19F8  (.) f8  +         1  e19
Q27 =  lq27f8  (.) f8  +         1  e27
Q21 =  lq21f8  (.) f8  +         1  e21
Q18 =  LQ18F7  (.) f7  +         1  e18
Q20 =  LQ20F7  (.) f7  +         1  e20
Q26 =  lq26f7  (.) f7  +         1  e26
Q22 =  lq22f6  (.) f6  +         1  e22
Q23 =  lq23f6  (.) f6  +         1  e23
Q24 =  lq24F6  (.) f6  +         1  e24
Q25 =  lq25F6  (.) f6  +         1  e25
f9  =  PF9F6   (.) f6  + PF9F7  (.) f7  + PF9F8  (.) f8  +        1  D9
B1A =  LB1AF10 (.) f10 +         1  e28
B1B =  LB2AF10 (.) f10 +         1  E29
B2D =  LB2DF10 (.) f10 +         1  E30
B2C =  LB2CF10 (.) f10 +         1  E31
B3B =  LB3BF10 (.) f10 +         1  E32
B3C =  LB3CF10 (.) f10 +         1  E33
B1C =  LB1CF11 (.) F11 +         1  E34
B1D =  LB1DF11 (.) F11 +         1  E35
B2A =  LB2AF11 (.) F11 +         1  E36
B2B =  LB2BF11 (.) F11 +         1  E37
B3A =  LB3AF11 (.) F11 +         1  E38
B3D =  LB3DF11 (.) F11 +         1  E39
f12 =  PF12F10 (.) f10 + PF12F7 (.) F11 +         1  D12
f13 =  pf13f5  (.) f5  + p13f9  (.) f9  + p13f12 (.) f12 +        1  d13
```

LSU DATA

RUN 1 - CFA - MEASUREMENT MODEL CULTURE 8/3/17

The CALIS Procedure

Covariance Structure Analysis: Descriptive Statistics

Simple Statistics			
Variable		Mean	Std Dev
Q8	RESPONSE	5.75862	1.11160
Q9	AWARNESS	5.72069	1.24836
Q10	REPORTING	5.99310	1.02222
Q11	TRAINING	5.83793	1.09003
Q12	INVOLVEMENT	5.48621	1.25398
Q13	PROMOTION	5.46876	1.32806
Q14	SYSTEM	6.02772	0.92967
Q15	UTILIZE	5.69655	1.13652
Q16	RECONIZE	3.40628	1.77006
Q17	LEADERSHIP	5.22497	1.34959
Q18	CONCERN_1	6.27931	0.79002
Q19	ACCEDENTS_2	4.80221	1.73277
Q20	MEASURES	6.25690	0.80006
Q21	PPE	4.97241	2.08950
Q22	CONCERN_2	6.43448	1.13646
Q23	NEEDS	5.72672	1.27174
Q24	HESITANT	5.36207	1.66272
Q25	REPORTING	4.99310	1.49044
Q26	LITERATURE	5.65172	1.22238
Q27	DISCARD	6.10734	1.25292
B1A	OPEN	6.05965	1.41908
B1B	PICKUP	3.28676	2.22170
B1C	LEAVE	4.92686	2.03725
B1D	REPORT	6.02790	1.42855
B2A	EHS	4.12759	2.12277
B2B	SOP	5.44138	1.70436
B2C	RUN	2.86507	1.89494
B2D	REVIEW	6.15862	1.27078
B3A	QUENCH	5.75000	1.53393
B3B	FINISH	5.45134	1.61879
B3C	CONTACT	4.90941	1.92924
B3D	OBSERVE	5.65628	1.60769

LSU DATA

RUN 1 - CFA - MEASUREMENT MODEL CULTURE 8/3/17

The CALIS Procedure

Covariance Structure Analysis: Optimization

Initial Estimation Methods	
1	Instrumental Variables Method
2	McDonald Method
3	Default Initial Values

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
1	LQ8f1	0.64318	0.02093
2	LQ9F1	0.74628	0.02404
3	lq10f1	0.73613	0.02400
4	LQ11F2	0.73145	0.02308
5	lq12f2	0.89564	0.02790
6	LQ13F2	0.95698	0.02988
7	LQ14F3	0.63033	0.01958
8	LQ15F3	0.82057	0.02513
9	LQ16F4	1.16440	0.03684
10	lq17f4	0.94366	0.03023
11	PF5F1	0.50000	0
12	PF5F2	0.50000	0
13	PF5F3	0.50000	0
14	PF5F4	0.50000	0
15	LQ19F8	1.22385	0.04085
16	lq27f8	0.61382	0.02049
17	lq21f8	0.52554	0.01623
18	LQ18F7	0.47260	0.01555
19	LQ20F7	0.34212	0.01116
20	lq26f7	0.54230	0.01734
21	lq22f6	0.31400	0.00954
22	lq23f6	0.68819	0.02054
23	lq24F6	1.09142	0.03230
24	lq25F6	0.28205	0.00830
25	PF9F6	0.50000	0

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
26	PF9F7	0.50000	0
27	PF9F8	0.50000	0
28	LB1AF10	0.83026	0.02963
29	LB2AF10	0.41855	0.01343
30	LB2DF10	0.15032	0.00544
31	LB2CF10	0.67252	0.02261
32	LB3BF10	0.81181	0.02775
33	LB3CF10	0.25645	0.00680
34	LB1CF11	0.95721	0.03301
35	LB1DF11	-0.07977	-0.00180
36	LB2AF11	-0.26246	-0.00713
37	LB2BF11	-0.15279	-0.00409
38	LB3AF11	-0.20848	-0.00690
39	LB3DF11	-0.11410	-0.00348
40	PF12F10	0.50000	0
41	PF12F7	0.50000	0
42	pf13f5	0.50000	0
43	p13f9	0.50000	0
44	p13f12	0.50000	0
45	vare8	50.00000	0.01939
46	vare9	50.00000	0.01922
47	vare10	50.00000	0.01943
48	vare11	50.00000	0.01938
49	vare12	50.00000	0.01916
50	vare13	50.00000	0.01905
51	vare14	50.00000	0.01955
52	vare15	50.00000	0.01931
53	vare16	50.00000	0.01839
54	vare17	50.00000	0.01903
55	vare18	50.00000	0.01969
56	vare19	50.00000	0.01836
57	vare20	50.00000	0.01971
58	vare21	50.00000	0.01819
59	vare22	50.00000	0.01946
60	vare23	50.00000	0.01924

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
61	vare24	50.00000	0.01861
62	vare25	50.00000	0.01909
63	vare26	50.00000	0.01932
64	vare27	50.00000	0.01926
65	vare28	50.00000	0.01896
66	vare29	50.00000	0.01798
67	vare30	50.00000	0.01935
68	vare31	50.00000	0.01843
69	vare32	50.00000	0.01875
70	vare33	50.00000	0.01850
71	vare34	50.00000	0.01806
72	vare35	50.00000	0.01918
73	vare36	50.00000	0.01819
74	vare37	50.00000	0.01883
75	vare38	50.00000	0.01905
76	vare39	50.00000	0.01896
77	VARD5	50.00000	0
78	vard9	50.00000	0
79	vard12	50.00000	0
80	vard13	50.00000	0
81	cF1F2	0.68541	-0.00295
82	CF1F3	0.66013	-0.00132
83	CF1F4	0.53697	-0.00223
84	CF1F6	0.70328	-0.00592
85	CF1F7	0.58317	-0.0006899
86	CF1F9	0.43353	-0.00171
87	CF1F1	0.23735	-0.0009935
88	CF2F3	0.79183	-0.00241
89	CF2F4	0.75155	-0.00483
90	CF2F7	0.69793	-0.00128
91	CF2F8	0.28243	-0.00149
92	CF2F10	-0.08975	0.0006775
93	CF2F11	-0.29490	0.0008174
94	CF3F4	0.74095	-0.00225
95	CF3F6	0.93914	-0.00239

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
96	CF3F7	0.78125	-0.0006881
97	CF3F8	0.35884	-0.0009345
98	CF3F10	-0.04285	0.0001977
99	CF3F11	-0.45935	0.0006567
100	CF4F6	0.54124	-0.00265
101	CF4F7	0.45650	-0.0007775
102	CF4F8	0.20196	-0.00100
103	CF4F10	-0.22869	0.00155
104	CF4F11	-0.29393	0.0008451
105	CF6F7	0.70578	-0.00102
106	CF6F8	0.75503	-0.00386
107	CF6F10	0.26668	-0.00131
108	CF6F11	-0.52259	0.00128
109	CF7F8	0.43859	-0.0007266
110	CF7F10	0.48479	-0.0008836
111	CF7F11	-0.48899	0.0004185
112	CF8C10	0.25366	-0.00143
113	CF8F11	-0.27264	0.0007289
114	CF10F11	-0.39878	0.00119
115	_Add1	-0.20966	0.0003381
Value of Objective Function = 81.436427146			

LSU DATA

RUN 1 - CFA - MEASUREMENT MODEL CULTURE 8/3/17

The CALIS Procedure

Covariance Structure Analysis: Optimization

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	115
Functions (Observations)	528

Optimization Start			
Active Constraints	0	Objective Function	81.436427146
Max Abs Gradient Element	0.0408542075	Radius	1

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
1	*	0	4	0		75.55917	5.8773	0.0356	4.545	1.139
2	*	0	6	0		75.28203	0.2771	0.0241	0.0717	0.956
3	*	0	8	0		74.76107	0.5210	0.0246	0.0328	0.982
4	*	0	10	0		73.69054	1.0705	0.0255	0.0159	1.030
5	*	0	12	0		70.21313	3.4774	0.0640	0.00476	1.063
6	*	0	15	0		69.42782	0.7853	0.0296	0.0366	0.884
7	*	0	17	0		67.88752	1.5403	0.0313	0.0153	1.043
8	*	0	19	0		64.82515	3.0624	0.0551	0.00766	1.017
9	*	0	22	0		64.03483	0.7903	0.0361	0.0542	0.936
10	*	0	24	0		62.61188	1.4229	0.0381	0.0230	0.997
11	*	0	26	0		59.76812	2.8438	0.0681	0.0114	0.978
12	*	0	28	0		52.37628	7.3918	0.1243	0.00509	1.202
13	*	0	30	0		28.78541	23.5909	0.1748	0.00138	2.110
14	*	0	33	0		15.60882	13.1766	0.3909	0.0113	1.780
15	*	0	36	0		11.88005	3.7288	0.3217	0.122	1.336
16	*	0	38	0		8.59039	3.2897	15.6766	0.0272	0.982
17	*	0	41	0		6.64252	1.9479	1.6002	0.212	0.426
18	*	0	43	0		6.36066	0.2819	4.9579	0.144	0.417
19	*	0	45	0		6.24710	0.1136	5.3010	0.138	0.103
20	*	0	48	0		5.88077	0.3663	2.1599	18.619	0.496
21	*	0	50	0		5.78599	0.0948	0.6055	1.817	0.777
22	*	0	52	0		5.73696	0.0490	1.7251	0.759	0.449
23	*	0	54	0		5.69429	0.0427	1.4992	0.646	0.323
24	*	0	56	0		5.68976	0.00453	2.6022	0.720	0.0295
25	*	0	58	0		5.64899	0.0408	1.9257	2.721	0.201
26	*	0	60	0		5.64170	0.00729	2.1028	1.863	0.0524
27	*	0	62	0		5.59195	0.0497	1.1501	8.707	0.392
28	*	0	64	0		5.57768	0.0143	0.8435	2.949	0.335

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
29	*	0	66	0		5.56429	0.0134	0.7437	3.083	0.374
30	*	0	68	0		5.55218	0.0121	0.6363	2.604	0.438
31	*	0	70	0		5.54012	0.0121	0.5739	2.655	0.479
32	*	0	72	0		5.52752	0.0126	0.5265	2.198	0.554
33	*	0	74	0		5.51587	0.0117	0.4806	2.464	0.562
34	*	0	76	0		5.47972	0.0361	0.5731	0.628	0.802
35	*	0	78	0		5.41907	0.0607	0.7940	0.317	0.774
36	*	0	80	0		5.31033	0.1087	1.3008	0.124	0.792
37	*	0	82	0		5.08571	0.2246	1.9615	0.0251	0.695
38	*	0	84	0		5.07188	0.0138	7.1738	0.0238	0.0290
39	*	0	86	0		4.86194	0.2099	5.4011	0.0643	0.209
40	*	0	89	0		4.85753	0.00442	7.0084	0.698	0.0071
41	*	0	91	0		4.64905	0.2085	3.2494	2.367	0.344
42	*	0	93	0		4.62317	0.0259	2.9192	0.869	0.131
43	*	0	95	0		4.59419	0.0290	2.2175	0.540	0.188
44	*	0	97	0		4.58666	0.00753	2.3098	0.576	0.0703
45	*	0	99	0		4.56112	0.0255	1.5599	1.597	0.285
46	*	0	101	0		4.55257	0.00855	1.2837	0.979	0.186
47	*	0	103	0		4.54539	0.00718	1.0667	0.599	0.211
48	*	0	105	0		4.54092	0.00446	0.9937	0.691	0.175
49	*	0	107	0		4.53604	0.00488	0.8393	0.475	0.229
50	*	0	109	0		4.53265	0.00339	0.8353	0.554	0.192
51	*	0	111	0		4.52863	0.00403	0.7155	0.424	0.255
52	*	0	113	0		4.52550	0.00313	0.7538	0.431	0.221
53	*	0	115	0		4.52184	0.00366	0.6542	0.409	0.275
54	*	0	117	0		4.51875	0.00308	0.6918	0.418	0.253
55	*	0	119	0		4.51495	0.00381	0.6063	0.362	0.316
56	*	0	121	0		4.51173	0.00322	0.6498	0.421	0.291
57	*	0	123	0		4.50781	0.00392	0.5590	0.378	0.357
58	*	0	125	0		4.50429	0.00352	0.6046	0.429	0.346
59	*	0	127	0		4.50012	0.00417	0.5087	0.402	0.415
60	*	0	129	0		4.49613	0.00399	0.5552	0.442	0.424
61	*	1	134	0		4.45741	0.0387	0.3816	0.0463	0.966

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
62	*	1	136	0		4.35261	0.1048	1.6331	0.0320	0.943
63	*	1	138	0		4.21347	0.1391	0.9134	0.00529	0.470
64	*	1	140	0		4.07043	0.1430	2.2259	0.00395	0.886
65	*	1	142	0		3.98074	0.0897	1.2310	0.00083	0.821
66	*	1	145	0		3.94192	0.0388	1.7285	0.00665	0.481
67	*	1	147	0		3.91898	0.0229	1.4612	0.00631	0.270
68	*	1	149	0		3.88761	0.0314	1.4813	0.00664	0.223
69	*	1	151	0		3.80171	0.0859	2.0810	0.00334	0.514
70	*	1	153	0		3.73382	0.0679	1.2402	0.00363	0.449
71	*	1	155	0		3.70975	0.0241	1.2806	0.00211	0.264
72	*	1	157	0		3.68112	0.0286	0.9724	0.00435	0.283
73	*	1	159	0		3.65988	0.0212	0.7447	0.00304	0.273
74	*	1	161	0		3.63072	0.0292	0.7396	0.00604	0.341
75	*	1	163	0		3.59760	0.0331	0.4141	0.00146	0.477
76	*	1	165	0		3.57744	0.0202	0.4208	0.00107	0.320
77	*	1	167	0		3.56904	0.00841	0.4940	0.00128	0.141
78	*	1	169	0		3.56043	0.00861	0.8032	0.00442	0.0972
79	*	1	171	0		3.52876	0.0317	1.1072	0.0165	0.232
80	*	1	173	0		3.48746	0.0413	1.0225	0.0147	0.318
81	*	1	176	0		3.47971	0.00775	1.5680	0.0444	0.100
82	*	1	178	0		3.46869	0.0110	1.0294	0.0128	0.159
83	*	1	181	0		3.45977	0.00892	1.1760	0.177	0.194
84	*	1	183	0		3.45392	0.00586	0.6775	0.0142	0.190
85	*	1	185	0		3.45307	0.000848	0.9144	0.0314	0.0393
86	*	1	187	0		3.44718	0.00589	0.5027	0.237	0.302
87	*	1	189	0		3.44636	0.000819	0.5434	0.0318	0.0923
88	*	1	191	0		3.44382	0.00254	0.3025	0.437	0.352
89	*	1	193	0		3.44327	0.000549	0.2658	0.0465	0.200
90	*	1	195	0		3.44289	0.000385	0.2151	0.0591	0.178
91	*	1	197	0		3.44268	0.000214	0.2147	0.0469	0.136
92	*	1	199	0		3.44248	0.000198	0.1658	0.0331	0.151
93	*	1	201	0		3.44235	0.000130	0.1824	0.0344	0.122
94	*	1	203	0		3.44223	0.000123	0.1377	0.0212	0.133

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
95	*	1	205	0		3.44214	0.000083	0.1607	0.0249	0.104
96	*	1	207	0		3.44206	0.000080	0.1223	0.0137	0.112
97	*	1	209	0		3.44201	0.000055	0.1452	0.0195	0.0858
98	*	1	211	0		3.44190	0.000105	0.1032	0.0844	0.188
99	*	1	213	0		3.44185	0.000049	0.1046	0.0440	0.127
100	*	1	215	0		3.44181	0.000041	0.0829	0.0293	0.129
101	*	1	217	0		3.44178	0.000032	0.0893	0.0309	0.118
102	*	1	219	0		3.44175	0.000030	0.0709	0.0256	0.129
103	*	1	221	0		3.44173	0.000025	0.0771	0.0272	0.122
104	*	1	223	0		3.44170	0.000024	0.0621	0.0233	0.135
105	*	1	225	0		3.44168	0.000021	0.0672	0.0245	0.131
106	*	1	227	0		3.44166	0.000021	0.0552	0.0220	0.147
107	*	1	229	0		3.44164	0.000019	0.0590	0.0228	0.146
108	*	1	231	0		3.44162	0.000019	0.0495	0.0212	0.164
109	*	1	233	0		3.44160	0.000017	0.0521	0.0216	0.167
110	*	1	235	0		3.44159	0.000018	0.0447	0.0208	0.186
111	*	1	237	0		3.44157	0.000017	0.0462	0.0209	0.194
112	*	1	239	0		3.44155	0.000017	0.0405	0.0205	0.213
113	*	1	241	0		3.44154	0.000017	0.0410	0.0204	0.226
114	*	1	243	0		3.44152	0.000018	0.0369	0.0184	0.257
115	*	1	245	0		3.44150	0.000017	0.0367	0.0203	0.261
116	*	1	247	0		3.44148	0.000018	0.0337	0.0187	0.293
117	*	1	249	0		3.44146	0.000018	0.0331	0.0185	0.315
118	*	1	251	0		3.44145	0.000018	0.0309	0.0191	0.331
119	*	1	253	0		3.44143	0.000018	0.0297	0.0189	0.357
120	*	1	255	0		3.44141	0.000018	0.0282	0.0195	0.374
121	*	2	259	0		3.44085	0.000563	0.1049	0.00057	0.945
122	*	2	262	0		3.44020	0.000649	0.0309	0.00145	1.018
123	*	2	264	0		3.43933	0.000868	0.1789	0.00094	0.703
124	*	2	266	0		3.43684	0.00249	0.1748	0.00154	0.812
125	*	2	269	0		3.43415	0.00268	0.0178	0.0101	1.048
126	*	2	271	0		3.43067	0.00348	0.1221	0.00704	0.997
127	*	2	273	0		3.42729	0.00338	0.2701	0.00554	0.274

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
128	*	2	275	0		3.41740	0.00989	0.2244	0.0159	0.162
129	*	2	277	0		3.27541	0.1420	0.1106	0.00847	0.891
130	*	2	279	0		3.24784	0.0276	0.0406	444E-16	1.219
131	*	2	281	0		3.24448	0.00336	0.0154	444E-16	1.295
132	*	2	283	0		3.24352	0.000964	0.0162	444E-16	1.234
133	*	2	285	0		3.24321	0.000310	0.00474	444E-16	1.080
134	*	2	287	0		3.24310	0.000107	0.00883	444E-16	0.844
135	*	2	289	0		3.24306	0.000039	0.00350	444E-16	0.587
136	*	2	291	0		3.24305	0.000016	0.00566	444E-16	0.383
137	*	2	293	0		3.24304	7.335E-6	0.00344	444E-16	0.255
138	*	2	295	0		3.24304	3.988E-6	0.00400	444E-16	0.188
139	*	2	297	0		3.24303	2.44E-6	0.00294	444E-16	0.152
140	*	2	299	0		3.24303	1.689E-6	0.00298	444E-16	0.136
141	*	2	301	0		3.24303	1.211E-6	0.00239	444E-16	0.126
142	*	2	303	0		3.24303	9.197E-7	0.00227	444E-16	0.123
143	*	2	305	0		3.24303	6.95E-7	0.00190	444E-16	0.119
144	*	2	307	0		3.24303	5.419E-7	0.00175	444E-16	0.119
145	*	2	309	0		3.24303	4.166E-7	0.00150	444E-16	0.117
146	*	2	311	0		3.24303	3.27E-7	0.00136	444E-16	0.117
147	*	2	313	0		3.24303	2.531E-7	0.00118	444E-16	0.116
148	*	2	315	0		3.24303	1.989E-7	0.00106	444E-16	0.116
149	*	2	317	0		3.24303	1.546E-7	0.000927	444E-16	0.115
150	*	2	319	0		3.24303	1.215E-7	0.000830	444E-16	0.116
151	*	2	321	0		3.24303	9.459E-8	0.000727	444E-16	0.115
152	*	2	323	0		3.24303	7.43E-8	0.000649	444E-16	0.116
153	*	2	325	0		3.24303	5.793E-8	0.000570	444E-16	0.115
154	*	2	327	0		3.24303	4.548E-8	0.000507	444E-16	0.115
155	*	2	329	0		3.24303	3.55E-8	0.000447	444E-16	0.115
156	*	2	331	0		3.24303	2.785E-8	0.000397	444E-16	0.115
157	*	2	333	0		3.24303	2.175E-8	0.000350	444E-16	0.115
158	*	2	335	0		3.24303	1.706E-8	0.000311	444E-16	0.115
159	*	2	337	0		3.24303	1.333E-8	0.000274	444E-16	0.115
160	*	2	339	0		3.24303	1.045E-8	0.000243	444E-16	0.115

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
161	*	2	341	0		3.24303	8.171E-9	0.000215	444E-16	0.115
162	*	2	343	0		3.24303	6.404E-9	0.000190	444E-16	0.115
163	*	2	345	0		3.24303	5.008E-9	0.000168	444E-16	0.115
164	*	2	347	0		3.24303	3.924E-9	0.000149	444E-16	0.115
165	*	2	349	0		3.24303	3.069E-9	0.000132	444E-16	0.115
166	*	2	351	0		3.24303	2.404E-9	0.000116	444E-16	0.115
167	*	2	353	0		3.24303	1.881E-9	0.000103	444E-16	0.115
168	*	2	355	0		3.24303	1.473E-9	0.000091	444E-16	0.115

Optimization Results			
Iterations	168	Function Calls	358
Jacobian Calls	172	Active Constraints	0
Objective Function	3.2430279309	Max Abs Gradient Element	0.0000911713
Lambda	4.440892E-14	Actual Over Pred Change	0.1152514362
Radius	391.23664108		

Convergence criterion (GCONV=1E-8) satisfied.

LSU DATA

RUN 1 - CFA - MEASUREMENT MODEL CULTURE 8/3/17

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Summary		
Modeling Info	Number of Observations	290
	Number of Variables	32
	Number of Moments	528
	Number of Parameters	115
	Number of Active Constraints	0
	Baseline Model Function Value	8.2109
	Baseline Model Chi-Square	2372.9448
	Baseline Model Chi-Square DF	496
	Pr > Baseline Model Chi-Square	<.0001
Absolute Index	Fit Function	3.2430

Fit Summary		
	Chi-Square	937.2351
	Chi-Square DF	413
	Pr > Chi-Square	<.0001
	Z-Test of Wilson & Hilferty	13.5647
	Hoelter Critical N	143
	Root Mean Square Residual (RMR)	0.2029
	Standardized RMR (SRMR)	0.0936
	Goodness of Fit Index (GFI)	0.8354
Parsimony Index	Adjusted GFI (AGFI)	0.7896
	Parsimonious GFI	0.6956
	RMSEA Estimate	0.0663
	RMSEA Lower 90% Confidence Limit	0.0607
	RMSEA Upper 90% Confidence Limit	0.0719
	Probability of Close Fit	<.0001
	ECVI Estimate	4.1415
	ECVI Lower 90% Confidence Limit	3.8356
	ECVI Upper 90% Confidence Limit	4.4777
	Akaike Information Criterion	1167.2351
	Bozdogan CAIC	1704.2714
	Schwarz Bayesian Criterion	1589.2714
	McDonald Centrality	0.4050
Incremental Index	Bentler Comparative Fit Index	0.7207
	Bentler-Bonett NFI	0.6050
	Bentler-Bonett Non-normed Index	0.6646
	Bollen Normed Index Rho1	0.5257
	Bollen Non-normed Index Delta2	0.7325
	James et al. Parsimonious NFI	0.5038

LSU DATA

RUN 1 - CFA - MEASUREMENT MODEL CULTURE 8/3/17

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Linear Equations

