SAFETY-RELATED STRESS EFFECT ON SAFETY BEHAVIOR OF ENGINEERING STUDENTS THROUGH THE UTILIZATION OF SAFETY KNOWLEDGE

By

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THESIS ACCEPTANCE CERTIFICATE

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Abstract

In the uncertain times as today, safety-related stress can affect the behavior of the engineering students at engineering universities due to which institutes require more resources and skills to help with their growth of their students (future employees) and to deal with any unforeseen circumstances. This study aims to explore the effect of safety knowledge of the engineering students on safety-related stress and safety behavior in engineering universities. To understand this, a positivist epistemology and objective ontology is gauged to understand this phenomenon and also a quantitative method was employed. Data was collected via survey/questionnaire from 379 final year engineering students of different departments from the top 10 engineering universities of Pakistan (NUST, PIEAS, IST, GIKI) according to Pakistan Engineering Council (PEC) rankings. The findings suggest that there exists a positive relationship between safety-related stress and safety behavior. Safety Knowledge acts as a mediator between safety-related stress and safety behavior. Furthermore, this relationship affects the engineering student's behavior and knowledge because safety is overlooked at universities due to which it creates conflicts, low self-efficacy, high stress levels, low participation and commitment towards their work in laboratories and in organizations. Hence, use of safety knowledge can help the engineering students use existing resources and procedures to perform better at universities and then in organizations while working at labs or at sites. This study adds to the existing research by emphasizing the role of safety knowledge on safety behavior and reducing the effect of safety-related stress factors because of the inverse relation between safety knowledge and safety-related stress and a positive relation between safety knowledge and safety behavior. These findings provide the grounds for engineering universities to be fully equipped with advanced technologies, follow safety protocols and the role of the instructors/supervisors to help create a favorable environment to work in labs of the institutes and to provide them safety-related instructions so not to feel stress induced and give them basic trainings so that they can be confident while participating in performing such hazardous experiments at engineering universities or in organizations site areas. This type of the environment can increase the individual's performance level and can help with their success and growth of their own. It also gives future researchers the groundwork for studying different factors related to safety-related stress and safety behavior that can help contribute to better performance of the engineering students and in understanding managerial factors associated with it so that they can perform better, be safe and healthy for to achieve maximum efficiency later in the desired organizations.

Keywords: Safety-related Stress, Safety Knowledge, Safety Behavior, Engineering Students, Laboratories, Work Environment, Engineering Universities

CHAPTER 1 INTRODUCTION

The word safety, behavior, stress, laboratories and knowledge have a wide variety of contexts in universities, colleges and schools. This research study focuses on the safety-related stress on the behavior of the engineering students who work in labs at universities and later in different organizations. The labs can be computer, biological and chemical science laboratories.

1.1Background

Work in past years has been accredited as stressful and dangerous in high-risk industries (Leung, Chan, & Yu, 2012). The International Labor Organization (2019) affirmed that 380,000 individuals died from the accidents that occurred at workstations and 374 million individuals were those that suffered non-fatal accidents at their workstations (Wadsworth & Walters, 2019). To decrease the sum of injuries, accidents or incidents, researchers and practitioners have emphasized on the safety behavior of the workforce to guarantee organizational safety (Curcuruto, Mearns, & Mariani, 2016; Li, Lu, Hsu, Gray, & Huang, 2015).

Accidents that occur at workplaces claim lives of millions of individuals and are the cause of physical disabilities each year according to statistical data that includes fatal injuries related to work (U.S. Bureau of labor statistics, 2011). International Labor Organization (ILO) in 2011 also reported that 2.34 million employees died because of the accidents or diseases in 2008 and 317 million injuries were reported at their workstations. According to global statistics that work-related fatalities increased due to number of increasing rate of accidents or violent deaths (Howard, 2014). U.S. Bureau of Labor Statistics, 2014, reported approximately three million injuries related to work and illnesses in 2013 occurred (Michael, 2014). According to the labor record, the statistics of workstations incidents such as accidents, injuries, physical safety related events and fatalities in Pakistan stated that 100,000 industrial accidents and occupational fatalities occur per year, as it was 44.25 percent in the year 2002. In 2018, the rate remained the same but was not reported. Increased numbers of injuries, incidents that occurred at work places were not reported because of different reasons according to U.S Government Accountability office 2018 report.

Most of such reported accidents have happened in high-risk industries such as oil and gas, aviation, electricity, constructions or other industries. These industries mostly hire engineers and

technical workers graduates of engineering schools. When engineering students graduate and enter high-risk industries, it is essential that they continue to prioritize safety. If safety precautions, safety management, safety gear, rules, and procedures are not followed, the consequences can be severe. Accidents, injuries, and even fatalities can occur, and these can have a significant impact on the individual, their colleagues, and their employer which can cause significant physical harm to them including broken bones, severe burns, and traumatic brain injuries (Ismail, 2023). These injuries can have lifelong consequences, affecting an individual's ability to work and earn a living. Therefore, it is essential that high-risk industries prioritize safety at all times.

The culture of safety varies across various organizations based on its requirements (Saleh, 2015). In academic institutions particularly engineering schools prepare students for joining high risk industries. The curriculum includes mandatory lab experiments which requires the students to use safety kits (Ménard & Trant, 2020). A recent review of safety culture by Bassioni et al. (2019) in engineering education found that safety should be integrated into all aspects of engineering education, including course content, teaching methods, assessment and lab work however, by and large the emphasis on the safety element is missing.

Managing health and safety in educational institutions is a wider concept specifically in universities where there many facilities such as hostels, laboratories of every kind and cafeterias which may cause health and safety issues requiring to be resolved specifically. For example, a laboratory setting may contain various hazardous equipment and chemicals which highlights a concern that students often face variety of risks, dangers and threats that may result in an accident, near miss or may be an injury as well (Ismail et al., 2016). University laboratories where horrendous accidents have occurred globally such as the death of Sheri Sangji in 2014 at the University of California Los Angeles (UCLA) in US, chemical explosions at Beijing Jiatong University lab in China in 2018 and at University of Kent a student was severely injured because of the chemical spill incident (Chantler-Hicks,2020). 5th April, 2015 in Jiangsu Province, an explosion occurred in the chemistry lab during undergraduate lab class which caused four injuries and one death (Sohu News, 2015). Another explosion occurred on 18th December, 2015 due to the hydrogen gas cylinder in a chemistry lab that costed the life of a post doctorate student. On 26th December, 2018 a tragic event happened that killed three students in an explosion at the lab of

municipal and environmental engineering at Beijing Jiaotong University, Beijing, China and it destroyed the whole lab (Peng, 2019).

The performance of lab testing might increase but the accidents that occur at labs cannot be prevented by the engineering control and also found that accidents at labs in universities rise despite of the control systems implementation (Gibson, 2014). Purohit (2018) stated that there is a need to consolidate and develop, enhance the safety culture and develop safety behavior as it will reduce the accidents and health & injury concerns.

Stress in contemporary researches had linked stress with health, injuries, and with accidental risks. Many individuals are familiar with high stress levels have low commitment and satisfaction towards their work (Saleem, F. & Gopinath, C., 2015; Kuzey, 2018). Stress is distinguished to have a negative effect on the psychological, behavioral, and physiological status of the individuals (Musyoka, 2012; Saleem F. M., 2021). It harms the motivation, morale, and performance of individuals. Lack of safety triggers safety-related stress. Stress-related to safety is a destructive response towards unreasonable conviction or the commands given to individuals it is subjugated by meaningful work, good diet and social solidarity that enhances personal and social bonding as well as deleterious reactions (Hystad, Bartone & Eid, 2014).

Engineering students are particularly vulnerable to the effects of safety-related stress. These students are often exposed to high-pressure situations, such as tight deadlines and complex projects which can lead to increased stress levels. Additionally, the coursework required for engineering degrees can be challenging and rigorous, adding an increase to the stress levels of the students. If stress is not properly managed, it can lead to poor decision-making and unsafe behavior in the workplace in future (Jaege, 2012). Safety-related stress can be a significant issue for those who work in such environments where safety hazards occur. Engineers working in laboratories are often trained on safety procedures and protocols, but even with training, accidents and incidents can still occur. In terms of age and how individuals react to safety-related stress, research suggests that young adult may be more likely to take risks and engage in unsafe behaviors compared to older individuals (Lau, et al, 2021). This could be due to various factors such as a lack of experience or a desire to fit in with peers. Additionally, individuals who experience high levels of

stress, anxiety, or fatigue may be more likely to engage in unsafe behaviors or make mistakes during risky work, which could lead to incidents (Lau, et al., 2021).

It's important to note that safety-related stress can affect both knowledgeable and non-knowledgeable individuals. However, it is established that knowledge is prerequisite to action (Moore, 1985; Ajzen et al., 2011; Ning et al. 2020), hence we can argue that individuals who have properly knowledge of or have been trained in safety procedures may be better equipped to manage their stress and respond appropriately in potentially hazardous situations. Not many of the studies have been found on safety-related stress and its effect on the safety behavior of the engineering students in Pakistan and especially in petroleum and construction sector. This study will be an effort to find out and discover what are the factors affecting stress among engineering students of the college of engineering and technology at various universities.

1.2 Problem statement

There was an incident reported in June 12, 2022, that occurred in the lab of chemical engineering department at Rahim Yar Khan. KFUEIT administration tried to hush up the case but 22 student of BS Chemistry 4th semester were performing an experiment without following the required SOPs. Glasses, masks, gloves, overcoats are essential for the students performing in the laboratory where acids and bases are kept. When the students were performing without following proper protocols suddenly a blast occurred and acid splattered on the walls of the lab and on students as well. It happened when PEC was on a visit for the accreditation and they did not inform the rescue teams to shift students to the hospital emergency. The officials warned the students to not to disclose it with anyone and to seek medical aid from private facilities and hospitals. A student claimed that it happened because of the casual behavior of engineering students (Haq, 2019).

Practicing students in academic settings are aware of accidents and near misses that occur at laboratories. But there is no comprehensive data set available or any investigator, university or a pro has assembled the annual report of lab accidents at universities. This incident mentioned above has created several questions regarding why such incidents occur. Is the lack of safety knowledge? Is that appropriate trainings are not delivered to prevent such incidents? Can safety behavior be shaped by proper training and imparting required knowledge?

The basic problem is how safety related stress can affect the behaviors of the individuals, to investigate the role of the safety knowledge utilization, a new procedure in process to retain what they know and to tackle such events.

Majority of laboratory research does not tell us anything related to prevalence rate of accidents. In general, the rate is worse than those that suggested that the evidence is not sufficient a basic issue in science. Previous studies showed that 25-38% of laboratory personnel have been involved in injury/accidents /near misses that weren't reported to higher authorities of universities. In lab settings it is not surprising that there is lack of research on accident rates and prevalence rates that cause accidents (Simmons et al., 2017). The factors that occur at multiple levels in labs: risks associated with the materials or equipment being used, risks related to the skills, knowledge and choices of the research personnel executing the study, characteristics or qualities of the instructors and the research lab in which the research is occurring and risk factors arising from the departmental or institutional level (Ménard & Trant, 2020).

There has been very little academic research regarding laboratory accidents and questions like how safety related stress can affect the behaviors of the individuals, or what role the safety knowledge utilization can have, remains unanswered (Ayi & Hon, 2018; Ménard & Trant, 2020; Sieloff et al., 2013; Simmons et al., 2017). There have been some accidents reported in past few years as stated in **Table 1.**

Table 1

A partial list of researchers killed in laboratory accidents at academic institutions (2008–2018)

Year	Institution	Location	Accident description
1.	2018 Jiaotong University	Beijing, China	Three graduate students (names unknown) killed during an explosion while researching wastewater treatment
2.	2018 Indian Institute of Science	Bengaluru, India	Manoj Kumar killed in high-pressure hydrogen cylinder explosion
3.	2015 Tsinghua University	Beijing, China	Meng Xiangjian, postdoctoral fellow, killed in hydrogen explosion
4.	2015 University of Health Sciences	Phnom Penh, Cambodia	Huy Siep killed when flammable gas ignited

5. 2014 Texas A&M University at Qatar Doha, Qatar Hassan Kamal Hussein killed in explosion in petroleum lab
6. 2012 Unknown university Shanghai, China Graduate student (name unknown) opened a poison gas cylinder and died from inhalation
7. 2011 Yale University New Haven, USA Michele Dufault died during a lathe accident
8. 2009 University of Chicago Chicago, USA Malcolm Casadaban died from exposure to plague-related bacterium
9. 2008 UCLA Los Angeles, USA Sheri Sangji died from burns caused by ignition of tert-butyllithium

Adapted from Laboratory Safety Institute(Ménard & Trant, 2020)

1.3Research Gap

Accidents at university labs have cause injuries and deaths of the students, faculties and damage to the costly equipment's, building and to valuable data. If we compare process safety accidents in industry with laboratory accidents, they have relatively minor consequences. However, it is important to note that a large number of laboratories, numerous personnel directly exposed to the hazard, and inadequate oversight of safety management adds up to considerable risk in university laboratories. Therefore, the safety of laboratories in universities should be given as much as importance to attenuate the risks for preventing accidents and guarantee the safety of personnel, facilities, and data. Al-Zyoud pointed out that laboratory safety awareness of college students is not good as expected (Al-Zyoud et al., 2019). University laboratory accidents are often reported (Al-Zyoud et al., 2019; Wang et al., 2019; Yang et al., 2019) and have drawn tremendous attention. The research on laboratory safety in academia is underdeveloped (Ménard and Trant, 2020). There is need to study the factors affecting stress among engineering students of the college of engineering and technology at various universities (Ortega & Lahina, 2021). Little attention has been given to the safety-related stress of students that may work in high-risk industries despite the acknowledgement that this may, in turn, affect the performance of the individuals, units, and the institutions as whole (Liu, Nkrumah, Akoto, Gyabeng, & Nkrumah, 2020) (Mohd et al., 2020), (Wang, Wang, & Xia, 2018), (Mohsin & Mansour, 2015). Furthermore, a call for academic research in university laboratory accidents needs to be answered by considering different cognitive variables that can shape the safety behavior of the students (Ayi & Hon, 2018).

