USING AN ADAPTED LOSA TO ASSESS SAFETY CONDITIONS OF AN UNDERGRADUATE CONSTRUCTION COURSE

by

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ABSTRACT

Students working in the agricultural mechanics laboratory are exposed to valuable career-building skills. However, this is also a hazardous environment in which many are injured annually (Chumbley et al., 2018; Perry et al., 2012; Saucier et al., 2014; Utah Department of Health, 2007). As students leave SBAE and go out into the workforce, the safety story does not improve much with workplace fatality numbers rising in recent years (Bureau of Labor Statistics, 2021). Agricultural mechanics teachers are forced to deal with this problem on an individual basis, so without a standardized method of assessing and teaching safety a gap has been left between how students interact with safety in school and in the workplace. One proposed solution is to utilize industry safety models to teach and assess safety in the classroom. A specific example of this is the Line Operation Safety Audit used by commercial airlines (Klinect et al., 2003). This paper will explore the background of this instrument and its applicability to the agricultural mechanics environment.

CHAPTER ONE

INTRODUCTION

Need for the Study

Safety assessment and training in the agricultural mechanics laboratory, and Career and Technical Education (CTE) at large, is an active sector of research (Chumbley et al., 2018; Love & Roy, 2023; McKim & Saucier, 2011; Perry et al., 2020). Because laboratories are inherently hazardous environments, there is a certain sense of urgency to improve how school-based agriculture education (SBAE) teachers can both train students and assess laboratory safety conditions (Chumbley et al., 2018; Perry et al., 2012; Saucier et al., 2014). In response to that urgency, a major emphasis in recent agricultural mechanics safety research has been professional development for teachers. However, data shows that this may not be sufficient in addressing the disconnect between teachers' perceived abilities in maintaining a safe environment and the level of skill present (Chumbley et al., 2018; McKim & Saucier, 2011; Perry et al., 2020). Evidence of this disconnect is clear with only 43% of CTE programs performing annual safety audits, and some states seeing over 160 CTE-related injuries per year (Love & Roy, 2023; Utah Department of Health, 2007).

Even with such a clear need for a change in the way safety is approached, literature reveals little in terms of action-oriented approaches to alleviate the problem. The question then emerges, how should this issue best be approached? Chumbley et al. (2018) suggested that one way to improve safety conditions is consistent monitoring, rather than focusing solely on professional development and teacher capability. The intersection of improvement and consistent

monitoring can be found in research generated by the rapid increase of human error research and systems thinking in aviation produced by the human factors field in the mid to late 1990s (Klinect et al., 2003). The Line Operation Safety Audit (LOSA) was developed in the 1990s and is now utilized at every level of flight operations in most major airlines around the world (Klinect, 2006). LOSA utilizes Threat and Error Management (TEM) to isolate behaviors or conditions that may negatively impact flight operations (Maurino, 2005). TEM defines threats as conditions outside of human control that could potentially cause harm or an error. Errors, on the other hand, are generally within human control and are caused by an action, or inaction, that results in an undesired outcome. LOSA's use of the TEM framework created a pathway for its application outside of aviation, most notably in the medical field (Civil Aviation Authority of New Zealand, n.d.; Hickey et al., 2015).

Considering that LOSA has been applied outside of aviation previously and that the need for improvements in safety conditions in SBAE laboratories is a cited need (Chumbley et al., 2018; Perry et al., 2012; Saucier et al., 2014), there is potential for applying LOSA to the agricultural mechanics laboratory. Seeing that agricultural mechanics instruction aligns itself with close ties to the trades and industry standards, utilizing industry safety training and assessment methods could be a catalyst for improving safety conditions (National FFA, 2023; Love & Roy, 2022). Through a pilot study conducted in the Spring 2023 semester in an agricultural mechanics course at Montana State University, an adapted LOSA was developed to focus on the human factors influencing laboratory safety conditions.

Statement of Purpose

This study focused on further developing the adapted LOSA instrument and improving observer protocols to more accurately detect threats and errors in the agricultural mechanics laboratory. Along with this, the study sought to determine the applicability of the adapted LOSA to the agricultural mechanic's laboratory environment by monitoring trends in safety conditions in a college-level construction course. Specific objectives were:

Objectives

1. Detect common threats and errors in an undergraduate college-level construction class at a four-year institution.
2. Identify changes in student response time to recognized threats and errors between observations.
3. Explore possible changes in the frequency of each outcome code between observations.
4. Examine the adapted LOSA's applicability in the SBAE mechanics laboratory environment.

Limitations

The following were limitations of the study:

1. The population for this study was limited to a single class at one university, which limits generalizability.
2. At the time of the intervention, observers had not had ample time to gain the trust of students in the class, potentially impacting student behavior and skewing data (Klinect et al., 2003).

Assumptions

1. Human error is pervasive and unavoidable (Hickey et al., 2015).
2. Students had received basic safety training for hand tools, power tools, and personal protective equipment (PPE).

CHAPTER TWO

LITERATURE REVIEW

Defining Safety

According to Maslow's Hierarchy of Needs, safety is a necessity for living, superseded by only basic biological functions like breathing, eating, or sleeping (Maslow, 1943). Presently, there is no agreed-upon universal definition of safety (Mauele, 2003). While it may seem atypical that such a basic human need does not have a consistently shared definition, some authors have made attempts to define safety, a concept that often exists as an abstract idea rather than a concrete thing or shared human experience. One dictionary offers this definition of the word safe: "free from or not liable to danger; involving no danger, risk or error" (Manuele, 2003, pg. 57). Where this definition waivers is its absolute nature due to the simple use of the word "no". This suggests zero danger, but unfortunately that is not reflective of reality. Other authors offer definitions more in tune with the inherently risk-filled world we live in (U.S. Bureau of Labor Statistics, 2021, US Department of Education, 2019). Gloss and Wardle (1984) write that "Safety is the measure of the relative freedom from risks or dangers. Safety is the degree of freedom from risks and hazards in any environment" (Gloss & Wardle, 1984, pg. 3). Further expanding on this thought, "safety is relative – nothing is 100% safe under all conditions" (Gloss & Wardle, 1984, pg. 3). Gloss and Wardle are not alone in this line of thinking. Hammer (1989) agreed, saying that "it is practically impossible to eliminate all hazards" (Hammer, 1989, pg. 142). For this study, the term "safety" was contextualized through the work of these authors

(Hammer, 1989; Gloss & Wardle, 1984), recognizing that while efforts to assess and mitigate risk are essential, risk cannot be eliminated in its entirety.

Introduction of Risk

It is no small claim to say that the world is full of risk and making that claim does not help in giving direction to safety efforts that may be trying to mitigate risk. Being able to identify specific risky environments, however, can give direction to research and trials, effectively managing that risk and creating safer environments piece by piece. Several environments in which safety is commonly discussed are the workplace, schools, and the medical field (Chumbley et al., 2018; Hickey et al., 2015; U.S. Bureau of Labor Statistics, 2022). Another interchangeable term for environment in this instance is socio-technical system. Socio-technical systems are complex environments, encompassing myriad interactions between people, technology, and procedures (Trist, 1978). However, within each of those interactive systems, there exist overlapping subsystems that can offer a granular look at where risk exists. These subsystems are goals and values, technical, psychosocial, structural, and managerial (Kelly, 2006) (Figure 1).

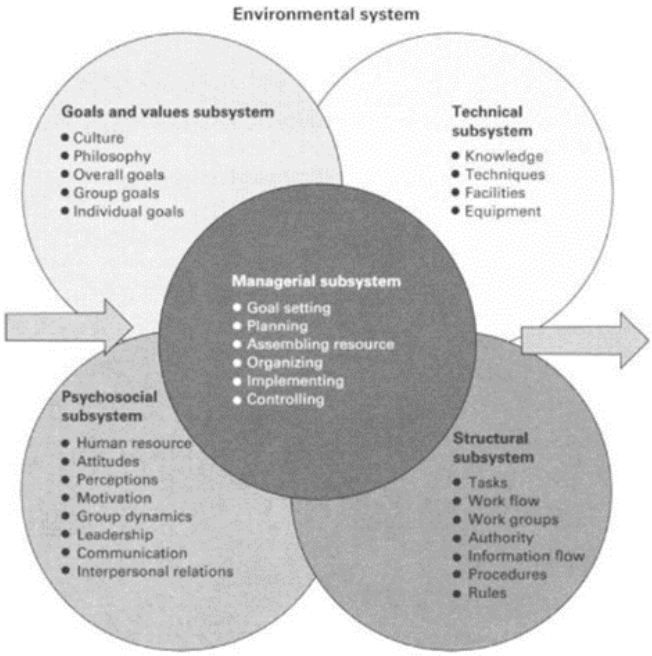


Figure 1. The Organizational System (Kelly, 2006)

Each of these subsystems are prone to different risks within the context of the larger environment. As illustrated in Figure 1, all other subsystems converge in the managerial subsystem, suggesting that the mitigation of risk in socio-technical environments is a matter of goal setting, planning, organizing, assembling resources, and implementing mitigation strategies. Further, experiential learning theory poses that this process ought to be cyclical and repeated so that experience and reflection can be utilized in improving implemented safety measures (Kolb, 1984; Roberts, 2006). Unfortunately, while this approach appears attainable in theory, the state of safety in many socio-technical environments, specifically industrial trades, is less than ideal (Brandt et al., 2021).