```
Q8  =   0.5869 (**) F1  + 1.0000  e8
Q9  =   0.8315 (**) F1  + 1.0000  e9
Q10 =   0.6899 (**) F1  + 1.0000  e10
Q11 =  -0.7268 (**) f2  + 1.0000  e11
```

Linear Equations

```
Q12 =  -0.9209 (**) f2  + 1.0000  e12
Q13 =  -0.9569 (**) f2  + 1.0000  e13
Q14 =   0.5478 (**) f3  + 1.0000  e14
Q15 =   0.7563 (**) f3  + 1.0000  e15
Q16 =   1.1173 (**) f4  + 1.0000  e16
Q17 =   0.9372 (**) f4  + 1.0000  e17
f5  =   0.5000      F1  + 0.5000  f2  + 0.5000  f3  + 0.5000  f4  + 1.0000  D5
Q19 =   1.0379 (**) f8  + 1.0000  e19
Q27 =   0.5445 (**) f8  + 1.0000  e27
Q21 =   0.6848 (**) f8  + 1.0000  e21
Q18 =  -0.4312 (**) f7  + 1.0000  e18
Q20 =  -0.3432 (**) f7  + 1.0000  e20
Q26 =  -0.5361 (**) f7  + 1.0000  e26
Q22 =   0.3251 (**) f6  + 1.0000  e22
Q23 =   0.5270 (**) f6  + 1.0000  e23
Q24 =   1.3530 (**) f6  + 1.0000  e24
Q25 =   0.2709 (**) f6  + 1.0000  e25
f9  =   0.5000      f6  + 0.4999  f7  + 0.5001  f8  + 1.0000  D9
B1A =  -0.2508 (**) f10 + 1.0000  e28
B1B =  -0.3166 (**) f10 + 1.0000  E29
B2D =  -0.1992 (**) f10 + 1.0000  E30
B2C =  -0.4426 (**) f10 + 1.0000  E31
B3B =  -1.2344 (**) f10 + 1.0000  E32
B3C =  -0.9034 (**) f10 + 1.0000  E33
B1C =  -0.0760 (ns) F11 + 1.0000  E34
B1D =   0.6560 (**) F11 + 1.0000  E35
B2A =   1.2435 (**) F11 + 1.0000  E36
B2B =   0.7892 (**) F11 + 1.0000  E37
B3A =   0.6188 (**) F11 + 1.0000  E38
B3D =   0.6257 (**) F11 + 1.0000  E39
f12 =   0.4999      f10 + 0.4999  F11 + 1.0000  D12
f13 =   0.4999      f5  + 0.4998  f9  + 0.5000  f12 + 1.0000  d13
```

Effects in Linear Equations						
Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Q8	F1	LQ8f1	0.58687	0.07084	8.2846	<.0001
Q9	F1	LQ9F1	0.83150	0.07750	10.7287	<.0001
Q10	F1	lq10f1	0.68988	0.06342	10.8783	<.0001
Q11	f2	LQ11F2	-0.72679	0.06297	-11.5415	<.0001
Q12	f2	lq12f2	-0.92091	0.07082	-13.0044	<.0001
Q13	f2	LQ13F2	-0.95695	0.07533	-12.7034	<.0001
Q14	f3	LQ14F3	0.54778	0.05342	10.2538	<.0001

Effects in Linear Equations						
Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Q15	f3	LQ15F3	0.75629	0.06488	11.6573	<.0001
Q16	f4	LQ16F4	1.11728	0.11073	10.0899	<.0001
Q17	f4	lq17f4	0.93722	0.08545	10.9680	<.0001
f5	F1	PF5F1	0.50000	.	.	.
f5	f2	PF5F2	0.50000	.	.	.
f5	f3	PF5F3	0.50000	.	.	.
f5	f4	PF5F4	0.50000	.	.	.
Q19	f8	LQ19F8	1.03794	0.13777	7.5338	<.0001
Q27	f8	lq27f8	0.54452	0.09230	5.8994	<.0001
Q21	f8	lq21f8	0.68485	0.15438	4.4361	<.0001
Q18	f7	LQ18F7	-0.43121	0.05283	-8.1625	<.0001
Q20	f7	LQ20F7	-0.34325	0.05300	-6.4761	<.0001
Q26	f7	lq26f7	-0.53605	0.08094	-6.6226	<.0001
Q22	f6	lq22f6	0.32515	0.07531	4.3176	<.0001
Q23	f6	lq23f6	0.52701	0.08297	6.3518	<.0001
Q24	f6	lq24F6	1.35300	0.12098	11.1838	<.0001
Q25	f6	lq25F6	0.27086	0.09969	2.7169	0.0066
f9	f6	PF9F6	0.49998	.	.	.
f9	f7	PF9F7	0.49993	.	.	.
f9	f8	PF9F8	0.50015	.	.	.
B1A	f10	LB1AF10	-0.25078	0.09780	-2.5641	0.0103
B1B	f10	LB2AF10	-0.31655	0.15345	-2.0629	0.0391
B2D	f10	LB2DF10	-0.19921	0.08770	-2.2716	0.0231
B2C	f10	LB2CF10	-0.44257	0.13001	-3.4042	0.0007
B3B	f10	LB3BF10	-1.23445	0.11784	-10.4757	<.0001
B3C	f10	LB3CF10	-0.90337	0.12899	-7.0032	<.0001
B1C	F11	LB1CF11	-0.07596	0.14893	-0.5100	0.6100
B1D	F11	LB1DF11	0.65605	0.10119	6.4833	<.0001
B2A	F11	LB2AF11	1.24353	0.15033	8.2721	<.0001
B2B	F11	LB2BF11	0.78918	0.12069	6.5387	<.0001
B3A	F11	LB3AF11	0.61876	0.10920	5.6661	<.0001
B3D	F11	LB3DF11	0.62570	0.11462	5.4589	<.0001
f12	f10	PF12F10	0.49993	.	.	.
f12	F11	PF12F7	0.49989	.	.	.
f13	f5	pf13f5	0.49986	.	.	.

Effects in Linear Equations						
Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
f13	f9	p13f9	0.49981	.	.	.
f13	f12	p13f12	0.50004	.	.	.

Estimates for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Error	e8	vare8	0.88225	0.08529	10.3441	<.0001
	e9	vare9	0.84897	0.10085	8.4180	<.0001
	e10	vare10	0.55660	0.06759	8.2352	<.0001
	e11	vare11	0.67372	0.06831	9.8630	<.0001
	e12	vare12	0.74651	0.08447	8.8377	<.0001
	e13	vare13	0.87186	0.09592	9.0896	<.0001
	e14	vare14	0.48965	0.05015	9.7631	<.0001
	e15	vare15	0.57757	0.07362	7.8458	<.0001
	e16	vare16	1.82321	0.20495	8.8959	<.0001
	e17	vare17	0.89966	0.12251	7.3435	<.0001
	e18	vare18	0.41296	0.04432	9.3186	<.0001
	e19	vare19	1.84877	0.26446	6.9907	<.0001
	e20	vare20	0.50628	0.04669	10.8430	<.0001
	e21	vare21	3.86374	0.34848	11.0875	<.0001
	e22	vare22	1.18582	0.10157	11.6746	<.0001
	e23	vare23	1.33958	0.11993	11.1697	<.0001
	e24	vare24	0.93403	0.25758	3.6261	0.0003
	e25	vare25	2.14804	0.18064	11.8915	<.0001
	e26	vare26	1.16785	0.10852	10.7615	<.0001
	e27	vare27	1.25228	0.12335	10.1519	<.0001
	e28	vare28	1.95004	0.16431	11.8681	<.0001
	E29	vare29	4.83439	0.40547	11.9230	<.0001
	E30	vare30	1.57467	0.13231	11.9018	<.0001
	E31	vare31	3.39226	0.28882	11.7453	<.0001
	E32	vare32	1.07595	0.23216	4.6346	<.0001
	E33	vare33	2.89480	0.27387	10.5700	<.0001
	E34	vare34	4.14451	0.34504	12.0117	<.0001
	E35	vare35	1.60232	0.15675	10.2223	<.0001
	E36	vare36	2.93091	0.34636	8.4620	<.0001

Estimates for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
	E37	vare37	2.27043	0.22296	10.1833	<.0001
	E38	vare38	1.96293	0.18307	10.7225	<.0001
	E39	vare39	2.18585	0.20183	10.8302	<.0001
Latent	F1		1.00000			
	f2		1.00000			
	f3		1.00000			
	f4		1.00000			
	f6		1.00000			
	f7		1.00000			
	f8		1.00000			
	f10		1.00000			
	F11		1.00000			
Disturbance	D5	VARD5	50.00001	.	.	.
	D9	vard9	50.00022	.	.	.
	D12	vard12	50.00055	.	.	.
	d13	vard13	49.99964	.	.	.

Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
F1	f2	cF1F2	-0.68179	0.05936	-11.4850	<.0001
F1	f3	CF1F3	0.50841	0.07692	6.6097	<.0001
F1	f4	CF1F4	0.53289	0.07769	6.8595	<.0001
F1	f6	CF1F6	0.04811	0.04248	1.1324	0.2574
F1	f7	CF1F7	-0.48416	0.09335	-5.1862	<.0001
F1	f8	CF1F9	0.21365	0.09483	2.2531	0.0243
F1	f10	CF1F1	-0.21598	0.08510	-2.5380	0.0111
f2	f3	CF2F3	-0.67130	0.06428	-10.4433	<.0001
f2	f4	CF2F4	-0.72766	0.06213	-11.7120	<.0001
f2	f6	CF1F6	0.04811	0.04248	1.1324	0.2574
f2	f7	CF2F7	0.59651	0.08352	7.1423	<.0001
f2	f8	CF2F8	-0.04731	0.09147	-0.5172	0.6050
f2	f10	CF2F10	-0.12215	0.08193	-1.4908	0.1360
f2	F11	CF2F11	-0.18214	0.08648	-2.1061	0.0352
f3	f4	CF3F4	0.68978	0.07599	9.0775	<.0001

Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
f3	f6	CF3F6	0.54576	0.07426	7.3497	<.0001
f3	f7	CF3F7	-0.75707	0.09018	-8.3951	<.0001
f3	f8	CF3F8	0.26580	0.10384	2.5597	0.0105
f3	f10	CF3F10	-0.03761	0.09244	-0.4068	0.6841
f3	F11	CF3F11	0.24105	0.09476	2.5437	0.0110
f4	f6	CF4F6	0.09746	0.07775	1.2535	0.2100
f4	f7	CF4F7	-0.36612	0.10203	-3.5884	0.0003
f4	f8	CF4F8	0.10274	0.10443	0.9838	0.3252
f4	f10	CF4F10	0.16619	0.09068	1.8327	0.0669
f4	F11	CF4F11	0.33775	0.09159	3.6874	0.0002
f6	f7	CF6F7	-0.32496	0.09242	-3.5161	0.0004
f6	f8	CF6F8	0.71298	0.09300	7.6661	<.0001
f6	f10	CF6F10	-0.38497	0.08387	-4.5900	<.0001
f6	F11	CF6F11	0.14529	0.09022	1.6105	0.1073
f7	f8	CF7F8	-0.32274	0.11784	-2.7389	0.0062
f7	f10	CF7F10	0.53199	0.09712	5.4775	<.0001
f7	F11	CF7F11	-0.51215	0.10055	-5.0934	<.0001
f8	f10	CF8C10	-0.34566	0.10198	-3.3895	0.0007
f8	F11	CF8F11	0.15884	0.10887	1.4590	0.1446
f10	F11	CF10F11	-0.46962	0.08686	-5.4066	<.0001
F11	F1	_Add1	0.15150	0.09181	1.6501	0.0989

Squared Multiple Correlations			
Variable	Error Variance	Total Variance	R-Square
Q8	0.88225	1.22667	0.2808
Q9	0.84897	1.54037	0.4489
Q10	0.55660	1.03253	0.4609
Q11	0.67372	1.20195	0.4395
Q12	0.74651	1.59458	0.5318
Q13	0.87186	1.78761	0.5123
Q14	0.48965	0.78971	0.3800
Q15	0.57757	1.14954	0.4976
Q16	1.82321	3.07152	0.4064
Q17	0.89966	1.77805	0.4940

Squared Multiple Correlations			
Variable	Error Variance	Total Variance	R-Square
f5	50.00001	50.82518	0.0162
Q19	1.84877	2.92609	0.3682
Q27	1.25228	1.54878	0.1914
Q21	3.86374	4.33276	0.1082
Q18	0.41296	0.59890	0.3105
Q20	0.50628	0.62410	0.1888
Q26	1.16785	1.45521	0.1975
Q22	1.18582	1.29154	0.0819
Q23	1.33958	1.61732	0.1717
Q24	0.93403	2.76465	0.6622
Q25	2.14804	2.22141	0.0330
f9	50.00022	50.78302	0.0154
B1A	1.95004	2.01293	0.0312
B1B	4.83439	4.93459	0.0203
B2D	1.57467	1.61435	0.0246
B2C	3.39226	3.58813	0.0546
B3B	1.07595	2.59981	0.5861
B3C	2.89480	3.71088	0.2199
B1C	4.14451	4.15028	0.00139
B1D	1.60232	2.03272	0.2117
B2A	2.93091	4.47728	0.3454
B2B	2.27043	2.89323	0.2153
B3A	1.96293	2.34579	0.1632
B3D	2.18585	2.57736	0.1519
f12	50.00055	50.26565	0.00527
f13	49.99964	87.97761	0.4317

Standardized Results for Linear Equations

```
Q8  =   0.5299 (**) F1  + 1.0000     e8
Q9  =   0.6700 (**) F1  + 1.0000     e9
Q10 =   0.6789 (**) F1  + 1.0000     e10
Q11 =  -0.6629 (**) f2  + 1.0000     e11
Q12 =  -0.7293 (**) f2  + 1.0000     e12
Q13 =  -0.7157 (**) f2  + 1.0000     e13
Q14 =   0.6164 (**) f3  + 1.0000     e14
Q15 =   0.7054 (**) f3  + 1.0000     e15
```

Standardized Results for Linear Equations