1.4Research Aim/Purpose

The main purpose is to anticipate that, the reason why accidents and work-related injuries continue to grow in developing countries like Pakistan cannot only be attributed to lack of implementation of the safety-related practices but also to the safety-related knowledge. Hence, study of such nature in high-risk industries in different sectors is expected to be of high importance to managers, practitioners and policy makers.

1.5Research Objectives

1. To investigate the relationship between safety-related stress and safety behavior of engineering students in engineering universities
2. To analyze the relationship between safety-related stress and safety knowledge of engineering students in engineering universities
3. To analyze the relationship between safety knowledge and safety behavior of engineering students in engineering universities
4. To test the mediating effect of safety knowledge on safety-related stress and safety behavior of engineering students in engineering universities

1.6Research Questions

1. Does safety-related stress affect engineering student's safety behavior?
2. What is the relationship between safety-related stress and safety knowledge?
3. What is the relationship between safety knowledge and safety behavior?
4. Does safety knowledge mediate the relationship between safety related stress and safety behavior?

1.7Significance of study

The research study is an important part of the management stream and is related to industrial and organizational psychology because without knowing these facts, rate of accidents or even the occupational hazards can make a life whether one may achieve their goals or dreams or could ruin their normal, happy selves into stressed individuals who will always be tensed and having aggressive or abusive behaviors if not given attention and focus.

Safety should be studied by researchers from different fields to understand what it is and how it should be improved and practiced at universities, colleges and at school levels

(Savolainen, 2023). To the best of our knowledge neither the occupational safety and health administration (OSHA) in US nor any of the provincial and territorial safety boards of Canada, despite of the accidental reports received and investigations complied or analyzed the data not in Asian countries even. However, the regulation of OSHA doesn't not apply to the universities and the lab supervisors in universities dependent on their employment status.

Since 2001, in US many excavations, accidents and serious injuries have been reported but these are only those who have been reported because of the consequences but some remain unaware of major accidents or significant near misses if no one was injured in the process. There were no such studies found that might have observed skills, knowledge, experience or attitudes of the individuals who work in labs where these accidents might occur or other proxy settings. Similarly, many studies have investigated the occurrence and recurrence of accidents with specifical such departments of universities nor the role of situational factors in causing accidents, such as time of day or late night. Hellman, Savage and Keefe (2017) examined demographic characteristics of victims, details about research activities, type/ location of injury, time of day, and time of year for 574 accidents. The contemporary research regarding labs is quite questionable and may incidents have occurred in undergrad teaching labs and many due to the obsolete techniques.

A number of historically based factors that limit the applicability of the results, the accidents have occurred during afternoon in academic time when the academic labs were is used by students; injured were male members because of the greater proportion of the undergrad students are male. However, the study's authors highlight the contribution of human factors to lab accidents and call for additional research, saying *"Of all the variables in accident prevention, the human behavior variable, even with education, was the hardest to control".* A study by Ayi and Hons (2018, p.13) the respondent and researchers have stated that this kind of research has been never conducted neither the assessments regarding risks associated before performing at labs.

CHAPTER 2 LITERATURE REVIEW

In this section, a review of the literature is used to probe into the facets of the safety-related stress of the engineering students in engineering universities of Pakistan on their safety behavior. The study of the relationship in the engineering universities with correspondence to high-risk industries has been encapsulated to suggest the hypothesis tested in the study.

2.1. Safety-Related Stress

Stress has been experienced by many individuals at some point in their lives whether related to career, family, peer pressure or academically but the problem can be more pervasive or dangerous for some who realize it later in their lives. Job stress or work-related stress of an individual's health and safety is a well-founded issue and it affects men and women working in different industries as experienced by many individuals, an issue that is more dangerous and widespread than realized by the employers (Spiegel, 2019). A stressed individual can become an unsafe employee. With the risk, the cost associated as U.S. employers spend $300 billion on absenteeism; accidents; low productivity; increased turnover; compensation cost; legal, medical or insurance costs. Safety-related strain is inaccessible because the personal issues need sorting out. This is a global phenomenon which influences every employee working in different countries. The community, individuals all are affected due to the increasing prices but increasing the knowledge for to create useful, effective and novel ways to combat the existing pressure (Davidescu, 2020).

Accidents happen due to unsafe acts that causes stress among different groups of individuals by in use of different kinds of the instrumentation used at workplaces, pinpoint the other possibilities available to hamper or decrease issues related to stress (Sutherland & Cooper, 1996). Safety-related stress can affect one's productivity and a stressful environment can lead to burnout syndromes which not only affect the employee's life and health but also the quality of work and safety performance at their jobs are also compromised (Bresic, 2007). The external environment, organizations, units and individuals may cause work-related stress because of the high demand of productivity, peer pressure and competitors. Stress occurs due to interactions among the individual and the environment available at work areas highlighted Brande et al., (2016) and by Cooper at., (2001) but it has its pros and cons associated with it.

Stress-related factors can be highlighted as role conflict, role ambiguity, role overload, job insecurity, benefits and rewards, capability of the employees, restrictions and interpersonal conflicts affect the life of an individual (Sampson et al., 2018; Wang et al., 2018; Xiang Wu, 2018). The fear that is associated with loss, injuries and death can be observed at all high-risk industries such as event of gas leakage, explosive materials that are a threat to life. Incidents demonstrates that human race have experienced difficulties either lead to equipment failure, criminal activity or in some cases political activity. In the cases stated, the affected are those who work in such premises, in the enclosing areas and the organization on the whole making use of such facilities.

Safety-related stress can be triggered by a variety of factors such as workplace accidents, exposure to hazardous substances, high levels of workload, poor work conditions, inadequate training, and lack of social support (Mearns et al., 2018). Health, wellbeing, and performance of engineering students as well as the organizations overall productivity and safety all can be negatively impacted by this kind of stress (Vijayan, 2017). Safety-related stress is a prevailing issue where engineering students are inducted annually or twice in a year, who are exposed to perilous working conditions as how they work at their institutional labs (Marcatto et al., 2016; Gupta et al., 2017).

High-risk industries, such as construction, mining, and healthcare, are specified by greater levels of physical and psychological demands, hazards, and risks (Salminen et al., 2022). Safety-related stress can reduce employees' ability to perform critical safety behaviors, increasing the probability of accidents and injuries (Wang et al., 2018).

Safety-related stress is a noteworthy concern for engineering students entering hazardous industries, such as petroleum, construction, transport and logistics, aviation, electric power, automotive, aerospace and different other industries. Stressors that engineering students may encounter in industries, including engrossed with hazardous materials, stressful environment, and the potential for accidental injuries have a notable impact on their well-being and performance. Various researches have explored the impact of safety-related stress on engineering students' outcomes in high-risk industries (Lindblom, 2017). It has been found that safety-related stress can have a negative effect on an individual's job satisfaction, commitment, and performance. It also suggests that interventions should reduce safety-related stress, such as safety training programs

and effective safety management which can improve engineering students' outcomes in these industries (Ford, 2018).

Another study found by Khosravi that safety-related stress can lead to burnout among individuals in hazardous industries. The study suggests that effective coping strategies, such as social support and problem-solving skills, can help them manage safety-related stress and reduce the risk of burnout (Khosravi, 2021).

It's important to note that safety-related stress can affect both knowledgeable and non-knowledgeable individuals (individuals who lack knowledge regarding safety, behavioral practices, working of the machines). However, individuals who have been properly trained in safety procedures may be better equipped to manage their stress and respond appropriately in potentially hazardous situations but sometimes the most knowledgeable can act absurd. This is why safety training and education is crucial in many industries, including engineering and laboratory work (Redfern et al., 2021). The utilization of safety knowledge is essential for promoting safe behavior in high-risk industries. People are better able to recognize and address potential safety concerns when they have the requisite knowledge and abilities, which lowers the likelihood of accidents and injuries.

Stressors related to safety is measured by role ambiguity (Tubre and Collins, 2000), role conflict (Sampson et al., 2014) and interpersonal conflict (Wang, D., Wang, X. & Xia, N., 2018). Safety-related stressors may hinder individual's performance and may trigger accidents resulting in injury at workplaces (Leung et al., 2012; Liu et al., 2013; Wallace et al., 2009). Work stressors can inhibit individual's engagement in organizational behavior. Based on *Action Theory*, it has been reviewed that stressors are categorized in three forms as mentioned above (Wang, Wang, Griffin, & Wang, 2020). Previously a study published in the Journal of Chemical Health and Safety found that role ambiguity, role conflict, and interpersonal conflicts are notable sources of safety-related stress among engineering students working in labs (Wang et al., 2017). The *Role Stress Theory* states that individuals immerse such roles which are affiliated with presuppositions and when these presuppositions are conflicting or ambiguous it leads to role conflict and ambiguity. It also consists of a pattern of behaviors that are perceived by the individuals as expected behaviors

when perceived roles are unclear or incompatible with the expected behavior of the students or the employees with other expected behaviors, then it occurs.

Role Ambiguity specifies that an individual is uncertain or incapable of the contemporary role given information and resources. It is a confusing state because of the undefined division of the work in the organization; most personnel are not knowledgeable about their job duties and responsibilities. Just in engineering universities if an engineering student is aware of the hazards while working in laboratories and in future in the designated industry, he/she might perform effectively because they don't focus on the safety precautions instead, they are more focused on how, what, when to complete and forward their work which creates role ambiguity from the start. It refers to the lack of clarity or uncertainty regarding one's safety responsibilities and expectations in the workplace. This can cause stress to individuals that may not know what is anticipated of them in connection with safety (Yang et al., 2020).

Role Conflict states that there are inconsistencies present at hand about the job performance expectations and the performance evaluation criteria such as incompatibility in the work roles as managerial roles, lab attendants, a supervisor or a student even. For example, if an individual receives different directions from the higher authority meaning the supervisor, instructor at labs or at plants does not know what direction they should follow, and then if others have a command in authority, they will find it difficult to follow it. Role conflict can take a number of forms such as when an individual feels conflict between his/her roles and their values, conflict between the role demands and capacity such as training or resources to complete them and conflict due to incompatibility between multiple requests from others or the expectations and policies of the institutions.

Role conflict and role ambiguity puts the workforce in a confused state about achieving their goals, right and wrong pathways and the effectiveness of the workforce response.T It occurs when an individual's safety responsibilities or expectations conflict with other job responsibilities or expectations. This can create stress as individuals may not know how to prioritize their responsibilities. Role ambiguity consist of lack of the information and role conflict defines the too much contradictory information. In addition, they are positively associated with stress, depression, anxiety among the teachers of the universities/schools. The presuppositions correlated with role are incompatible, the outcome is role conflict whereas the presuppositions are not consistent,

confusing or uncertain leads to role ambiguity. It also refers to a situation where they are unsure about what their responsibilities are and what is expected of them and the standards set for them.

Interpersonal Conflict states that there are discrepancies that arise in the operation of the equipment, conflicts between individuals working in the organization. Moreover, it is a natural outcome of human interaction (Wang et al., 2018). Personal emotions are a result of stressors which can proved to be dangerous because they are not a part of curriculum or the coping strategies are not being taught to engineering students. Interpersonal conflicts arise due to the miscommunication between students and faculty, conflicting nature of the students or the undecipherable or inaccessibility of the supervisors are expressed as difficulties faced by engineering students in universities (Hegenauer, 2018). Conflicts over safety-related actions, decisions, or priorities between individuals or between superiors and subordinates are referred to as interpersonal safety conflicts. Interpersonal safety conflict involves conflicts or disagreements with peers or superiors regarding safety practices or procedures. This can create stress and tension in the workplace, leading to reduced safety behavior and an increased likelihood of accidents or incidents (Dulebohn et al., 2012).

To summarize, the negative aspects of the stressors, a possibility arises that there will be unfavorable effects on safety performance and behaviors of engineering students because of the safety-related stress affects the behavior and in turn the productivity of an individual is affected as in this case engineering students.