Occupational Safety

The inherent risk to these socio-technical environments is made tangible through its impacts on the humans involved in their day-to-day operations (Brandt et al., 2021). In 2021, there were over 5,100 worker deaths in the U.S. (U.S. Bureau of Labor Statistics, 2021). This is an increase from the approximately 4,700 workers killed on the job in 2016 and marked the highest rate of worker death since. Of these deaths, nearly half occurred in the construction and transportation trades. A report from OSHA (2023) showed that in 2022 alone, 1,702 workplace incidents resulting in injury were reported. High-risk environments, like those indicated in these reports, have a vested interest in mitigating safety hazards. While statistics do bring valuable insight, little context is provided as to why the incidents occurred, leaving those who operate in the managerial subsystem with a shortage of usable data to inform risk mitigation moving forward. Further complicating the issue, research suggests that an individual could easily have up to 16 different jobs throughout their career, meaning that they will undergo many changes in the socio-technical system they are a part of (University of Queensland, 2023). This means that determining the cause of these incidents is near-impossible because the incident may not be entirely isolated to the current environment.

The number of jobs held by an individual increases if secondary and post-secondary schooling are considered, creating a game of telephone in which certain details, in this case relating to safety, are lost in the shuffle of each environmental transition. A certain amount of the burden of safety lies on the individual (Civil Aviation Authority of New Zealand, n.d.; Reason, 2016), but those charged with managing socio-technical systems, like those that contribute to the previously mentioned workplace statistics, still have a responsibility to improve safety conditions

for employees who are beholden to the managerial subsystem (Kelly, 2006). The responsibility to improve conditions places an impossible task on the shoulders of those within the managerial subsystem, simply because no amount of planning could account for the background training or information that each participant within a socio-technical system brings in with them. This then begs the question, what socio-technical systems were these individuals a part of before their incidents? The US Department of Education (2019) attempted to answer this question by suggesting that CTE classrooms serve as the training ground for workforce development.

CTE and the Trades

Before entering the workforce, many workers were enrolled in CTE programs, like agriculture education (Advance CTE, 2023), where the risk of potential injury is high (US Department of Education, 2019). According to a survey conducted by the Utah Department of Health (2007), 160 students per year were injured in CTE classes, with 90% of those injuries being related to equipment use (National Center for Education Statistics, N.D.; Utah Department of Health, 2007). While several factors could have contributed to those incidents, the importance of these statistics lies in the futures of the students who come out of CTE programs and the transfer of safety skills that occurs between the classroom and the workforce (Love & Roy, 2022).

Recent years have witnessed positive trends in students entering the trades (National Student Clearinghouse, 2023). Enrollment in construction, mechanics and repair, and precision and production trade programs have increased by 19.3%, 11.5%, and 16.7% respectively with many of those students having been enrolled in high school CTE classes (US Department of Education, 2019; National Center for Education Statistics, N.D.). Since possession of skills

appropriate to the task at hand is required for an individual's safety in a given environment, and seeing that such skills are developed through CTE classes, it stands to reason that current safety assessment and education practices may not be adequate in preparing students for their transition into a new socio-technical system (Deegan et al., 2016; Freeman et al., 2021; Perry et al., 2012).

Danger of Agricultural Mechanics Laboratories

Many researchers agree that the agricultural mechanics laboratory environment possesses numerous safety hazards (Chumbley et al., 2018; Perry et al., 2012; Saucier et al., 2014). In early reports, Swan (1993) indicated a mean of 13.3 minor accidents (not requiring medical attention) and 1.3 major accidents (requiring medical attention) per classroom, per year. With such high risk for students, the question of who is responsible for ensuring safety in the laboratory is raised. This responsibility often falls to the teacher, the managerial body of the agricultural mechanics laboratory, as the most important task amongst "the myriad of responsibilities affixed upon the shoulders of agricultural mechanization teachers" (Chumbley et al., 2018, p. 309).

SBAE Teacher Safety

There is a wide array of safety concerns for agricultural mechanics teachers, including but not limited to, whether they can properly prepare students to use dangerous equipment, their diligence in maintaining the laboratory space, and whether they can sufficiently supervise students in the laboratory (McKim & Saucier, 2011). In a study of SBAE teachers, data showed that most of the laboratory management competencies that needed improvement were related to safety, despite these same teachers holding high self-perceptions of their abilities in the respective areas (McKim & Saucier, 2011). These findings are consistent with previous research

on teachers' abilities to instruct laboratory safety (Dyer & Andreason, 1999). Chumbley et al. (2018) saw this same theme of high self-perceptions in readiness to teach a variety of safety topics for agriculture teachers in Texas, with no safety topic category receiving a mean score less than 3.48 on a scale of one to five. Similarly, agricultural educators in Georgia indicated that safe practices were the most essential professional development needed in the realm of agricultural mechanics (Yopp et al., 2016). While little current data exists about rates of injury in the agricultural mechanics laboratory, McKim & Saucier (2011) and Chumbley et al. (2018) agree with the conclusion of Dyer & Andreasen (1999) that agriculture teachers need more training to be able to properly inform their safety curriculum. However, extra training for teachers may not be enough. Perry et al. (2020) found that even after agriculture teachers went through a 10-hour "train-the-trainer" workshop, their respective students still only averaged a minimum passing score on an administered safety test. Despite agricultural mechanics instructors teaching safety through hands-on materials, videos, worksheets, and more; there is still a disconnect (Chumbley et al., 2018). The answer to closing this gap may instead fall in the same vein as suggested by Chumbley et al. (2018), continuous evaluation of safety conditions.

Laboratory Safety Assessment

To continuously evaluate safety conditions, it is implied that there would be some regularity to those assessments. However, the regularity of safety assessment is less-than-ideal with annual safety audits of any kind occurring in only 43% of CTE programs (Love & Roy, 2023). The methodology of assessment is also greatly varied. In Texas, schools are required to complete a school safety and security audit every three years (Texas School Safety Center, 2023). Elsewhere, SBAE teachers try to piece together audits from OSHA guidelines. Dyer and

Andreasen (1999) suggest another solution, bringing in administration regularly to assess laboratory spaces. All these options create yet another decision left to the teacher with an already full plate (Chumbley et al., 2018), determining how to assess laboratory safety. Since students carry what they know about safety into their careers, perhaps agricultural mechanics teachers should be looking to the industry to properly prepare students (Love & Roy, 2022).

Threat and Error Management

One specific industry that has been taking steps for over 30 years to find and address safety issues is the aviation industry. The aviation industry adopted the preventative philosophy of Threat and Error Management (TEM) through a tool, now used by many commercial airlines, known as LOSA (Hickey et al., 2015; Klinect et al., 2003; Merrit & Klinect, 2006; Maurino, 2005). In short, TEM is "a conceptual framework that assists in understanding, from an operational perspective, the inter-relationship between safety and human performance in dynamic and challenging operational contexts" (Maurino, 2005, pg. 1). Within this framework, threats are defined as events that occur beyond human influence, and errors are actions or inactions that can result in an unexpected outcome. Threats and errors are often linked together forming what is known as an "error chain". One illustration of an error chain is the Swiss Cheese

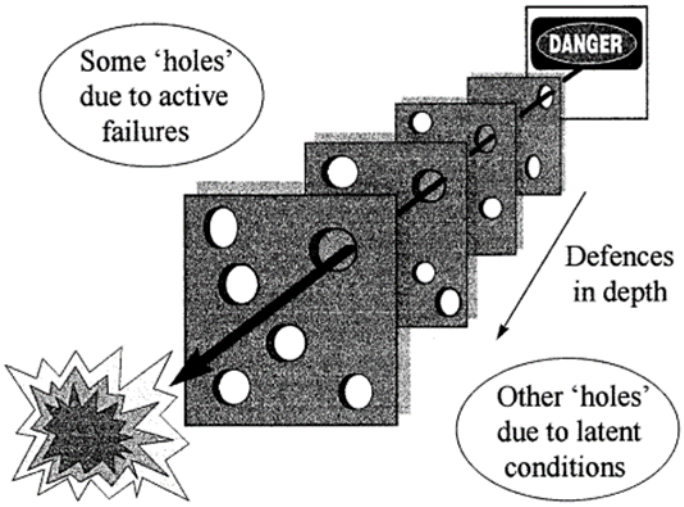


Figure 2. Swiss Cheese Model (Reason, 2016).