```
Q16 =   0.6375 (**) f4  + 1.0000      e16
Q17 =   0.7029 (**) f4  + 1.0000      e17
f5  =   0.0701 (**) F1  + 0.0701 (**) f2  + 0.0701 (**) f3  + 0.0701 (**) f4  + 1.0000  D5
Q19 =   0.6068 (**) f8  + 1.0000      e19
Q27 =   0.4375 (**) f8  + 1.0000      e27
Q21 =   0.3290 (**) f8  + 1.0000      e21
Q18 =  -0.5572 (**) f7  + 1.0000      e18
Q20 =  -0.4345 (**) f7  + 1.0000      e20
Q26 =  -0.4444 (**) f7  + 1.0000      e26
Q22 =   0.2861 (**) f6  + 1.0000      e22
Q23 =   0.4144 (**) f6  + 1.0000      e23
Q24 =   0.8137 (**) f6  + 1.0000      e24
Q25 =   0.1817 (**) f6  + 1.0000      e25
f9  =   0.0702 (**) f6  + 0.0702 (**) f7  + 0.0702 (**) f8  + 1.0000      D9
B1A =  -0.1768 (**) f10 + 1.0000      e28
B1B =  -0.1425 (**) f10 + 1.0000      E29
B2D =  -0.1568 (**) f10 + 1.0000      E30
B2C =  -0.2336 (**) f10 + 1.0000      E31
B3B =  -0.7656 (**) f10 + 1.0000      E32
B3C =  -0.4690 (**) f10 + 1.0000      E33
B1C =  -0.0373 (ns) F11 + 1.0000      E34
B1D =   0.4601 (**) F11 + 1.0000      E35
B2A =   0.5877 (**) F11 + 1.0000      E36
B2B =   0.4640 (**) F11 + 1.0000      E37
B3A =   0.4040 (**) F11 + 1.0000      E38
B3D =   0.3897 (**) F11 + 1.0000      E39
f12 =   0.0705 (**) f10 + 0.0705 (**) F11 + 1.0000      D12
f13 =   0.3799 (**) f5  + 0.3797 (**) f9  + 0.3780 (**) f12 + 1.0000      d13
```

Standardized Effects in Linear Equations

Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Q8	F1	LQ8f1	0.52988	0.05391	9.8284	<.0001
Q9	F1	LQ9F1	0.66996	0.04762	14.0691	<.0001
Q10	F1	lq10f1	0.67892	0.04731	14.3494	<.0001
Q11	f2	LQ11F2	-0.66293	0.04108	-16.1390	<.0001
Q12	f2	lq12f2	-0.72928	0.03694	-19.7448	<.0001
Q13	f2	LQ13F2	-0.71573	0.03774	-18.9632	<.0001
Q14	f3	LQ14F3	0.61641	0.04688	13.1477	<.0001
Q15	f3	LQ15F3	0.70538	0.04501	15.6719	<.0001
Q16	f4	LQ16F4	0.63751	0.04956	12.8621	<.0001
Q17	f4	lq17f4	0.70286	0.04889	14.3754	<.0001

Standardized Effects in Linear Equations						
Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
f5	F1	PF5F1	0.07013	0.0000488	1436.2	<.0001
f5	f2	PF5F2	0.07013	0.0000488	1436.2	<.0001
f5	f3	PF5F3	0.07013	0.0000488	1436.2	<.0001
f5	f4	PF5F4	0.07013	0.0000488	1436.2	<.0001
Q19	f8	LQ19F8	0.60678	0.07106	8.5392	<.0001
Q27	f8	lq27f8	0.43754	0.06808	6.4266	<.0001
Q21	f8	lq21f8	0.32901	0.07057	4.6624	<.0001
Q18	f7	LQ18F7	-0.55720	0.05826	-9.5646	<.0001
Q20	f7	LQ20F7	-0.43449	0.06041	-7.1923	<.0001
Q26	f7	lq26f7	-0.44437	0.06014	-7.3884	<.0001
Q22	f6	lq22f6	0.28611	0.06316	4.5297	<.0001
Q23	f6	lq23f6	0.41440	0.05888	7.0377	<.0001
Q24	f6	lq24F6	0.81373	0.05809	14.0085	<.0001
Q25	f6	lq25F6	0.18173	0.06562	2.7693	0.0056
f9	f6	PF9F6	0.07016	0.0000636	1102.5	<.0001
f9	f7	PF9F7	0.07015	0.0000636	1102.5	<.0001
f9	f8	PF9F8	0.07018	0.0000637	1102.5	<.0001
B1A	f10	LB1AF10	-0.17675	0.06777	-2.6081	0.0091
B1B	f10	LB2AF10	-0.14250	0.06832	-2.0858	0.0370
B2D	f10	LB2DF10	-0.15679	0.06811	-2.3021	0.0213
B2C	f10	LB2CF10	-0.23364	0.06661	-3.5074	0.0005
B3B	f10	LB3BF10	-0.76560	0.05906	-12.9631	<.0001
B3C	f10	LB3CF10	-0.46895	0.05924	-7.9155	<.0001
B1C	F11	LB1CF11	-0.03729	0.07306	-0.5104	0.6098
B1D	F11	LB1DF11	0.46015	0.06398	7.1919	<.0001
B2A	F11	LB2AF11	0.58769	0.06056	9.7039	<.0001
B2B	F11	LB2BF11	0.46396	0.06386	7.2654	<.0001
B3A	F11	LB3AF11	0.40400	0.06579	6.1403	<.0001
B3D	F11	LB3DF11	0.38975	0.06625	5.8831	<.0001
f12	f10	PF12F10	0.07051	0.0000305	2315.6	<.0001
f12	F11	PF12F7	0.07051	0.0000304	2315.6	<.0001
f13	f5	pf13f5	0.37993	0.0002506	1516.1	<.0001
f13	f9	p13f9	0.37973	0.0003202	1185.8	<.0001
f13	f12	p13f12	0.37797	0.0001943	1945.5	<.0001

Standardized Results for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Error	e8	vare8	0.71922	0.05714	12.5880	<.0001
	e9	vare9	0.55115	0.06381	8.6378	<.0001
	e10	vare10	0.53906	0.06424	8.3907	<.0001
	e11	vare11	0.56052	0.05446	10.2921	<.0001
	e12	vare12	0.46815	0.05387	8.6901	<.0001
	e13	vare13	0.48773	0.05403	9.0272	<.0001
	e14	vare14	0.62004	0.05780	10.7275	<.0001
	e15	vare15	0.50244	0.06350	7.9128	<.0001
	e16	vare16	0.59359	0.06320	9.3928	<.0001
	e17	vare17	0.50598	0.06873	7.3618	<.0001
	e18	vare18	0.68953	0.06492	10.6210	<.0001
	e19	vare19	0.63182	0.08623	7.3270	<.0001
	e20	vare20	0.81122	0.05250	15.4530	<.0001
	e21	vare21	0.89175	0.04644	19.2041	<.0001
	e22	vare22	0.91814	0.03614	25.4036	<.0001
	e23	vare23	0.82827	0.04880	16.9718	<.0001
	e24	vare24	0.33785	0.09454	3.5738	0.0004
	e25	vare25	0.96697	0.02385	40.5408	<.0001
	e26	vare26	0.80253	0.05345	15.0139	<.0001
	e27	vare27	0.80856	0.05958	13.5715	<.0001
	e28	vare28	0.96876	0.02396	40.4354	<.0001
	E29	vare29	0.97969	0.01947	50.3137	<.0001
	E30	vare30	0.97542	0.02136	45.6731	<.0001
	E31	vare31	0.94541	0.03113	30.3719	<.0001
	E32	vare32	0.41386	0.09043	4.5764	<.0001
	E33	vare33	0.78008	0.05557	14.0390	<.0001
	E34	vare34	0.99861	0.00545	183.3	<.0001
	E35	vare35	0.78826	0.05888	13.3873	<.0001
	E36	vare36	0.65462	0.07118	9.1961	<.0001
	E37	vare37	0.78474	0.05926	13.2431	<.0001
	E38	vare38	0.83679	0.05316	15.7404	<.0001
	E39	vare39	0.84810	0.05164	16.4231	<.0001
Latent	F1		1.00000			
	f2		1.00000			
	f3		1.00000			

Standardized Results for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
	f4		1.00000			
	f6		1.00000			
	f7		1.00000			
	f8		1.00000			
	f10		1.00000			
	F11		1.00000			
Disturbance	D5	VARD5	0.98376	0.00137	718.1	<.0001
	D9	vard9	0.98459	0.00179	551.3	<.0001
	D12	vard12	0.99473	0.0008592	1157.8	<.0001
	d13	vard13	0.56832	0.0004019	1413.9	<.0001

Standardized Results for Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
F1	f2	cF1F2	-0.68179	0.05936	-11.4850	<.0001
F1	f3	CF1F3	0.50841	0.07692	6.6097	<.0001
F1	f4	CF1F4	0.53289	0.07769	6.8595	<.0001
F1	f6	CF1F6	0.04811	0.04248	1.1324	0.2574
F1	f7	CF1F7	-0.48416	0.09335	-5.1862	<.0001
F1	f8	CF1F9	0.21365	0.09483	2.2531	0.0243
F1	f10	CF1F1	-0.21598	0.08510	-2.5380	0.0111
f2	f3	CF2F3	-0.67130	0.06428	-10.4433	<.0001
f2	f4	CF2F4	-0.72766	0.06213	-11.7120	<.0001
f2	f6	CF1F6	0.04811	0.04248	1.1324	0.2574
f2	f7	CF2F7	0.59651	0.08352	7.1423	<.0001
f2	f8	CF2F8	-0.04731	0.09147	-0.5172	0.6050
f2	f10	CF2F10	-0.12215	0.08193	-1.4908	0.1360
f2	F11	CF2F11	-0.18214	0.08648	-2.1061	0.0352
f3	f4	CF3F4	0.68978	0.07599	9.0775	<.0001
f3	f6	CF3F6	0.54576	0.07426	7.3497	<.0001
f3	f7	CF3F7	-0.75707	0.09018	-8.3951	<.0001
f3	f8	CF3F8	0.26580	0.10384	2.5597	0.0105
f3	f10	CF3F10	-0.03761	0.09244	-0.4068	0.6841
f3	F11	CF3F11	0.24105	0.09476	2.5437	0.0110

Standardized Results for Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
f4	f6	CF4F6	0.09746	0.07775	1.2535	0.2100
f4	f7	CF4F7	-0.36612	0.10203	-3.5884	0.0003
f4	f8	CF4F8	0.10274	0.10443	0.9838	0.3252
f4	f10	CF4F10	0.16619	0.09068	1.8327	0.0669
f4	F11	CF4F11	0.33775	0.09159	3.6874	0.0002
f6	f7	CF6F7	-0.32496	0.09242	-3.5161	0.0004
f6	f8	CF6F8	0.71298	0.09300	7.6661	<.0001
f6	f10	CF6F10	-0.38497	0.08387	-4.5900	<.0001
f6	F11	CF6F11	0.14529	0.09022	1.6105	0.1073
f7	f8	CF7F8	-0.32274	0.11784	-2.7389	0.0062
f7	f10	CF7F10	0.53199	0.09712	5.4775	<.0001
f7	F11	CF7F11	-0.51215	0.10055	-5.0934	<.0001
f8	f10	CF8C10	-0.34566	0.10198	-3.3895	0.0007
f8	F11	CF8F11	0.15884	0.10887	1.4590	0.1446
f10	F11	CF10F11	-0.46962	0.08686	-5.4066	<.0001
F11	F1	_Add1	0.15150	0.09181	1.6501	0.0989

Stepwise Multivariate Wald Test					
	Cumulative Statistics			Univariate Increment	
Parm	Chi-Square	DF	Pr > ChiSq	Chi-Square	Pr > ChiSq
CF3F10	0.16551	1	0.6841	0.16551	0.6841
CF2F8	0.41915	2	0.8109	0.25363	0.6145
LB1CF11	0.67832	3	0.8783	0.25918	0.6107
CF4F8	1.36268	4	0.8507	0.68435	0.4081
CF4F6	2.33365	5	0.8013	0.97097	0.3244
CF8F11	3.97197	6	0.6805	1.63832	0.2006
CF6F11	4.89160	7	0.6732	0.91963	0.3376
CF1F6	7.07622	8	0.5284	2.18462	0.1394
_Add1	9.26094	9	0.4135	2.18472	0.1394
CF2F11	12.21647	10	0.2708	2.95553	0.0856
CF3F11	13.68129	11	0.2511	1.46482	0.2262
CF1F9	17.21281	12	0.1418	3.53152	0.0602

RUN 2 - CFA - MEASUREMENT MODEL CULTURE 8/7/17

LSU DATA
RUN 2 - CFA - REVISED MEASUREMENT MODEL CULTURE 8/7/17

The CONTENTS Procedure

Data Set Name	WORK.TEST_1	Observations	306
Member Type	DATA	Variables	39
Engine	V9	Indexes	0
Created	08/07/2017 13:13:37	Observation Length	368
Last Modified	08/07/2017 13:13:37	Deleted Observations	0
Protection		Compressed	NO
Data Set Type		Sorted	NO
Label			
Data Representation	WINDOWS_64		
Encoding	wlatin1 Western (Windows)		

Engine/Host Dependent Information	
Data Set Page Size	65536
Number of Data Set Pages	2
First Data Page	1
Max Obs per Page	177
Obs in First Data Page	164
Number of Data Set Repairs	0
ExtendObsCounter	YES
Filename	C:\Users\Machine\AppData\Local\Temp\SAS Temporary Files_TD11388_LAPTOP-OV06L7T4_\test_1.sas7bdat
Release Created	9.0401M2
Host Created	X64_8HOME

Alphabetic List of Variables and Attributes						
#	Variable	Type	Len	Format	Informat	Label
28	B1A	Num	8			OPEN
29	B1B	Num	8			PICKUP
30	B1C	Num	8			LEAVE
31	B1D	Num	8			REPORT

Alphabetic List of Variables and Attributes						
#	Variable	Type	Len	Format	Informat	Label
32	B2A	Num	8			EHS
33	B2B	Num	8			SOP
34	B2C	Num	8			RUN
35	B2D	Num	8			REVIEW
36	B3A	Num	8			QUENCH
37	B3B	Num	8			FINISH
38	B3C	Num	8			CONTACT
39	B3D	Num	8			OBSERVE
2	F2	Num	8			EMPLOYEE
3	Q1	Char	16	$16.	$16.	Q1
4	Q2	Char	6	$6.	$6.	Q2
5	Q3	Char	19	$19.	$19.	Q3
6	Q4	Char	35	$35.	$35.	Q4
7	Q5	Char	19	$19.	$19.	Q5
8	Q8	Num	8			RESPONSE
9	Q9	Num	8			AWARNESS
10	Q10	Num	8			REPORTING
11	Q11	Num	8			TRAINING
12	Q12	Num	8			INVOLVEMENT
13	Q13	Num	8			PROMOTION
14	Q14	Num	8			SYSTEM
15	Q15	Num	8			UTILIZE
16	Q16	Num	8			RECONIZE
17	Q17	Num	8			LEADERSHIP
18	Q18	Num	8			CONCERN_1
19	Q19	Num	8			ACCEDENTS_2
20	Q20	Num	8			MEASURES
21	Q21	Num	8			PPE
22	Q22	Num	8			CONCERN_2
23	Q23	Num	8			NEEDS
24	Q24	Num	8			HESITANT
25	Q25	Num	8			REPORTING
26	Q26	Num	8			LITERATURE
27	Q27	Num	8			DISCARD
1	_	Num	8			3

LSU DATA
RUN 2 - CFA - REVISED MEASUREMENT MODEL CULTURE 8/7/17

The MEANS Procedure

Variable	Label	N	Mean	Std Dev	Minimum	Maximum
_	3	306	158.5000000	88.4788110	6.0000000	311.0000000
F2	EMPLOYEE	306	4641360188	17856917.76	4620258107	4686241915
Q8	RESPONSE	306	5.7549020	1.1053041	1.0000000	7.0000000
Q9	AWARNESS	306	5.7516340	1.2269169	1.0000000	7.0000000
Q10	REPORTING	306	6.0032680	1.0097829	2.0000000	7.0000000
Q11	TRAINING	306	5.8398693	1.0790913	1.0000000	7.0000000
Q12	INVOLVEMENT	306	5.4901961	1.2472535	2.0000000	7.0000000
Q13	PROMOTION	306	5.4671242	1.3375670	1.0000000	7.0000000
Q14	SYSTEM	306	6.0197386	0.9441478	2.0000000	7.0000000
Q15	UTILIZE	306	5.6895425	1.1502053	1.0000000	7.0000000
Q16	RECONIZE	306	3.4242484	1.7725230	1.0000000	7.0000000
Q17	LEADERSHIP	306	5.2360784	1.3391988	1.0000000	7.0000000
Q18	CONCERN_1	306	6.2581699	0.8109993	3.0000000	7.0000000
Q19	ACCEDENTS_2	306	4.8158170	1.7270122	1.0000000	7.0000000
Q20	MEASURES	306	6.2532680	0.8006078	1.0000000	7.0000000
Q21	PPE	306	4.9477124	2.0891314	1.0000000	7.0000000
Q22	CONCERN_2	306	6.4360784	1.1293452	1.0000000	7.0000000
Q23	NEEDS	306	5.7475490	1.2539259	1.0000000	7.0000000
Q24	HESITANT	306	5.3366013	1.6697208	1.0000000	7.0000000
Q25	REPORTING	306	4.9901961	1.4787795	1.0000000	7.0000000
Q26	LITERATURE	306	5.6405229	1.2393249	1.0000000	7.0000000
Q27	DISCARD	306	6.1311438	1.2449954	1.0000000	7.0000000
B1A	OPEN	290	6.0596516	1.4190779	1.0000000	7.0000000
B1B	PICKUP	290	3.2867609	2.2216998	1.0000000	7.0000000
B1C	LEAVE	290	4.9268640	2.0372512	1.0000000	7.0000000
B1D	REPORT	290	6.0279009	1.4285485	1.0000000	7.0000000
B2A	EHS	290	4.1275862	2.1227710	1.0000000	7.0000000
B2B	SOP	290	5.4413793	1.7043639	1.0000000	7.0000000
B2C	RUN	290	2.8650690	1.8949368	1.0000000	7.0000000
B2D	REVIEW	290	6.1586207	1.2707835	1.0000000	7.0000000
B3A	QUENCH	290	5.7500000	1.5339300	1.0000000	7.0000000
B3B	FINISH	290	5.4513448	1.6187906	1.0000000	7.0000000
B3C	CONTACT	290	4.9094138	1.9292365	1.0000000	7.0000000
B3D	OBSERVE	290	5.6562759	1.6076900	1.0000000	7.0000000

LSU DATA
RUN 2 - CFA - REVISED MEASUREMENT MODEL CULTURE 8/7/17

The CALIS Procedure
Covariance Structure Analysis: Model and Initial Values

Modeling Information	
Maximum Likelihood Estimation	
Data Set	WORK.TEST_1
N Records Read	306
N Records Used	290
N Obs	290
Model Type	LINEQS
Analysis	Covariances

Variables in the Model		
Endogenous	Manifest	B1A B1D B2A B2B B2C B3A B3B B3C B3D Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19 Q20 Q21 Q22 Q23 Q24 Q25 Q26 Q27 Q8 Q9
	Latent	f12 f13 f5 f9
Exogenous	Manifest	
	Latent	F1 F10 F11 f2 f3 f4 f6 f7 f8
	Error	E29 E33 E34 E35 E30 E36 E31 E32 E28 e10 e11 e12 e13 e14 e15 e16 e17 e18 e19 e20 e21 e22 e23 e24 e25 e26 e27 e8 e9 D12 d13 D5 D9
Number of Endogenous Variables = 33 Number of Exogenous Variables = 42		

Initial Estimates for Linear Equations

```
Q8  =  LQ8f1   (.) F1  +         1  e8
Q9  =  LQ9F1   (.) F1  +         1  e9
Q10 =  lq10f1  (.) F1  +         1  e10
Q11 =  LQ11F2  (.) f2  +         1  e11
Q12 =  lq12f2  (.) f2  +         1  e12
Q13 =  LQ13F2  (.) f2  +         1  e13
Q14 =  LQ14F3  (.) f3  +         1  e14
Q15 =  LQ15F3  (.) f3  +         1  e15
Q16 =  LQ16F4  (.) f4  +         1  e16
Q17 =  lq17f4  (.) f4  +         1  e17
f5  =  PF5F1   (.) F1  + PF5F2  (.) f2  + PF5F3  (.) f3  + PF5F4 (.) f4  +  1 D5
Q19 =  LQ19F8  (.) f8  +         1  e19
Q27 =  lq27f8  (.) f8  +         1  e27
Q21 =  lq21f8  (.) f8  +         1  e21
Q18 =  LQ18F7  (.) f7  +         1  e18
Q20 =  LQ20F7  (.) f7  +         1  e20
Q26 =  lq26f7  (.) f7  +         1  e26
Q22 =  lq22f6  (.) f6  +         1  e22
Q23 =  lq23f6  (.) f6  +         1  e23
Q24 =  lq24F6  (.) f6  +         1  e24
Q25 =  lq25F6  (.) f6  +         1  e25
f9  =  PF9F6   (.) f6  + PF9F7  (.) f7  + PF9F8  (.) f8  +        1  D9
B1A =  LB1AF10 (.) F10 +         1  E29
B2C =  LB2CF10 (.) F10 +         1  E30
B3B =  LB3BF10 (.) F10 +         1  E31
B3C =  LB3CF10 (.) F10 +         1  E32
B1D =  LB1DF11 (.) F11 +         1  E33
B2A =  LB2AF11 (.) F11 +         1  E34
B2B =  LB2BF11 (.) F11 +         1  E35
B3A =  LB3AF11 (.) F11 +         1  E36
B3D =  LB3DF11 (.) F11 +         1  E28
f12 =  PF12F10 (.) F10 + PF12F7 (.) F11 +         1  D12
f13 =  pf13f5  (.) f5  + p13f9  (.) f9  + p13f12 (.) f12 +        1  d13
```

LSU DATA
RUN 2 - REVISED MEASUREMENT MODEL - 8/7/17

The CALIS Procedure
Covariance Structure Analysis: Descriptive Statistics

Simple Statistics			
Variable		Mean	Std Dev
Q8	RESPONSE	5.75862	1.11160
Q9	AWARNESS	5.72069	1.24836
Q10	REPORTING	5.99310	1.02222
Q11	TRAINING	5.83793	1.09003
Q12	INVOLVEMENT	5.48621	1.25398
Q13	PROMOTION	5.46876	1.32806
Q14	SYSTEM	6.02772	0.92967
Q15	UTILIZE	5.69655	1.13652
Q16	RECONIZE	3.40628	1.77006
Q17	LEADERSHIP	5.22497	1.34959
Q18	CONCERN_1	6.27931	0.79002
Q19	ACCEDENTS_2	4.80221	1.73277
Q20	MEASURES	6.25690	0.80006
Q21	PPE	4.97241	2.08950
Q22	CONCERN_2	6.43448	1.13646
Q23	NEEDS	5.72672	1.27174
Q24	HESITANT	5.36207	1.66272
Q25	REPORTING	4.99310	1.49044
Q26	LITERATURE	5.65172	1.22238
Q27	DISCARD	6.10734	1.25292
B1A	OPEN	6.05965	1.41908
B1D	REPORT	6.02790	1.42855
B2A	EHS	4.12759	2.12277
B2B	SOP	5.44138	1.70436
B2C	RUN	2.86507	1.89494
B3A	QUENCH	5.75000	1.53393
B3B	FINISH	5.45134	1.61879
B3C	CONTACT	4.90941	1.92924
B3D	OBSERVE	5.65628	1.60769

LSU DATA

RUN 2 - REVISED MEASUREMENT MODEL - 8/7/17

The CALIS Procedure
Covariance Structure Analysis: Optimization

Initial Estimation Methods	
1	Instrumental Variables Method
2	McDonald Method
3	Default Initial Values

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
1	LQ8f1	0.65774	0.02138
2	LQ9F1	0.75049	0.02417
3	lq10f1	0.71699	0.02323
4	LQ11F2	0.73407	0.02304
5	lq12f2	0.88702	0.02754
6	LQ13F2	0.96318	0.03005
7	LQ14F3	0.62042	0.01933
8	LQ15F3	0.83368	0.02556
9	LQ16F4	1.15688	0.03608
10	lq17f4	0.94980	0.03006
11	PF5F1	0.50000	0
12	PF5F2	0.50000	0
13	PF5F3	0.50000	0
14	PF5F4	0.50000	0
15	LQ19F8	1.20008	0.03985
16	lq27f8	0.63936	0.02131
17	lq21f8	0.51084	0.01549
18	LQ18F7	0.45895	0.01471
19	LQ20F7	0.34224	0.01077
20	lq26f7	0.55701	0.01706
21	lq22f6	0.31887	0.00975
22	lq23f6	0.67861	0.02012
23	lq24F6	1.09723	0.03236
24	lq25F6	0.28870	0.00843
25	PF9F6	0.50000	0

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
26	PF9F7	0.50000	0
27	PF9F8	0.50000	0
28	LB1AF10	0.62611	0.02190
29	LB2CF10	0.52425	0.01742
30	LB3BF10	0.96450	0.03248
31	LB3CF10	0.24731	0.00675
32	LB1DF11	0.77067	0.02517
33	LB2AF11	1.10576	0.03411
34	LB2BF11	1.10953	0.03640
35	LB3AF11	0.38413	0.01172
36	LB3DF11	0.49675	0.01548
37	PF12F10	0.50000	0
38	PF12F7	0.50000	0
39	pf13f5	0.50000	0
40	p13f9	0.50000	0
41	p13f12	0.50000	0
42	vare8	50.00000	0.01938
43	vare9	50.00000	0.01922
44	vare10	50.00000	0.01944
45	vare11	50.00000	0.01938
46	vare12	50.00000	0.01917
47	vare13	50.00000	0.01905
48	vare14	50.00000	0.01955
49	vare15	50.00000	0.01931
50	vare16	50.00000	0.01840
51	vare17	50.00000	0.01903
52	vare18	50.00000	0.01969
53	vare19	50.00000	0.01838
54	vare20	50.00000	0.01971
55	vare21	50.00000	0.01819
56	vare22	50.00000	0.01946
57	vare23	50.00000	0.01924
58	vare24	50.00000	0.01861
59	vare25	50.00000	0.01909
60	vare26	50.00000	0.01932

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
61	vare27	50.00000	0.01925
62	vare28	50.00000	0.01890
63	vare29	50.00000	0.01907
64	vare30	50.00000	0.01848
65	vare31	50.00000	0.01868
66	vare32	50.00000	0.01850
67	vare33	50.00000	0.01902
68	vare34	50.00000	0.01790
69	vare35	50.00000	0.01849
70	vare36	50.00000	0.01902
71	VARD5	50.00000	0
72	vard9	50.00000	0
73	vard12	50.00000	0
74	vard13	50.00000	0
75	cF1F2	0.68662	-0.00294
76	CF1F3	0.65670	-0.00132
77	CF1F4	0.53839	-0.00221
78	CF1F6	0.70119	-0.00590
79	CF1F7	0.58128	-0.0006802
80	CF1F9	0.43910	-0.00169
81	CF1F10	0.29897	-0.0009590
82	CF1F11	0.19366	-0.0009780
83	CF2F3	0.78759	-0.00241
84	CF2F4	0.75231	-0.00478
85	CF2F7	0.69567	-0.00127
86	CF2F8	0.28696	-0.00148
87	CF2F10	-0.05052	0.0004583
88	CF2F11	0.25812	-0.00217
89	CF3F4	0.73935	-0.00225
90	CF3F6	0.93408	-0.00240
91	CF3F7	0.77456	-0.0006814
92	CF3F8	0.36190	-0.0009246
93	CF3F10	0.07274	-0.0000796
94	CF3F11	0.29207	-0.00119
95	CF4F6	0.53842	-0.00261

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
96	CF4F7	0.45970	-0.0007538
97	CF4F8	0.20692	-0.0009823
98	CF4F10	-0.18734	0.00117
99	CF4F11	0.39629	-0.00370
100	CF6F7	0.70186	-0.00100
101	CF6F8	0.76182	-0.00382
102	CF6F10	0.44588	-0.00176
103	CF6F11	0.29370	-0.00198
104	CF7F8	0.44400	-0.0007088
105	CF7F10	0.61310	-0.0008728
106	CF7F11	0.58214	-0.00159
107	CF8C10	0.38026	-0.00168
108	CF8F11	0.21093	-0.00165
109	CF10F11	0.44991	-0.00330
Value of Objective Function = 75.287500055			

LSU DATA

RUN 2 - REVISED MEASUREMENT MODEL - 8/7/17

The CALIS Procedure

Covariance Structure Analysis: Optimization

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	109
Functions (Observations)	435

Optimization Start			
Active Constraints	0	Objective Function	75.287500055
Max Abs Gradient Element	0.03984522	Radius	1

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
1	*	0	4	0		69.58390	5.7036	0.0245	4.297	1.159
2	*	0	6	0		69.32695	0.2569	0.0244	0.0657	0.971
3	*	0	8	0		68.82237	0.5046	0.0249	0.0311	1.006
4	*	0	10	0		67.78543	1.0369	0.0259	0.0154	1.034
5	*	0	12	0		64.38824	3.3972	0.0583	0.00458	1.079
6	*	0	15	0		63.62981	0.7584	0.0304	0.0352	0.887
7	*	0	17	0		62.14014	1.4897	0.0322	0.0150	1.039
8	*	0	19	0		59.28951	2.8506	0.0648	0.00750	0.959
9	*	0	22	0		58.43367	0.8558	0.0375	0.0569	0.942
10	*	0	24	0		57.07354	1.3601	0.0398	0.0235	0.935
11	*	0	26	0		54.27977	2.7938	0.0546	0.0113	0.955
12	*	0	28	0		46.64028	7.6395	0.2224	0.00482	1.242
13	*	0	30	0		20.58107	26.0592	0.2461	0.00103	2.443
14	*	0	34	0		19.01029	1.5708	0.2846	0.358	1.148
15	*	0	36	0		15.46979	3.5405	0.4016	0.146	1.295
16	*	0	38	0		8.71463	6.7552	0.4781	0.0440	1.563
17	*	0	41	0		7.49160	1.2230	0.2967	0.366	1.160
18	*	0	43	0		5.82446	1.6671	0.1922	0.103	1.206
19	*	0	45	0		4.14933	1.6751	1.4597	0.0178	1.207
20	*	0	48	0		3.76666	0.3827	0.3116	0.0969	0.967
21	*	0	50	0		3.50704	0.2596	0.5253	0.0191	0.971
22	*	0	52	0		3.44555	0.0615	0.5668	0.00803	0.220
23	*	0	55	0		3.13409	0.3115	0.8167	0.975	0.895
24	*	0	57	0		2.84005	0.2940	0.5622	0.129	1.023
25	*	0	59	0		2.72305	0.1170	0.8004	0.0191	0.878
26	*	0	62	0		2.60212	0.1209	1.3720	0.0752	0.888
27	*	0	64	0		2.54452	0.0576	0.6421	0.0143	0.543
28	*	0	66	0		2.49275	0.0518	1.4765	0.00139	0.615
29	*	0	68	0		2.47533	0.0174	0.5664	0.00008	0.353
30	*	0	70	0		2.46797	0.00736	1.4030	0.00002	0.224
31	*	0	72	0		2.45860	0.00937	0.5188	0.00007	0.281
32	*	0	74	0		2.45395	0.00464	1.0342	0.00002	0.209
33	*	0	76	0		2.44866	0.00529	0.4613	0.00005	0.261

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
34	*	0	78	0		2.44632	0.00234	0.6780	0.00001	0.181
35	*	0	80	0		2.44402	0.00230	0.4100	0.00004	0.213
36	*	0	82	0		2.44288	0.00113	0.4537	3.31E-6	0.158
37	*	0	84	0		2.44201	0.000876	0.3641	0.00003	0.156
38	*	0	86	0		2.44081	0.00120	0.1650	3.55E-6	0.293
39	*	0	89	0		2.44030	0.000509	0.1621	0.00011	0.264
40	*	0	91	0		2.43991	0.000389	0.0831	0.00005	0.299
41	*	0	93	0		2.43984	0.000071	0.1176	0.00015	0.0974
42	*	0	95	0		2.43962	0.000221	0.0540	0.00022	0.317
43	*	0	97	0		2.43953	0.000089	0.0626	0.00049	0.207
44	*	0	99	0		2.43937	0.000164	0.0262	0.00037	0.453
45	*	0	101	0		2.43928	0.000086	0.0431	0.00067	0.368
46	*	0	103	0		2.43911	0.000177	0.00854	0.00064	0.718
47	*	0	105	0		2.43897	0.000136	0.0326	0.00103	0.714
48	*	0	107	0		2.43872	0.000253	0.00845	0.00114	0.992
49	*	0	109	0		2.43850	0.000216	0.0898	0.00086	0.437
50	*	0	111	0		2.43716	0.00134	0.0834	0.00130	0.883
51	*	0	114	0		2.43540	0.00177	0.0109	0.0111	1.096
52	*	0	116	0		2.43315	0.00225	0.0582	0.00964	1.116
53	*	0	118	0		2.42802	0.00513	0.1379	0.00650	0.752
54	*	0	121	0		2.39568	0.0323	0.0602	0.0523	1.257
55	*	0	123	0		2.35537	0.0403	0.1422	0.0513	1.086
56	*	0	125	0		2.28033	0.0750	0.0409	444E-16	1.284
57	*	0	127	0		2.27124	0.00909	0.0131	444E-16	1.135
58	*	0	129	0		2.27068	0.000562	0.0116	444E-16	0.950
59	*	0	131	0		2.27059	0.000094	0.00455	444E-16	0.705
60	*	0	133	0		2.27056	0.000027	0.00473	444E-16	0.532
61	*	1	137	0		2.27055	0.000011	0.00246	444E-16	0.429
62	*	1	139	0		2.27054	5.091E-6	0.00237	444E-16	0.376
63	*	1	141	0		2.27054	2.673E-6	0.00135	444E-16	0.349
64	*	1	143	0		2.27054	1.459E-6	0.00130	444E-16	0.331
65	*	1	145	0		2.27054	8.217E-7	0.000757	444E-16	0.321
66	*	1	147	0		2.27054	4.656E-7	0.000733	444E-16	0.313

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
67	*	1	149	0		2.27054	2.672E-7	0.000432	444E-16	0.308
68	*	1	151	0		2.27054	1.535E-7	0.000420	444E-16	0.304
69	*	1	153	0		2.27054	8.869E-8	0.000249	444E-16	0.300
70	*	1	155	0		2.27054	5.123E-8	0.000243	444E-16	0.297
71	*	1	157	0		2.27054	2.97E-8	0.000144	444E-16	0.295
72	*	1	159	0		2.27054	1.72E-8	0.000140	444E-16	0.292
73	*	1	161	0		2.27054	9.985E-9	0.000084	444E-16	0.290
74	*	1	163	0		2.27054	5.793E-9	0.000081	444E-16	0.288
75	*	1	165	0		2.27054	3.365E-9	0.000049	444E-16	0.286
76	*	1	167	0		2.27054	1.954E-9	0.000047	444E-16	0.285

Optimization Results			
Iterations	76	Function Calls	170
Jacobian Calls	79	Active Constraints	0
Objective Function	2.270538281	Max Abs Gradient Element	0.0000472353
Lambda	4.440892E-14	Actual Over Pred Change	0.284578936
Radius	170.26176261		

Convergence criterion (GCONV=1E-8) satisfied.

LSU DATA

RUN 2 - REVISED MEASUREMENT MODEL - 8/7/17

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Summary		
Modeling Info	Number of Observations	290
	Number of Variables	29
	Number of Moments	435
	Number of Parameters	109
	Number of Active Constraints	0
	Baseline Model Function Value	7.4837
	Baseline Model Chi-Square	2162.8019
	Baseline Model Chi-Square DF	406

Fit Summary		
	Pr > Baseline Model Chi-Square	<.0001
Absolute Index	Fit Function	2.2705
	Chi-Square	656.1856
	Chi-Square DF	326
	Pr > Chi-Square	<.0001
	Z-Test of Wilson & Hilferty	10.0845
	Hoelter Critical N	163
	Root Mean Square Residual (RMR)	0.1473
	Standardized RMR (SRMR)	0.0640
	Goodness of Fit Index (GFI)	0.8654
Parsimony Index	Adjusted GFI (AGFI)	0.8204
	Parsimonious GFI	0.6949
	RMSEA Estimate	0.0592
	RMSEA Lower 90% Confidence Limit	0.0526
	RMSEA Upper 90% Confidence Limit	0.0657
	Probability of Close Fit	0.0113
	ECVI Estimate	3.1122
	ECVI Lower 90% Confidence Limit	2.8654
	ECVI Upper 90% Confidence Limit	3.3894
	Akaike Information Criterion	874.1856
	Bozdogan CAIC	1383.2026
	Schwarz Bayesian Criterion	1274.2026
	McDonald Centrality	0.5659
Incremental Index	Bentler Comparative Fit Index	0.8121
	Bentler-Bonett NFI	0.6966
	Bentler-Bonett Non-normed Index	0.7659
	Bollen Normed Index Rho1	0.6222
	Bollen Non-normed Index Delta2	0.8202
	James et al. Parsimonious NFI	0.5593

Linear Equations