2.2. Safety Behavior

Safety behavior role antecedes to prehistoric times. Contemporary, conditional safety has been prioritized with governmental safety focusing on providing feasible working environments. The institutions should motivate their employee's safety behavior through which wellness and safety of the individuals can be enhanced(Jiang et al., 2010). The safety behavior from a learning point can hinder individuals' ability and behaviors in three ways: First, preventing the violation of the expectation that what might occur and what in reality takes place, i.e., no accident or injury. Second, safety behavior can block the theories of the safety-based relations by confining the safety learning to particular domains. And third is that it could hamper the tolerance by limiting people from learning so that they can carry on with the tasks difficulty levels instead of increasing-anxiety, sorrow or pain levels (Blakey, et al., 2019). The safety behavior is the application of behavioral research on the performance of individuals at workplace and the problems faced due to

safety and its approaches applied such as distracting an individual during panic attacks or any accidental hazards, or rehearsing how one will communicate in social phobias, etc. As there are three types of safety behaviors which are avoidance, escape, and subtle avoidance and the effects of safety behavior in a favorable environment can be practical if for shorter or longer terms (Rachman, Radomsky, & Shafran, 2008). Margaret Heffernan said in one of her TED talks that at least we cannot forecast any situation or any event still we can plan it, if something happens one can reach to the solution and strategize oneself for future purposes (Heffernan, 2019).

Safety that focuses on the behavior of individuals is related to positive working environment and less injuries and illnesses are reported (Nkrumah, Liu, Fiergbor, & Akoto, 2021). Safety behavior determinants are safety training and andragogy, safety work procedures, safety commitment, accident investigation and management of disasters and safety performance (Olugboyega & Windapo, 2019). Safety can be an issue for leaders who need to prioritize the occupational safety and health of individuals and the whole corporation that reflects their priorities in their behaviors. Leaders can influence their employees to adopt such behaviors and attitudes through role model and social identification process. This type of response can encourage leaders to be productive and, in Safety Critical Organizations (SCO) leads to focused safety behavior through different steps of the work ownership and engagement of the employees and strong commitment to the safety climate (Hystad, Bartone, & Eid, 2013).

Based on the performance of the work, Griffin and Neal (2000) conceptualized safety performance as the quality of the safety-related work and the behaviors of the individuals related to the safety of the organization, which is bounded by the psychological predecessors and to be evaluated by the system (Griffin & Neal, 2000). Safety Behavior is regulated by safety compliance and safety participation and both the regulators measure behaviors of the employees that tailor accidents and injury prevention at workplaces (Nkrumah, Liu, Fiergbor, & Akoto, 2021). Several studies have investigated the relationship between safety compliance, safety participation, safety commitment, and safety outcomes. For instance, a study by Glendon and Litherland (2001) uncovered that safety participation and safety commitment were positively associated with safety performance in a manufacturing company. The study suggests that students who are committed to safety and actively participate in safety activities are more likely to follow safety procedures and maintain a safe work environment. Similarly, a study by Kines et al. (2010) found that safety compliance was positively associated with safety outcomes in the construction industry. The study

suggests that students who comply with safety regulations and course of action are less likely to experience accidents and injuries in the workplace. Other studies have also examined the factors that influence safety compliance, safety participation, and safety commitment. For example, a study by Neal and Griffin (2006) found that safety leadership, safety climate, and safety communication were important predictors of safety compliance and safety participation in a mining company.

Effective safety management practices can improve engineering students' safety behaviors and attitudes in the workplace as referred by previous studies. Organizations can also provide employees with adequate training, feedback, and supervision to enhance their safety knowledge, skills, and motivation (Markopoulos et al., 2019). Previous studies suggests that every individual should wear personal protective gears (PPE), increase in the use of PPEs could lead a positive behavior at workplace which could be observed through the studies but it has been not or is much worse than before. The use of protective equipment's might motivate the researchers to take precautionary measures and decrease the number of accidents. Questions addressed above can make sure lab safety and safety of the students. A researcher expressed his concern in his previous studies that researchers tend to believe that work should be completed in a safe working environment everyday and if everything is going well according to the plan, the rate of accidents is decreased. Hendershot cautioned, that one's experience in few years would not be relevant when the actual performance of the industries is in range of the fatalities in the exposure hours (Hendershot, 2019, p.36).

Important prospects of occupational health and safety are safety compliance, safety participation and safety commitment (Inness & Turner, 2010). Griffin and Neal (2000) further suggested two alternates as safety compliance and safety participation.

Safety Compliance indicates the safety related activities, which includes prescribed conformity, wearing safety gadgets, necessary precautions and many more.

Safety Participation indicates that workforce, who contribute voluntarily in the safety activities, in the meetings prove to be advantageous for the organizations safety programs and improve safety concerns. Meanwhile, safety participation incorporates the extent of workforce engagement in safety projects, safety meetings, and showing compassion to portray safety

standards and helping colleagues in their initiatives at workstations, and upgrade safety and security at labs or at sites (Nelson & Zega, 2021).

Safety compliance similar to tasks performance while safety participation parallel to contextual performance and these are also stated as the determinants of safety performance (Griffin & Neal, 2000; Wang, Wang & Xia,2018). Safety participation is an individual's active involvement in safety-related activities, such as identifying and reporting hazards, providing feedback on safety practices, and participating in safety improvement initiatives (Bayram et al., (2019). Many detrimental effects, such as decreased job satisfaction, increased absenteeism, and decreased safety behavior, can be brought on by this stress. Engineering students comply with the task performance but the involvement in the safety activities and their laboratory work is sometimes voluntarily and sometimes involuntarily it differs according to the behavior of the individual while at work and performing experiments or handling dangerous equipment's.

Safety Compliance is more in-role behavior, and safety participation is voluntary, having extra-role behavior and focuses on components of the safety behavior (Griffin & Neal,2000). Safety Compliance and Safety Participation have indicated previously that these components are related to mishaps, and or close calls in the high-risk industries. Industrial revolution started in 1799 and the era continues till today, many mishaps, close calls have been faced at workstations (Griffin & Neal, 2000).

Safety Commitment defined by Neal and Griffin (2004) as the measurement of the management to perceive as to put safety as the high priority and to report the issues related to safety. Various reports have demonstrated that commitment to safety is measured frequently and the influential organizational factors for safety performance and injuries. Different studies have measured safety commitment as an aspect of management action, including manager's decision and policymaking, active involvement of employees, and communication with their peers and or subordinates. In contrast, others have focused on the managerial influences on the organizational practices, safety values reflecting safety commitment. Safety commitment also appears to be along with the ineffective leadership, lack of the appreciation for safety and lack of feedback, reinforcement from the high authorities as the senior managers contributes to the accidental reports presented for investigation (Fruhen et al., 2014). Safety commitment is the readiness of a personnel or organization to devote time, resources, an effort to safety-related activities and projects. It is

characterized by a commitment to promote and sustain safe working conditions and behaviors in the workplace (Metzler, 2019).

In this study, safety behavior is disintegrated into safety compliance, safety participation and safety commitment. Previous studies have suggested that these three stated above types are essential elements of safety behavior which might have associations with other constructs such as safety climate and safety outcomes (Christian et al., 2009; Sampson et al., 2014). To summarize the concepts, research on the predecessors of the types of the safety behaviors and safety management programs, this can play a role in preventing injuries and mishaps at workstations such as labs, research facilities.

Different studies have reported different constructs of safety behavior i.e., safety compliance, safety commitment or discretionary i.e., safety participation. The *Action Theory* states that safety compliance, participation and commitment of the engineering students are evaluated and graded in form of points. The academia industry is committed, strong and passion driven because of the faculty members, students and researchers. The new faculty members are more communicative and supportive towards their students through which they communicate the knowledge effectively to them. Empathic and compassionate leaders are those who guide and coach the academia's and it has shown good progress overall in universities (Véchot et al., 2022). Safety commitment among students has become a vital element in reducing accident rates in the laboratory (Salazar-Escoboza et al., 2020).

Previously it has been reported that engineering students' knowledge related to safety and behaviors in the laboratory shoed that 71 percent students used the equipment appropriately and 61 percent were reported that they only focused on performance while performing dangerous experiments. Similarly, Marendaz et al. (2011) and Pedersen and Kines (2011) stated that lab safety programs at institutions enhance commitment and knowledge of the engineering students(Li et al., 2021). Jeknavorian, (2016) stated that engineering students are committed to monitor lab accidents that occur but their engagement was weak due to the lack of supervision by supervisors (Abdullah & Aziz, 2020). It has been reported previously by students those issues identified such as use of PPE, keeping work spaces clean, horseplay etc., over the study time period, with the exception of cell phone usage were reduced.

2.3 Impact of Safety-Related Stress on Safety Behavior

Engineers may fail to recognize potential safety risks if they lack the necessary safety knowledge, which could have catastrophic repercussions. For the development of efficient training programs and treatments targeted at promoting safe behavior in high-risk industries, understanding the link between safety-related stress and safety behavior is essential. Organizations may make the workplace safer for all by recognizing the elements that lead to safety-related stress and implementing management solutions to deal with it. This can include implementing stress-management techniques, providing resources for mental health support, and developing training programs that focus on promoting safe behavior in high-pressure situations (Abdullah, 2020). Understanding the numerous elements that can influence safety behavior is crucial for promoting workplace safety.

Stress caused by safety-related elements in the workplace, such as exposure to dangers or risks, a lack of resources or training in safety and pressure to reach safety goals, is referred to as safety-related stress. (Tong, 2022). One way in which safety-related stress can affect safety behavior is by reducing the ability of engineering students to concentrate and make sound decisions. When individuals experience high levels of stress, their cognitive functioning can be impaired, making it more difficult for them to pay attention to safety risks and respond appropriately. This can result in errors or accidents that could have been prevented if the individual was less stressed (Bielefeldt, 2022). Moreover, safety-related stress can also lead to emotional exhaustion and burnout, which can negatively impact safety behavior. When individuals are emotionally exhausted, they may be less likely to invest effort in safety-related tasks, leading to a decrease in safety behavior. Stress pertaining to safety can influence behavior in both positive and bad ways. On one hand, stress associated with safety can heighten a person's awareness of safety dangers and the significance of implementing preventative safety measures. On the other hand, safety-related stress can also lead to a reduction in safety behaviors (Iorga, 2012). High levels of stress may make people more likely to participate in risky activities or make bad choices, which may lead to mishaps and injuries.

The connection between safety-related stress and safety behavior in high-risk industries has been the subject of numerous researches. For instance, a study by Lee and her colleagues (2020) found that job demands, workload, and role ambiguity were negatively associated with

safety compliance among construction workers. Similarly, a study conducted in 2014 by Bakker and her colleagues found that work-family conflict and job pressures were adversely related to healthcare students' participation in safety. Safety-related stress can lead to fatigue, burnout, anxiety, and depression, which can impair employees' attention, memory, decision-making, and motivation (Siu, et al., 2014). Additionally, safety-related stress can reduce students' perceived control over their work environment, leading to feelings of helplessness and disengagement (Salminen et al., 2022). Organizations can put a number of methods into practice to lessen the detrimental impact of safety-related stress on safety behavior in high-risk industries. For example, organizations can provide engineering students with sufficient rest breaks, social support, and resources to cope with safety-related stress (Neal et al., 2019). Several studies have examined the relationship between safety compliance, safety participation, safety commitment, and safety outcomes. For instance, a study by Glendon and Litherland (2001) found that safety participation and safety commitment were positively associated with safety performance in a manufacturing company.

The study suggests that engineering students who are committed to safety and actively participate in safety activities are more likely to follow safety procedures and maintain a safe work environment. Similarly, a study by Kines et al. (2010) found that safety compliance was positively associated with safety outcomes in the construction industry. The study suggests that engineering students who comply with safety regulations and procedures are less likely to experience accidents and injuries in the workplace. Other studies have also examined the factors that influence safety compliance, safety participation, and safety commitment. For example, a study by Neal and Griffin (2006) found that safety leadership, safety climate, and safety communication were important predictors of safety compliance and safety participation in a mining company. The study suggests that effective safety management practices can improve engineering students' safety behaviors and attitudes in the workplace. Organizations can also provide employees with adequate training, feedback, and supervision to enhance their safety knowledge, skills, and motivation (Markopoulos et al., 2019).

Finally, organizations can develop and implement safety policies and procedures that consider students physical and psychological well-being and promote a positive safety culture (Salminen et al., 2014). One study by Rafique and colleagues (2021) found that safety knowledge

and safety behavior were positively correlated among engineering students but did not explore the impact of safety-related stress on safety behavior (Rafique, 2021).