As shown in Figure 2, defenses set in place by the managerial subsystem have holes left by latent conditions or conditions that are present, but not actively causing harm (Kelly, 2006; Reason, 2016). The specific sequence of active failures that align the holes in the cheese is the "error chain" (Maurino, 2005). In this illustration, the cheese represents existing systemic safeguards, like safety guidelines, that catch almost everything but cannot account for every possible situation (Perneger, 2005; Reason, 2016).

In aviation, TEM has been able to explain over 90% of crashes (Hickey et al., 2015). Between 1996 and 2000, LOSA had become a widely accepted tool by flight crews from 20 major airlines in 10 different countries (Klinect, 2006). LOSA, combined with the preventative philosophy of TEM, allowed pilots to look at a massive data set collected by an impartial observer and make adjustments accordingly (Klinect et al., 2003). This was shown to be overtly effective via a 70% decrease in unstable approaches to landing as well as a general improvement in flight crew performance over four years (Gunther, 2002).

It should be noted that LOSA is not the sole contributor to such great leaps in flight safety. Other systems, like the Flight Operational Quality Assurance (FOQA), are also in place to help find problems before they present themselves (FAA, 2004). FOQA's focus is to gather data through a Flight Data Recorder (FDR) concerning "pertinent parameters and technical information about the flight" (FAA, 2004, pg. 4), or in layman's terms, gathering data about things like flap positions, landing gear, and other instrumentation. Though this system is not the focal point of this study, it is important to mention to clarify that LOSA did not "fix" aviation safety on its own. Rather, LOSA is one cog in the flight safety machine that has high potential in SBAE laboratories. LOSA and FOQA, along with other tools and trainings, have all contributed to air travel in the US being safer than almost any other mode of travel (Morris, 2023).

LOSA in Other Industries

With LOSA seeing success in the airline industry, other industries took notice, notably the medical community. Human factors research, the foundation of LOSA, has been a major contributor to the enhancement of safety conditions in socio-technical systems (de Leval et al., 2000). One such socio-technical system is the surgical team. Human factors research in this environment has been applied to help doctors understand adverse events and strategize ways to avoid them in the future. A specific example of this comes from Hickey et al. (2015). In this study, 524 pediatric cardiac surgery patients were monitored. A LOSA-style audit was applied to the surgical team, including nurses, surgeons, and post-operation care. Data showed that while approximately 86% of threats were effectively managed, there were over 100 threats amongst 75 patients that resulted in errors. The error data showed that 49% of patient procedures had at least one error present, meaning that there was a mistake made that was within human control. It

should be noted that the nature of Hickey et al.'s (2015) study did not lend itself to the continuous observation of a true LOSA, but the value of the observations is not diminished.

Hickey et al. (2015) noted that three key elements connect surgery, aviation, and other complex, high-stakes systems in their philosophies of human error.

1. All have developed a preoccupation with failure and have engrained a culture of systemic vigilance;
2. All have endorsed and promoted mechanisms for blame-free error assessment and analysis; and
3. All accept that human error is both ubiquitous and inevitable. (Hickey et al., 2015, p. 504)

What these three elements describe are socio-technical environments that acknowledge the unavoidable presence of risk caused by human error (Hammer, 1989; Hickey et al., 2015), but that are still focused on consistent improvement without punishing individuals who fall short. In Hickey et al. (2015), it was further confirmed that human error was not only common, but two-thirds of the recorded errors were consequential, meaning that they resulted in an unintended consequence. This doesn't account for threats and error types that were not recorded because they were unable to be as granular or continuous in observation as preferred.

LOSA's Application to the Agricultural Mechanics Environment

Recognizing how LOSA and TEM have been used to inform safety decisions and find weak points in flight operations and surgical settings (Klinect et al., 2003; Maurino, 2005; Hickey et al., 2015), it stands to reason that there may be use for this tool in the SBAE agricultural mechanics laboratory. According to Hickey et al. (2015), human error is present and

inevitable in industry-style environments, much like the agricultural mechanics laboratory. Part of why these environments are so prone to human error is stress and its negative impact on information absorption and decision-making (Helmreich, 1997). By instituting LOSA, airline personnel, and surgeons have been able to see where threats already exist and where their action or inaction has created a threat or error, thus leading to the creation of targets for enhancement (Hickey et al., 2015; Kinect, 2008). The recognition of shortcomings and the creation of an improvement goal is where LOSA intersects with SBAE safety instruction. LOSA offers a direct application of experiential learning theory by providing specific data that students can engage with to improve the safety conditions of the laboratory (Kolb, 2014).

LOSA as a Reflection Tool

According to experiential learning theory, learning is a process wherein reflection is a required step in transforming information into knowledge (Kolb, 2014). In the cases of the previously mentioned pilots and surgeons, the information was LOSA data and the created knowledge was the target for enhancement. The effectiveness of this method was highlighted by Klinect (2008) through a case study of 182,500 flights where an initial LOSA observation found that 11% of flights had unstable approaches to landing and 50% of flights experienced checklist errors. Upon reflection and implementation of targets for enhancement, unstable approaches dropped to 4% and checklist errors to 24% after one year. The effectiveness of experiential learning methods is well documented in research beyond Klinect's (Coleman et al., 2021; Jose et al., 2017; Le et al., 2015), revealing a natural intersection between industry safety assessment and SBAE safety instruction.

Frameworks

This study will use the Threat and Error Management (TEM) and Kolb's Model of Experiential Learning frameworks to interpret different portions of the LOSA data. The TEM model is used to help understand "the inter-relationship between safety and human performance in dynamic and challenging operational contexts" (Maurino, 2005, pg. 1) and is heavily tied to the original LOSA (Klinect et al., 2003; Maurino, 2005; Merritt & Klinect, 2006). As such, the TEM will be used as a base for understanding the adapted LOSA safety codes and to help inform suggestions for future researchers and practitioners. Kolb's Model of Experiential Learning will be used in forming suggestions for practitioners (i.e. teachers). The intended purpose of involving experiential learning is in the direct application of the adapted LOSA data to the agricultural mechanics laboratory. While TEM is largely responsible for generating the data and influencing the way the audit contextualizes safety, Kolb's Model is where students and other practitioners will find practical value.

Threat and Error Management

A basic presupposition of the TEM framework is that human error has existed as long as humans themselves and permeates everything humans do (Brennan et al., 2020). TEM is a way by which an individual or group can predict and avoid errors or potential threats, specifically when applied through LOSA (Maurino, 2005). Originally developed at The University of Texas, this framework was a product of LOSA observations and was based on flight crew responses to threats and errors (Civil Aviation Authority of New Zealand, n.d.; Klinect et al., 2003). Threats occur when "a situation or event has the potential to hurt safety" (Civil Aviation Authority of New Zealand, n.d., pg. 4). There are several different types of threats that can be related to

environment or humans but are largely considered to be outside of a person's control (Maurino, 2005). Errors on the other hand are generally rooted in human action or inaction and sometimes result in a negative impact on safety (Civil Aviation Authority of New Zealand, n.d.). With this in mind, it should be noted that errors are almost always considered unintentional by the observer, effectively removing any assumption of malintent.

Because TEM is heavily tied to the aviation world, a large portion of the literature focuses on its applicability at all levels of flight operation, but there is an "obvious safety benefit of recognizing and managing threats, errors, and undesired states before they lead to a serious incident" that applies beyond a singular industry (Civil Aviation Authority of New Zealand, n.d., pg. 2). This line of thinking is what causes TEM to present as an ideal framework for reimagining how agricultural mechanics laboratory safety audits function. When TEM is used as a safety audit tool, analysis of single events or systemic patterns found in larger data sets is appropriate. In addition, literature supports TEM's use as a training tool to help in the improvement of safety instruction as well as to inform safety policy (Maurino, 2005). The focus on human performance distinguishes this framework from other existing safety audit systems by providing behavioral feedback to the user instead of a list of physical improvements to the observed space or routine.

Of the many possible applications of TEM, this study will focus on its use in helping shape the adapted LOSA. A basic assumption of this study is that human error pervades all human action and that we cannot avoid it (Brennan et al., 2020; Hickey et al., 2015). In the agricultural mechanics laboratory, it is crucial to assess safety conditions in a way that accounts for all aspects of the socio-technical system (Kelly, 2006; Trist, 1978). With this in mind, it

would be irresponsible to claim that TEM, when specifically focused through LOSA, is a fix-all solution. However, it does offer a unique perspective on how people interact with active and latent hazards (Maurino, 2005).

Experiential Learning

Both the why and how of implementing any framework are equally as valuable as the content itself. Data analysis and application can require a framework of its own, which is where experiential learning theory enters the current study. For data from the adapted LOSA to be of practical use, a practitioner needs a framework through which to contextualize that data for effective communication. Kolb's Model of Experiential Learning (Figure 3) is one such framework that brings a perspective on the learning process that emphasizes a concrete experience (Kolb, 2014).