```
Q8  =   0.6007 (**) F1  + 1.0000  e8
Q9  =   0.8061 (**) F1  + 1.0000  e9
Q10 =   0.7315 (**) F1  + 1.0000  e10
Q11 =   0.6967 (**) f2  + 1.0000  e11
Q12 =   0.9221 (**) f2  + 1.0000  e12
Q13 =   0.9531 (**) f2  + 1.0000  e13
Q14 =   0.6151 (**) f3  + 1.0000  e14
```

```
                                Linear Equations
Q15 =   0.8525 (**) f3  + 1.0000  e15
Q16 =   1.1501 (**) f4  + 1.0000  e16
Q17 =   0.9598 (**) f4  + 1.0000  e17
f5  =   0.5000      F1  + 0.5000  f2  + 0.5000  f3  + 0.5000  f4  + 1.0000  D5
Q19 =   1.0644 (**) f8  + 1.0000  e19
Q27 =   0.5735 (**) f8  + 1.0000  e27
Q21 =   0.6823 (**) f8  + 1.0000  e21
Q18 =   0.4633 (**) f7  + 1.0000  e18
Q20 =   0.3658 (**) f7  + 1.0000  e20
Q26 =   0.5705 (**) f7  + 1.0000  e26
Q22 =   0.2868 (**) f6  + 1.0000  e22
Q23 =   0.6596 (**) f6  + 1.0000  e23
Q24 =   1.1249 (**) f6  + 1.0000  e24
Q25 =   0.3096 (**) f6  + 1.0000  e25
f9  =   0.5004      f6  + 0.5000  f7  + 0.5002  f8  + 1.0000  D9
B1A =   0.2120 (**) F10 + 1.0000  E29
B2C =   0.4331 (**) F10 + 1.0000  E30
B3B =   1.2858 (**) F10 + 1.0000  E31
B3C =   0.9035 (**) F10 + 1.0000  E32
B1D =   0.6719 (**) F11 + 1.0000  E33
B2A =   1.2484 (**) F11 + 1.0000  E34
B2B =   0.8145 (**) F11 + 1.0000  E35
B3A =   0.6128 (**) F11 + 1.0000  E36
B3D =   0.6362 (**) F11 + 1.0000  E28
f12 =   0.5007      F10 + 0.5006  F11 + 1.0000  D12
f13 =   0.5004      f5  + 0.5004  f9  + 0.4999  f12 + 1.0000  d13
```

Effects in Linear Equations						
Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Q8	F1	LQ8f1	0.60071	0.06975	8.6124	<.0001
Q9	F1	LQ9F1	0.80614	0.07640	10.5520	<.0001
Q10	F1	lq10f1	0.73147	0.06193	11.8103	<.0001
Q11	f2	LQ11F2	0.69674	0.06298	11.0620	<.0001
Q12	f2	lq12f2	0.92208	0.06999	13.1753	<.0001
Q13	f2	LQ13F2	0.95308	0.07457	12.7812	<.0001
Q14	f3	LQ14F3	0.61506	0.05368	11.4576	<.0001
Q15	f3	LQ15F3	0.85248	0.06527	13.0606	<.0001
Q16	f4	LQ16F4	1.15014	0.11006	10.4505	<.0001
Q17	f4	lq17f4	0.95980	0.08478	11.3211	<.0001
f5	F1	PF5F1	0.50000	.	.	.
f5	f2	PF5F2	0.50000	.	.	.

Effects in Linear Equations						
Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
f5	f3	PF5F3	0.50000	.	.	.
f5	f4	PF5F4	0.50000	.	.	.
Q19	f8	LQ19F8	1.06437	0.13816	7.7037	<.0001
Q27	f8	lq27f8	0.57345	0.09264	6.1899	<.0001
Q21	f8	lq21f8	0.68226	0.15453	4.4150	<.0001
Q18	f7	LQ18F7	0.46334	0.05205	8.9022	<.0001
Q20	f7	LQ20F7	0.36581	0.05222	7.0047	<.0001
Q26	f7	lq26f7	0.57048	0.07976	7.1525	<.0001
Q22	f6	lq22f6	0.28681	0.07160	4.0057	<.0001
Q23	f6	lq23f6	0.65965	0.07823	8.4319	<.0001
Q24	f6	lq24F6	1.12486	0.10357	10.8610	<.0001
Q25	f6	lq25F6	0.30964	0.09419	3.2874	0.0010
f9	f6	PF9F6	0.50037	.	.	.
f9	f7	PF9F7	0.50000	.	.	.
f9	f8	PF9F8	0.50018	.	.	.
B1A	F10	LB1AF10	0.21202	0.09746	2.1755	0.0296
B2C	F10	LB2CF10	0.43308	0.12963	3.3408	0.0008
B3B	F10	LB3BF10	1.28583	0.12705	10.1210	<.0001
B3C	F10	LB3CF10	0.90347	0.13087	6.9036	<.0001
B1D	F11	LB1DF11	0.67189	0.10106	6.6482	<.0001
B2A	F11	LB2AF11	1.24839	0.15026	8.3085	<.0001
B2B	F11	LB2BF11	0.81449	0.12052	6.7581	<.0001
B3A	F11	LB3AF11	0.61275	0.10917	5.6128	<.0001
B3D	F11	LB3DF11	0.63622	0.11446	5.5584	<.0001
f12	F10	PF12F10	0.50075	.	.	.
f12	F11	PF12F7	0.50060	.	.	.
f13	f5	pf13f5	0.50037	.	.	.
f13	f9	p13f9	0.50038	.	.	.
f13	f12	p13f12	0.49985	.	.	.

Estimates for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Error	e8	vare8	0.87246	0.08383	10.4076	<.0001
	e9	vare9	0.90432	0.09877	9.1557	<.0001
	e10	vare10	0.50642	0.06504	7.7862	<.0001
	e11	vare11	0.70588	0.06909	10.2166	<.0001
	e12	vare12	0.72775	0.08207	8.8675	<.0001
	e13	vare13	0.86127	0.09369	9.1929	<.0001
	e14	vare14	0.49110	0.04975	9.8719	<.0001
	e15	vare15	0.57480	0.07252	7.9255	<.0001
	e16	vare16	1.81640	0.20388	8.9092	<.0001
	e17	vare17	0.90442	0.12143	7.4478	<.0001
	e18	vare18	0.41071	0.04421	9.2894	<.0001
	e19	vare19	1.85907	0.26911	6.9084	<.0001
	e20	vare20	0.50706	0.04665	10.8694	<.0001
	e21	vare21	3.89621	0.35060	11.1129	<.0001
	e22	vare22	1.20928	0.10190	11.8675	<.0001
	e23	vare23	1.18218	0.10906	10.8397	<.0001
	e24	vare24	1.49934	0.18030	8.3157	<.0001
	e25	vare25	2.12553	0.17828	11.9224	<.0001
	e26	vare26	1.17065	0.10844	10.7949	<.0001
	e27	vare27	1.23790	0.12456	9.9384	<.0001
	E28	vare28	2.18015	0.20189	10.7989	<.0001
	E29	vare29	1.96825	0.16516	11.9170	<.0001
	E30	vare30	3.40080	0.28909	11.7637	<.0001
	E31	vare31	0.94567	0.26925	3.5122	0.0004
	E32	vare32	2.89511	0.27683	10.4581	<.0001
	E33	vare33	1.58961	0.15681	10.1375	<.0001
	E34	vare34	2.94870	0.34713	8.4945	<.0001
	E35	vare35	2.24190	0.22293	10.0567	<.0001
	E36	vare36	1.97772	0.18362	10.7710	<.0001
Latent	F1		1.00000			
	f2		1.00000			
	f3		1.00000			
	f4		1.00000			
	f6		1.00000			
	f7		1.00000			

Estimates for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
	f8		1.00000			
	F10		1.00000			
	F11		1.00000			
Disturbance	D5	VARD5	50.00101	.	.	.
	D9	vard9	49.99972	.	.	.
	D12	vard12	50.00027	.	.	.
	d13	vard13	49.99952	.	.	.

Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
F1	f2	cF1F2	0.66340	0.05983	11.0878	<.0001
F1	f3	CF1F3	0.62422	0.06547	9.5350	<.0001
F1	f4	CF1F4	0.54717	0.07475	7.3198	<.0001
F1	f6	CF1F6	0.69752	0.05929	11.7655	<.0001
F1	f7	CF1F7	0.56099	0.08511	6.5915	<.0001
F1	f8	CF1F9	0.46282	0.09152	5.0572	<.0001
F1	F10	CF1F10	0.34948	0.08172	4.2766	<.0001
F1	F11	CF1F11	0.20929	0.08952	2.3379	0.0194
f2	f3	CF2F3	0.81099	0.05175	15.6714	<.0001
f2	f4	CF2F4	0.75586	0.05943	12.7175	<.0001
f2	f6	CF1F6	0.69752	0.05929	11.7655	<.0001
f2	f7	CF2F7	0.69193	0.07516	9.2057	<.0001
f2	f8	CF2F8	0.34752	0.09079	3.8277	0.0001
f2	F10	CF2F10	0.03599	0.08241	0.4368	0.6623
f2	F11	CF2F11	0.23819	0.08521	2.7952	0.0052
f3	f4	CF3F4	0.74170	0.06707	11.0591	<.0001
f3	f6	CF3F6	0.94191	0.06607	14.2569	<.0001
f3	f7	CF3F7	0.79462	0.07767	10.2314	<.0001
f3	f8	CF3F8	0.39676	0.09633	4.1190	<.0001
f3	F10	CF3F10	0.12212	0.08664	1.4095	0.1587
f3	F11	CF3F11	0.27216	0.08940	3.0442	0.0023
f4	f6	CF4F6	0.58934	0.08351	7.0575	<.0001
f4	f7	CF4F7	0.42919	0.09542	4.4980	<.0001
f4	f8	CF4F8	0.27381	0.10181	2.6893	0.0072

Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
f4	F10	CF4F10	-0.06013	0.08945	-0.6723	0.5014
f4	F11	CF4F11	0.36768	0.08921	4.1215	<.0001
f6	f7	CF6F7	0.70837	0.09189	7.7091	<.0001
f6	f8	CF6F8	0.77357	0.09544	8.1049	<.0001
f6	F10	CF6F10	0.38657	0.08908	4.3396	<.0001
f6	F11	CF6F11	0.29517	0.09706	3.0411	0.0024
f7	f8	CF7F8	0.44645	0.11013	4.0537	<.0001
f7	F10	CF7F10	0.54642	0.09188	5.9471	<.0001
f7	F11	CF7F11	0.51790	0.09526	5.4364	<.0001
f8	F10	CF8C10	0.34419	0.09841	3.4976	0.0005
f8	F11	CF8F11	0.19906	0.10635	1.8717	0.0612
F10	F11	CF10F11	0.44204	0.08617	5.1300	<.0001

Squared Multiple Correlations			
Variable	Error Variance	Total Variance	R-Square
Q8	0.87246	1.23331	0.2926
Q9	0.90432	1.55418	0.4181
Q10	0.50642	1.04146	0.5137
Q11	0.70588	1.19133	0.4075
Q12	0.72775	1.57799	0.5388
Q13	0.86127	1.76963	0.5133
Q14	0.49110	0.86940	0.4351
Q15	0.57480	1.30152	0.5584
Q16	1.81640	3.13923	0.4214
Q17	0.90442	1.82565	0.5046
f5	50.00101	53.07268	0.0579
Q19	1.85907	2.99196	0.3786
Q27	1.23790	1.56675	0.2099
Q21	3.89621	4.36169	0.1067
Q18	0.41071	0.62539	0.3433
Q20	0.50706	0.64087	0.2088
Q26	1.17065	1.49610	0.2175
Q22	1.20928	1.29154	0.0637
Q23	1.18218	1.61732	0.2690

Squared Multiple Correlations			
Variable	Error Variance	Total Variance	R-Square
Q24	1.49934	2.76465	0.4577
Q25	2.12553	2.22141	0.0432
f9	49.99972	51.71523	0.0332
B1A	1.96825	2.01320	0.0223
B2C	3.40080	3.58835	0.0523
B3B	0.94567	2.59902	0.6361
B3C	2.89511	3.71136	0.2199
B1D	1.58961	2.04105	0.2212
B2A	2.94870	4.50719	0.3458
B2B	2.24190	2.90529	0.2283
B3A	1.97772	2.35319	0.1596
B3D	2.18015	2.58493	0.1566
f12	50.00027	50.72323	0.0143
f13	49.99952	90.25038	0.4460

Standardized Results for Linear Equations

```
Q8  =  0.5409 (**) F1  + 1.0000      e8
Q9  =  0.6466 (**) F1  + 1.0000      e9
Q10 =  0.7168 (**) F1  + 1.0000      e10
Q11 =  0.6383 (**) f2  + 1.0000      e11
Q12 =  0.7340 (**) f2  + 1.0000      e12
Q13 =  0.7165 (**) f2  + 1.0000      e13
Q14 =  0.6596 (**) f3  + 1.0000      e14
Q15 =  0.7472 (**) f3  + 1.0000      e15
Q16 =  0.6491 (**) f4  + 1.0000      e16
Q17 =  0.7104 (**) f4  + 1.0000      e17
f5  =  0.0686 (**) F1  + 0.0686 (**) f2  + 0.0686 (**) f3  + 0.0686 (**) f4  + 1.0000  D5
Q19 =  0.6153 (**) f8  + 1.0000      e19
Q27 =  0.4581 (**) f8  + 1.0000      e27
Q21 =  0.3267 (**) f8  + 1.0000      e21
Q18 =  0.5859 (**) f7  + 1.0000      e18
Q20 =  0.4569 (**) f7  + 1.0000      e20
Q26 =  0.4664 (**) f7  + 1.0000      e26
Q22 =  0.2524 (**) f6  + 1.0000      e22
Q23 =  0.5187 (**) f6  + 1.0000      e23
Q24 =  0.6765 (**) f6  + 1.0000      e24
Q25 =  0.2078 (**) f6  + 1.0000      e25
f9  =  0.0696 (**) f6  + 0.0695 (**) f7  + 0.0696 (**) f8  + 1.0000      D9
B1A =  0.1494 (**) F10 + 1.0000      E29
B2C =  0.2286 (**) F10 + 1.0000      E30
```