Safety-related stress can have a significant impact on the safety behavior of engineering students who are working in high-risk industries. Safety-related stress refers to the psychological and physiological responses to work-related stressors that are related to safety, such as job demands, pressure to meet deadlines, and fear of accidents. A crucial component of workplace safety is safety performance, which includes a variety of actions and results pertaining to workplace safety (Metzler, (2019). Engineering students working in high-risk industries may experience safety-related stress due to the high level of technical complexity involved in their work and the high stakes of their projects. According to a different study by Abdullah and colleagues (2020), safety training programs had a favorable effect on engineering students' safety behavior (Abdullah, 2020). The hypotheses that are being tested through data analysis techniques are:

H1: *Safety-related stress has an impact on safety behavior of students*

2.4. Role of Safety Knowledge

"To move forward its necessary to close the data gap, because knowledge is the key to prevention", Guy Ryder quoted this very important message on the World Day for Safety and Health at Work on 28th April, 2022, Director General ILO (International Labor Organization, 2022). Safety Knowledge is an important part of the study where an employee experiences and uses their knowledge regarding their work or during the hazard, injury, or accident. As the word knowledge states, it is more than that, its information, awareness or the experience gained through the work or through learning or familiarity The relation between information and knowledge is quite communal. Major needs of the industry are to enhance the professional's interest in participating actively in safety management, increasing awareness programs, and implementing in the organization. Many argue that awareness of the risk factors and knowledge on how to minimize these factors among the employees and the contractors to develop their site safety (Okoye, Ezeokonkwo, & Ezeokoli, 2016). The safety knowledge includes the awareness of occupational health and risks (OH&S), which revolves around evaluating the occupational health and safety program in the industry. It consists of the investigation of the incident, teamwork, collaborations and surveys regarding the culture of the organization and of safety. The maintenance of the OH&S is a specification of the problem solving which requires decisions to be taken as knowledge is

dependent on the information and it needs to be applied. According to the study by French (2017), safety knowledge is the understanding of the potential hazards, risks, and protective measures related to a particular task or activity. It includes knowledge of safety rules, regulations, procedures, and techniques that are essential for safe work practices.

Safety knowledge is stated as the "employee's degree of knowledge about the current safety system procedures, guidelines and the standards in the company while the occupational health and safety management frameworks (OHSMF) refers to the promotion and implementation of the safety programs, processes, which are intended to eliminate or minimize the risk possibility and hazardous exposure at the working areas" (Liu, S. et al., 2020). Knowledge itself is a belief that intensifies the ability of the individual to take action or make decisions. If safety controls, risk and exposure towards hazards is required then safety knowledge defined as one's ability to understand what safety is and act in accordance with it. As described as among other factors as risk perception, depression and stress to mediate the relationship between safety performance and injuries, near miss or accidents (Jung, Lim, & Chi, 2020).

The notion of the industries is labor-oriented, but knowledge-sharing behavior can be observed everywhere in industrial laboratories. Engineering students not skilled enough are grouped with experienced employees to fasten there learning through observation and interaction. Therefore, the significance of sharing the knowledge among the unskilled individuals such as engineering students from the safety perspective is safety regulations, accidental record, experts' safety experiences and practices. The experience and valuable information within and across the engineering universities, corporations and geographical boundaries is of great importance and lack of information and knowledge sharing might lead to hazardous mishaps and productivity of engineering students will lessen (Ni, et al., 2020).

It is found that safety knowledge has a positive impact on future employees (engineering students) safe work conduct, training, internal motivation, work autonomy and management support can affect the level of knowledge-sharing behavior (Nesheim & Gressgård, 2014). The new generation employees engineering students have higher IQs, education and learning abilities. However, little is known about the antecedents of safety knowledge (Ni, et al., 2020).

It is accepted that lack of safety knowledge is one of the causes for safety accidents. Shin et al. indicated that among variables like safety motivation and affective commitment, safety knowledge has the strongest direct effect on safety behavior (Shin, Gwak, & Lee, 2015). Similarly,

Mohammadfam et al. found that safety knowledge is one of the best predictors of safety behavior (Mohammadfam, 2017). Safety knowledge also includes awareness of the potential consequences of failing to adhere to safety protocols and procedures. According to Chughtai and colleagues' (2015) research, students who have a strong understanding of risk assessment are more likely to follow safe working procedures and are less likely to have accidents.

In addition, when in engineering universities where safety education becomes a part of the curricula, rarely the institutes supervisors lack industrial experience or have research in the field of safety which results in the content of the safety teaching being disconnected from the actual practices and challenges faced by industry (Pitt, 2012). Responsible industries have to train their employees on the job, continuously educating them (Véchot et al., 2022). According to a study published in the Journal of Safety Research, engineering students are at higher risk of workplace injuries and accidents due to their lack of safety knowledge and training (Zhang et al., 2019).

Safety Training has been formulated to enable their employees to acquire attitudes, knowledge and skills, which can help in reducing the risks, perceived, and related life hazards at their working sites but now it's a need for the engineering institutes to teach the students from the beginning. Hazards caused by incomplete trainings or absence during their trainings due to which they are not appropriately trained to do their jobs and may think that they will not become a victim to a hazard, which makes them more frustrated. In addition, when they receive proper training and guidance regarding their health and safety procedures, they feel contented, less stressed out about their work (Adim, Victor, Mezeh, & Andy, 2020). Job satisfaction also increases where there is more associability of training their employees to perform better. Training can boost the knowledge about safety measures which will much likely reduce the safety-related stress (Unknown, 2012).

Several studies have investigated the stressors that engineering students face related to safety education and training. For instance, a study by Bhagwat and her colleagues (2021) found that engineering students perceived safety education and training as time-consuming, complex, and burdensome. The study also found that students felt pressured to prioritize technical knowledge and skills over safety knowledge and skills and students also felt that safety education and training lacked engagement, feedback, and real-world relevance. A study by Sudhakar and Subramaniam (2019), it was found that safety education is essential for preparing engineering students for workplace hazards. Similarly, in a study by Raji and Lawal (2019), found that safety

education is necessary for engineering students to be aware of the risks and hazards associated with their profession. Universities play a crucial role in providing safety education and training to engineering students. In a study by Wong et al. (2019), it was found that universities should prioritize safety education for engineering students to ensure that they are adequately prepared for the workplace. Similarly, in a study by Kallio et al. (2018), found that universities should provide hands-on training to engineering students to enhance their safety skills. A study by Noroozi and Abdullah (2018), it was found that safety education significantly improves the safety knowledge and skills of engineering students.

Similarly, in a study by Barros et al. (2018), found that safety education improves the safety attitudes and behaviors of engineering students. Van Bruggen et al. (2020) in his systematic review of the literature on safety education in engineering found that safety, stress, knowledge and training are critical in engineering education, and there is a need for a systematic approach to safety education. The authors emphasized the importance of hands-on training and simulations in educational institutes for better learning and implications (Van Bruggen, 2020). The academia doesn't provide its students quality education on how to handle dangerous equipment's, chemicals, risk assessment and awareness which is the case then attitudes and beliefs regarding safety at labs might shape the engineering students but if the quality education includes safety education as a part of the curricula, then the student's safety will be ensured by themselves. However, should these students continue on to graduate school and further work in academic research labs, a casual disregard towards safety may be a much greater liability when they are working with more dangerous chemicals and processes?

The first notion holds significance and can mold their attitudes and approaches initially. Unfortunately, research on safety training is of questionable validity with regards to policy making on wider scale and the case on Sangjis death, a research student at UCLA, it was clear that training was not given to the researcher and she had not much knowledge regarding safety practices. Although this is an essential component of training and knowledge, it should supplement rather than replace the use of formal training, institutional and laboratory-specific standard operating procedures, protocols and information from manufacturers, professional societies. Again, an additional concern here is that these results reflect the self-perception of participants that they could handle a fire or spill, not an objective evaluation of their capacity to do so. Another study found that mainly researchers are not trained enough in hazard handling for which they work.

Research on safety training or lack thereof, stands in stark contrast to findings suggesting that many researchers feel their lab is a safe environment. What are we to make of this discrepancy between objective injury data and subjective feelings of safety? Our interpretation is that risky practices and a cavalier attitude toward safety are so normalized within academia that the low standards in the field are not troubling or even apparent to those on the inside(Ménard & Trant, 2020).

Again, the same methodological issues that plague research on undergraduate safety programs are also true for academic research labs (for example, lack of control groups and randomization to interventions, inclusion of several interventions at once, no measurement of objective data such as accident frequency or inspection violations) and make interpretation and generalizability of results questionable. Training and knowledge are essential components; it should supplement rather than replace the use of formal training, institutional and laboratory-specific standard operating procedures, protocols and information from manufacturers, professional societies and compendia of reagents. This informal approach to training is particularly troubling because the knowledge being passed down may not conform to best practices, as was clear from the report on Sangji's death (Ménard & Trant, 2020).

Self-Efficacy (SE) is a human judgment about the ability to mobilize the inspiration, and flow of action to achieve some goal within a given context (Ackerman, 2018). An ability to control the outcomes and overcome the challenges put in their ways. If the individual can control its high SE, it means that whatever comes its way, challenged. Mostly individuals are motivated while accomplishing their tasks. Self-efficacy, that determines how efficacy can help an individual to perform in a situation, and safety-related stress, will affect the performance of the individual.

Self-Efficacy is critical for the development of knowledge in individual (Alonso, Kok, & Sakellarios, 2019).The higher the self-efficacy, the greater the chances of employees better performing at the workplace (Carter, 2018). Self-Efficacy refers to individuals' belief regarding their ability to utilize the cognitive ability and motivation to attain their work-related goals (Luthans & Rego, 2012). This belief is by &large developed through learning, experience, feedback, psychological arousal (such as training) and individuals' social beliefs (Wang, D., Wang, X. & Xia, N., 2018). Self-efficacy has a critical role in development of individual's knowledge and can enhance the training effectiveness (Badlishah, Ali, & Fareed, 2019).

A student's self-efficacy largely impacts their perceptions of and reactions to strenuous situations they may face in college/universities, affecting their capability to perform tasks and overcome difficulties. The self-efficacy of students is dependent on students' capability of handling different who are successful will have higher self-efficacy, making them more confident than those are not will likely have lower self-efficacy. The impact of low self-efficacy includes avoiding challenging tasks, low expectations and goals, harboring self-doubt, low self-esteem, self-defeating thoughts, negative self-image and exhibiting low commitment and those with high self-efficacy are more likely to set ambitious goals, face challenges and obstacles with confidence, have higher levels of commitment and employ positive-coping strategies (Hegenauer, 2018).

2.5. Mediating Effect of Safety Knowledge on Safety-Related Stress and Safety Behavior

Safety knowledge acts a mediator between the safety-related stress and safety behavior by training individuals and their self-confidence motivates them to work in a safe environment and free of accidents or injury. The use of the personal protective equipment's as a part of the compliance, performance can be determined. High-risk industries, where employees receive trainings that are essential for the development of the knowledge and skills with respect to their performance (Burke, M., 2002).

Safety-related stress is one such factor that can have a significant impact on an individual's ability to act safely and make informed decisions. Engineering students, in particular, are vulnerable to the effects of safety-related stress, as they are often exposed to high-pressure situations and challenging coursework. It is crucial to provide efficient training programs and treatments that concentrate on stress management and safety knowledge in order to address the issue of safety-related stress and encourage safe conduct in engineering (Saleh, 2012). By providing students with the tools and resources they need to manage stress and make informed decisions, organizations can create a safer and more productive work environment. This includes providing access to mental health support services, developing stress-management techniques, and emphasizing the importance of safety knowledge and training (Musto, (2010).

H2: *Safety-Related Stress has an Impact on Safety Knowledge*

Safety Behavior as in the study suggests that safety behavior can be enhanced by safety knowledge, considered as an influential variable with direct and indirect effects on the behavioral

outcomes. Safety knowledge is required to strengthen the health actions taken in the industry and by the employees working in there. As the safety knowledge can be increased through training and using the efficacies of the employees, safety performance can be enhanced. The employee's occupational safety and health can lead towards safer work behaviors and a decreased number of incidents. The safety training is mostly research and practiced in safety management (Wachter & Yorio, 2014). The individuals who receive training get less injured less with accordance to those who have not been trained (Zacharatos, Barling, & Iverson, 2005). Safety behavior of the ones working in the high-risk industries utilizing their skills, safety knowledge, safety training, and attitudes to perform safely in their units to increase the organizations productivity is also the purpose of the organization. Research reveals that knowledge sharing behavior further improves the quality of staff's knowledge, their safety participation inclination and compliance with occupational safety regulations (Ni, G. et al., 2020).

A study by Zhang et al. (2019) found that safety training was positively associated with self-efficacy and safety performance in engineering students who had internships in the manufacturing industry. The study suggested that safety training can increase engineering students' knowledge and skills related to safety, which in turn can improve their self-efficacy and safety behavior in the workplace. Similarly, a study by Alipour et al. (2018) found that safety training was positively associated with safety self-efficacy and safety behavior in engineering students who had internships in the construction industry. The study suggests that safety training can increase engineering students' confidence in their ability to perform safety-related tasks and promote safety behaviors in the workplace. Other studies have also examined the factors that influence safety self-efficacy in engineering students. For example, a study by Aghazadeh et al. (2017) found that safety knowledge, safety motivation, and safety culture were important predictors of safety self-efficacy in engineering students who had internships in the petrochemical industry. The study suggests that promoting safety culture and providing safety knowledge and motivation can improve engineering students' self-efficacy and safety performance in the workplace. Christian et al. (2009) and Keiser and Payne (2019) pointed out that safety knowledge had a relationship with safety behavior, including safety compliance, safety participation and safety commitment. This is because safety knowledge increases vigilance and makes people more responsible and alert while conducting their tasks. A study conducted by Gressgård (2014) on employees of petroleum, construction, power, aviation and many more industries indicated that safety compliance was influenced by safety

knowledge. Nevertheless, a study conducted by Al-Zyoud et al. (2019) expressed that comprehension of safety symbols and hazards in the laboratory among chemical engineering students at the German-Jordanian University in Jordan was mild. This showed that students' attitudes towards laboratory safety was lacking and needed more safety training and awareness activities or programs in the university.