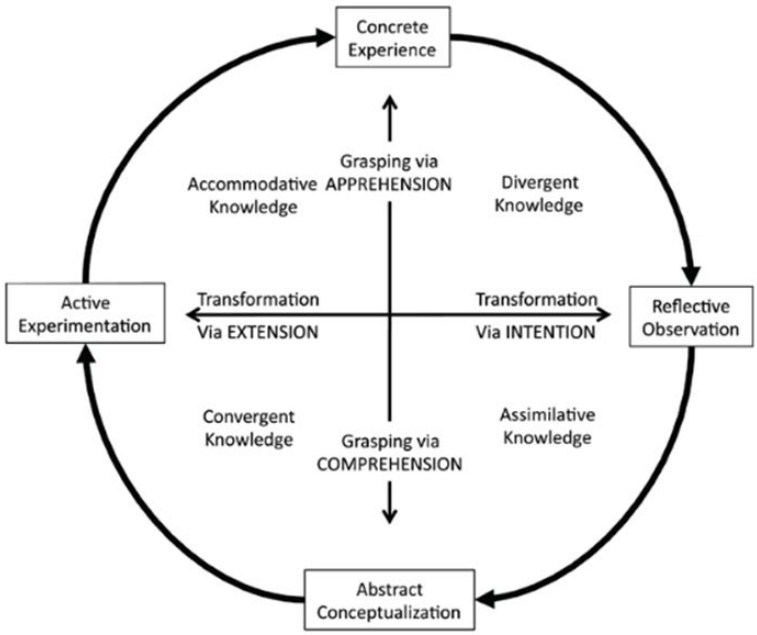


Figure 3. Model of Experiential Learning Process. Experiential Learning: Experience as the Source of Learning and Development (Kolb, 1984, p. 42)

Experiential learning theory is rooted in the work of several notable philosophers who were considered "Foundational Scholars of Experiential Learning" by Kolb (2014, pg. xvii). Among these notable individuals are William James, John Dewey, Jean Piaget, and Lev Vygotsky. Kolb (1984) developed the Experiential Learning Theory to bring the common themes of these scholars' works into a systematic framework that would be a useful perspective for the modern person in any situation or area of life. This work is important to the implementation of TEM and LOSA in agricultural mechanics due to its inclusion of reflection as a vital step in the creation of knowledge. Referring to the work of Maurino (2005), TEM is useful as a safety training tool, but greater value is added when data is used to create targets for improvement (Hickey et al., 2015). Whether a flight crew, a team of surgeons, or an SBAE teacher with their students, reviewing LOSA data points together to create targets for improvement is an expression of experiential learning. Kolb (2014) writes that "experiential learning… links education, work, and personal development" (pg. 4), providing more rationale for tying industry safety practices into the classroom and laboratory.

For this study, experiential learning theory was used in discussing and providing recommendations for utilizing LOSA data in the safety curriculum in conjunction with its use as a safety assessment tool. Teachers are responsible for providing learning experiences that lead to educational growth, so the apparent lack of opportunity to learn safety experientially may inhibit students' abilities to perceive potential threats and understand subsequent errors (Chumbley et al., 2018; Dewey, 1938). Mere access to data points would not be transformative in and of itself. Where the LOSA experience finds its value, is when the teacher and students alike transform the experience into learning by reflection (Kolb 2015).

Schön (1983) outlines two different types of reflection that can occur. The first, reflection-in-action, occurs in real-time, allowing for conversion from performance to knowledge. An example of this in SBAE could be an instructor reminding a student of proper hand positioning while using a saw. The second form is reflection-on-action. This occurs after the experience and is heavily reliant on a learner's ability to intuit information from an internal representation, or memory, of the experience. This is the form of reflection that best supports the intended use of LOSA data. Schön (1983) goes on to say that "reflection enables the inquirer to criticize, test, and restructure his understandings" (p. 277). The restructuring of understandings is where experiential learning ties back into the recommendation of Dyer and Andreason (1999), continuous evaluation of safety conditions. The reason continuous evaluation is important is because experiential learning is cyclical (Roberts, 2006), meaning that it happens repeatedly. This means that reflection on an experience, in this case, the LOSA experience, is not a matter of creating new knowledge once, but rather continuously revisiting existing knowledge to improve and bring practices more in line with reality.

Summary

In summary, TEM and LOSA are tools used in multiple industries that have the potential to bring positive change to the safety culture of agricultural mechanics laboratories. With an increasingly dangerous work environment, students need to be properly equipped to enter the workforce (Department of Labor, 2023; Love & Roy, 2022; U.S. Bureau of Labor Statistics, 2022). Teachers need something to fill the gaps that the current systemic defenses leave (Chumbley et al., 2018; Dyer & Andreasen, 1999; National Center for Education Statistics, N.D.; Perry et al., 2012; Saucier et al., 2014; Utah Department of Health, 2007). SBAE does not

currently apply frameworks that consider human error to their safety assessments, making it clear that an examination of the threats and errors present in the agricultural mechanics laboratory using the adapted LOSA is warranted. To apply such a framework, this study sought to further develop the applicability and observer protocols of the adapted LOSA instrument due to the "obvious safety benefit of recognizing and managing threats, errors and undesired states before they lead to a serious incident" that apply beyond a singular industry (Civil Aviation Authority of New Zealand, n.d., pg. 2).

CHAPTER THREE

METHODS

This study focused on further developing the adapted LOSA instrument and improving observer protocols to more accurately detect threats and errors in the agricultural mechanics laboratory. Along with this, the study sought to determine the applicability of the adapted LOSA to the agricultural mechanic's laboratory environment by monitoring trends in safety conditions in a college-level construction course. Study objectives are as follows:

1. Detect common threats and errors in an undergraduate college-level construction class at a four-year institution.
2. Identify changes in student response time to recognized threats and errors between observations.
3. Explore possible changes in the frequency of each outcome code between observations.
4. Examine the adapted LOSA's applicability in the SBAE mechanics laboratory environment.

Population

The selected population for this study (N=21) was all students enrolled in the fall 2023 section of AGED 333, an undergraduate construction technologies course offered at Montana State University. Students in this course were upperclassmen with 13 enrolling as a major requirement and eight as an elective. This course was selected for its close representation of the SBAE agriculture mechanics laboratory environment. According to the Power, Structural, and Technical Systems career pathway, an agricultural mechanics program "…applies knowledge of

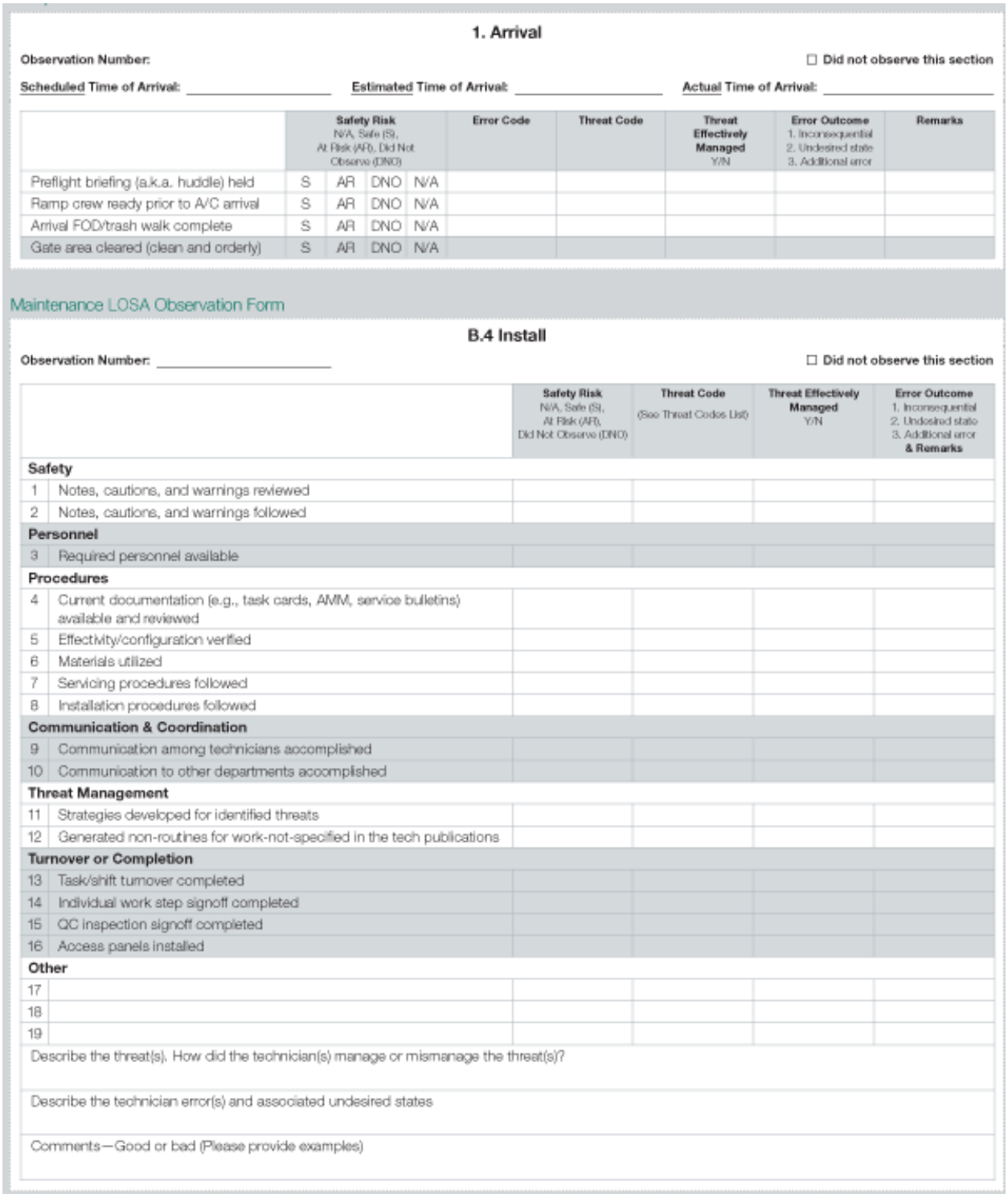
engineering, hydraulics, pneumatics, electronics, power, structures and controls to the field of agriculture" (National FFA, 2023). Under that umbrella, construction and carpentry fall within the structures category and are identified as potential careers for students who complete this pathway.