```
                         Standardized Results for Linear Equations
B3B =   0.7976 (**) F10 + 1.0000      E31
B3C =   0.4690 (**) F10 + 1.0000      E32
B1D =   0.4703 (**) F11 + 1.0000      E33
B2A =   0.5880 (**) F11 + 1.0000      E34
B2B =   0.4778 (**) F11 + 1.0000      E35
B3A =   0.3994 (**) F11 + 1.0000      E36
B3D =   0.3957 (**) F11 + 1.0000      E28
f12 =   0.0703 (**) F10 + 0.0703 (**) F11 + 1.0000      D12
f13 =   0.3837 (**) f5  + 0.3788 (**) f9  + 0.3747 (**) f12 + 1.0000      d13
```

Standardized Effects in Linear Equations						
Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Q8	F1	LQ8f1	0.54091	0.05217	10.3681	<.0001
Q9	F1	LQ9F1	0.64663	0.04678	13.8227	<.0001
Q10	F1	lq10f1	0.71676	0.04388	16.3361	<.0001
Q11	f2	LQ11F2	0.63834	0.04230	15.0917	<.0001
Q12	f2	lq12f2	0.73404	0.03620	20.2791	<.0001
Q13	f2	LQ13F2	0.71645	0.03726	19.2282	<.0001
Q14	f3	LQ14F3	0.65964	0.04141	15.9292	<.0001
Q15	f3	LQ15F3	0.74724	0.03820	19.5597	<.0001
Q16	f4	LQ16F4	0.64914	0.04781	13.5767	<.0001
Q17	f4	lq17f4	0.71035	0.04690	15.1462	<.0001
f5	F1	PF5F1	0.06863	0.0000756	907.3	<.0001
f5	f2	PF5F2	0.06863	0.0000756	907.3	<.0001
f5	f3	PF5F3	0.06863	0.0000756	907.3	<.0001
f5	f4	PF5F4	0.06863	0.0000756	907.3	<.0001
Q19	f8	LQ19F8	0.61534	0.07009	8.7796	<.0001
Q27	f8	lq27f8	0.45814	0.06739	6.7982	<.0001
Q21	f8	lq21f8	0.32668	0.07043	4.6382	<.0001
Q18	f7	LQ18F7	0.58590	0.05439	10.7724	<.0001
Q20	f7	LQ20F7	0.45695	0.05764	7.9271	<.0001
Q26	f7	lq26f7	0.46640	0.05733	8.1350	<.0001
Q22	f6	lq22f6	0.25237	0.06044	4.1757	<.0001
Q23	f6	lq23f6	0.51870	0.05136	10.0985	<.0001
Q24	f6	lq24F6	0.67652	0.04721	14.3286	<.0001
Q25	f6	lq25F6	0.20775	0.06145	3.3808	0.0007
f9	f6	PF9F6	0.06958	0.0000711	978.3	<.0001
f9	f7	PF9F7	0.06953	0.0000711	978.3	<.0001

Standardized Effects in Linear Equations						
Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
f9	f8	PF9F8	0.06955	0.0000711	978.3	<.0001
B1A	F10	LB1AF10	0.14943	0.06785	2.2023	0.0276
B2C	F10	LB2CF10	0.22862	0.06649	3.4383	0.0006
B3B	F10	LB3BF10	0.79759	0.06569	12.1422	<.0001
B3C	F10	LB3CF10	0.46897	0.06034	7.7715	<.0001
B1D	F11	LB1DF11	0.47030	0.06345	7.4124	<.0001
B2A	F11	LB2AF11	0.58803	0.06023	9.7625	<.0001
B2B	F11	LB2BF11	0.47785	0.06320	7.5604	<.0001
B3A	F11	LB3AF11	0.39945	0.06576	6.0741	<.0001
B3D	F11	LB3DF11	0.39572	0.06588	6.0064	<.0001
f12	F10	PF12F10	0.07031	0.0000299	2348.3	<.0001
f12	F11	PF12F7	0.07029	0.0000299	2348.3	<.0001
f13	f5	pf13f5	0.38371	0.0003886	987.4	<.0001
f13	f9	p13f9	0.37878	0.0003335	1135.9	<.0001
f13	f12	p13f12	0.37473	0.0003035	1234.6	<.0001

Standardized Results for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Error	e8	vare8	0.70741	0.05644	12.5341	<.0001
	e9	vare9	0.58187	0.06050	9.6177	<.0001
	e10	vare10	0.48626	0.06290	7.7310	<.0001
	e11	vare11	0.59252	0.05400	10.9723	<.0001
	e12	vare12	0.46119	0.05314	8.6788	<.0001
	e13	vare13	0.48670	0.05339	9.1158	<.0001
	e14	vare14	0.56487	0.05463	10.3395	<.0001
	e15	vare15	0.44163	0.05709	7.7353	<.0001
	e16	vare16	0.57862	0.06207	9.3212	<.0001
	e17	vare17	0.49540	0.06663	7.4350	<.0001
	e18	vare18	0.65672	0.06373	10.3043	<.0001
	e19	vare19	0.62136	0.08626	7.2037	<.0001
	e20	vare20	0.79120	0.05268	15.0186	<.0001
	e21	vare21	0.89328	0.04602	19.4118	<.0001
	e22	vare22	0.93631	0.03051	30.6929	<.0001
	e23	vare23	0.73095	0.05328	13.7178	<.0001

Standardized Results for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
	e24	vare24	0.54233	0.06388	8.4894	<.0001
	e25	vare25	0.95684	0.02553	37.4749	<.0001
	e26	vare26	0.78247	0.05348	14.6310	<.0001
	e27	vare27	0.79011	0.06175	12.7954	<.0001
	E28	vare28	0.84341	0.05214	16.1752	<.0001
	E29	vare29	0.97767	0.02028	48.2156	<.0001
	E30	vare30	0.94773	0.03040	31.1715	<.0001
	E31	vare31	0.36386	0.10478	3.4725	0.0005
	E32	vare32	0.78007	0.05660	13.7820	<.0001
	E33	vare33	0.77882	0.05968	13.0505	<.0001
	E34	vare34	0.65422	0.07084	9.2355	<.0001
	E35	vare35	0.77166	0.06040	12.7750	<.0001
	E36	vare36	0.84044	0.05254	15.9971	<.0001
Latent	F1		1.00000			
	f2		1.00000			
	f3		1.00000			
	f4		1.00000			
	f6		1.00000			
	f7		1.00000			
	f8		1.00000			
	F10		1.00000			
	F11		1.00000			
Disturbance	D5	VARD5	0.94212	0.00208	453.6	<.0001
	D9	vard9	0.96683	0.00198	489.2	<.0001
	D12	vard12	0.98575	0.0008395	1174.2	<.0001
	d13	vard13	0.55401	0.0008925	620.7	<.0001

Standardized Results for Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
F1	f2	cF1F2	0.66340	0.05983	11.0878	<.0001
F1	f3	CF1F3	0.62422	0.06547	9.5350	<.0001
F1	f4	CF1F4	0.54717	0.07475	7.3198	<.0001
F1	f6	CF1F6	0.69752	0.05929	11.7655	<.0001
F1	f7	CF1F7	0.56099	0.08511	6.5915	<.0001

Standardized Results for Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
F1	f8	CF1F9	0.46282	0.09152	5.0572	<.0001
F1	F10	CF1F10	0.34948	0.08172	4.2766	<.0001
F1	F11	CF1F11	0.20929	0.08952	2.3379	0.0194
f2	f3	CF2F3	0.81099	0.05175	15.6714	<.0001
f2	f4	CF2F4	0.75586	0.05943	12.7175	<.0001
f2	f6	CF1F6	0.69752	0.05929	11.7655	<.0001
f2	f7	CF2F7	0.69193	0.07516	9.2057	<.0001
f2	f8	CF2F8	0.34752	0.09079	3.8277	0.0001
f2	F10	CF2F10	0.03599	0.08241	0.4368	0.6623
f2	F11	CF2F11	0.23819	0.08521	2.7952	0.0052
f3	f4	CF3F4	0.74170	0.06707	11.0591	<.0001
f3	f6	CF3F6	0.94191	0.06607	14.2569	<.0001
f3	f7	CF3F7	0.79462	0.07767	10.2314	<.0001
f3	f8	CF3F8	0.39676	0.09633	4.1190	<.0001
f3	F10	CF3F10	0.12212	0.08664	1.4095	0.1587
f3	F11	CF3F11	0.27216	0.08940	3.0442	0.0023
f4	f6	CF4F6	0.58934	0.08351	7.0575	<.0001
f4	f7	CF4F7	0.42919	0.09542	4.4980	<.0001
f4	f8	CF4F8	0.27381	0.10181	2.6893	0.0072
f4	F10	CF4F10	-0.06013	0.08945	-0.6723	0.5014
f4	F11	CF4F11	0.36768	0.08921	4.1215	<.0001
f6	f7	CF6F7	0.70837	0.09189	7.7091	<.0001
f6	f8	CF6F8	0.77357	0.09544	8.1049	<.0001
f6	F10	CF6F10	0.38657	0.08908	4.3396	<.0001
f6	F11	CF6F11	0.29517	0.09706	3.0411	0.0024
f7	f8	CF7F8	0.44645	0.11013	4.0537	<.0001
f7	F10	CF7F10	0.54642	0.09188	5.9471	<.0001
f7	F11	CF7F11	0.51790	0.09526	5.4364	<.0001
f8	F10	CF8C10	0.34419	0.09841	3.4976	0.0005
f8	F11	CF8F11	0.19906	0.10635	1.8717	0.0612
F10	F11	CF10F11	0.44204	0.08617	5.1300	<.0001

Stepwise Multivariate Wald Test					
	Cumulative Statistics			Univariate Increment	
Parm	Chi-Square	DF	Pr > ChiSq	Chi-Square	Pr > ChiSq
CF2F10	0.19075	1	0.6623	0.19075	0.6623
CF4F10	1.30149	2	0.5217	1.11073	0.2919
CF3F10	4.36487	3	0.2247	3.06338	0.0801
CF8F11	7.77740	4	0.1001	3.41253	0.0647
CF1F11	11.54476	5	0.0416	3.76736	0.0523
CF2F11	14.99021	6	0.0203	3.44545	0.0634
CF3F11	16.36126	7	0.0220	1.37105	0.2416
CF6F11	17.49444	8	0.0254	1.13318	0.2871

RUN 3 - CFA - MEASUREMENT MODEL CULTURE 8/15/17

LSU DATA
Run 3 CFA - FULL MEASUREMENT MODEL CULTURE 8/15/17
****

The CONTENTS Procedure

Data Set Name	WORK.TEST_1	Observations	306
Member Type	DATA	Variables	39
Engine	V9	Indexes	0
Created	08/15/2017 14:37:53	Observation Length	368
Last Modified	08/15/2017 14:37:53	Deleted Observations	0
Protection		Compressed	NO
Data Set Type		Sorted	NO
Label			
Data Representation	WINDOWS_64		
Encoding	wlatin1 Western (Windows)		

Engine/Host Dependent Information	
Data Set Page Size	65536
Number of Data Set Pages	2
First Data Page	1
Max Obs per Page	177
Obs in First Data Page	164
Number of Data Set Repairs	0
ExtendObsCounter	YES
Filename	C:\Users\Machine\AppData\Local\Temp\SAS Temporary Files_TD7200_LAPTOP-OV06L7T4_\test_1.sas7bdat
Release Created	9.0401M2
Host Created	X64_8HOME

LSU DATA

RUN 3 - CFA - REVISED MEASUREMENT MODEL CULTURE 8/15/17
The CALIS Procedure
Covariance Structure Analysis: Model and Initial Values

Modeling Information	
Maximum Likelihood Estimation	
Data Set	WORK.TEST_1
N Records Read	306
N Records Used	290
N Obs	290
Model Type	LINEQS
Analysis	Covariances

Variables in the Model		
Endogenous	Manifest	B1D B2A B2B B2C B3A B3B B3C B3D Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19 Q20 Q21 Q22 Q23 Q24 Q25 Q26 Q27 Q8 Q9
	Latent	f12 f13 f5 f9
Exogenous	Manifest	
	Latent	F1 F10 F11 f2 f3 f4 f6 f7 f8
	Error	E32 E33 E34 E31 E35 E29 E30 E28 e10 e11 e12 e13 e14 e15 e16 e17 e18 e19 e20 e21 e22 e23 e24 e25 e26 e27 e8 e9 D12 d13 D5 D9
Number of Endogenous Variables = 32 Number of Exogenous Variables = 41		

Initial Estimates for Linear Equations

```
Q8  =  LQ8f1   (.) F1  +         1  e8
Q9  =  LQ9F1   (.) F1  +         1  e9
Q10 =  lq10f1  (.) F1  +         1  e10
Q11 =  LQ11F2  (.) f2  +         1  e11
Q12 =  lq12f2  (.) f2  +         1  e12
Q13 =  LQ13F2  (.) f2  +         1  e13
Q14 =  LQ14F3  (.) f3  +         1  e14
Q15 =  LQ15F3  (.) f3  +         1  e15
Q16 =  LQ16F4  (.) f4  +         1  e16
Q17 =  lq17f4  (.) f4  +         1  e17
f5  =  PF5F1   (.) F1  + PF5F2  (.) f2  + PF5F3  (.) f3  + PF5F4 (.) f4  +  1 D5
Q19 =  LQ19F8  (.) f8  +         1  e19
Q27 =  lq27f8  (.) f8  +         1  e27
Q21 =  lq21f8  (.) f8  +         1  e21
```

Initial Estimates for Linear Equations

```
Q18 =  LQ18F7  (.) f7  +        1  e18
Q20 =  LQ20F7  (.) f7  +        1  e20
Q26 =  lq26f7  (.) f7  +        1  e26
Q22 =  lq22f6  (.) f6  +        1  e22
Q23 =  lq23f6  (.) f6  +        1  e23
Q24 =  lq24F6  (.) f6  +        1  e24
Q25 =  lq25F6  (.) f6  +        1  e25
f9  =  PF9F6   (.) f6  + PF9F7  (.) f7  + PF9F8  (.) f8  +        1  D9
B3B =  LB3BF10 (.) F10 +        1  E29
B3C =  LB3CF10 (.) F10 +        1  E30
B2C =  LB2CF10 (.) F10 +        1  E31
B1D =  LB1DF11 (.) F11 +        1  E32
B2A =  LB2AF11 (.) F11 +        1  E33
B2B =  LB2BF11 (.) F11 +        1  E34
B3A =  LB3AF11 (.) F11 +        1  E35
B3D =  LB3DF11 (.) F11 +        1  E28
f12 =  PF12F10 (.) F10 + PF12F7 (.) F11 +        1  D12
f13 =  pf13f5  (.) f5  + p13f9  (.) f9  + p13f12 (.) f12 +        1  d13
```

LSU DATA
RUN 3 - CFA - REVISED MEASUREMENT MODEL CULTURE 8/15/17
The CALIS Procedure
Covariance Structure Analysis: Optimization

Initial Estimation Methods	
	Instrumental Variables Method
	McDonald Method
	Default Initial Values

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
1	LQ8f1	0.65388	0.02126
2	LQ9F1	0.75053	0.02418
3	lq10f1	0.72100	0.02340
4	LQ11F2	0.73523	0.02304
5	lq12f2	0.88294	0.02735
6	LQ13F2	0.96619	0.03012
7	LQ14F3	0.61814	0.01923

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
8	LQ15F3	0.83675	0.02568
9	LQ16F4	1.15510	0.03600
10	lq17f4	0.95127	0.03012
11	PF5F1	0.50000	0
12	PF5F2	0.50000	0
13	PF5F3	0.50000	0
14	PF5F4	0.50000	0
15	LQ19F8	1.18969	0.03960
16	lq27f8	0.64706	0.02169
17	lq21f8	0.51071	0.01559
18	LQ18F7	0.45812	0.01488
19	LQ20F7	0.33857	0.01075
20	lq26f7	0.56044	0.01743
21	lq22f6	0.31236	0.00962
22	lq23f6	0.68857	0.02052
23	lq24F6	1.08205	0.03205
24	lq25F6	0.29665	0.00879
25	PF9F6	0.50000	0
26	PF9F7	0.50000	0
27	PF9F8	0.50000	0
28	LB3BF10	0.71251	0.02382
29	LB3CF10	0.44873	0.01404
30	LB2CF10	1.29111	0.04462
31	LB1DF11	0.78749	0.02586
32	LB2AF11	1.17392	0.03664
33	LB2BF11	1.00011	0.03262
34	LB3AF11	0.42052	0.01323
35	LB3DF11	0.52084	0.01647
36	PF12F10	0.50000	0
37	PF12F7	0.50000	0
38	pf13f5	0.50000	0
39	p13f9	0.50000	0
40	p13f12	0.50000	0
41	vare8	50.00000	0.01939
42	vare9	50.00000	0.01922

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
43	vare10	50.00000	0.01944
44	vare11	50.00000	0.01938
45	vare12	50.00000	0.01917
46	vare13	50.00000	0.01905
47	vare14	50.00000	0.01955
48	vare15	50.00000	0.01931
49	vare16	50.00000	0.01840
50	vare17	50.00000	0.01903
51	vare18	50.00000	0.01969
52	vare19	50.00000	0.01839
53	vare20	50.00000	0.01971
54	vare21	50.00000	0.01819
55	vare22	50.00000	0.01946
56	vare23	50.00000	0.01924
57	vare24	50.00000	0.01862
58	vare25	50.00000	0.01909
59	vare26	50.00000	0.01932
60	vare27	50.00000	0.01925
61	vare28	50.00000	0.01890
62	vare29	50.00000	0.01880
63	vare30	50.00000	0.01846
64	vare31	50.00000	0.01804
65	vare32	50.00000	0.01901
66	vare33	50.00000	0.01785
67	vare34	50.00000	0.01856
68	vare35	50.00000	0.01901
69	VARD5	50.00000	0
70	vard9	50.00000	0
71	vard12	50.00000	0
72	vard13	50.00000	0
73	cF1F2	0.68616	-0.00295
74	CF1F3	0.65585	-0.00132
75	CF1F4	0.53866	-0.00221
76	CF1F6	0.70667	-0.00590
77	CF1F7	0.58056	-0.0006845

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
78	CF1F9	0.44133	-0.00169
79	CF1F10	0.21321	-0.00102
80	CF1F11	0.19573	-0.00101
81	CF2F3	0.78644	-0.00241
82	CF2F4	0.75240	-0.00478
83	CF2F7	0.69560	-0.00127
84	CF2F8	0.28861	-0.00148
85	CF2F10	-0.13004	0.00108
86	CF2F11	0.25338	-0.00212
87	CF3F4	0.73890	-0.00224
88	CF3F6	0.93933	-0.00240
89	CF3F7	0.77309	-0.0006838
90	CF3F8	0.36245	-0.0009257
91	CF3F10	-0.03747	0.0002006
92	CF3F11	0.29016	-0.00119
93	CF4F6	0.54281	-0.00260
94	CF4F7	0.45973	-0.0007468
95	CF4F8	0.20865	-0.0009756
96	CF4F10	-0.16209	0.00130
97	CF4F11	0.40197	-0.00375
98	CF6F7	0.70641	-0.00101
99	CF6F8	0.76472	-0.00378
100	CF6F10	0.24095	-0.00135
101	CF6F11	0.29433	-0.00200
102	CF7F8	0.44621	-0.0007181
103	CF7F10	0.30690	-0.0006155
104	CF7F11	0.59521	-0.00166
105	CF8C10	0.22932	-0.00144
106	CF8F11	0.21459	-0.00171
107	CF10F11	0.28029	-0.00292
Value of Objective Function = 72.865899136			

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	107
Functions (Observations)	406

Optimization Start			
Active Constraints	0	Objective Function	72.865899136
Max Abs Gradient Element	0.0446224683	Radius	1

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
1	*	0	4	0		67.26424	5.6017	0.0301	4.214	1.154
2	*	0	6	0		67.00903	0.2552	0.0245	0.0657	0.964
3	*	0	8	0		66.51221	0.4968	0.0250	0.0307	1.002
4	*	0	10	0		65.49022	1.0220	0.0260	0.0151	1.034
5	*	0	12	0		62.14447	3.3457	0.0611	0.00449	1.075
6	*	0	15	0		61.38895	0.7555	0.0306	0.0356	0.868
7	*	0	17	0		59.92149	1.4675	0.0326	0.0149	1.036
8	*	0	19	0		57.19689	2.7246	0.0758	0.00741	0.918
9	*	0	22	0		56.29451	0.9024	0.0393	0.0585	0.938
10	*	0	24	0		54.95072	1.3438	0.0404	0.0236	0.912
11	*	0	26	0		52.22113	2.7296	0.0807	0.0111	0.927
12	*	0	28	0		44.71602	7.5051	0.2349	0.00493	1.249
13	*	0	30	0		16.03510	28.6809	0.3088	0.00068	2.716
14	*	0	34	0		14.16716	1.8679	0.3717	0.376	1.206
15	*	0	36	0		10.35911	3.8081	0.5269	0.140	1.372
16	*	0	38	0		5.54541	4.8137	0.4894	0.0225	1.455
17	*	0	41	0		4.91947	0.6259	0.5275	0.157	1.018
18	*	0	43	0		4.18429	0.7352	0.6231	0.0501	0.987
19	*	0	45	0		3.82609	0.3582	0.5361	0.00886	0.523
20	*	0	48	0		3.32461	0.5015	0.2787	1.164	0.829

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
21	*	0	50	0		2.94657	0.3780	0.2321	0.140	0.988
22	*	0	52	0		2.72765	0.2189	0.3940	0.0234	0.675
23	*	0	54	0		2.57605	0.1516	1.0883	0.00898	0.683
24	*	0	56	0		2.43615	0.1399	0.7630	0.00222	0.837
25	*	0	59	0		2.39434	0.0418	0.2408	0.0160	0.720
26	*	0	61	0		2.37300	0.0213	0.1279	0.0177	0.871
27	*	0	63	0		2.36686	0.00614	0.1935	0.0123	0.149
28	*	0	65	0		2.29214	0.0747	0.1509	0.00204	0.787
29	*	0	67	0		2.27952	0.0126	0.5310	0.00002	0.532
30	*	0	70	0		2.27573	0.00379	0.1588	0.00011	0.585
31	*	0	72	0		2.27483	0.000905	0.1557	0.00017	0.490
32	*	0	74	0		2.27441	0.000417	0.1391	0.00023	0.423
33	*	0	76	0		2.27435	0.000064	0.1852	0.00038	0.0778
34	*	0	78	0		2.27335	0.000993	0.0494	0.00119	0.761
35	*	0	81	0		2.27305	0.000301	0.0420	0.00342	0.533
36	*	0	83	0		2.27266	0.000387	0.0351	0.00348	0.628
37	*	0	85	0		2.27234	0.000326	0.0406	0.00517	0.500
38	*	0	87	0		2.27170	0.000639	0.0304	0.00528	0.735
39	*	0	89	0		2.27112	0.000580	0.0419	0.00835	0.623
40	*	0	92	0		2.26951	0.00161	0.0494	0.00576	1.004
41	*	0	95	0		2.26790	0.00161	0.0357	0.0177	1.066
42	*	0	97	0		2.26443	0.00347	0.0895	0.00968	1.090
43	*	0	100	0		2.25704	0.00739	0.0332	0.0365	1.324
44	*	0	102	0		2.24595	0.0111	0.1180	0.0263	1.206
45	*	0	104	0		2.20284	0.0431	0.1087	444E-16	1.739
46	*	0	106	0		2.16154	0.0413	0.0710	444E-16	1.647
47	*	0	108	0		2.14429	0.0172	0.0935	444E-16	1.512
48	*	0	110	0		2.13560	0.00869	0.0294	444E-16	1.564
49	*	0	112	0		2.12934	0.00627	0.0804	444E-16	1.526
50	*	0	114	0		2.12421	0.00513	0.0252	444E-16	1.504
51	*	0	116	0		2.11968	0.00453	0.0684	444E-16	1.543
52	*	0	118	0		2.11566	0.00402	0.0227	444E-16	1.581
53	*	0	120	0		2.11213	0.00353	0.0534	444E-16	1.647

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
54	*	0	122	0		2.10919	0.00294	0.0213	444E-16	1.681
55	*	0	124	0		2.10690	0.00229	0.0369	444E-16	1.719
56	*	0	126	0		2.10523	0.00167	0.0178	444E-16	1.727
57	*	0	128	0		2.10409	0.00114	0.0229	444E-16	1.741
58	*	0	130	0		2.10335	0.000738	0.0126	444E-16	1.741
59	*	0	132	0		2.10289	0.000462	0.0134	444E-16	1.748
60	*	0	134	0		2.10261	0.000282	0.00803	444E-16	1.749
61	*	1	138	0		2.10244	0.000169	0.00762	444E-16	1.752
62	*	1	140	0		2.10234	0.000100	0.00490	444E-16	1.754
63	*	1	142	0		2.10228	0.000059	0.00434	444E-16	1.756
64	*	1	144	0		2.10225	0.000035	0.00292	444E-16	1.757
65	*	1	146	0		2.10223	0.000020	0.00247	444E-16	1.758
66	*	1	148	0		2.10222	0.000012	0.00172	444E-16	1.759
67	*	1	150	0		2.10221	6.868E-6	0.00141	444E-16	1.759
68	*	1	152	0		2.10221	3.99E-6	0.00101	444E-16	1.760
69	*	1	154	0		2.10220	2.317E-6	0.000811	444E-16	1.760
70	*	1	156	0		2.10220	1.344E-6	0.000590	444E-16	1.760
71	*	1	158	0		2.10220	7.792E-7	0.000466	444E-16	1.760
72	*	1	160	0		2.10220	4.516E-7	0.000343	444E-16	1.761
73	*	1	162	0		2.10220	2.616E-7	0.000269	444E-16	1.761
74	*	1	164	0		2.10220	1.516E-7	0.000200	444E-16	1.761
75	*	1	166	0		2.10220	8.778E-8	0.000155	444E-16	1.761
76	*	1	168	0		2.10220	5.083E-8	0.000116	444E-16	1.761
77	*	1	170	0		2.10220	2.943E-8	0.000089	444E-16	1.761
78	*	1	172	0		2.10220	1.704E-8	0.000067	444E-16	1.761

Optimization Results			
Iterations	78	Function Calls	175
Jacobian Calls	81	Active Constraints	0
Objective Function	2.1021996361	Max Abs Gradient Element	0.0000671935
Lambda	4.440892E-14	Actual Over Pred Change	1.76079388
Radius	9.1905941E12		

Convergence criterion (GCONV=1E-8) satisfied.

LSU DATA
RUN 3 - CFA - REVISED MEASUREMENT MODEL CULTURE 8/15/17
The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimates

Fit Summary		
Modeling Info	Number of Observations	290
	Number of Variables	28
	Number of Moments	406
	Number of Parameters	107
	Number of Active Constraints	0
	Baseline Model Function Value	7.3016
	Baseline Model Chi-Square	2110.1750
	Baseline Model Chi-Square DF	378
	Pr > Baseline Model Chi-Square	<.0001
Absolute Index	Fit Function	2.1022
	Chi-Square	607.5357
	Chi-Square DF	299
	Pr > Chi-Square	<.0001
	Z-Test of Wilson & Hilferty	9.8058
	Hoelter Critical N	162
	Root Mean Square Residual (RMR)	0.1475
	Standardized RMR (SRMR)	0.0639
	Goodness of Fit Index (GFI)	0.8688
Parsimony Index	Adjusted GFI (AGFI)	0.8219
	Parsimonious GFI	0.6873
	RMSEA Estimate	0.0598
	RMSEA Lower 90% Confidence Limit	0.0529
	RMSEA Upper 90% Confidence Limit	0.0666
	Probability of Close Fit	0.0101
	ECVI Estimate	2.9253
	ECVI Lower 90% Confidence Limit	2.6881
	ECVI Upper 90% Confidence Limit	3.1926
	Akaike Information Criterion	821.5357
	Bozdogan CAIC	1321.2130
	Schwarz Bayesian Criterion	1214.2130
	McDonald Centrality	0.5875
Incremental Index	Bentler Comparative Fit Index	0.8219

	Bentler-Bonett NFI	0.7121
	Bentler-Bonett Non-normed Index	0.7748
	Bollen Normed Index Rho1	0.6360
	Bollen Non-normed Index Delta2	0.8296
	James et al. Parsimonious NFI	0.5633
Fit Summary		
Modeling Info	Number of Observations	290
	Number of Variables	28
	Number of Moments	406
	Number of Parameters	107
	Number of Active Constraints	0
	Baseline Model Function Value	7.3016
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	James et al. Parsimonious NFI	0.5633

LSU DATA
RUN 3 - CFA - REVISED MEASUREMENT MODEL CULTURE 8/15/17
The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimates

```
                              Linear Equations
Q8  =  0.6018 (**) F1  + 1.0000  e8
Q9  =  0.8055 (**) F1  + 1.0000  e9
Q10 =  0.7311 (**) F1  + 1.0000  e10
Q11 =  0.6958 (**) f2  + 1.0000  e11
Q12 =  0.9223 (**) f2  + 1.0000  e12
Q13 =  0.9541 (**) f2  + 1.0000  e13
Q14 =  0.6147 (**) f3  + 1.0000  e14
Q15 =  0.8529 (**) f3  + 1.0000  e15
Q16 =  1.1509 (**) f4  + 1.0000  e16
Q17 =  0.9591 (**) f4  + 1.0000  e17
f5  =  0.5000      F1  + 0.5000  f2  + 0.5000  f3  + 0.5000  f4  + 1.0000  D5
Q19 =  1.0658 (**) f8  + 1.0000  e19
Q27 =  0.5712 (**) f8  + 1.0000  e27
Q21 =  0.6854 (**) f8  + 1.0000  e21
Q18 =  0.4638 (**) f7  + 1.0000  e18
Q20 =  0.3642 (**) f7  + 1.0000  e20
Q26 =  0.5712 (**) f7  + 1.0000  e26
Q22 =  0.2903 (**) f6  + 1.0000  e22
Q23 =  0.6546 (**) f6  + 1.0000  e23
Q24 =  1.1324 (**) f6  + 1.0000  e24
Q25 =  0.3076 (**) f6  + 1.0000  e25
f9  =  0.5005      f6  + 0.5008  f7  + 0.4998  f8  + 1.0000  D9
B3B =  1.3920 (**) F10 + 1.0000  E29
B3C =  0.8496 (**) F10 + 1.0000  E30
B2C =  0.3936 (**) F10 + 1.0000  E31
B1D =  0.6622 (**) F11 + 1.0000  E32
B2A =  1.2460 (**) F11 + 1.0000  E33
B2B =  0.8109 (**) F11 + 1.0000  E34
B3A =  0.6253 (**) F11 + 1.0000  E35
B3D =  0.6348 (**) F11 + 1.0000  E28
```

Linear Equations

```
f12 =   0.4993      F10 + 0.4992  F11 + 1.0000  D12
f13 =   0.5000      f5  + 0.5002  f9  + 0.4996  f12 + 1.0000  d13
```

Effects in Linear Equations						
Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Q8	F1	LQ8f1	0.60181	0.06975	8.6278	<.0001
Q9	F1	LQ9F1	0.80548	0.07643	10.5384	<.0001
Q10	F1	lq10f1	0.73107	0.06196	11.7984	<.0001
Q11	f2	LQ11F2	0.69579	0.06301	11.0433	<.0001
Q12	f2	lq12f2	0.92233	0.06998	13.1796	<.0001
Q13	f2	LQ13F2	0.95412	0.07455	12.7986	<.0001
Q14	f3	LQ14F3	0.61471	0.05368	11.4506	<.0001
Q15	f3	LQ15F3	0.85286	0.06527	13.0664	<.0001
Q16	f4	LQ16F4	1.15087	0.11019	10.4448	<.0001
Q17	f4	lq17f4	0.95910	0.08488	11.2992	<.0001
f5	F1	PF5F1	0.50000	.	.	.
f5	f2	PF5F2	0.50000	.	.	.
f5	f3	PF5F3	0.50000	.	.	.
f5	f4	PF5F4	0.50000	.	.	.
Q19	f8	LQ19F8	1.06579	0.13820	7.7120	<.0001
Q27	f8	lq27f8	0.57124	0.09259	6.1696	<.0001
Q21	f8	lq21f8	0.68535	0.15447	4.4369	<.0001
Q18	f7	LQ18F7	0.46383	0.05215	8.8948	<.0001
Q20	f7	LQ20F7	0.36422	0.05231	6.9626	<.0001
Q26	f7	lq26f7	0.57123	0.07988	7.1508	<.0001
Q22	f6	lq22f6	0.29032	0.07156	4.0569	<.0001
Q23	f6	lq23f6	0.65456	0.07818	8.3723	<.0001
Q24	f6	lq24F6	1.13240	0.10352	10.9385	<.0001
Q25	f6	lq25F6	0.30761	0.09418	3.2663	0.0011
f9	f6	PF9F6	0.50052	.	.	.
f9	f7	PF9F7	0.50082	.	.	.
f9	f8	PF9F8	0.49979	.	.	.
B3B	F10	LB3BF10	1.39195	0.14169	9.8238	<.0001
B3C	F10	LB3CF10	0.84958	0.13189	6.4415	<.0001
B2C	F10	LB2CF10	0.39361	0.12599	3.1242	0.0018

Linear Equations

B1D	F11	LB1DF11	0.66222	0.10110	6.5499	<.0001
B2A	F11	LB2AF11	1.24602	0.15022	8.2944	<.0001
B2B	F11	LB2BF11	0.81087	0.12053	6.7277	<.0001
B3A	F11	LB3AF11	0.62531	0.10908	5.7325	<.0001
B3D	F11	LB3DF11	0.63485	0.11447	5.5461	<.0001
f12	F10	PF12F10	0.49927	.	.	.
f12	F11	PF12F7	0.49924	.	.	.
f13	f5	pf13f5	0.49997	.	.	.
f13	f9	p13f9	0.50018	.	.	.
f13	f12	p13f12	0.49961	.	.	.

Estimates for Variances of Exogenous Variables

Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Error	e8	vare8	0.87115	0.08380	10.3961	<.0001
	e9	vare9	0.90542	0.09885	9.1592	<.0001
	e10	vare10	0.50702	0.06510	7.7889	<.0001
	e11	vare11	0.70717	0.06916	10.2245	<.0001
	e12	vare12	0.72726	0.08206	8.8629	<.0001
	e13	vare13	0.85926	0.09362	9.1786	<.0001
	e14	vare14	0.49148	0.04976	9.8774	<.0001
	e15	vare15	0.57407	0.07253	7.9149	<.0001
	e16	vare16	1.81460	0.20424	8.8848	<.0001
	e17	vare17	0.90568	0.12167	7.4434	<.0001
	e18	vare18	0.41025	0.04431	9.2588	<.0001
	e19	vare19	1.85601	0.26933	6.8913	<.0001
	e20	vare20	0.50821	0.04674	10.8731	<.0001
	e21	vare21	3.89194	0.35047	11.1049	<.0001
	e22	vare22	1.20725	0.10176	11.8636	<.0001
	e23	vare23	1.18887	0.10925	10.8818	<.0001
	e24	vare24	1.48231	0.18025	8.2236	<.0001
	e25	vare25	2.12678	0.17836	11.9241	<.0001
	e26	vare26	1.16979	0.10854	10.7780	<.0001
	e27	vare27	1.24045	0.12451	9.9631	<.0001
	E28	vare28	2.18188	0.20192	10.8055	<.0001
	E29	vare29	0.65943	0.33925	1.9438	0.0519

Estimates for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
	E30	vare30	2.99141	0.28050	10.6645	<.0001
	E31	vare31	3.43397	0.28968	11.8543	<.0001
	E32	vare32	1.60248	0.15699	10.2077	<.0001
	E33	vare33	2.95453	0.34697	8.5152	<.0001
	E34	vare34	2.24774	0.22299	10.0801	<.0001
	E35	vare35	1.96217	0.18324	10.7082	<.0001
Latent	F1		1.00000			
	f2		1.00000			
	f3		1.00000			
	f4		1.00000			
	f6		1.00000			
	f7		1.00000			
	f8		1.00000			
	F10		1.00000			
	F11		1.00000			
Disturbance	D5	VARD5	50.00070	.	.	.
	D9	vard9	49.99893	.	.	.
	D12	vard12	49.99859	.	.	.
	d13	vard13	50.00106	.	.	.

Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
F1	f2	cF1F2	0.66329	0.05984	11.0844	<.0001
F1	f3	CF1F3	0.62443	0.06547	9.5371	<.0001
F1	f4	CF1F4	0.54750	0.07477	7.3224	<.0001
F1	f6	CF1F6	0.69404	0.05927	11.7098	<.0001
F1	f7	CF1F7	0.56156	0.08512	6.5975	<.0001
F1	f8	CF1F9	0.46225	0.09151	5.0515	<.0001
F1	F10	CF1F10	0.33715	0.07861	4.2887	<.0001
F1	F11	CF1F11	0.20953	0.08964	2.3376	0.0194
f2	f3	CF2F3	0.81047	0.05177	15.6559	<.0001
f2	f4	CF2F4	0.75570	0.05944	12.7127	<.0001
f2	f6	CF1F6	0.69404	0.05927	11.7098	<.0001

Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
f2	f7	CF2F7	0.69215	0.07517	9.2083	<.0001
f2	f8	CF2F8	0.34725	0.09074	3.8267	0.0001
f2	F10	CF2F10	0.04576	0.07762	0.5895	0.5555
f2	F11	CF2F11	0.23638	0.08535	2.7696	0.0056
f3	f4	CF3F4	0.74166	0.06707	11.0577	<.0001
f3	f6	CF3F6	0.93778	0.06599	14.2109	<.0001
f3	f7	CF3F7	0.79472	0.07768	10.2300	<.0001
f3	f8	CF3F8	0.39668	0.09629	4.1194	<.0001
f3	F10	CF3F10	0.12701	0.08182	1.5523	0.1206
f3	F11	CF3F11	0.27284	0.08948	3.0491	0.0023
f4	f6	CF4F6	0.58468	0.08348	7.0036	<.0001
f4	f7	CF4F7	0.42867	0.09546	4.4906	<.0001
f4	f8	CF4F8	0.27316	0.10181	2.6831	0.0073
f4	F10	CF4F10	-0.03447	0.08442	-0.4083	0.6831
f4	F11	CF4F11	0.36768	0.08934	4.1157	<.0001
f6	f7	CF6F7	0.70594	0.09175	7.6941	<.0001
f6	f8	CF6F8	0.77483	0.09517	8.1412	<.0001
f6	F10	CF6F10	0.38707	0.08551	4.5266	<.0001
f6	F11	CF6F11	0.29319	0.09699	3.0229	0.0025
f7	f8	CF7F8	0.44630	0.11012	4.0528	<.0001
f7	F10	CF7F10	0.51252	0.09025	5.6788	<.0001
f7	F11	CF7F11	0.51944	0.09535	5.4477	<.0001
f8	F10	CF8C10	0.32336	0.09413	3.4351	0.0006
f8	F11	CF8F11	0.20030	0.10643	1.8821	0.0598
F10	F11	CF10F11	0.42748	0.08375	5.1041	<.0001

Squared Multiple Correlations			
Variable	Error Variance	Total Variance	R-Square
Q8	0.87115	1.23332	0.2937
Q9	0.90542	1.55421	0.4174
Q10	0.50702	1.04149	0.5132
Q11	0.70717	1.19130	0.4064
Q12	0.72726	1.57796	0.5391

Squared Multiple Correlations			
Variable	Error Variance	Total Variance	R-Square
Q13	0.85926	1.76960	0.5144
Q14	0.49148	0.86935	0.4347
Q15	0.57407	1.30144	0.5589
Q16	1.81460	3.13909	0.4219
Q17	0.90568	1.82554	0.5039
f5	50.00070	53.07223	0.0579
Q19	1.85601	2.99192	0.3797
Q27	1.24045	1.56677	0.2083
Q21	3.89194	4.36165	0.1077
Q18	0.41025	0.62538	0.3440
Q20	0.50821	0.64086	0.2070
Q26	1.16979	1.49609	0.2181
Q22	1.20725	1.29154	0.0653
Q23	1.18887	1.61732	0.2649
Q24	1.48231	2.76465	0.4638
Q25	2.12678	2.22141	0.0426
f9	49.99893	51.71506	0.0332
B3B	0.65943	2.59697	0.7461
B3C	2.99141	3.71319	0.1944
B2C	3.43397	3.58891	0.0432
B1D	1.60248	2.04102	0.2149
B2A	2.95453	4.50710	0.3445
B2B	2.24774	2.90526	0.2263
B3A	1.96217	2.35318	0.1662
B3D	2.18188	2.58491	0.1559
f12	49.99859	50.71019	0.0140
f13	50.00106	90.19679	0.4456

Standardized Results for Linear Equations

```
Q8  =   0.5419 (**) F1  + 1.0000      e8
Q9  =   0.6461 (**) F1  + 1.0000      e9
Q10 =   0.7164 (**) F1  + 1.0000      e10
Q11 =   0.6375 (**) f2  + 1.0000      e11
Q12 =   0.7342 (**) f2  + 1.0000      e12
Q13 =   0.7172 (**) f2  + 1.0000      e13
```