The association between safety knowledge and safety behavior could also be clarified by the connection of safety knowledge and safety participation. Individuals with stable emotions are considered fit to take part in safety activities, disseminate safety information, and help colleagues resolve technical safety problems (Mirza et al., 2019). After having considered the association between safety knowledge and safety behaviors as found in previous literature (Abdullah & Aziz, 2020). By promoting strong safety knowledge and behavior, organizations can help engineering students mitigate the impact of safety-related stress and perform their jobs safely and effectively. When a person's safety-related duties and expectations at work conflict with other requirements of their job or with those of another, it creates conflict and uncertainty about how to prioritize or carry out safety-related tasks (Yang et al., 2020).

H3: *Safety Knowledge has an Impact on Safety Behavior*

Safety knowledge is used as a mediator between safety-related stress and safety behavior to strengthen their relation for the use in the high-risk industries. The accidents related to chemical units, human or technological errors could trigger a reaction, which may end up in a major accident and having prior knowledge of the processes, dangers associated with it and the different procedures to prevent them are required for the workers in the plant of the company (Vinodkumar & Bhasi, 2010). The more effective safety management system will not be to improve the safety knowledge of the employees but to motivate them as well to protect themselves from the accidents and defined by the two components such as safety training and self-efficacy (Nkrumah, Liu, Fiergbor, & Akoto, 2021). Studies have found that safety knowledge provides individuals with the necessary skills and competencies to recognize, evaluate, and respond to safety hazards and risks.

The role of safety knowledge as a mediator can be to help engineering students manage safety-related stress and promote safe behavior in high-risk industries. By providing adequate safety training and building self-efficacy, engineering students can develop the necessary knowledge and skills to identify and mitigate potential safety risks. In turn, this can help to reduce the stress associated with safety-related tasks, leading to a more confident and competent approach

to safety behavior. However, it is important to note that simply providing safety training may not be sufficient, and engineering students may require ongoing support and reinforcement to maintain safe behavior in the face of high-risk situations (Alavi, 2020). It is also important to address any resistance to safety measures that may be exhibited by engineering students. This could involve providing additional training or education on the importance of safety, or working to understand and address any underlying concerns or barriers to safe behavior. Additionally, regular evaluation and feedback on safety performance can help to reinforce the importance of safe behavior and encourage continuous improvement (Sarker, 2020).

We need to identify barriers that prevent the systematic acceptance of the necessity for the learning and application of safety principles among students, faculty and staff. We need to understand how best to implement meaningful and impactful safety training starting in first year undergraduate level (or earlier) and how to build upon it continually throughout the degree and into graduate and postdoctoral training and faculty mentoring. We need to use proper methodology to determine the effectiveness of the training methodology and look at quantifiable outcomes. We need to determine how to address inherent challenges to safety research and training in the academic settings (Ménard & Trant, 2020). Organizations can also provide support and resources to help engineering students manage stress and promote a positive safety culture that prioritizes safety and well-being (Amaya-Gómez, 2023).

H4: *Safety Knowledge Mediates the Relationship between Safety-Related Stress and Safety Behavior*

The conceptual model shown in **Figure 1** illustrates the interrelationship among the variables, which are discussed in detail in mentioned sections. As it shows the impact of the antecedents, safety-related stress and safety knowledge on safety behavior. As some of the variables of the model are taken from the paper by (Wang, D., Wang, X. & Xia, N., 2018) and some of the new variables like safety knowledge (safety training and self-efficacy) and safety behavior (safety commitment) have been introduced to cater the engineering students safety-related stress towards their performance in the universities and later in companies by locating their behavior which is being influenced by safety knowledge.

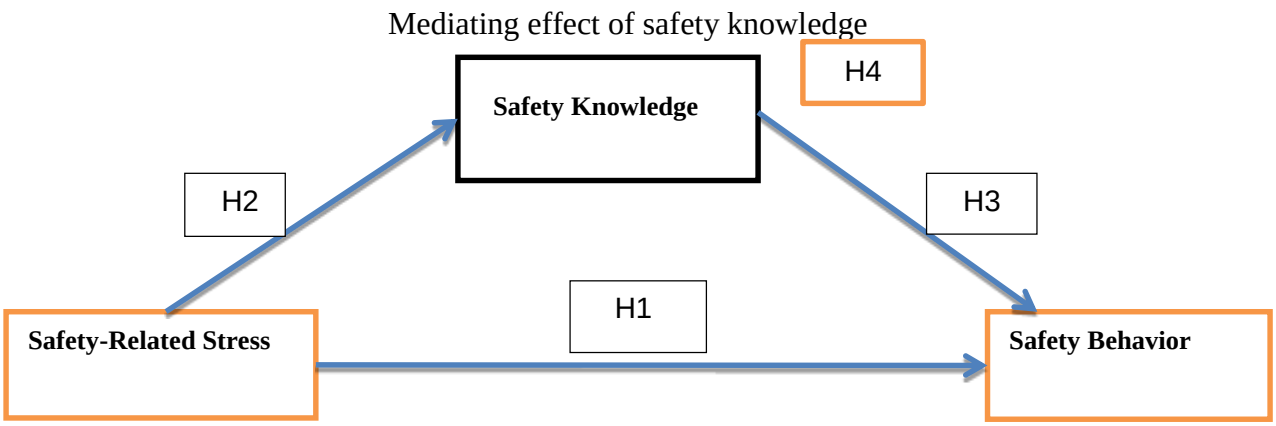

Figure 1 Conceptual model

Moreover, safety-related stress being obtained by the environment, individual's behavior can also be influenced by psychological perspectives, according to *Social Cognitive Theory* (Bandura, 2001). *Social Cognitive Theory* states that the individual's experiences, the action of others and environmental factors that affect the individual's health behaviors. It also provides opportunities for social support through introducing expectations, self-efficacy, and observational learning and reinforcement to achieve the change in behavior. The components of the *Social Cognitive Theory* are self-efficacy, behavioral capability, expectations, expectancies, self-control, observational learning, and reinforcements. The SCT theory applied in this context is to determine that performance can be transformed if the required knowledge through training and efficacy can regulate their safety behavior to be maintained over time for engineering students (LaMorte, 2019).

The above stated model is supported by the mentioned theory, which can lead towards better outcomes and perform their work safely in high-risk industries by utilizing their knowledge to decrease the safety-related stress and increase the role of safety behavior in the organization.

CHAPTER 3 METHODOLOGY

The chapter provides the research methodology utilized for data collection. It also incorporates the philosophical stance of the research; a detailed research design and justification and data collection tools and techniques are used to understand the relationship between mentioned variables: Safety-related stress and safety behavior with safety knowledge as a mediator.

3.0 Philosophical Orientation

Research studies are based on fundamental ontological, epistemological and methodological assumptions (Hunt, 2014), which influence the research procedures (Creswell, 2014). Therefore, it is essential to identify the appropriate philosophical support for research. The association of safety-related stress with safety behavior can be gauged by objective ontology and positivist epistemology, where by the phenomena is independent of social actors and interpreted within a social context.

3.0.1 Ontology

Ontology describes the nature of reality, that is, has existence or is the product of one's mind (Holden & Lynch, 2004). It in effect is reflecting the nature of reality or the underlying philosophy (Petty et al., 2012; Saunders et al., 2019). Ontological assumptions guide how one sees and studies the research objects and broadly answer the 'what' of the phenomena i.e., what is known about a specific thing or object? In the business domain, the objects include organizations, management, employees' job lives, corporate events, artifacts and engineering students (Saunders et al., 2016). Ontology, therefore, provides reasoning with a body of knowledge to support reality. The ontological perspective can be categorized into two dominant approaches, essentially, objective ontology and subjective ontology. The first ontological approach, subjectivism, asserts the importance of social actors' perceptions and consequent actions that shape the social reality (Saunders et al., 2019). In contrast to subjectivism, the objectivist perspective maintains that the social reality is independent of other social actors and the researcher (Saunders et al., 2019).

The research aims at empirically testing the association of safety-related stress on safety behavior via safety knowledge as a mediator. Furthermore, the framework is backed by *Social Cognitive Theory*. The theoretical backing implies that the meaning will be derived exclusively from the objects and not from the principles of the researcher or other social actors (Scotland, 2012). Consequently, it makes sense to study it through an objective ontological lens. The identification of an appropriate research philosophy further guides the research design.

3.0.2 Epistemology

Epistemology concerns the how of the process- how is it possible to gain knowledge of the world? (Hughes & Sharrock, 1997). In other words, epistemology refers to the criteria that researchers use to evaluate knowledge claims which ultimately allows them to understand and recognize reality (Feast, 2010). Epistemology is categorized into two dominant research domains: positivism and interpretivism (Petty et al., 2012).

Interpretivism is a subjectivist approach adhering to the view that individuals' explanations and perceptions impact the understanding and interpretation of social reality. Diverse perceptions imply that individuals may construct distinct understanding and interpretation of specific experiences or situations of social reality. Contrarily, positivist researchers keep their experiences and knowledge separate from the research and assume that researchers can observe and measure a stable reality in a logical, rigorous, and systematic manner to gather objective knowledge and facts (Petty et al., 2012). Since this approach considers objective facts, it provides the best scientific evidence for quantitative research methods (Abu-Alhaija, 2019).

Current research employs a quantitative research design, positivist epistemology is used, adhering to the view that research findings are usually observable and quantifiable. Highly structured data collection techniques, i.e., surveys, are used and analyzed through statistical tools (Saunders et al., 2019).

3.1 Research Design Selection and Justification

Research design is the framework or overview of research methods and techniques chosen by a researcher to conduct a study and provides direction for the study(Saunders et al., 2019c). It also reflects the tools and techniques to attain the specific objectives which are also called procedures of inquiry(Creswell, 2015; Easterby-Smith et al., 2018). Research design is required that helps in augmenting the methods systematically to achieve the satisfactory results for research due to which it is advised that a suitable design to produce significant outcomes(Hunt, 2014).

The research methodology/strategy is guided by a particular ontological and epistemological stance. While objectivist research employs quantitative methods, subjectivist researchers prefer qualitative methods (Creswell, 2014). Similarly, positivist researchers utilize quantitative methods that prevent them from their own biases. The current study is based on objectivist ontology and positivist epistemology, a quantitative research design is appropriate.

Questionnaire/survey technique has been employed for quantitative research in this peculiar study and it enables the researchers to reach out to large populations(Creswell, 2015). Research surveys are economical and allow a rapid turnaround of data collection. Within the survey strategy, questionnaires are most extensively used for data collection(Creswell, 2015; Saunders et al., 2019c). Access gained by the researcher for face to face solving questionnaires along with internet mediated channels such as through emails and links shared with the respective managements, administrative staff and engineering students' body from engineering universities.

First, the key people which includes the engineering universities administration listed according to the Pakistan Engineering Council (PEC) are approached to understand the institutions specific practices. According to PEC rankings engineering universities are identified and shortlisted based on the locations and accessibility. According to Saunders et al. (2019), both internet questionnaires and directly delivering the questionnaires are preferred methods. Engineering students from undergraduate and master's program who are not currently employed are provided with an online questionnaire through a web link (Google Form) and a paper-based survey questionnaire in person. And as engineering students complete the survey in approximately 5-7 minutes. Before beginning the survey, the researcher asked the engineering students to go through the directions, demographic information, and consent form added on the first page of the questionnaire. Various authors have emphasized that the messages in the cover letter or welcome screen impact the response rate (Saunders et al., 2019). In web questionnaires, the welcome screen serves the purpose, whereas, in the paper-based questionnaires, the cover letter fulfills this purpose. Students who disagree with the terms are allowed to close the browser (in the case of web questionnaire) or return the form (in the case of paper-based questionnaires). Final year engineering students that volunteered by providing the informed consent proceeded the next page of the survey (see Appendix B). For a cross-sectional design, data that is obtained from the collected samples in certain period of time. The research design ensures the operationalization of the objectives and questions of the study in its true meaning by utilizing the right survey strategy. The deductive approach is utilized to test the hypothesis. The conclusion derived and tested logically from the known premises is to prove their effectiveness and accuracy and research design selected is partly deductive and partly inductive in a cross-sectional path study (Saunders et al. 2019).

3.2Sampling technique

Sampling is a method that let the researcher to deduce information about a population being based on the results of the sample which are the subsets of that population, without investigating every individual for the required study. As there are different sampling techniques used for to investigate different factors. There two sampling techniques finding out the sample i.e., probability sampling technique which includes simple random sampling, stratified sampling, systematic sampling and cluster sampling and non-probability sampling include quota sampling, snowball sampling, convenience sampling and judgment sampling(Saunders et al., 2019c).

Research study is conducted among final year engineering students of Pakistan's engineering universities according to the Pakistan Engineering Council (PEC) rankings. Top engineering universities are selected according to the 2023 list (Appendix A)(Khan, 2022). There are different engineering universities located in Pakistan and consists of different disciplines in every university including engineering schools, business and social sciences, medical colleges, IT programs. The technique in the first phase used is cluster sampling to select among the cluster of engineering universities according to the rankings and then in the second phase it is snowball sampling technique because the engineering students are extensive in number as compared to the other fields despite of the gender and their belongingness from different parts of Pakistan. Basically, multistage sampling techniques are selected in which final year engineering students are selected from the top 10 engineering universities of Pakistan.