Instrumentation

Precursors to the LOSA were created by The University of Texas Human Factors Research Project in 1994 and commissioned by Delta Airlines to help determine if training concepts transferred to real-time operations (Klinect et al., 2003). The tool that resulted from this project was designed with flight crew comfort and trust in mind. Researchers postulated that if the LOSA felt like traditional evaluations then it would "elicit fake behavior and defeat the purpose of the project" (Klinect et al., 2003 pg. 1). To get around this, data were never used to evaluate a specific pilot nor to justify disciplinary action. Instead, Crew Resource Management (CRM) behavior markers, like leadership, workload management, and communication environment, provided the airline with a quantified performance baseline. Using data from those markers, baseline targets for improvement could be established, tying together the LOSA, TEM, and Kolb's model of experiential learning (Klinect et al., 2003; Klinect, 2008; Kolb, 2014; Maurino, 2005).

Instrumentation for this study was adapted from a LOSA form obtained from the Department of Aviation at the University of North Dakota (B. Wild, personal communication, February 6, 2023). This specific LOSA (Figure 4) is for the ground operations crew. The sections to be observed using this instrument were the arrival of the aircraft and the installation of an unspecified component. LOSA relies on coded responses, as shown in the headings for each

column, rather than long-form notes that may leave subjectivity in reviewing the data, a feature that was maintained in the adapted tool. The original LOSA also has specific prompts of what an observer should be looking for in their observation. This can be seen in the *Arrival* section with only a handful of prompts, or in the *Install* section where there are enough prompts that subheadings are used to help keep them organized for the observer.



1. Arrival

Observation Number: ☐ Did not observe this section

Scheduled Time of Arrival: _____ **Estimated Time of Arrival:** _____ **Actual Time of Arrival:** _____

	Safety Risk N/A, Safe (S), At Risk (AR), Did Not Observe (DNO)				Error Code	Threat Code	Threat Effectively Managed Y/N	Error Outcome 1. Inconsequential 2. Undesired state 3. Additional error	Remarks
Preflight briefing (a.k.a. huddle) held	S	AR	DNO	N/A					
Ramp crew ready prior to A/C arrival	S	AR	DNO	N/A					
Arrival FOD/trash walk complete	S	AR	DNO	N/A					
Gate area cleared (clean and orderly)	S	AR	DNO	N/A					

Maintenance LOSA Observation Form

B.4 Install

Observation Number: _____ ☐ Did not observe this section

		Safety Risk N/A, Safe (S), At Risk (AR), Did Not Observe (DNO)	Threat Code (See Threat Codes List)	Threat Effectively Managed Y/N	Error Outcome 1. Inconsequential 2. Undesired state 3. Additional error & Remarks
Safety					
1	Notes, cautions, and warnings reviewed				
2	Notes, cautions, and warnings followed				
Personnel					
3	Required personnel available				
Procedures					
4	Current documentation (e.g., task cards, AMM, service bulletins) available and reviewed				
5	Effectivity/configuration verified				
6	Materials utilized				
7	Servicing procedures followed				
8	Installation procedures followed				
Communication & Coordination					
9	Communication among technicians accomplished				
10	Communication to other departments accomplished				
Threat Management					
11	Strategies developed for identified threats				
12	Generated non-routines for work-not-specified in the tech publications				
Turnover or Completion					
13	Task/shift turnover completed				
14	Individual work step signoff completed				
15	QC inspection signoff completed				
16	Access panels installed				
Other					
17					
18					
19					

Describe the threat(s). How did the technician(s) manage or mismanage the threat(s)?

Describe the technician error(s) and associated undesired states

Comments—Good or bad (Please provide examples)

Figure 1. Ramp LOSA Observation Form

For this study, four adaptations of LOSA were developed through a pilot study conducted in the Spring of 2023. The pilot study relied on the feedback of observers to use as a rationale for the changes made to each version of the adapted LOSA. Version one (Figure 5) was adopted as visually similar to the original LOSA form obtained for the pilot, with only slight changes to the wording of the form to better align with the agricultural mechanics laboratory. Based on observer discussions on the first round of observations, this version was deemed unsuitable as it was too focused on individual behavior rather than recognition and an approach to managing/maintaining a safe environment that is more aligned with TEM (Maurino, 2005).

Adapted LOSA Form v. 1 - Pilot Study Only				
Observation:		Observer Name:		
	Safety Risk -N/A -(S) Safe -(AR) At Risk -(DNO) Did not observe	**Observed Threat**	**Threat Effectivley Managed** Y/N	**Threat Outcome** 1.Inconsequential 2.Undesired State 3.Additional Error
Safety				
Proper Student PPE				
Proper Instructor PPE				
Procedures				
Students know classroom procedures				
Lab materials are readily accessible				
Safety supercedes procedure				
Communication/Coordination				
Student questions are answered promptly				
Instruction sets are thorough				
Instructional errors are corrected promptly				
Environment is condusive to communication				
Lab wrapup				
All students participate in cleaning work space				
Instructor ensures lab is secure before dismissing class*				
Personnel				
Students remain in lab area unless otherwise excused				
Instructor remains in lab area unless communicating otherwise to class				

Figure 2. LOSA version 1

Version two (Figure 6) reimagined the instrument and introduced all the features of the final form except for the time stamps. This iteration introduced the cover page (Figure 7) as well as the code index (Figure 8). The code index, sourcing most of its categories and definitions from OSHA, was developed to help organize the near-infinite potential safety instances that could take place in the agricultural mechanics laboratory into 13 codes. The version shown in Figure 8 was the final version used for this study.

Adapted LOSA Form v. 2 - Pilot Study Only

Observation: Observer Name:

Threat/Error	Code	Threat Recognized (Y/N)	Threat Addressed (Y/N)	Resolution 1) Inconsequential 2) Undesired State 3) Additional Error

Figure 4. LOSA version 2

Adapted LOSA v2 Pilot Only

Shop Demographics

Indicate which operations occur within the space you are observing. Check all that apply.

☐ Welding
☐ Small Engines/Automotive
☐ Woodworking/Construction
☐ Painting
☐ Electricity
☐ Other (please list below)

Proper PPE

☐ Students
☐ Instructor

Figure 3. LOSA version 2 cover page

Threat/Error Code Index Single threat/errors may fall into more than one category. Please list all that apply on audit sheet.

01 **Trip/Slip/Spill** OSHA
-Any object or material that is generally foreign to a walkway that could be considered a threat. Examples may include puddles, leaks, cords, tool boxes, etc.

02 **Fall** OSHA
-An action or situation in which an individual is at risk of falling from an elevated surface (i.e. a roof or scaffolding). Look for consistent three points of contact to precent falls.

03 **Falling Object** OSHA
-Any object that is at risk of falling from its current position and hitting someone. Examples may include poorly stacked lumber, improperly stored tools, or unsecured structures.

04 **Crush** see link
-Any space, between mobile objects, that a person or appendage could be caught between. Examples may include tool carts or scaffolding. (https://ag-safety.extension.org/mechanical-hazards-crush-points/)

05 **Tool Handling** OSHA
-Any instance of a tool not being used for its intended purpose or being otherwise abused. Examples may include using a drill as a hammer, not oiling pneumatic tools, or leaving a tool in a walkway.

06 **Material Handling/Disposal** OSHA
-This relates to the handling of lubricants, adhesives, fuels, and solvents. Handling procedure should align with manufacturer guidelines and any flammables should be disposed of in a designated receptacle.

07 **Flammables** OSHA
-This includes use of aerosol sprays, paints, stains, fuel, and some solvents. Observers should look for proper ventilation and proximity to other potentially flammable materials during use (i.e. wood, sawdust).