```
                         Standardized Results for Linear Equations
Q14 =   0.6593 (**) f3  + 1.0000      e14
Q15 =   0.7476 (**) f3  + 1.0000      e15
Q16 =   0.6496 (**) f4  + 1.0000      e16
Q17 =   0.7098 (**) f4  + 1.0000      e17
f5  =   0.0686 (**) F1  + 0.0686 (**) f2  + 0.0686 (**) f3  + 0.0686 (**) f4  + 1.0000  D5
Q19 =   0.6162 (**) f8  + 1.0000      e19
Q27 =   0.4564 (**) f8  + 1.0000      e27
Q21 =   0.3282 (**) f8  + 1.0000      e21
Q18 =   0.5865 (**) f7  + 1.0000      e18
Q20 =   0.4550 (**) f7  + 1.0000      e20
Q26 =   0.4670 (**) f7  + 1.0000      e26
Q22 =   0.2555 (**) f6  + 1.0000      e22
Q23 =   0.5147 (**) f6  + 1.0000      e23
Q24 =   0.6811 (**) f6  + 1.0000      e24
Q25 =   0.2064 (**) f6  + 1.0000      e25
f9  =   0.0696 (**) f6  + 0.0696 (**) f7  + 0.0695 (**) f8  + 1.0000      D9
B3B =   0.8638 (**) F10 + 1.0000      E29
B3C =   0.4409 (**) F10 + 1.0000      E30
B2C =   0.2078 (**) F10 + 1.0000      E31
B1D =   0.4635 (**) F11 + 1.0000      E32
B2A =   0.5869 (**) F11 + 1.0000      E33
B2B =   0.4757 (**) F11 + 1.0000      E34
B3A =   0.4076 (**) F11 + 1.0000      E35
B3D =   0.3949 (**) F11 + 1.0000      E28
f12 =   0.0701 (**) F10 + 0.0701 (**) F11 + 1.0000      D12
f13 =   0.3835 (**) f5  + 0.3787 (**) f9  + 0.3746 (**) f12 + 1.0000      d13
```

Standardized Effects in Linear Equations

Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Q8	F1	LQ8f1	0.54190	0.05214	10.3930	<.0001
Q9	F1	LQ9F1	0.64610	0.04683	13.7954	<.0001
Q10	F1	lq10f1	0.71636	0.04393	16.3087	<.0001
Q11	f2	LQ11F2	0.63748	0.04236	15.0507	<.0001
Q12	f2	lq12f2	0.73424	0.03619	20.2905	<.0001
Q13	f2	LQ13F2	0.71724	0.03721	19.2735	<.0001
Q14	f3	LQ14F3	0.65928	0.04143	15.9138	<.0001
Q15	f3	LQ15F3	0.74759	0.03820	19.5725	<.0001
Q16	f4	LQ16F4	0.64957	0.04790	13.5620	<.0001
Q17	f4	lq17f4	0.70985	0.04702	15.0982	<.0001
f5	F1	PF5F1	0.06863	0.0000757	907.2	<.0001

Standardized Effects in Linear Equations						
Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
f5	f2	PF5F2	0.06863	0.0000757	907.2	<.0001
f5	f3	PF5F3	0.06863	0.0000757	907.2	<.0001
f5	f4	PF5F4	0.06863	0.0000757	907.2	<.0001
Q19	f8	LQ19F8	0.61616	0.07009	8.7907	<.0001
Q27	f8	lq27f8	0.45637	0.06739	6.7723	<.0001
Q21	f8	lq21f8	0.32816	0.07037	4.6634	<.0001
Q18	f7	LQ18F7	0.58653	0.05452	10.7579	<.0001
Q20	f7	LQ20F7	0.45497	0.05783	7.8678	<.0001
Q26	f7	lq26f7	0.46702	0.05743	8.1321	<.0001
Q22	f6	lq22f6	0.25546	0.06034	4.2335	<.0001
Q23	f6	lq23f6	0.51470	0.05145	10.0037	<.0001
Q24	f6	lq24F6	0.68105	0.04705	14.4756	<.0001
Q25	f6	lq25F6	0.20639	0.06146	3.3579	0.0008
f9	f6	PF9F6	0.06960	0.0000711	978.4	<.0001
f9	f7	PF9F7	0.06964	0.0000712	978.4	<.0001
f9	f8	PF9F8	0.06950	0.0000710	978.4	<.0001
B3B	F10	LB3BF10	0.86376	0.07610	11.3502	<.0001
B3C	F10	LB3CF10	0.44089	0.06170	7.1453	<.0001
B2C	F10	LB2CF10	0.20777	0.06485	3.2040	0.0014
B1D	F11	LB1DF11	0.46353	0.06366	7.2812	<.0001
B2A	F11	LB2AF11	0.58692	0.06025	9.7418	<.0001
B2B	F11	LB2BF11	0.47573	0.06327	7.5193	<.0001
B3A	F11	LB3AF11	0.40763	0.06549	6.2239	<.0001
B3D	F11	LB3DF11	0.39486	0.06591	5.9912	<.0001
f12	F10	PF12F10	0.07011	0.0000289	2429.2	<.0001
f12	F11	PF12F7	0.07011	0.0000289	2429.2	<.0001
f13	f5	pf13f5	0.38351	0.0003861	993.2	<.0001
f13	f9	p13f9	0.37874	0.0003326	1138.8	<.0001
f13	f12	p13f12	0.37461	0.0002982	1256.4	<.0001

Standardized Results for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Error	e8	vare8	0.70635	0.05651	12.4995	<.0001
	e9	vare9	0.58256	0.06052	9.6261	<.0001
	e10	vare10	0.48682	0.06293	7.7356	<.0001
	e11	vare11	0.59361	0.05400	10.9924	<.0001
	e12	vare12	0.46089	0.05314	8.6732	<.0001
	e13	vare13	0.48557	0.05338	9.0960	<.0001
	e14	vare14	0.56534	0.05463	10.3493	<.0001
	e15	vare15	0.44110	0.05711	7.7237	<.0001
	e16	vare16	0.57806	0.06222	9.2902	<.0001
	e17	vare17	0.49611	0.06675	7.4327	<.0001
	e18	vare18	0.65599	0.06396	10.2570	<.0001
	e19	vare19	0.62034	0.08638	7.1817	<.0001
	e20	vare20	0.79301	0.05262	15.0710	<.0001
	e21	vare21	0.89231	0.04618	19.3205	<.0001
	e22	vare22	0.93474	0.03083	30.3180	<.0001
	e23	vare23	0.73509	0.05296	13.8793	<.0001
	e24	vare24	0.53617	0.06408	8.3665	<.0001
	e25	vare25	0.95740	0.02537	37.7357	<.0001
	e26	vare26	0.78190	0.05364	14.5766	<.0001
	e27	vare27	0.79172	0.06151	12.8718	<.0001
	E28	vare28	0.84408	0.05205	16.2172	<.0001
	E29	vare29	0.25393	0.13146	1.9315	0.0534
	E30	vare30	0.80562	0.05441	14.8068	<.0001
	E31	vare31	0.95683	0.02695	35.5076	<.0001
	E32	vare32	0.78514	0.05902	13.3031	<.0001
	E33	vare33	0.65553	0.07072	9.2693	<.0001
	E34	vare34	0.77368	0.06020	12.8526	<.0001
	E35	vare35	0.83384	0.05339	15.6165	<.0001
Latent	F1		1.00000			
	f2		1.00000			
	f3		1.00000			
	f4		1.00000			
	f6		1.00000			
	f7		1.00000			
	f8		1.00000			

Standardized Results for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
	F10		1.00000			
	F11		1.00000			
Disturbance	D5	VARD5	0.94213	0.00208	453.6	<.0001
	D9	vard9	0.96682	0.00198	489.2	<.0001
	D12	vard12	0.98597	0.0008118	1214.6	<.0001
	d13	vard13	0.55436	0.0008855	626.0	<.0001

Standardized Results for Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
F1	f2	cF1F2	0.66329	0.05984	11.0844	<.0001
F1	f3	CF1F3	0.62443	0.06547	9.5371	<.0001
F1	f4	CF1F4	0.54750	0.07477	7.3224	<.0001
F1	f6	CF1F6	0.69404	0.05927	11.7098	<.0001
F1	f7	CF1F7	0.56156	0.08512	6.5975	<.0001
F1	f8	CF1F9	0.46225	0.09151	5.0515	<.0001
F1	F10	CF1F10	0.33715	0.07861	4.2887	<.0001
F1	F11	CF1F11	0.20953	0.08964	2.3376	0.0194
f2	f3	CF2F3	0.81047	0.05177	15.6559	<.0001
f2	f4	CF2F4	0.75570	0.05944	12.7127	<.0001
f2	f6	CF1F6	0.69404	0.05927	11.7098	<.0001
f2	f7	CF2F7	0.69215	0.07517	9.2083	<.0001
f2	f8	CF2F8	0.34725	0.09074	3.8267	0.0001
f2	F10	CF2F10	0.04576	0.07762	0.5895	0.5555
f2	F11	CF2F11	0.23638	0.08535	2.7696	0.0056
f3	f4	CF3F4	0.74166	0.06707	11.0577	<.0001
f3	f6	CF3F6	0.93778	0.06599	14.2109	<.0001
f3	f7	CF3F7	0.79472	0.07768	10.2300	<.0001
f3	f8	CF3F8	0.39668	0.09629	4.1194	<.0001
f3	F10	CF3F10	0.12701	0.08182	1.5523	0.1206
f3	F11	CF3F11	0.27284	0.08948	3.0491	0.0023
f4	f6	CF4F6	0.58468	0.08348	7.0036	<.0001
f4	f7	CF4F7	0.42867	0.09546	4.4906	<.0001

Standardized Results for Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
f4	f8	CF4F8	0.27316	0.10181	2.6831	0.0073
f4	F10	CF4F10	-0.03447	0.08442	-0.4083	0.6831
f4	F11	CF4F11	0.36768	0.08934	4.1157	<.0001
f6	f7	CF6F7	0.70594	0.09175	7.6941	<.0001
f6	f8	CF6F8	0.77483	0.09517	8.1412	<.0001
f6	F10	CF6F10	0.38707	0.08551	4.5266	<.0001
f6	F11	CF6F11	0.29319	0.09699	3.0229	0.0025
f7	f8	CF7F8	0.44630	0.11012	4.0528	<.0001
f7	F10	CF7F10	0.51252	0.09025	5.6788	<.0001
f7	F11	CF7F11	0.51944	0.09535	5.4477	<.0001
f8	F10	CF8C10	0.32336	0.09413	3.4351	0.0006
f8	F11	CF8F11	0.20030	0.10643	1.8821	0.0598
F10	F11	CF10F11	0.42748	0.08375	5.1041	<.0001

Stepwise Multivariate Wald Test					
	Cumulative Statistics			Univariate Increment	
Parm	Chi-Square	DF	Pr > ChiSq	Chi-Square	Pr > ChiSq
CF4F10	0.16670	1	0.6831	0.16670	0.6831
CF2F10	1.04784	2	0.5922	0.88114	0.3479
CF3F10	4.13244	3	0.2475	3.08460	0.0790
vare29	6.89798	4	0.1414	2.76554	0.0963
CF8F11	10.28161	5	0.0676	3.38363	0.0658
CF1F11	13.92421	6	0.0305	3.64260	0.0563
CF2F11	17.23277	7	0.0160	3.30856	0.0689
CF3F11	18.72786	8	0.0164	1.49509	0.2214
CF6F11	19.78433	9	0.0193	1.05648	0.3040

RUN 4 - CFA - MEASUREMENT MODEL CULTURE 9/21/17

LSU DATA
Run 4 CFA - FULL MEASUREMENT MODEL CULTURE 9/21/17
****

The CONTENTS Procedure

Data Set Name	WORK.TEST_1	Observations	306
Member Type	DATA	Variables	39
Engine	V9	Indexes	0
Created	09/22/2017 12:43:15	Observation Length	368
Last Modified	09/22/2017 12:43:15	Deleted Observations	0
Protection		Compressed	NO
Data Set Type		Sorted	NO
Label			
Data Representation	WINDOWS_64		
Encoding	wlatin1 Western (Windows)		

Engine/Host Dependent Information	
Data Set Page Size	65536
Number of Data Set Pages	2
First Data Page	1
Max Obs per Page	177
Obs in First Data Page	164
Number of Data Set Repairs	0
ExtendObsCounter	YES
Filename	C:\Users\Machine\AppData\Local\Temp\SAS Temporary Files_TD3024_LAPTOP-OV06L7T4_\test_1.sas7bdat
Release Created	9.0401M2
Host Created	X64_8HOME

Alphabetic List of Variables and Attributes						
#	Variable	Type	Len	Format	Informat	Label
28	B1A	Num	8			OPEN
29	B1B	Num	8			PICKUP
30	B1C	Num	8			LEAVE

Alphabetic List of Variables and Attributes						
#	Variable	Type	Len	Format	Informat	Label
31	B1D	Num	8			REPORT
32	B2A	Num	8			EHS
33	B2B	Num	8			SOP
34	B2C	Num	8			RUN
35	B2D	Num	8			REVIEW
36	B3A	Num	8			QUENCH
37	B3B	Num	8			FINISH
38	B3C	Num	8			CONTACT
39	B3D	Num	8			OBSERVE
2	F2	Num	8			EMPLOYEE
3	Q1	Char	16	$16.	$16.	Q1
4	Q2	Char	6	$6.	$6.	Q2
5	Q3	Char	19	$19.	$19.	Q3
6	Q4	Char	35	$35.	$35.	Q4
7	Q5	Char	19	$19.	$19.	Q5
8	Q8	Num	8			RESPONSE
9	Q9	Num	8			AWARNESS
10	Q10	Num	8			REPORTING
11	Q11	Num	8			TRAINING
12	Q12	Num	8			INVOLVEMENT
13	Q13	Num	8			PROMOTION
14	Q14	Num	8			SYSTEM
15	Q15	Num	8			UTILIZE
16	Q16	Num	8			RECONIZE
17	Q17	Num	8			LEADERSHIP
18	Q18	Num	8			CONCERN_1
19	Q19	Num	8			ACCEDENTS_2
20	Q20	Num	8			MEASURES
21	Q21	Num	8			PPE
22	Q22	Num	8			CONCERN_2
23	Q23	Num	8			NEEDS
24	Q24	Num	8			HESITANT
25	Q25	Num	8			REPORTING
26	Q26	Num	8			LITERATURE

Alphabetic List of Variables and Attributes						
#	Variable	Type	Len	Format	Informat	Label
27	Q27	Num	8			DISCARD
1	_	Num	8			3

LSU DATA

Run 4 CFA - FULL MEASUREMENT MODEL CULTURE 9/21/17
****
The CALIS Procedure

Covariance Structure Analysis: Model and Initial Values

Modeling Information	
Maximum Likelihood Estimation	
Data Set	WORK.TEST_1
N Records Read	306
N Records Used	290
N Obs	290
Model Type	LINEQS
Analysis	Covariances

Variables in the Model		
Endogenous	Manifest	B1D B2A B2B B3B B3C Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19 Q20 Q23 Q24 Q26 Q27 Q8 Q9
	Latent	f12 f13 f5 f9
Exogenous	Manifest	
	Latent	F1 F10 F11 f2 f3 f4 F6 f7 f8
	Error	E21 E22 E25 E28 E29 e10 e11 e12 e13 e14 e15 e16 e17 e18 e19 e20 e23 e24 e26 e27 e8 e9 D12 d13 D5 D9
Number of Endogenous Variables = 26 Number of Exogenous Variables = 35		

Initial Estimates for Linear Equations

```
Q8  =  LQ8f1   (.) F1  +        1  e8
Q9  =  LQ9F1   (.) F1  +        1  e9
Q10 =  lq10f1  (.) F1  +        1  e10
Q11 =  LQ11F2  (.) f2  +        1  e11
```

```
                    Initial Estimates for Linear Equations
Q12 =  lq12f2  (.) f2  +         1  e12
Q13 =  LQ13F2  (.) f2  +         1  e13
Q14 =  LQ14F3  (.) f3  +         1  e14
Q15 =  LQ15F3  (.) f3  +         1  e15
Q16 =  LQ16F4  (.) f4  +         1  e16
Q17 =  lq17f4  (.) f4  +         1  e17
f5  =  PF5F1   (.) F1  + PF5F2  (.) f2  + PF5F3  (.) f3  + PF5F4 (.) f4  +  1 D5
Q19 =  LQ19F8  (.) f8  +         1  e19
Q27 =  lq27f8  (.) f8  +         1  e27
Q18 =  LQ18F7  (.) f7  +         1  e18
Q20 =  LQ20F7  (.) f7  +         1  e20
Q26 =  lq26f7  (.) f7  +         1  e26
Q23 =  lq23f6  (.) F6  +         1  e23
Q24 =  lq24F6  (.) F6  +         1  e24
f9  =  PF9F6   (.) F6  + PF9F7  (.) f7  + PF9F8  (.) f8  +        1  D9
B3B =  LB3BF10 (.) F10 +         1  E28
B3C =  LB3CF10 (.) F10 +         1  E29
B1D =  LB1DF11 (.) F11 +         1  E21
B2A =  LB2AF11 (.) F11 +         1  E22
B2B =  LB2BF11 (.) F11 +         1  E25
f12 =  PF12F10 (.) F10 + PF12F7 (.) F11 +         1  D12
f13 =  pf13f5  (.) f5  + p13f9  (.) f9  + p13f12 (.) f12 +        1  d13
```

The CALIS Procedure
Covariance Structure Analysis: Optimization

Initial Estimation Methods	
1	Instrumental Variables Method
2	McDonald Method
3	Default Initial Values

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
1	LQ8f1	0.65563	0.02129
2	LQ9F1	0.73164	0.02346
3	lq10f1	0.73693	0.02395
4	LQ11F2	0.73545	0.02315
5	lq12f2	0.90082	0.02810

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
6	LQ13F2	0.94712	0.02953
7	LQ14F3	0.61165	0.01903
8	LQ15F3	0.84563	0.02606
9	LQ16F4	1.13398	0.03520
10	lq17f4	0.96898	0.03067
11	PF5F1	0.50000	0
12	PF5F2	0.50000	0
13	PF5F3	0.50000	0
14	PF5F4	0.50000	0
15	LQ19F8	0.99078	0.03283
16	lq27f8	0.55476	0.01863
17	LQ18F7	0.45756	0.01474
18	LQ20F7	0.36509	0.01162
19	lq26f7	0.54188	0.01672
20	lq23f6	0.80161	0.02401
21	lq24F6	0.90408	0.02561
22	PF9F6	0.50000	0
23	PF9F7	0.50000	0
24	PF9F8	0.50000	0
25	LB3BF10	1.66707	0.05772
26	LB3CF10	0.59379	0.01874
27	LB1DF11	0.68952	0.02289
28	LB2AF11	1.23082	0.03956
29	LB2BF11	0.91568	0.03022
30	PF12F10	0.50000	0
31	PF12F7	0.50000	0
32	pf13f5	0.50000	0
33	p13f9	0.50000	0
34	p13f12	0.50000	0
35	vare8	50.00000	0.01938
36	vare9	50.00000	0.01923
37	vare10	50.00000	0.01943
38	vare11	50.00000	0.01938
39	vare12	50.00000	0.01916
40	vare13	50.00000	0.01906

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
41	vare14	50.00000	0.01956
42	vare15	50.00000	0.01930
43	vare16	50.00000	0.01842
44	vare17	50.00000	0.01902
45	vare18	50.00000	0.01969
46	vare19	50.00000	0.01852
47	vare20	50.00000	0.01971
48	vare21	50.00000	0.01905
49	vare22	50.00000	0.01779
50	vare23	50.00000	0.01920
51	vare24	50.00000	0.01872
52	vare25	50.00000	0.01860
53	vare26	50.00000	0.01933
54	vare27	50.00000	0.01928
55	vare28	50.00000	0.01807
56	vare29	50.00000	0.01842
57	VARD5	50.00000	0
58	vard9	50.00000	0
59	vard12	50.00000	0
60	vard13	50.00000	0
61	cF1F2	0.68600	-0.00294
62	CF1F3	0.65438	-0.00132
63	CF1F4	0.54210	-0.00220
64	CF1F6	0.75569	-0.00505
65	CF1F7	0.58266	-0.0006808
66	CF1F9	0.53045	-0.00129
67	CF1F10	0.30755	-0.00185
68	CF1F11	0.19206	-0.0008020
69	CF2F3	0.78465	-0.00242
70	CF2F4	0.75541	-0.00476
71	CF2F7	0.69472	-0.00126
72	CF2F8	0.34263	-0.00112
73	CF2F10	0.02967	0.0000286
74	CF2F11	0.30067	-0.00214
75	CF3F4	0.73920	-0.00224

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
76	CF3F6	1.00545	-0.00207
77	CF3F7	0.77438	-0.0006877
78	CF3F8	0.50160	-0.0008569
79	CF3F10	0.12793	-0.0004391
80	CF3F11	0.31033	-0.00106
81	CF4F6	0.66397	-0.00260
82	CF4F7	0.46404	-0.0007529
83	CF4F8	0.24923	-0.0007444
84	CF4F10	-0.03554	0.0006318
85	CF4F11	0.44592	-0.00343
86	CF6F7	0.71315	-0.0007994
87	CF6F8	0.89011	-0.00221
88	CF6F10	0.34038	-0.00193
89	CF6F11	0.39126	-0.00187
90	CF7F8	0.51408	-0.0005216
91	CF7F10	0.52797	-0.00140
92	CF7F11	0.56566	-0.00129
93	CF8C10	0.33524	-0.00172
94	CF8F11	0.10014	-0.0002815
95	CF10F11	0.19632	-0.00212
Value of Objective Function = 59.27659925			

LSU DATA

Run 4 CFA - FULL MEASUREMENT MODEL CULTURE 9/21/17

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	95
Functions (Observations)	253

Optimization Start			
Active Constraints	0	Objective Function	59.27659925
Max Abs Gradient Element	0.0577172152	Radius	1

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
1	*	0	4	0		54.22004	5.0566	0.0264	3.616	1.174
2	*	0	6	0		53.98474	0.2353	0.0253	0.0616	0.946
3	*	0	8	0		53.52990	0.4548	0.0258	0.0280	1.003
4	*	0	10	0		52.59293	0.9370	0.0271	0.0138	1.033
5	*	0	12	0		49.89646	2.6965	0.0714	0.00435	0.988
6	*	0	15	0		49.06286	0.8336	0.0325	0.0367	0.888
7	*	0	17	0		47.66711	1.3958	0.0416	0.0135	0.980
8	*	0	19	0		44.68473	2.9824	0.0727	0.00665	1.057
9	*	0	21	0		36.16932	8.5154	0.6359	0.00283	1.476
10	*	0	24	0		34.09822	2.0711	0.6777	0.0289	1.108
11	*	0	26	0		29.24823	4.8500	0.8906	0.0127	1.287
12	*	0	28	0		14.05489	15.1933	0.6237	0.00331	2.164
13	*	0	31	0		8.75222	5.3027	0.4305	0.0554	1.536
14	*	0	33	0		2.95590	5.7963	1.9442	0.00332	1.699
15	*	0	36	0		2.07527	0.8806	1.4734	0.0451	0.692
16	*	0	38	0		1.56900	0.5063	0.2860	0.0189	0.726
17	*	0	40	0		1.43221	0.1368	0.2850	0.00411	0.920
18	*	0	42	0		1.39015	0.0421	0.4214	0.00061	0.740
19	*	0	45	0		1.37839	0.0118	0.1295	0.00243	0.737
20	*	0	47	0		1.37355	0.00484	0.1646	0.00361	0.723
21	*	0	49	0		1.36911	0.00444	0.0792	0.00394	0.949
22	*	0	51	0		1.36588	0.00323	0.1648	0.00276	0.408
23	*	0	53	0		1.36119	0.00469	0.1206	0.00558	0.157
24	*	0	55	0		1.31196	0.0492	0.0280	0.00068	1.027
25	*	0	57	0		1.31025	0.00170	0.1295	0.00003	0.823
26	*	0	60	0		1.30948	0.000773	0.0135	0.00027	0.911
27	*	0	62	0		1.30916	0.000322	0.0421	0.00018	0.925
28	*	0	65	0		1.30868	0.000474	0.0275	0.00031	1.047
29	*	0	67	0		1.30860	0.000087	0.1088	0.00024	0.0813
30	*	0	69	0		1.30467	0.00393	0.0445	0.00119	1.033
31	*	0	72	0		1.30055	0.00411	0.0651	0.00450	1.261
32	*	0	74	0		1.28809	0.0125	0.1479	0.00454	1.055
33	*	0	77	0		1.22458	0.0635	0.0873	0.0728	1.361

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
34	*	0	79	0		1.14276	0.0818	0.0832	0.0474	1.117
35	*	0	81	0		1.08950	0.0533	0.0560	444E-16	1.120
36	*	0	83	0		1.08597	0.00353	0.00909	444E-16	1.092
37	*	0	85	0		1.08472	0.00124	0.0206	444E-16	1.213
38	*	0	87	0		1.08422	0.000504	0.00336	444E-16	1.265
39	*	0	89	0		1.08402	0.000194	0.00706	444E-16	1.318
40	*	0	91	0		1.08395	0.000074	0.00152	444E-16	1.347
41	*	0	93	0		1.08392	0.000028	0.00242	444E-16	1.376
42	*	0	95	0		1.08391	0.000011	0.000636	444E-16	1.398
43	*	0	97	0		1.08391	4.109E-6	0.000849	444E-16	1.421
44	*	0	99	0		1.08390	1.61E-6	0.000256	444E-16	1.440
45	*	0	101	0		1.08390	6.41E-7	0.000328	444E-16	1.460
46	*	0	103	0		1.08390	2.589E-7	0.000113	444E-16	1.477
47	*	0	105	0		1.08390	1.059E-7	0.000143	444E-16	1.494
48	*	0	107	0		1.08390	4.377E-8	0.000051	444E-16	1.509
49	*	0	109	0		1.08390	1.825E-8	0.000062	444E-16	1.522
50	*	0	111	0		1.08390	7.657E-9	0.000023	444E-16	1.534

Optimization Results			
Iterations	50	Function Calls	114
Jacobian Calls	52	Active Constraints	0
Objective Function	1.0839033943	Max Abs Gradient Element	0.000022627
Lambda	4.440892E-14	Actual Over Pred Change	1.5342219143
Radius	954329.85402		

Convergence criterion (GCONV=1E-8) satisfied.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Summary		
Modeling Info	Number of Observations	290
	Number of Variables	22
	Number of Moments	253
	Number of Parameters	95
	Number of Active Constraints	0
	Baseline Model Function Value	5.9168
	Baseline Model Chi-Square	1709.9539
	Baseline Model Chi-Square DF	231
	Pr > Baseline Model Chi-Square	<.0001
Absolute Index	Fit Function	1.0839
	Chi-Square	313.2481
	Chi-Square DF	158
	Pr > Chi-Square	<.0001
	Z-Test of Wilson & Hilferty	6.8704
	Hoelter Critical N	174
	Root Mean Square Residual (RMR)	0.1095
	Standardized RMR (SRMR)	0.0523
	Goodness of Fit Index (GFI)	0.9090
Parsimony Index	Adjusted GFI (AGFI)	0.8543
	Parsimonious GFI	0.6218
	RMSEA Estimate	0.0583
	RMSEA Lower 90% Confidence Limit	0.0488
	RMSEA Upper 90% Confidence Limit	0.0677
	Probability of Close Fit	0.0741
	ECVI Estimate	1.7982
	ECVI Lower 90% Confidence Limit	1.6338
	ECVI Upper 90% Confidence Limit	1.9920
	Akaike Information Criterion	503.2481
	Bozdogan CAIC	946.8868
	Schwarz Bayesian Criterion	851.8868
	McDonald Centrality	0.7652
Incremental Index	Bentler Comparative Fit Index	0.8950
	Bentler-Bonett NFI	0.8168
	Bentler-Bonett Non-normed Index	0.8465
	Bollen Normed Index Rho1	0.7322

Fit Summary		
	Bollen Non-normed Index Delta2	0.9000
	James et al. Parsimonious NFI	0.5587

Standardized Results for Linear Equations