3.3Sampling size

According to Sekran and Bougie (2016), it is not possible to collect data from every individual in the population. The sample size is either determined by statistical technique and statistical power used for the study (Hair et al., 2012;(Schumacker & Lomax, 2012), or established by the total population (Sekran & Bougie, 2003). As per the available literature, two selection techniques can be used to determine the sample size. First, a minimum of 200 sample size is considered the rule of thumb for SEM. Second, the sample size is determined by the total no. of parameters to be estimated, the total no. of observed variables, and the desired statistical power. Lomax & Schumacker (2012) have recommended that at least 20 observations for each construct can be a part of study. As there are three constructs in the current model the exact population size of the engineering students in engineering universities is not accurately verified. The sampling size

according to the literature is considered to be around 400 and according to online calculators (calculator.net) it is suggested to be 385. This means that the size should be 385 because of the population size which is not known and unlimited surveys are needed to have a confidence interval of 95% that the real value should be within ±5% of the surveyed value. According to Raosoft calculator, it is suggested that the sample size should be 377 for not knowing the accurate population size which is 20000 as the formula is stated below where N is population size, r is fraction of the responses that we are interested in and $Z(c/100)^2$ is the critical value for confidence level c, E is the margin of error and n is the sample size.

$$x = Z(c/100)^2 r(100-r)$$

$$n = Nx/((N-1)E^2 + x)$$

$$E = \text{Sqrt}\left[(N-n)x/n(N-1)\right]$$

3.4Instrument and Data Collection

Students are contacted through the universities internal email system with an introductory letter and information for inviting them to contact the researcher if they had some query related to the study. It is basically voluntary participation by the final year engineering students belonging to NUST, PIEAS, GIKI and IST engineering universities. Total of 379 students participated in this survey thorough the electronically produced survey link send to their administrators and after to the student bodies. Survey conducted through questionnaires containing specific questions that cater our problem and leads to specific results that we are required. Before conducting a survey and sending research questionnaires to our respondents, I have conducted a pilot test and prepared 30-40 questionnaires to get their responses and feedback from engineering students. This increased the validity of the questionnaires and confirmed that they understand the questionnaires and they are able to respond according to the questions without facing any kind of difficulty. These questionnaires are appropriate enough to cater our problem and be able to develop a relation between our variables.

Academia has a long and solid experience in building and managing educational programs and teaching and conveying ideas in a sequential and structured way. It has the rigor of the academic approach to teach scientifically sound process safety fundamentals knowledge, and what

is maybe the most important, academia knows how do develop individual problem-solving skills and critical thinking based on a deep understanding of these fundamentals. Academia also has a very strong knowledge and experience in evaluating students (Véchot et al., 2022).

The first part of the survey consists of questions about the participants demographic characteristics such as gender, name of university, department/program name, CGPA, city and industry which they would join after completing their studies. The industry is included as a part of the study to determine where most of the students would want to become a part of the high-risk industries and if they do will they be able to cope with the environment as a healthy environment is provided at different institutions and a positive behavior with required knowledge is taught to students belonging from any engineering background. The second part of questionnaire consists of the 38-item structured questionnaire as instrument composed of three relevant variables: safety-related stress, safety knowledge, and safety behavior are used to measure. The scales and questionnaires have been adapted from previously authenticated and recognized studies; thus, their validity and reliability are verified. The questionnaires and studies listed below in Table 2 are used to design the questionnaire.

Safety-related stress which consists of the safety role ambiguity, safety role conflict and interpersonal safety conflict has been addressed by many researchers as a part of the work-related stress is measured by using 13-items adapted from Wang et al. 2018. For safety role ambiguity one item is "*There are clear, planned safety goals and objectives for my job",* for safety role conflict is *"I have to ignore a rule or policy in order to carry out an assignment safely"*, and for interpersonal safety conflict is "*You get into arguments about safety with others at work"*(Wang et al., 2018). Safety knowledge consists of the safety training and self-efficacy is measured by using total of 13-items from which for safety knowledge one is "*I know how to perform my job in a safe manner*"(Guo et al., 2016; Vinodkumar & Bhasi, 2010), for safety training is *"Training provides adequate skills and experience to carry out normal duties safely"* (Evans et al., 2007) and for self-efficacy which is *"I am confident that I could deal efficiently with unexpected events"* (Bandura, 2011; Schwarzer & Jerusalem, 2012). Safety behavior consists of safety compliance, safety participation and safety commitment which are measured by total of 12-items. Safety compliance is "*I use all necessary safety equipment to do my job*", safety participation is "*I encourage my co-workers to work safely*" safety commitment is *"In my workplace management*

acts quickly to correct safety problems". On a five-point Likert scale, the measurement ranges from 1 (strongly disagree) to 5 (strongly agree). The scale has been employed in various studies and in different sectors like petroleum, construction and mining industries as well as mentioned in the **Table 2**.

Table 2

Variables, measures of the studied variables, number of items, and supporting literature

Variables	Measures of the studied variables	Items	Supporting Literature
Safety-related stress			Sampson et al. 2014; Wang et al. 2018; Wang et al. 2020; Ye at al. 2022
	Safety role ambiguity	4	
	Safety role conflict	5	
	Interpersonal safety conflict	4	
Safety Knowledge		6	Vinodkumar & Bhasi, 2010; Guo et al. 2016
	Safety training	3	Evans et al. 2017
	Self-efficacy	4	Bandura, A. 1989; Schwarzer, R., & Jerusalem, M. (1995) Griffin &Neal, 2000; Griffin & Hu, 2013; Boughaba et al. 2014; Sampson et al. 2014; Guo et al. 2016; Wang et al. 2018
Safety Behavior	Safety compliance	4	Cox & Cheyne, 2000; Nkhrumah et al. 2021
	Safety participation	4	
	Safety commitment	4	

3.5Pilot test

According to Mumtaz et al. (2017), pretest and pilot test serve different purposes, so a pilot test was conducted. As there are multiple rules to determine the sample size for a pilot study, a sample of 30 participants is usually preferred (Memon et al., 2017). Cooper and Schindler (2006) suggest a sample between 25 and 100 participants. Hence, the pilot study was done on a sample of 60-80 respondents. Pilot study revealed some insights. Furthermore, pilot test revealed the

instrument reliability. Cronbach alpha coefficient was used to test the reliability. The test showed that the instrument reliable. The Cronbach alpha coefficient for all the variables was greater than 0.7 (Safety-related stress (0.775), safety behavior (0.790), safety knowledge (0.764)). As all the Cronbach alpha values are greater than 0.7, reliability has been established. As all the variables are correlated, the validity is established.

3.5Unit of analysis

The units of analysis for this study are final year engineering students from engineering universities of Pakistan such as NUST, PIEAS, GIKI, and IST from different disciplines/programs in which the engineering students are enrolled consisting of 100-150 engineering students in final year of every batch approximately.

3.6Data Analysis

For data analysis, the present study utilizes SPSS and structural equation modeling. The hypothesized relationships are tested in SmartPLS software. The choice of software was based on several factors. According to Ringle et al. (2015), SmartPLS is user-friendly software for executing PLS-SEM. Sarstedt& Cheah (2019) also highlight several advantages of using the software. The software has an intuitive graphical user interface that allows users to form a path model by drag and drop technique (Sarstedt& Cheah., 2019). It provides an additional advantage of adding quadratic and moderating effects in the model (Hair et al. 2018; Kumar and Purani 2018). Moreover, the bootstrapping technique in SmartPLS is quite comprehensive and enables users to derive standard errors and pre-specify confidence interval types and significance levels (Sarstedt& Cheah., 2019). Furthermore, the results output can be exported to Excel of HTMT format (Sarstedt& Cheah., 2019). According to Mehmood et al. (2021), variance-based SEM is a modern approach that has various advantages. First, it has high predictive nature and enhanced predictive relevance of the model (Yong et al. 2019; Hair et al. 2017). Second, it does not impose the limitation of the normal distribution of data (Hair et al., 2017). Third, PLS-SEM can test complex and large number of constructs in a single model and quantify multidimensional constructs (Ramayah et al., 2018; Ringle et al., 2020). For all the aforementioned reasons, SmartPLS is used to conduct PLS-SEM analysis.

Data screening has been performed on SPPS 22.0 software for descriptive and reliability analysis. Similarly, Herman's single factor test is used to check for common method bias on SPSS.

Next, demographics and descriptive statistics have been presented using SPSS. Next, the model has been analyzed in two steps. In the initial stage, the measurement model testing is done, and in the second stage, structural model testing is done. The measurement model testing has been done initially for only first order constructs are evaluated for their reliability, validity and collinearity. After establishing the reliability and validity, structural model testing has been done to check for significance of path coefficients, effect size as well as R2. Lastly, mediation analysis is performed**.**

3.7. Ethical considerations

There are different regulatory authorities such as for oil and gas it is OGRA, for construction it is Building Control e.g., SBCA, for power it NEPRA, in Pakistan the body who promotes private and public investments, increase competition, protect public interests in the country while conducting the research it is made sure that, no harm is done to any participant or to any institution. Participants who are involved in the study are final year engineering students from the top 10 engineering universities of Pakistan according to the Pakistan Engineering Council (PEC). Voluntary participation is appreciated and their privacy is maintained through proper parameters. Before and during data collection ethics is taken care of and according to Saunders et al. there are different internet mediated ethical issues which are also taken into consideration (Saunders et al., 2019b). Basic ethical principles involving human subjects relevant to the ethics of research, integrity, objectivity of researcher, respect for others inter alia, avoidance of harm, privacy of the participants, voluntary participation, confidentiality of data and responsibility in analysis, reporting and management of data(Saunders et al., 2019b). For research purposes, researcher promotes accuracy and remains truthful, respects the participants and their rights and dignity to avoid every kind of harm or discomfort whether physical, mental or emotional and ensured privacy and anonymity of the participants in the data collection, analysis and reporting of findings. Information sheet and cover letter provided the research details and their voluntary participation, anonymity and confidentiality, is mentioned as well in the cover letter. The higher authorities of the institutes were contacted which helped in data collection purposes and lastly the research work is researchers own piece of work and free from plagiarism.

Engineering students while fulfilling their responsibilities and duties while working at laboratories or the machineries that they use it is to be made sure that they are safe, healthy and perform services in consigned areas. They should act as a faithful trustee of the engineering university and should report if code of conduct is not followed, avoid deceptive acts, conduct

themselves as honorable, respectable, ethical and lawful as to enhance their honor, reputation and usefulness of their profession.

CHAPTER 4: RESULTS AND INTERPRETATIONS

This chapter provides the analysis of the collected data. The first part of the chapter comprises the demographic factors, secondly followed by an analysis of the variables. Results are presented in the tables and explanation as proceeded. The data analysis is performed on 379 responses of final year engineering students collectively from different engineering universities of Pakistan from different departments of the engineering universities who are exposed to laboratory works, chemical and equipment's which are dangerous and of high risk.

4.1 Demographic characteristics

Out of the 379 respondents, 243(64%) are males, and 130 (34%) are females and prefer not to say are 6(1.6%). Half of the participants are males as shown in **Table 3**. From NUST university total of 159(63%), from IST 100(25.8%), from PIEAS total of 105 (27.1%) and from GIKI 15(4.1%) final year engineering students are the respondents for the study. With regards to different departments of engineering universities most of the respondents are from electrical engineering (23.5%), mechanical engineering (21.2%), chemical engineering (12.7%), metallurgy and materials engineering (7.2%), civil engineering (6.2%) and the number of the respondents decreases as in other engineering departments such as the least number is from environmental engineering (0.8%). CGPA that most of the respondents have scored ranging from 2.9-4.0 and the respondents belong to different towns and cities of Pakistan. The industries in engineering students would want to become a part of it are petroleum (28.2 %), electric power (14.2%), construction (13.2%), transport and logistics industry (9. 6%) and the lowest number is recorded in cement industry (0.3%).