08 **PPE/Appropriate Attire** OSHA
-Eye protection is required at all times, and ear protection should be worn when operating or working near loud equipment (i.e. table saw, grinders, pneumatic nail guns). Loose clothing or jewelry also poses risk, potentially becoming ensnared in equipment and leading to injury. Similarly, open toed shoes leave the individual at risk for trips/slips, crush hazards, and feet coming in contact with other sharp items.

09 **Communication Obstruction/Miscommunication**
-Any condition or scenario that inhibits communication between individuals in the laboratory space. This could be noise from equipment effecting conversation between classmates, or an instructor not speaking loudly enough, causing some students to miss important information.

10 **Missing Guards** OSHA
-Any tool that should have a guard installed per manufacturer instructions, but does not. (i.e. table saw, grinder)

11 **Electric Shock**
-Any behavior or scenario that results in individual(s) coming in contact with live, exposed wires.

12 **Lifting/Transporting**
-Any instance in which an individual(s) moves equipment or building materials in a way that puts them at risk of injury

13 **Miscellaneous**
-Any threat or error identified by an observer that does not fall within the provided categories. Record details in provided not section.

Figure 5. LOSA code index

Observer discussions after version two resulted in the addition of a beginning time stamp and the change of result three in the resolution section from “additional error” to “injury” for version three, along with an overhaul of the cover page that added a notes section and removed the PPE section in favor of a PPE code in the code index. The observers felt this version accurately captured what was happening in the laboratory and only suggested the addition of an ending time stamp column for version four (Figure 9), an oversight from version three.

Adapted LOSA Form v. 4 - Pilot Study Only

Observation: Observer Name:

Threat/Error	Code	Threat/Error Recognized (Y/N)	Time	Threat/Error Addressed (Y/N)	Time	Resolution 1) Inconsequential 2) Undesired State 3) Injury

Figure 6. LOSA version 4

The most significant discussions surrounding the form involved the time stamps and resolution columns. When discussing time stamps, observers shared that even though a given threat or error may have been both recognized and addressed, it may take most of the class time

for that to happen—including the option of time stamps provided greater context for readers on the back end as well as another data point for reflection and instruction. Regarding the resolution column, it was found that this field was the most subjective since it can sometimes be difficult to find the exact line between what is inconsequential and an undesired state. This is less of an issue if each observer is consistent.

There was another round of changes made to the instrument after the pilot study. Feedback was received from the principal investigator's committee to help the usability of the tool for use in a full-sized study. Changes resulting from this feedback included the inclusion of a code index at the top of the data collection sheet, written descriptors of each code in the index, and some changes to the index itself including descriptions, new codes, and the combining of some existing codes (as depicted in Figure 8). After implementing these changes, version five (Figure 10) was approved by members of the committee along with the updated code index. All items in the code index are based on existing OSHA standards.

01) Trip/Slip | **02)** Fall | **03)** Falling Object | **04)** Crush | **05)** Tool Handling | **06)** Material Handling/Disposal | **07)** Flammables
08) PPE/Appropriate Attire | **9)** Communication Obstruction | **10)** Missing Guards | **11)** Electric Shock | **12)** Lifting/Transporting | **13)** Miscellaneou

Adapted LOSA Form v. 5

Observation: Observer Name:

Threat/Error	Code	Time	Threat/Error Recognized (Y/N)	Time	Threat/Error Addressed (Y/N)	Resolution 1) Inconsequential 2) Undesired State 3) Injury

Figure 7. LOSA version 5

During this study, one change was made to the instrumentation before round two of data collection. A column was added to allow the observers to denote multiple instances of the same threat/error (Figure 11). This change was made at the request of the observers and was intended to increase the ease of use for the adapted LOSA.

01) Trip/Slip | **02)** Fall | **03)** Falling Object | **04)** Crush | **05)** Tool Handling | **06)** Material Handling/Disposal | **07)** Flammables | **08)** PPE/Appropriate Attire | **09)** Communication Obstruction **10)** Missing Guards | **11)** Electric Shock | **12)** Lifting/Transporting | **13)** Miscellaneous

Adapted LOSA Form v. 5

Observation: Observer Name:

Mark here for multiple instances	Threat/Error	Code	Time	Threat/Error Recognized (Y/N)	Time	Threat/Error Addressed (Y/N)	Resolution 1) Inconsequential 2) Undesired State 3) Injury

Figure 8. LOSA version 5 with an added column

Data Collection

Using the adapted LOSA, data collection sessions occurred according to the schedule laid out in Figure 11, during regular laboratory meetings of AGED 333.

Observation 1: 10/5/23
Observation 2: 10/16/23
Observation 3: 11/30/23

Figure 9. Data Collection Dates

Two third-party observers were given a brief orientation to aid in using the adapted LOSA before the first observed laboratory meeting. Orientation involved a member of the research team meeting with the observers and walking through each portion of the adapted

LOSA instrument itself as well as the written observer protocols. These written protocols included how to utilize the "laboratory context" checkboxes and code index provided on the cover page as well as how to properly fill out each column on the adapted LOSA instrument. There was no personal or identifying information collected from students or instructors. Adapted LOSA sheets were collected and entered into Excel files specific to the round of observation being recorded. As previously mentioned, each threat/error was given a number from the code index (i.e. spill, trip hazard, material handling) to expedite the data-cleaning process (See Figure 9). This data was used to provide an idea of what threats and errors were most prevalent during the observed class meeting along with percentage scores regarding which threats/errors were acknowledged and addressed, and a mean response time. After the quantitative data was collected and organized, exit interviews with the observers were recorded and transcribed to explore the instrument's usage and potential suggestions for improvement. Portions of either the written protocol or the adapted LOSA itself were open to be changed, or eliminated. Because this project was primarily focused on instrument development, changes to the instrument were made throughout the study to improve the observers' understanding of the tool.

Data Analysis

Quantitative data from each round of observation was analyzed using Microsoft Excel because of its data organization and visualization capabilities that are available to this project at little to no cost (Guerrero et al., 2019). All data points were sorted by threat/error code in ascending numerical order to help organize the Excel sheet. Percentage scores were then generated to reflect how often specific types of threats and errors were recognized and/or responded to, and the time stamps were used to generate a mean response time between

threat/error recognition and when/if it is addressed. Percentage scores were generated for the outcome column to show how often observed threats/errors were either inconsequential, left in an undesired state, or resulted in injury.

Qualitative data gathered from semi structured exit interviews was recorded and transcribed using the Otter app and exported to Microsoft Word for analysis and storage (Fox, 2009). These transcripts were treated as the primary support for changes made to the instrument based on observer comments concerning clarity of instructions and user-friendliness (Cresswell, 2015).

Summary

Through multiple rounds of revision, five versions of the adapted LOSA were generated along with an accompanying code index and cover page. These were then used by two third party observers to record data over three rounds of observation in an undergraduate level construction class. After each round of observation, a semi-structured exit interview was conducted with observers to gain further insights into the usability of the instrument and the written protocols provided to observers. These interviews were recorded and transcribed using the Otter app. Quantitative data was then imported to Microsoft Excel where it could be organized and analyzed. Following this, both quantitative and qualitative data was used to inform changes to the instrumentation and protocols between each round of observation.

CHAPTER FOUR

RESULTS

This study focused on further developing the adapted LOSA instrument and improving observer protocols to more accurately detect threats and errors in the agricultural mechanics laboratory. Along with this, the study sought to determine the applicability of the adapted LOSA to the agricultural mechanic's laboratory environment by monitoring trends in safety conditions in a college-level construction course. Specific objectives were as follows:

1. Detect common threats and errors in an undergraduate college-level construction class at a four-year institution.
2. Identify changes in student response time to recognized threats and errors between observations.
3. Explore possible changes in the frequency of each outcome code between observations.
4. Examine the adapted LOSA's applicability in the SBAE mechanics laboratory environment.

Data generated by the adapted LOSA were analyzed according to these objectives. Relevant statistics included mean response time, threat/error code frequency, threat/error recognition rate, threat/error addressed rate, and outcome code frequency. T-tests were run to compare appropriate means and rates between each round of observation to determine whether a statistically significant difference existed between each round following a brief student intervention (Ravid, 2015). Exit interviews were also recorded and transcribed to provide qualitative insights for instrument improvement after each round of observation. Results are organized by objective.

Objective one sought to detect common threats and errors in an undergraduate college-level construction course. The relevant statistics for this objective were threat/error code frequency, threat/error recognition rate, and threat/error addressal rate.