```
Q8  =  -0.5437 (**) F1  + 1.0000      e8
Q9  =  -0.6446 (**) F1  + 1.0000      e9
Q10 =  -0.7156 (**) F1  + 1.0000      e10
Q11 =  -0.6437 (**) f2  + 1.0000      e11
Q12 =  -0.7301 (**) f2  + 1.0000      e12
Q13 =  -0.7155 (**) f2  + 1.0000      e13
Q14 =  -0.6645 (**) f3  + 1.0000      e14
Q15 =  -0.7415 (**) f3  + 1.0000      e15
Q16 =  -0.6465 (**) f4  + 1.0000      e16
Q17 =  -0.7139 (**) f4  + 1.0000      e17
f5  =   0.0686 (**) F1  + 0.0686 (**) f2  + 0.0686 (**) f3  + 0.0686 (**) f4  + 1.0000  D5
Q19 =  -0.6122 (**) f8  + 1.0000      e19
Q27 =  -0.4104 (**) f8  + 1.0000      e27
Q18 =  -0.6018 (**) f7  + 1.0000      e18
Q20 =  -0.4530 (**) f7  + 1.0000      e20
Q26 =  -0.4532 (**) f7  + 1.0000      e26
Q23 =  -0.5403 (**) F6  + 1.0000      e23
Q24 =  -0.6343 (**) F6  + 1.0000      e24
f9  =   0.0696 (**) F6  + 0.0695 (**) f7  + 0.0695 (**) f8  + 1.0000      D9
B3B =  -0.8296 (**) F10 + 1.0000      E28
B3C =  -0.4604 (**) F10 + 1.0000      E29
B1D =  -0.5635 (**) F11 + 1.0000      E21
B2A =  -0.5283 (**) F11 + 1.0000      E22
B2B =  -0.5684 (**) F11 + 1.0000      E25
f12 =   0.0703 (**) F10 + 0.0703 (**) F11 + 1.0000      D12
f13 =   0.3834 (**) f5  + 0.3788 (**) f9  + 0.3743 (**) f12 + 1.0000      d13
```

Standardized Effects in Linear Equations						
Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Q8	F1	LQ8f1	-0.54368	0.05200	-10.4546	<.0001
Q9	F1	LQ9F1	-0.64464	0.04684	-13.7625	<.0001
Q10	F1	lq10f1	-0.71564	0.04387	-16.3123	<.0001
Q11	f2	LQ11F2	-0.64371	0.04196	-15.3393	<.0001
Q12	f2	lq12f2	-0.73014	0.03645	-20.0307	<.0001
Q13	f2	LQ13F2	-0.71551	0.03734	-19.1619	<.0001

Standardized Effects in Linear Equations						
Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Q14	f3	LQ14F3	-0.66449	0.04122	-16.1200	<.0001
Q15	f3	LQ15F3	-0.74146	0.03839	-19.3115	<.0001
Q16	f4	LQ16F4	-0.64649	0.04819	-13.4162	<.0001
Q17	f4	lq17f4	-0.71394	0.04727	-15.1045	<.0001
f5	F1	PF5F1	0.06863	0.0000756	907.6	<.0001
f5	f2	PF5F2	0.06863	0.0000756	907.6	<.0001
f5	f3	PF5F3	0.06863	0.0000756	907.6	<.0001
f5	f4	PF5F4	0.06863	0.0000756	907.6	<.0001
Q19	f8	LQ19F8	-0.61216	0.08417	-7.2732	<.0001
Q27	f8	lq27f8	-0.41041	0.07049	-5.8225	<.0001
Q18	f7	LQ18F7	-0.60184	0.05415	-11.1152	<.0001
Q20	f7	LQ20F7	-0.45302	0.05776	-7.8438	<.0001
Q26	f7	lq26f7	-0.45322	0.05775	-7.8481	<.0001
Q23	F6	lq23f6	-0.54034	0.05281	-10.2319	<.0001
Q24	F6	lq24F6	-0.63429	0.05185	-12.2327	<.0001
f9	F6	PF9F6	0.06959	0.0000826	842.4	<.0001
f9	f7	PF9F7	0.06951	0.0000825	842.4	<.0001
f9	f8	PF9F8	0.06954	0.0000825	842.4	<.0001
B3B	F10	LB3BF10	-0.82962	0.08676	-9.5624	<.0001
B3C	F10	LB3CF10	-0.46038	0.06605	-6.9703	<.0001
B1D	F11	LB1DF11	-0.56354	0.06717	-8.3897	<.0001
B2A	F11	LB2AF11	-0.52830	0.06704	-7.8802	<.0001
B2B	F11	LB2BF11	-0.56844	0.06721	-8.4575	<.0001
f12	F10	PF12F10	0.07033	0.0000319	2203.5	<.0001
f12	F11	PF12F7	0.07025	0.0000319	2203.5	<.0001
f13	f5	pf13f5	0.38335	0.0003918	978.4	<.0001
f13	f9	p13f9	0.37881	0.0003621	1046.2	<.0001
f13	f12	p13f12	0.37433	0.0003073	1218.3	<.0001

Standardized Results for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Error	e8	vare8	0.70441	0.05655	12.4570	<.0001
	e9	vare9	0.58444	0.06039	9.6777	<.0001
	e10	vare10	0.48786	0.06279	7.7694	<.0001
	e11	vare11	0.58564	0.05403	10.8399	<.0001
	e12	vare12	0.46689	0.05323	8.7713	<.0001
	e13	vare13	0.48804	0.05343	9.1334	<.0001
	e14	vare14	0.55846	0.05478	10.1942	<.0001
	e15	vare15	0.45024	0.05694	7.9077	<.0001
	e16	vare16	0.58205	0.06231	9.3418	<.0001
	e17	vare17	0.49029	0.06749	7.2646	<.0001
	e18	vare18	0.63779	0.06517	9.7861	<.0001
	e19	vare19	0.62526	0.10305	6.0678	<.0001
	e20	vare20	0.79477	0.05233	15.1881	<.0001
	E21	vare21	0.68243	0.07571	9.0142	<.0001
	E22	vare22	0.72090	0.07084	10.1769	<.0001
	e23	vare23	0.70804	0.05707	12.4066	<.0001
	e24	vare24	0.59768	0.06578	9.0862	<.0001
	E25	vare25	0.67687	0.07641	8.8583	<.0001
	e26	vare26	0.79459	0.05235	15.1799	<.0001
	e27	vare27	0.83157	0.05786	14.3731	<.0001
	E28	vare28	0.31174	0.14395	2.1656	0.0303
	E29	vare29	0.78805	0.06081	12.9583	<.0001
Latent	F1		1.00000			
	f2		1.00000			
	f3		1.00000			
	f4		1.00000			
	F6		1.00000			
	f7		1.00000			
	f8		1.00000			
	F10		1.00000			
	F11		1.00000			
Disturbance	D5	VARD5	0.94205	0.00208	453.8	<.0001
	D9	vard9	0.96629	0.00229	421.2	<.0001
	D12	vard12	0.98838	0.0008971	1101.8	<.0001
	d13	vard13	0.55404	0.0009166	604.4	<.0001

Standardized Results for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|

Standardized Results for Covariances Among Exogenous Variables						
Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
F1	f2	cF1F2	0.66473	0.05985	11.1070	<.0001
F1	f3	CF1F3	0.62848	0.06544	9.6044	<.0001
F1	f4	CF1F4	0.54449	0.07459	7.2997	<.0001
F1	F6	CF1F6	0.72910	0.06514	11.1930	<.0001
F1	f7	CF1F7	0.56667	0.08480	6.6826	<.0001
F1	f8	CF1F9	0.50706	0.10261	4.9419	<.0001
F1	F10	CF1F10	0.35491	0.08246	4.3038	<.0001
F1	F11	CF1F11	0.20127	0.09184	2.1915	0.0284
f2	f3	CF2F3	0.81340	0.05177	15.7110	<.0001
f2	f4	CF2F4	0.75767	0.05922	12.7932	<.0001
f2	F6	CF1F6	0.72910	0.06514	11.1930	<.0001
f2	f7	CF2F7	0.68801	0.07518	9.1515	<.0001
f2	f8	CF2F8	0.36125	0.09952	3.6298	0.0003
f2	F10	CF2F10	0.05213	0.08054	0.6472	0.5175
f2	F11	CF2F11	0.31548	0.08529	3.6988	0.0002
f3	f4	CF3F4	0.74238	0.06711	11.0623	<.0001
f3	F6	CF3F6	0.98706	0.07500	13.1614	<.0001
f3	f7	CF3F7	0.79445	0.07751	10.2498	<.0001
f3	f8	CF3F8	0.47440	0.10564	4.4906	<.0001
f3	F10	CF3F10	0.13640	0.08495	1.6056	0.1084
f3	F11	CF3F11	0.28746	0.09145	3.1433	0.0017
f4	F6	CF4F6	0.67676	0.08663	7.8122	<.0001
f4	f7	CF4F7	0.41975	0.09518	4.4101	<.0001
f4	f8	CF4F8	0.28702	0.10943	2.6229	0.0087
f4	F10	CF4F10	-0.03330	0.08728	-0.3815	0.7029
f4	F11	CF4F11	0.37556	0.09130	4.1132	<.0001
F6	f7	CF6F7	0.68257	0.09956	6.8557	<.0001
F6	f8	CF6F8	0.80825	0.12237	6.6048	<.0001
F6	F10	CF6F10	0.37008	0.09461	3.9115	<.0001
F6	F11	CF6F11	0.37084	0.10278	3.6082	0.0003
f7	f8	CF7F8	0.49404	0.12023	4.1090	<.0001
f7	F10	CF7F10	0.53905	0.09500	5.6740	<.0001

Standardized Results for Variances of Exogenous Variables						
Variable Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
f7	F11	CF7F11	0.46289	0.09966	4.6448	<.0001
f8	F10	CF8C10	0.35786	0.10671	3.3536	0.0008
f8	F11	CF8F11	0.08583	0.11660	0.7361	0.4617
F10	F11	CF10F11	0.17560	0.09185	1.9119	0.0559

Stepwise Multivariate Wald Test					
	Cumulative Statistics			Univariate Increment	
Parm	Chi-Square	DF	Pr > ChiSq	Chi-Square	Pr > ChiSq
CF4F10	0.14552	1	0.7029	0.14552	0.7029
CF8F11	0.72351	2	0.6965	0.57799	0.4471
CF2F10	1.66552	3	0.6446	0.94201	0.3318
CF3F10	4.78969	4	0.3096	3.12416	0.0771
CF10F11	7.88837	5	0.1625	3.09868	0.0784
vare28	10.44715	6	0.1070	2.55878	0.1097
CF1F11	13.80716	7	0.0547	3.36001	0.0668

APPENDIX C. SAS PROC CALLIS MODELING RUN EXAMPLE LOG

```
NOTE: Copyright (c) 2002-2012 by SAS Institute Inc., Cary, NC, USA.
NOTE: SAS (r) Proprietary Software 9.4 (TS1M2)
      Licensed to LOUISIANA STATE UNIVERSITY-SFA-T&R, Site 70080688.
NOTE: This session is executing on the X64_8HOME  platform.



NOTE: Updated analytical products:

      SAS/STAT 13.2
      SAS/ETS 13.2
      SAS/OR 13.2
      SAS/IML 13.2
      SAS/QC 13.2

NOTE: Additional host information:

 X64_8HOME WIN 6.2.9200  Workstation

NOTE: SAS initialization used:
      real time           1.42 seconds
      cpu time            1.34 seconds

1     'log;clear;output;clear';
      ------------------------
      180

ERROR 180-322: Statement is not valid or it is used out of proper order.

2    ods html close; ods html;
NOTE: Writing HTML Body file: sashtml.htm
3    ods graphics on;
4    options nodate nocenter pageno=1 ls=90 ps=56;
5    ODS listing;
6
7    ODS HTML style=minimal body='Climate.html';
NOTE: Writing HTML Body file: Climate.html
8    ODS RTF style=minimal body='climate.rtf';
NOTE: Writing RTF Body file: climate.rtf
9    *ODS PDF style=minimal body='prec.PDF';
```

```
**********************************************************************************;
**********************************************************************************;
title1 'LSU DATA';
title2 'CFA - FULL MEASUREMENT MODEL CULTURE 8/1/17';
Title3
**********************;
***  Culture Analysis  ***;
*** Jerry E. Steward***;
**********************;
PROC IMPORT OUT= Test_1
DATAFILE= "C:\users\machine\documents\SAS_2017\Coded_Dated_7_5_17_F.xlsx"
            DBMS=EXCEL REPLACE;
     RANGE="DATA$";
     GETNAMES=YES;
     MIXED=YES;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
     LABEL
        Q8  = 'RESPONSE'
    Q9  = 'AWARNESS'
    Q10 = 'REPORTING'
    Q11 = 'TRAINING'
    Q12 = 'INVOLVEMENT'
    Q13 = 'PROMOTION'
    Q14 = 'SYSTEM'
    Q15 = 'UTILIZE'
    Q16 = 'RECONIZE'
    Q17 = 'LEADERSHIP'
    Q18 = 'CONCERN_1'
    Q19 = 'ACCEDENTS_2'
    Q20 = 'MEASURES'
    Q21 = 'PPE'
    Q22 = 'CONCERN_2'
```

```
      Q23 = 'NEEDS'
      Q24 = 'HESITANT'
      Q25 = 'REPORTING'
      Q26 = 'LITERATURE'
      Q27 = 'DISCARD'
      B1A = 'OPEN'
      B1B = 'PICKUP'
      B1C = 'LEAVE'
      B1D = 'REPORT'
      B2A = 'EHS'
      B2B = 'SOP'
      B2C = 'RUN'
      B2D = 'REVIEW'
      B3A = 'QUENCH'
      B3B = 'FINISH'
      B3C = 'CONTACT'
      B3D = 'OBSERVE'
      F1  = 'PRECEPTION'
      F2  = 'EMPLOYEE'
      F3  = 'DEPARTMENT'
      F4  = 'MANAGEMENT'
      F5  = 'CLIMATE'
      F6  = 'TEAM'
      F7  = 'PERSON'
      F8  = 'INSTITUTION'
      F9  = 'ATTITUDES'
      F10 = 'UNSAFE'
      F11 = 'SAFE'
      F12 = 'BEHAVIOR'
      F13 = 'Culture';
   RUN;

NOTE: Data source is connected in READ ONLY mode.
NOTE: WORK.TEST_1 data set was successfully created.
NOTE: The data set WORK.TEST_1 has 306 observations and 39 variables.
NOTE: PROCEDURE IMPORT used (Total process time):
      real time           0.28 seconds
      cpu time            0.21 seconds
```

```
proc contents data=test_1; run;

NOTE: PROCEDURE CONTENTS used (Total process time):
      real time           0.26 seconds
      cpu time            0.17 seconds


*proc sort data=test_1; *run;
*proc print data=test_1; *run;
proc means data=test_1; *run;

*PROC CORR NOMISS noprob;
*var Q8 Q9 Q10 q11 q12 q13 q14 q15 q16 q17;
*run;

*PROC CORR ALPHA NOMISS;
 *var Q8 Q9 Q10 q11 q12 q13 q14 q15 q16 q17 Q18 Q19  Q20 Q21 Q22 Q23 Q24 Q25 Q26 Q27
B1a B1b B1d B2a B2b B2c B3a B3b B3c B3d;
*run;

*PROC FACTOR  METHOD=prin
SIMPLE
SCREE
PRIORS=SMC
ROTATE=varimax
round
flag=.4
S C;
 *var Q8 Q9 Q10 q11 q12 q13 q14 q15 q16 q17 Q18 Q19  Q20 Q21 Q22 Q23 Q24 Q25 Q26 Q27
B1a B1b B1c B1d B2a B2b B2c B2d B3a B3b B3c B3d;
*run;

NOTE: There were 306 observations read from the data set WORK.TEST_1.
NOTE: PROCEDURE MEANS used (Total process time):
      real time           0.17 seconds
      cpu time            0.14 seconds


PROC CALIS
COV MAXIT=1000 RESIDUAL modification;
```

```
lineqs
  q8  = LQ8f1 F1 + e8,
  q9  = LQ9F1 f1 + e9,
 q10 = lq10f1 f1 + e10,
 q11 = LQ11F2 f2 + e11,
 q12 = lq12f2 f2 + e12,
 q13 = LQ13F2 f2 + e13,
 q14 = LQ14F3 f3 + e14,
 q15 = LQ15F3 f3 + e15,
 q16 = LQ16F4 f4 + e16,
 q17 = lq17f4 f4 + e17,
 f5 =  PF5F1 F1 + PF5F2 F2 + PF5F3 F3 + PF5F4 F4 +D5,

 q19  = LQ19F8 f8 + e19,
 q27  = lq27f8 f8 + e27,
 q21  = lq21f8 f8 + e21,
 q18  = LQ18F7 f7 + e18,
 q20  = LQ20F7 f7 + e20,
 q26  = lq26f7 F7 + e26,
 q22  = lq22f6 f6 + e22,
 q23  = lq23f6 F6 + e23,
 q24  = lq24F6 f6 + e24,
 q25  = lq25F6 F6 + e25,
 f9 =  PF9F6 F6 + PF9F7 F7 + PF9F8 F8 + D9,


 B1A = LB1AF10 F10 + E28,
 B3B = LB3BF10 F10 + E29,
 B3C = LB3CF10 F10 + E30,
 B2C = LB2CF10 F10 + E31,
 B1D = LB1DF11 F11 + E32,
 B2A = LB2AF11 F11 + E33,
 B2B = LB2BF11 F11 + E34,
 B3A = LB3AF11 F11 + E35,
 B3D = LB3DF11 F11 + E36,
 f12 =  PF12F10 F10 + PF12F7 F11 + D12,
 f13 = pf13f5 f5 + p13f9 f9 + p13f12 f12 +d13;


std
e8-e36 = vare8-vare36,
f1 = 1,
F2 = 1,
F3 = 1,
```

```
F4 = 1,
F6 = 1,
F7 = 1,
F8 = 1,
F10 = 1,
F11 = 1,
 D5 = VARD5,
 d9 = vard9,
 d12 = vard12,
 d13 = vard13;

 Cov

F1 F2 = cF1F2,
F1 F3 = CF1F3,
F1 F4 = CF1F4,
F1 F6 = CF1F6,
F1 F7 = CF1F7,
F1 F8 = CF1F9,
F1 F10 = CF1F10,
F1 F11 = CF1F11,
F2 F3 = CF2F3,
F2 F4 = CF2F4,
F2 F6 = CF1F6,
F2 F7 = CF2F7,
F2 F8 = CF2F8,
F2 F10 = CF2F10,
F2 F11 = CF2F11,
F3 F4 = CF3F4,
F3 F6 = CF3F6,
F3 F7 = CF3F7,
F3 F8 = CF3F8,
F3 F10 = CF3F10,
F3 F11 = CF3F11,
F4 F6 = CF4F6,
F4 F7 = CF4F7,
F4 F8 = CF4F8,
F4 F10 = CF4F10,
F4 F11 = CF4F11,
F6 F7 = CF6F7,
F6 F8 = CF6F8,
F6 F10 = CF6F10,
F6 F11 = CF6F11,
F7 F8 = CF7F8,
```

```
201  F7 F10 = CF7F10,
202  F7 F11 = CF7F11,
203  F8 F10 = CF8C10,
204  F8 F11 = CF8F11,
205  F10 F11 = CF10F11;
206
207
208  var Q8 Q9 Q10 q11 q12 q13 q14 q15 q16 q17 Q18 Q19   Q20 Q21 Q22 Q23 Q24 Q25 Q26 Q27
208! B1A B1d B2a B2b B2c B3a B3b B3c B3d;
209  run;

WARNING: 16 of 306 observations in data set WORK.TEST_1 omitted due to missing values.
NOTE: Convergence criterion (GCONV=1E-8) satisfied.
WARNING: Although all predicted variances for the latent variables are positive, the
         corresponding predicted covariance matrix is not positive definite. It has one
         negative eigenvalue.
NOTE: PROCEDURE CALIS used (Total process time):
      real time           29.53 seconds
      cpu time            29.36 seconds


210
211
212
213  ods html close;
214  ods rtf close;
215  ods pdf close;
```

APPENDIX D. LSU/UTAH DATA EMAIL

Reply   Reply All   Forward

Wed 1/6/2016 11:22 AM

Eric Jorgensen <eric.jorgensen@usu.edu>

RE: Thesis Questions

To   Jerry E Steward

You replied to this message on 1/6/2016 11:54 AM.

LSU Data.xlsx
31 KB

Bing Maps   + Get more apps

Jerry,

Let me apologize early for the bomb I am dropping on you, but I am assuming that it may be better for you if you pull out what you want then for me to guess what may be useful. Below I have attached a table from the literature review that is part of my draft dissertation. I have also included a small part of the "Results" section that deals with the creation of the Attitude section of my instrument. Please note that the literature breaks attitude evaluation in to four factors (Awareness, Recognition, Evaluation, and Control). My findings from the Exploratory Factor Analysis (CFA not complete yet) are that there is definitely one factor that accounts for 30.2% of the variance. There are two addition factors accounting for 12.8 and 11.6% of the variance that may come into play. I will have to see the results of the CFA goodness of fit numbers to be sure. There are only four of the ten items that load on factors 2 or 3 and all four strongly cross load on factor 1. This difference in the number of factors contributing to the latent variable attitude may be simply the result of my instrument having so few total items (10).

The LSU data is in the attached file.

Have a good day and stay dry and out of the tornados

Eric F. Jorgensen
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VITA

Mr. Steward is currently the Chemical Safety Manager at the Baton Rouge Campus of Louisiana State University in the Office of Environmental Health and Safety (EHS). The Chemical Safety Manager is responsible for the administration of the University's EHS programs in laboratories across campus. A primary responsibility is ensuring compliance with the regulatory requirements. Another responsibility is educating students and faculty in the methodologies for maintaining a safe work environment in the laboratory. He currently resides in Baton Rouge and has over thirty years of experience as a safety and environmental professional in industry, consulting, and defense.