Table 3

Demographic profile of the participants

Variables		**Frequency**	**%**
Gender	Male	243	63.0
	Female	130	33.9
	Prefer not to say	6	1.6
Universities	NUST	159	41.3
	GIKI	15	4.1
	PIEAS	105	27.1
	IST	100	25.8

Department	Civil Engineering	24	6.2
	Mechanical Engineering	82	21.2
	Electrical Engineering	91	23.5
	Metallurgy and Materials Engineering	28	7.2
	Chemical Engineering	49	12.7
	Mechatronics Engineering	14	3.6
	Geoinformatics Engineering	13	3.4
	Material Science and Chemical Engineering	1	.3
	Electronics Engineering	2	.5
	Software Engineering	2	.5
	Aeronautics and Astronautics	22	5.7
	Materials Science and Engineering	23	5.9
	Aerospace Engineering	13	3.4
	Avionics Engineering	7	1.8
	Telecom Engineering	1	.3
	Computer Science	2	.5
	Engineering Sciences	1	.3
	Naval Architecture Engineering	2	.5
	Embedded Systems Engineering	1	.3
	Environmental Engineering	3	.8
CGPA	2.9	33	8.5
	3.1	81	20.9
	3.2	45	11.6
	3.3	24	6.2
	3.4	44	11.4
	3.5	53	13.7
	3.6	35	9.0
	3.7	17	4.4
	3.8	28	7.2
	3.9	19	4.9
	4.0	2	.5
City	Islamabad	48	12.4
	Rawalpindi	59	15.2
	Peshawar	31	8.0
	Lahore	33	8.5
	Karachi	30	7.8

	Multan	13	3.4
	Gujranwala	12	3.1
	Kohat	14	3.6
	Sialkot	14	3.6
	Bahawalpur	9	2.3
	Gilgit	9	2.3
	Hyderabad	7	1.8
	Attock	11	2.8
	Gujrat	10	2.6
	Quetta	9	2.3
	Azad Kashmir	7	1.8
	Nowshera	5	1.3
	Jhelum	5	1.3
	Wah Cantt	4	1.0
	Kharian	8	2.1
	Sahiwal	4	1.0
	Kotli	4	1.0
	Swat	3	.8
	Dera Ismail Khan	3	.8
	Mandi Bahauddin	3	.8
	Sheikhupura	4	1.0
	Rawat	5	1.3
	Abbottabad	2	.5
	Sukkur	2	.5
	Mirpur	2	.5
	Faisalabad	1	.3
	Narowal	1	.3
	Sui	2	.5
	Sibbi	2	.5
	Sargodha	1	.3
	Mansehra	1	.3
	Kashmore	1	.3
	Risalpur	1	.3
	Mangla	1	.3
Industry	Petroleum Industry	109	28.2
	Electric Power Industry	55	14.2
	Construction Industry	51	13.2

Transport and Logistics Industry	37	9.6
Aviation Industry	21	5.4
Automotive Industry	15	3.9
Aerospace Industry	12	3.1
Already In Military	12	3.1
Telecom Industry	7	1.8
Pharmaceutical Industry	7	1.8
Paint Industry	6	1.6
Education Sector	5	1.3
Chemical Industry	6	1.6
Robotics and Mechatronics based Industry	7	1.8
Food and Beverage Industry	4	1.0
Manufacturing Industry	4	1.0
Health and human services	4	1.0
Environmental Industry	5	1.3
Software Development	3	.8
Fertilizer Industry	1	.3
Aircraft Manufacturing Organizations	1	.3
Makeup Industry	1	.3
Supply chain industry	3	.8
Marine Industry	2	.5
Electronics System Design and Manufacturing	2	.5
Cement Industry	1	.3

4.2Descriptive analyses

As a first step data screening is performed to detect the outliers and the missing values. There are no missing values reported (Hair et al., 2021). From the collected data Cronbach alpha is determined to evaluate the reliability of each variable. **Table 4** presents descriptive statistics, Pearson's correlation coefficients among the variables (Pearson, 1985).

Pearson's Correlation is a measure of the relationship between the variables and has wide applications in business and statistics. The variables are safety-related stress, safety knowledge and safety behavior that is studied together but the main issue is how to identify the relationship, link, or an association between them at one time together. This analysis of the variables is

correlation analysis and describes the strength and direction of the linear relationships between two variables. The Pearson's correlation coefficient varies between +1 and -1 where +1 is a positive correlation and -1 is perfect negative correlation and 0 identifies that there is no linear correlation at all. In **Table 4**, it indicates that safety-related stress and safety knowledge have a negative inverse correlation relationship which means that if there is safety-related stress, safety knowledge will be not so great or vice versa of engineering students. Safety knowledge and safety behavior have a positive correlation meaning that if there is safety knowledge then safety behavior will better to a greater extent but if there is reduced safety knowledge, experience, and training, safety behavior of final year engineering students will be affected as well.

Significance of two-tailed is the p-value or probability value and N is the number of observations that are correlated. If the value of p is < 0.05, there is significant bivariate association between the two variables and if the value of p is > 0.05 it means that there is no significant association between the two variables. The standard value is 0.05 which means that it is highly significant. Safety-related stress and safety knowledge value lies between -0.60 to 0.2 which means that there is inverse and weaker relationship and safety knowledge and safety behavior value lies between 0.2 to 0.096 which means that there is a significant relationship between the two. The relationship between SRS and SB is also significant consisting of positive values.

Table 4

Correlation Co-efficient

Correlations			
	SRS	SK	SB
SRS	1		
SK	-0.06	1	
SB	0.086	.427**	1

** Correlation is significant at the 0.01 level (2-tailed). p-value should be <0.05. N= 379.
SRS is safety related stress; SB is safety behavior and SK is safety knowledge.

4.3Testing of measurement through SPSS and PLS-SEM

Partial least squares structural equation modeling (PLS-SEM) is used to test the research hypothesis as well because of the strength it holds, is used as a method of analysis. Previously

many researchers have focused on different constructs model and theoretical errors resulting from model misspecification (Bollen & Lennox, 1991; Diamantopoulos & Winklhofer, 2001; Jarvis et al. 2003, Mackenzie et al. 2005; Roy et al. 2012). There are two models which consists of one is reflective model which is considered as the cause and indicators as its manifestations. For example, Eboli in 2018 claimed that intelligence being determined as the response of a subject designed questionnaire to assess this aspect and not vice versa. So, if the intelligence is increased, it will increase the number of correct answers to the entire question which means that construct determines its indicators and can be removed if statistically not significant.

In a formative model, the indicators determine the latent constructs such as in many cases the indicators could be viewed as causing rather than being caused by the latent variable measured by the indicators. In this kind of model a single factor cannot be removed without affecting the definition of the construct(Crocetta et al., 2021).

The current model is a reflective-reflective model which has been evaluated for internal consistency, convergent validity and discriminate validity (Hair et al., 2021).Measurement model assessment has Andersen and Gerbing (1988), a two stage analytical procedure was adopted in which the first stage involves of testing the measurement model i.e. internal consistency reliability, convergent and discriminate validity and second stage involve the examining of the structural model i.e. the hypotheses testing. Smart PLS, version 4 is used to establish the quality of the constructs, after which structural model assessment has been done (Ringle et al. 2015).

Factor loadings*:* Factor loadings show the correlation between the items and the construct (Hair et al. 2017). Most of the factor loadings are above 0.7 and 0.5 and below <0.5 values are removed or deleted. SRS 9, SRS13, and SK6, SK7 are the items removed from safety related stress and safety knowledge because of the low values. This is as per as the recommendations made by Hair et al. 2017.

Reliability Analysis: Reliability demonstrates the stability and the consistency of the measurement of the instrument. There are two most used methods to establish the internal consistency reliability is Cronbach alpha and composite reliability measures. Hair et al. (2017) recommended that both methods should be reported. Cronbach alpha of the constructs is a measure of internal consistency, how closely related a set of items are as a group as given in **Table 5** ranges from 0.736 to 0.864.

The variables safety-related stress, safety knowledge and safety behavior demonstrated good reliability as indicated by presenting the value of Cronbach alpha was above 0.70, which is stated by Nunnally in 1978. The Cronbach alpha of safety-related stress is 0.736, for safety knowledge is 0.864, and for safety behavior it is 0.760, respectively, meaning that the reliability of the variables is guaranteed.

The composite reliability (CR) of all the constructs used in this study exceeds the recommended value of 0.7 because it shows how well a construct is measured by its assigned indicators. As it ranges from 0.870 to 0.898 as shown in **Table 5** because the reliability should range from 0.7 to 0.9 considered as satisfactory and if above >0.9 that is not desirable and <0.6 is for exploratory studies (Hair et al. 2017).

Convergent Validity: Convergent validity measures the extent to which the construct explains the average variance extracted (AVE) of the indicators. As suggested the value for the study is above 0.5 for each construct (Fornell & Larcker, 1981). The AVE should be greater than 0.5 indicates that the constructs represent the half of the variance in indicators and if the value is <0.5 which indicates that more variance exists in the error of the items than in the represented variance of the construct. As the AVE values are above the >0.5 threshold, the composite reliability shows no issue means that constructs are valid.

Table 5

Convergent Validity, Composite Reliability and Internal Consistency Reliability (Cronbach Alpha)

Constructs	AVE	CR	Cronbach alpha
Safety Behavior	0.53	0.87	0.760
Safety Knowledge	0.528	0.898	0.864
Safety-related Stress	0.504	0.876	0.736

Discriminant Validity: The degree to which a construct is distinct from other constructs. Discriminant validity as a result established demonstrates that the construct is noticeable from the others in the models and states the phenomena are not represented by other conceptions. For this purpose, HTMT criteria is used which is the ratio of the between trait correlations to the within trait correlations. It also provides a measure of the expected true correlation between the constructs

if they are measured accurately (Hair, 2017). **Table 6** shows the values that are below the range of 0.9 which depicts that the validity is confirmed. According to Henseler et al. (2015), suggests a maximum value of 0.90 and Bootstrap confidence intervals shows significance of the HTMT ratios. This demonstrates that the constructs are empirically different from one another.

Table 6

Discriminant Validity (HTMT)

	SB	SK	SRS
Safety Behavior			
Safety Knowledge	0.525		
Safety-related Stress	0.167	0.209	

4.4 Results of Hypothesis Testing

This step is the evaluation of the hypothesized relationships to prove or to reject the hypothesis. Both the software's (SPSS & PLS-SEM) depicts that results are valid and their relationships are significant.

H1: Safety-related stress has an impact on safety behavior

Table 7 demonstrates that safety-related stress has a direct impact on the outcome variable which is safety behavior. The values predict significant relationship (R-square =0.1924, coeff=-0.880, MSE=0.21, F= 43.94, df1=2.00, df2=369, p=0.01, se= 0.03, t=2.37, LCI=0.15 and UCI= 0.16). Model 4 shows that it is a mediation model and upper confidence interval and lower confidence intervals shows that there is a relationship that exists among them. In both, model summary and coefficient data results show that the result is significant and there exists a relationship between them. The relationship between safety-related stress and safety behavior is significant and the hypothesis is accepted.

If there is an increased amount of stress which affects the behavior to react in certain unforeseen situations because there is less clarity among the roles, increased conflicts with colleagues and with personal relationships that mold the behavior of an individual to not to perform effectively and efficiently. Engineering students mostly face stress while performing lab work as stated in the literature which affects their productivity and changed behaviors and they do not comply or participate in such lab works that will require safety protocols and handling with great

care because their commitment level is decreased due to the increased stress levels with limited level of energy to engage in certain activities(Wang et al., 2018).

Table 7

Model Summary

Model

4	R	R-sq	MSE	F	df1	df2	p
	.4386	.1924	.2115	43.9493	2.0000	369.0000	.0000

Coefficients

Model 4	co-eff	se	t	p	LLCI	ULCI
Constant	1.8999	.2227	8.5327	.0000	1.4621	2.3378
SRS	.0880	.0371	2.3726	.0182	.0151	.1610

Outcome variable safety behavior

H2: Safety-related stress has an impact on safety knowledge

Table 8 demonstrates that safety-related stress has a direct impact on the outcome variable which is safety knowledge. The values predict that there is a negative relationship between safety-related stress and safety knowledge (R-square=0.003, coeff=-0.199, MSE=3.189, F=1.23, df1=1.0, df2=370, p=0.00, se=0.04, t=-1.11, LCI=-0.13, UCI=0.03). In both, model summary and coefficient data result shows that the result is significant but safety-related stress has an inverse relationship with variable safety knowledge.

The second hypothesis states safety-related stress does have a relation with safety knowledge but due to the negative values there exists an inverse relationship with each other that means that if safety-related stress increases the safety knowledge will somehow be affected. Increase in safety-related stress will pressurize the engineering students to not to be self-sufficient enough and not to get trained because the required experience and knowledge will be suppressed and won't be able to use their knowledge or expertise where it is required and some also are bullied enough because they follow their safety procedures due to which it also stresses them out and in organizations, they don't use their knowhow of safety practices because they think it will affect their productivity.

Table 8
Model Summary

Model	R	R-sq	MSE	F	df1	df2	p
4	.0576	.0033	.3189	1.2322	1.0000	370.0000	.2677

Coefficients

Model 4	co-eff	se	t	p	LLCI	ULCI
Constant	4.3135	.1564	27.5788	.0000	4.0060	4.6211
SRS	-0.199	.0455	4.12200	.0000	-.1399	.0390

Outcome variable safety knowledge

H3: Safety Knowledge has an impact on safety behavior

Table 9 indicates that safety knowledge has a direct effect on safety behavior. The values show a positive relation between safety knowledge and safety behavior of engineering students (R-square=0.19, MSE=0.21, F= 43, df1=2, df2=369, coeff=0.389, se=9.19, p=0.00, LCI=0.30, UCI=0.47) which means that the path is significant and safety knowledge has an impact on safety behavior. If there are required trainings conducted and experience gained to increase their knowledge, safety behavior will eventually be observed more and they will feel committed, motivated and confident to comply with the procedures and processes. The voluntarily participation and self-efficacy is increased due to the prior knowledge while working in the laboratories or at site areas handling different and complex engineering systems(Khairul & Aziz, 2020; Simmons et al., 2017).