Threat/Error Code Frequency

Table 1. Threat/Error Code Frequency

Code	Round 1		Round 2		Round 3	
	n	%	*n*	%	*n*	%
PPE/Attire	12	23.08%	40	57.97%	55	59.78%
Falling Object	12	23.08%	5	7.25%	2	2.17%
Communication Obstruction/Miscommunication	8	15.38%	8	11.59%	3	3.26%
Trip/Slip/Spill	7	13.46%	5	7.25%	6	6.52%
Lifting/Transporting	4	7.69%	2	2.90%	-	-
Tool Handling	3	5.77%	5	7.25%	-	-
Crush	2	3.85%	-	-	-	-
Missing Guards	2	3.85%	-	-	-	-
Electric Shock	1	1.92%	-	-	-	-
Flammables	-	-	2	2.90%	2	2.17%
Fall	-	-	-	-	4	4.35%
Material Handling	-	-	-	-	16	17.39%
Miscellaneous	1	1.92%	2	2.90%	4	4.35%

The frequency of each code, as illustrated in Table 1, showed that out of all recorded codes in round one of observations (*n*=52), the most common were PPE/Attire (*n*=12) and Falling Objects (*n*=12). The next most common were Communication Obstruction/ Miscommunications (*n*=8) and Trip/Slip/Spill (*n*=7). Other codes observed in the first round of observation were Lifting/Transporting (*n*=4), Tool Handling (*n*=3), Crush (*n*=2), Missing Guards (*n*=2), Electric Shock (*n*=1), and Miscellaneous (*n*=1). Not all codes were observed in this round of data collection.

Once again, round two observation data (*n*=69), as shown in Table 1, had PPE/Attire (*n*=40) as the most common code. The next most common code was Communication Obstruction/Miscommunications (*n*=8). Other codes observed in the second round were Trip/Slip/Spill (*n*=5), Falling Objects (*n*=5), Tool Handling (*n*=5), Flammables (*n*=2), Lifting/Transporting (*n*=2), and Miscellaneous (*n*=2).

Remaining consistent with previous observations, the most commonly recorded code from the round three observation data set (*n*=92) was PPE/Attire (*n*=55). The second most common was Material Handling (*n*=16). Other codes observed in round three were Trip/Slip/Spill (*n*=6), Fall (*n*= 4), Miscellaneous (*n*=4), Communication Obstruction/ Miscommunication (*n*=3), Falling Object (*n*=2), and Flammables (*n*=2).

Threat/Error Recognition Rate

Table 2. Threat/Error Recognition Rate

Recognition Status	Round 1		Round 2		Round 3	
	n	%	*n*	%	*n*	%
Yes	16	30.77%	5	7.25%	3	3.26%
No	36	69.23%	64	92.75%	89	96.74%

Threat and error recognition data (Table 2) indicated that 16 of 52 total observed threats and errors were recognized, resulting in a recognition rate of 30.77%. Some data descriptions seemed inconsistent with the code provided by the observers and were adjusted in post based on further information and clarification provided in the exit interviews.

Round two showed that 5 of the 69 total observed threats and errors were recognized, resulting in a recognition rate of 7.25%. The data set for round three had 3 of 92 threats and errors being recognized for a rate of 3.26%.

Threat/Error Addressal Rate

Table 3. Threat/Error Addressal Rate

Addressal Status	Round 1		Round 2		Round 3	
	n	%	*n*	%	*n*	%
Yes	13	25.00%	5	7.25%	3	3.26%
No	39	75.00%	64	92.75%	89	96.74%

In round one, 13 of the 52 total observed threats and errors were marked as being addressed, resulting in an addressal rate of 25.00%. When compared with recognition rate, there is a difference of three threats and errors meaning that 5.77% of recognized threats and errors went unaddressed through this class period. This decreased in the second round with 5 of the 69 total observed threats and errors being marked as being addressed, resulting in an addressal rate of 7.25%. Round two data showed no difference in recognition and addressal rates, meaning that all recognized threats and errors were addressed through this observation.

The final round of observations showed 3 of the 92 observed threats and errors marked as being addressed, resulting in a rate of 3.26%. When compared with recognition rate, there is no difference, meaning that all recognized threats and errors were addressed through this class period.

Objective two sought to identify changes in response time between each observation. The relevant statistic to this objective was mean response time.

Mean Response Time

Table 4. Mean Response Time

	Round 2	Round 3
Completed Time Stamps	5	3
Mean Response Time	3.00 min.	3.00 min.
Standard Deviation	.5	.5

While a mean response time was generated for round one of observation, it was determined that, due to holes in the LOSA protocol provided to observers, there were

discrepancies in how time stamps were recorded between observers. These discrepancies were not able to be rectified, but after interviews the protocol was refined for future observations.

Observers' use of the refined time-stamp protocol resulted in usable data for rounds two and three. Depicted in Table 4 are the number of completed time stamps from rounds two and three, mean response times from both rounds, and the standard deviations of response times within each round. Total completed time stamps in round two (n=5) resulted in a mean response time of three minutes for this round of observation. Total completed time stamps for round three (n=3) also resulted in a mean response time of three minutes.

Objective three sought to identify changes in outcome between each observation (Table 5). The relevant statistic for this objective was outcome code frequency.

Outcome Code Frequency

Table 5. Outcome Code Frequency

Code	Round 1		Round 2		Round 3	
	n	%	*n*	%	*n*	%
Inconsequential	14	48.15%	15	21.74%	10	10.87%
Undesired State	13	51.85%	54	78.26%	82	89.13%
Injury	0	0.00%	0	0.00%	0	0.00%

Outcome data for round one observation showed 13 undesired states (48.15%) and 14 inconsequential states (51.85%). Zero injuries were recorded. Round two had 54 undesired states (78.26%) and 15 inconsequential states (21.74%). This round of observation saw no injuries.

Round three had 82 undesired states (89.13%), 10 inconsequential states (10.87%), and no injuries.

The purpose of objective four was to examine the adapted LOSA's applicability in the SBAE laboratory environment. Insights into the applicability of the instrument were collected through interviews held with observers after each round of data collection. In the first round of observation, observers commented that the instrument "addressed what you're trying to get at" (Observer 2, personal communication, 10/23/23), and that it was "a good exercise…that needs to be done [while students are] using tools" (Observer 1, personal communication, 10/23/23), a reference to what work was being done in class that day.

Round two of data collection used the same tool with one significant change to the instrument itself. A column was added for observers to denote multiple occurrences of the same threat/error with a tally mark, assuming the recognition/addressed status and outcome were the same. This change received positive feedback regarding the ease of use for observers. No specific comments were made about applicability in the interviews for this round.

After data collection, observers were asked whether they felt the adapted LOSA applied to the agricultural mechanics laboratory setting. Observer 1 said, "I think it's viable, feasible in any kind of setting… I think it's a good tool that is easy to use by anyone." (Observer 1, personal communication, 12/13/23). When asked the same question, Observer 2 said, "It's only viable if change can be made" (Observer 2, personal communication, 12/13/23).

CHAPTER FIVE

CONCLUSIONS

This study focused on further developing the adapted LOSA instrument and improving observer protocols to more accurately detect threats and errors in the agricultural mechanics laboratory. Along with this, the study sought to determine the applicability of the adapted LOSA to the agricultural mechanic's laboratory environment by monitoring trends in safety conditions in a college-level construction course. Specific objectives were as follows:

1. Detect common threats and errors in an undergraduate college-level construction class at a four-year institution.
2. Identify changes in student response time to recognized threats and errors between observations.
3. Explore possible changes in the frequency of each outcome code between observations.
4. Examine the adapted LOSA's applicability in the SBAE mechanics laboratory environment.

Objective one sought to detect common threats and errors. Data for this objective supported that PPE and proper laboratory attire were the most common type of threat/error, with 107 out of 213 total recorded observations (50.23%) falling into this category. The most commonly cited safety violation that warranted this code was a lack of hearing protection. According to Woodford et al. (1996), the agricultural mechanics laboratory is a place where potentially damaging levels of noise are common. That same study went on to find that 78.3% of surveyed agricultural education instructors had some high-frequency hearing loss. With this in mind, it is evident that a lack of hearing protection use is neither a new problem nor one that should be

ignored in a class that is meant to prepare preservice SBAE teachers. Whether it is due to instructors not enforcing PPE requirements, or a refusal to use hearing protection on the part of the student, something needs to be done to not only better prepare pre-service teachers but also prepare those who will be entering the industry or returning to agricultural operations.

Between each round of data collection, student interventions took place to outline the common threats and errors seen in the previous round. These interventions were found to be ineffective, with the rates of threat and error recognition falling dramatically between each round. According to Kolb's (1984) Experiential Learning Theory, having this information would allow students to reflect on their experience and create an action plan moving forward. However, this would assume that the students intentionally reflect upon the information presented in that intervention. With little to no follow-up after the initial intervention, this information could be easily forgotten or ignored. A deeper look into how to effectively hold student intervention could be a fruitful area of future research. In keeping with Kolb (2015), the LOSA experience finds its value when it can be transformed into knowledge by intentional reflection. In this case it is both reflection-in-action and reflection-on-action. It is also worth noting that LOSA is not intended to compare two individual instances, but rather to detect patterns over time (Klinect et al., 2003).

Other codes were also observed consistently throughout the study. Specifically, communication obstruction/miscommunication and trip/slip/fall were all seen multiple times in each round of data collection. Similar to PPE/Attire, these codes are somewhat wide-sweeping in nature, so their consistent presence in the data is not a surprise. While processing data, it became evident that there was some confusion about the purpose of these codes, with either of them being used almost interchangeably at some points. This was addressed with the observers, but no

real change was evident after the intervention. This confusion can likely be attributed to the use of the word obstruction since this is synonymous with trip/slip/fall in some cases. It would be beneficial to revisit this wording to help better distinguish these codes for future research. While these two codes were the only two to be fully confused with each other, observers expressed their desire for more complete explanations of each code in the index saying “I wish we had a sample here... of what fits in what code” (Observer 1, personal communication, 11/13/23)

Based on conclusions from objective one, one urgent recommendation for practitioners as a target for improvement, specifically those involved with the AGED 333 course and other classes that require students to use similar equipment in a similar space, is to enforce the use of hearing protection and intentionally reflect upon the “why” of this action. Noise-induced hearing loss can occur with even brief exposures to sounds over 110 decibels (Daniel, 2007), so courses that have students regularly working with pneumatic nail guns that register at 120 decibels, like construction-focused courses, should enforce the use of ear protection for the student’s long-term safety (Jayakumar et al., 2015, Woodford et al., 1996).

Other recommendations stemming from this objective are targeted at instrument development and protocol and would include improving the provided descriptions in the code index. Both observers commented on confusion with both the scope of particular codes, as well as a need for more specific examples to help them differentiate what types of threats/errors would belong under certain codes. Along with this, a larger emphasis on the observers applying as many codes as they feel are relevant to each threat/error they record.

The purpose of objective two was to identify changes in response time between each observation. Results for objective two showed no change in the mean response time from when a

threat or error was recognized to when it was addressed. In round one of observation, neither observer filled out the time stamps correctly, resulting in unusable data for the round. One observer noted some frustrations with the current timestamp system saying that there "is a time for when you recognize [a] threat. And then the threat addressed time this… is very confusing" (Observer 1, personal communication, October 23, 2023). This was likely a combination of shortcomings in both the written observer protocols and the oral instructions. Even after making adjustments, there is no way to tell if the corrections made by observers were based upon the written protocols or the specific oral instructions given to them between observations.

The mean response times between rounds two and three were identical (3 minutes). The measurement of this variable had a similar issue that the change in threat/error recognition rate had, it is a deviation from the actual purpose of LOSA data. Because the tool is not intended to measure differences between individual observations, comparisons between mean response times are nearly irrelevant. A case could be made for comparing these variables between different semesters or years, but the data from individual lab section meetings should not be analyzed this way.

Another weak spot in this data point is its reliance on whether the relevant threat/error was both recognized and addressed. If a threat or error is only recognized and never addressed, a response time cannot be calculated. Likewise, if an error is never recognized it cannot be addressed meaning that there is no response time. This reality resulted in very few usable time stamps when they were correctly recorded with five complete time stamps in round two and three complete time stamps in round three. Based on these results and regarding the observers' difficulty with recording time stamps in early observations, future researchers should consider

eliminating time stamps from the adapted LOSA. While the timestamps could generate some useful data, it was not found to be relevant to the purpose of LOSA-style audits.

The results for objective three align with those of the other comparison-based objectives. Along with increased total observations with each round of observation, there was an increase in the rate of undesired states, with this rate peaking at 89.12% of total observed threats and errors for round three. This number could seem alarming at first glance, but the other notable side of the story is that there were zero observed threats or errors that resulted in injury. As previously established, risk cannot be eliminated (Hammer, 1989), so this data may suggest that students can still function without incident in environments that are not objectively safe. Still, a large focus of TEM is to close gaps in existing safety protocols before a problem arises (Klinect et al., 2003; Reason, 2016). The observations of Hammer (1989) and the focus of TEM are both reasonable, but to exist together there must be a threshold that those in the managerial subsystem of the socio-technical system can use to justify taking action to reduce undesired states. Further research is required to set this action threshold, but it is not a stretch to say that if nearly 90% of observed safety infractions result in an undesired state, some action must be taken. For this study in particular, the number of undesired states is a direct result of the low rates of threats and errors being recognized, let alone addressed. This pattern justifies the managerial body (i.e., the teacher or administration) to implement some sort of plan, but the establishment of a specific action threshold will likely need to be a topic of discussion for future researchers.

Initial recommendations for future research stemming from objective three include revisiting the definitions of inconsequential and undesired states in the adapted LOSA instrument. These terms are sourced from original LOSA documentation (B. Wild, personal

communication, February 6, 2023), but because this tool has been adapted to a new environment, there could be a benefit in providing more rigid definitions for these terms. Along with this, establishing a recommended action threshold based on the rate of undesired states could increase the applicability of the adapted LOSA down the road by answering the "now what" question that may arise when looking at uninterpreted data.

Recommendations for practitioners are for instructors to consider transitioning to viewing safety as a skill that students can learn. Amongst the myriad pressures this class puts on the instructors, safety, particularly PPE, often falls into the background. If SBAE teachers are meant to teach safety effectively, the courses that prepare them for that career ought to have a stronger emphasis on its simplest aspects.

To discuss the final objective, attention needs to shift to the total observed instances which increased through rounds one, two, and three respectively. This is likely due to a combination of observer comfortability with the adapted LOSA and changes made to user protocols. By making the instrument more user-friendly and simply spending more time using it, observers became more accustomed to how to observe and record efficiently. The familiarity with the environment also likely contributed to the observers' ability to detect threats or errors that were outside of the ordinary. It should be noted that observer bias may have also played a role in this increase (Mahtani et al., 2018). With the differing backgrounds of the observers, they would naturally be more attuned to certain types of safety issues. This did express itself in the data and is especially expressed in Threat/Error Code Frequency data.

Observers expressed their belief that the adapted LOSA applies to the agricultural mechanics laboratory. This belief was summed up well by Observer 1 who said "That tool is

ready to work. And I think so many people can now use it without your presence and they can easily audit their classroom or someone else's classroom and help them figure out what they need to do. To make sure their learners can be safe" (personal communication, 11/13/23). However, Observer 2 made a strong point in saying "It's only viable if change can be made" (personal communication, 12/13/23). Considering this line of thinking, possibilities for future research are made apparent.

Based on these findings, future researchers should consider repeating this study with a greater number of observers and without making any changes to the instrument or its protocols. This will allow for data that is more usable in assessing inter-rater reliability by eliminating the maximum number of confounding variables (Vogt, 1993). Because changes were made mid-study to the instrumentation, identifiable confounding factors external to the observers themselves now impact the data and therefore skew any insights into the instrument's reliability granted by a statistical test.

As the instrument continues to develop, LOSA data should be used to develop student intervention protocols. LOSA offers a direct application of experiential learning theory by providing specific data that students can engage with to improve the safety conditions of the laboratory (Kolb, 2014). The students being able to recognize the shortcomings in safety conditions in evaluating the LOSA data themselves provides a valuable learning opportunity as well as a moment for them to develop a feeling of ownership in the agricultural education program. Future researchers may focus on how to best foster an interaction between students and the LOSA data generated from previous semesters of a class. Using this data, students could be involved with the safety planning process and be generally more aware of the hazards that are

present in the agricultural mechanics laboratory by being allowed to enter the managerial subsystem, thus fully realizing the preventative intention of TEM and completing at least one cycle of Kolb's Model (Kolb, 1984; Maurino, 2005).

Summary

Data from this study would suggest that the adapted LOSA is an applicable tool for the agricultural mechanics laboratory environment due to its ability to assess multiple sectors of the socio-technical system at once continuously over time (Dyer & Andreason, 1999). Remaining consistent with the definition of a high-stakes system offered by Hickey et al. (2015), agricultural mechanics laboratories are a natural fit for this style of safety assessment. Qualitatively, the general themes of instrument usability and viability confirm that the adapted LOSA is on the right track, but there is still much work to be done before this tool is ready for use outside of a research context. General recommendations for future researchers in this area would be to develop a common vocabulary for future publications that stem from this study. Moving away from using the terms "threat" and "error" would help remove confusion for those who are not fully informed on the background literature. In addition, the adapted LOSA does not differentiate between threats and errors which leaves the interpretation up to the researcher. This subjectivity could be a source of confusion that is entirely unnecessary since the distinction ultimately does not matter in analyzing the data.

The intended purpose of the adapted LOSA, if fully realized through the work of future researchers, will contribute to creating a blame-free environment in which safety can be assessed without fear of punishment on the part of the student (Hickey et al., 2015). If safety can be approached with a spirit of collaboration between student and instructor, the reflection-on-action

portion of the learning process will not only lead to safer laboratories but also a workforce that is better equipped to carry out their jobs safely (Schön, 1983). As the adapted LOSA continues to evolve, its ability to create a blame-free environment and inspire a spirit of collaboration will only improve.

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