Table 9

Model Summary

Model 4	R	R-sq	MSE	F	df1	df2	p
	.4386	.1924	.2115	43.9493	2.0000	369.0000	.0000

Coefficient

Model 4	coeff	se	t	p	LLCI	ULCI
constant	1.8999	.2227	8.5327	.0000	1.4621	2.3378
SK	.3892	.0423	9.1919	.0000	.3059	.4724

Outcome variable safety behavior

H4: Safety Knowledge mediates the relationship with safety-related stress and safety behavior

The fourth hypothesis is proved in a manner that despite the inverse relationship there is significant relationship with each variable and the software shows different values among variables

that safety knowledge does mediates safety-related stress and safety behavior cause if there is enough knowledge being gained by engineering students to be used in certain times or in high-risk industries, casualties, near misses and injuries can be reduced to a certain number and can perform effectively in their respective institutes. The required knowledge can enhance one's behavior and reduces safety-related stressors because engineering students are clear in their roles and safety protocols are taught and practiced, it will display a positive behavior among each other and the positive behavior can increase productivity and self-efficacy of engineering students.

Mostly final year engineering students don't want to get stuck in labs while just observing machineries and systems how they work and instructors and supervisors don't attend to them which makes it more difficult for them to handle their stress and use the prior knowledge(Khairul & Aziz, 2020).

Table 10

Total effect of X on Y

Effect	se	t	p	LLCI	ULCI
.0684	.0410	1.6675	.0963	-.0123	.1490

Direct effect of X on Y

Effect	se	t	p	LLCI	ULCI
.0880	.0371	2.3726	.0182	.0151	.1610

Indirect effect(s) of X on Y:

	Effect	SE	LLCI	ULCI
SK	-.0197	.0178	-.0541	.0166

The above table shows the direct of Safety-related stress on safety behavior and the indirect effects shows the mediation of safety knowledge on safety-related stress and safety behavior. Further a table is attached in the **Appendix C** for further clarification. Bootstrapping is used and it automatically runs for 5000 times to check any errors.

In order to summarize the results, from the gathered data, the profile the respondents' states that most of the engineering students are male, they belong to different departments/programs of the engineering universities and they enroll themselves in top universities because of the good environment, supportive faculty, reliable management, advanced laboratories equipped with technologies so that they can be recruited in the industries as they have chosen in **Table 3,** safety-related stress changes the behavior of the individuals because of the high levels of stress and safety knowledge mediates the relation to bring a positive change in the lives of the engineering students.

CHAPTER 5 DISCUSSION

5.1Discussion

The present study aimed to establish the association of safety-related stress on safety behavior among engineering students through the utilization of the safety knowledge. The social cognitive theory has been employed to support the relationship. As expected, the analyses and findings indicated safety-related stress affected the final engineering students and their safety behavior because increased safety-related stress will show a molded behavior or sometimes neutral behavior, attitude towards the safety practices being taught in the educational institutions. These effects have been discussed in greater detail in the subsequent sections. Further safety knowledge has been identified as a mediator. The findings also support the mediating role of safety knowledge in the relationship between safety-related stress and safety behavior. The findings confirmed that safety knowledge (safety training and self-efficacy) affects the behavior (safety compliance, safety participation and safety commitment) of the individuals which also affects their performance, effectiveness and efficiency while at universities and then in organizations.

The safety-related stress (role ambiguity, role conflict and interpersonal conflict) also states that if an individual is not trained enough or not knowledgeable enough, he /she will be affected more and stress will eventually be increased so to decrease their level of safety-related stress they should be taught safety knowledge so that a positive outcome is specified and used and also the accidental rate can also be decreased.

Research Objective 1: To investigate the relationship between safety-related stress and safety behavior of engineering students in engineering universities

The findings confirm that there is understanding of the safety-related stress and safety behavior among the engineering students but the knowledge levels may vary according to the institutional teachings. Many studies have examined the relationship between safety-related stress and safety behavior in a variety of industries. For instance, Wu and Liu, (2022) indicated that stress in relation with safety had a negative impact on construction employees' safety knowledge and the safety behavior while working onsite which results in casualties but the ones who use their required knowledge may suffer less stress and more productivity depicting a positive behavior. The engineering students are affected by the effects of the stress and safety procedures cause in some

working labs there I no proper facility for work or to operate such works and they feel stressed where to use this knowledge.

In a study by Tamakloe et al. (2019), the authors found that safety-related stress education has an impact on safety behavior of students. The study also depicts that the ones who receive such education are likely to engage in safe work practices that is the lab work, experiments etc. In a study by Neal et al. (2019), the authors found that the institutions that prioritized safety stress education were more likely to provide safety stress education to their students. However, the ones who don't were less likely to provide safety-related stress education. The study also discusses the relationship between safety-related stress and safety behavior in high-risk industries, where safety-related stress can reduce employees' cognitive and emotional resources to deal with safety hazards and risks, leading to accidents and injuries.

Research Objective 2: To analyze the relationship between safety-related stress and safety knowledge of engineering students in engineering universities

The findings demonstrated that there is inverse relation between safety-related stress and safety knowledge by describing that if universities, colleges and schools train their students how to work, how to use PPEs while working and safety gadgets, the related knowledge and experience gained enough that can reduce the stress and positive productivity will be shown. Most of the laboratories that are mostly made safe but it has been said that laboratories may not follow Murphy's Law- "What can go wrong will usually not go wrong, and so flawed and incomplete safety systems are maintained until too late". The level of high stress situations can reveal the flaws and inadequacies at when an accident or an incident happens. It is like in a laboratory when electricity is shutdown, alarms are ringing, language barriers and clear channels of communications are lacking which leads to a failure to evacuate and properly investigate the situation (Schmidt, 2018). The literature also talks about the particular stressors that engineering students experience in relation to safety education and training, resulting in lower engagement and motivation. In a similarly, Van Gorp, et al. (2015) observed that safety-related stress had an impact on healthcare professionals' safety and security.

The findings also confirmed that the number of accidents can be reduced if there is knowledge and training being given to the students to reduce the number of accidents and injuries

in the labs by reducing their safety-related stress. The idea of safety-related stress at work is covered in the paper, along with how it affects students' health, happiness, and ability to execute their jobs, as well as the overall productivity and safety. It highlights the factors that contribute to safety-related stress, such as workplace accidents, hazardous substances, high workload, poor work conditions, inadequate training, lack of social support and self-confidence. Engineering students who are preparing to enter these high-risk industries need to have a strong understanding of safety knowledge, but they also need to be able to apply this knowledge in real-world situations.

The safety-related stress and safety knowledge of engineering students has been perceived by many previous researchers such as Devis and her colleagues in 2021 found that engineering students' safety-related stress education and training are irrelevant to their future careers and less interesting than other technical aspects of engineering education (Devis et al., 2021).

Research Objective 3: To analyze the relationship between safety knowledge and safety behavior of engineering students in engineering universities

According to Miller (2019), safety knowledge is an important factor in promoting safety behavior in engineering students. However, simply possessing safety knowledge is not enough. Students also need to be able to effectively apply this knowledge in real-world situations, particularly in high-risk industries. Several researchers have looked at the connection between engineering students' safety knowledge and safety behavior. For instance, Liang et al study from (2021) indicated that engineering students' safety behavior was positively influenced by their knowledge of safety. Similarly, a study by Fang et al. (2015) discovered that engineering students who were conducting internships in high-risk industry showed positive changes after learning about safety knowledge. Finding also suggest that safety knowledge and safety behavior have a positive relation among each other it changes the behavior of an individual if proper knowledge is utilized at certain situations.

Research objective 4: To test the mediating effect of safety knowledge on safety-related stress and safety behavior

The literature suggests that universities can mitigate the unique stressors that engineering students face related to safety education and training by providing practical and relevant safety

education and training that integrates technical knowledge, ethical considerations, and real-world constraints and providing students with opportunities to apply safety knowledge and skills to real-world problems through experiential learning, internships, and research projects. The report suggests that Engineering students who have higher levels of safety knowledge are better equipped to manage safety-related stress and exhibit safer behavior in high-risk industries. Training programs that focus on enhancing safety knowledge and stress management skills may improve safety behavior among engineering students in high-risk industries. Training programs that focus on enhancing safety knowledge and stress management skills may improve safety behavior among engineering students in high-risk industries. The findings suggest that safety management should prioritize both safety knowledge and stress management to promote safety behavior in high-risk industries. Stress that is connected to safety has been found to have a big impact on safety behavior.

At construction sites, safety-related stress and safety behavior mediated by safety knowledge and motivation, according to a study by Vinodkumar et al., (2010) came to the conclusion that in order to increase safety knowledge, safety training programs should put equal emphasis on boosting safety knowledge and motivation as well as easing stress associated to safety. Another study by McCabe et al. (2020) looked at the connections between engineering students' safety knowledge, safety motivation, stress linked with safety, and safety behavior. The findings suggests that safety-related stress have a detrimental effect on safety behavior while safety knowledge, and motivation have beneficial effects. According to the study, in order to improve safety practices among engineering students, safety training programs should target the safety climate and stress associated to safety. The effect of the safety knowledge on safety behavior among Chinese engineering students is also the subject of a study by Behm et al. (2014). To improve engineering students' safety behaviors, the study strongly emphasizes the importance of promoting a safe atmosphere and raising safety awareness. In another study by Chen & Wu (2018), safety-related stress education is a predictor to enhance safety knowledge, safety motivation and self-efficacy which can lead to improved safety behavior.

To summarize the discussion, safety-related stress does impact the safety behavior of the engineering students in engineering universities laboratories because of the positive relation it showed in chapter 4. The impact of safety-related stress with safety knowledge is inverse relation which shows that stress does lowers the use of the knowledge or the trained and self-confident

engineering students can lower the stress levels because they are trained and knowledgeable enough. The safety behavior and safety knowledge have a positive impact on each other because of the explicit and tacit knowledge that the engineering students possess depicts a positive attitude, behavior and skills that are usable in the labs and the stress levels are possibly reduced when an individual is knowledgeable, self-aware of the unforeseen situations that might occur while working at laboratories.

CHAPTER 6 CONCLUSION

As per the requirement of the study, data analysis results have been presented and discussed in detail in the preceding chapters. The final chapter provides an explanation, implications and contribution of the findings of research based on the survey data being collected. To conclude the research, implications, limitations and future directions for new perspectives are provided.

6.1Theoretical and Practical Implications

Theoretical Implications

Safety-related stress affecting the engineering student's safety behavior is an emerging study that can benefit academic institutions and the organizations in the long run. Engineering students who are recruited in high-risk industries may exhibit significantly different safety behaviors as a result of stress relation with safety. By promoting safety knowledge and providing effective stress management tools, organizations can help students mitigate the negative effects of stress and make informed decisions that prioritize safety. The students who work in such settings such as in laboratories, field works they require specific safety knowledge regarding hazards, accidents, chemicals, first aid treatments, putting out fires and survival trainings, which are a part of the university's curriculum in major cities of Pakistan, are required to reduce the stress related to safety and security.

The study also signifies that where there is stress, use of safety knowledge is less. Safety-related stress is increased among students who are not likely to have positive perspectives, attitudes and behaviors towards health and safety, which is the individual's belief system that their behavior is guided by their decisions and efforts their stress levels are also effected (Hamaideh, 2011). Several studies have looked into the relationship between safety stress and safety behavior in a variety of settings (institutions, industries). The authors have noted that male engineering students are less likely to report safety concerns and more likely to engage in risky and unsafe behaviors as compared to the female counterparts. Safety-related stress has an impact on safety behavior of engineering students which needs to be monitored because of the stressor's safety behavior is affected and they are on the verge of getting involve in risky situations due to their high stress and disruptive behaviors means a relation of safety-related stress does exist with safety behavior.

Safety-related stress can be reduced by training students to prepare them to positively acquire the specific safety knowledge and be confident enough to manage their stress and display their positive behaviors in order to maximize their opportunities effectively for learning and growth during their lives academically and in social environments as well. The significance of the study for scholars and literature in field can be due to many reasons. First is the impact of safety-related stress on engineering students through the utilization of safety knowledge as established in the current study has not been studied before. Second is through the lens of the *Social Cognitive Theory* (SCT) which has been employed to explain the mechanism through positive outcomes can be generated. Because SCT influences one's behavior if there is workable environment for the students to work in labs and personal factors (knowledge, attitude, expectations). Engineering students who are fully committed with their work and social activities, theorists have articulated that behavior of the engineering students can be shaped based on the situation or environment- the context win which they learn such as: situation-botched lab experiment-safety-related stress occurs resulting in avoidant behavior and lack of safety knowledge (El-Sayad et al., 2021).

Practical Implications

The empirical findings of the research also provide practical implications relevant to the policy makers, researchers, engineering and non-engineering institutes and their management. The significance of the study for practice can be due to many reasons. First understanding the safety-related stress and its stressors and how to reduce safety-related stress in universities and in organizations by showing a positive behavior towards the safety practices being followed. Secondly, a strong safety culture that values the well-being of individuals is essential for creating a safe and productive work environment in high-risk industries, including different sectors such as engineering. In a developing country like Pakistan to flourish in the field of science and technology there are many challenges engineering students are facing with adequate resources for to bring a positive outcome.

Discussion of hazards, risk assessments and other strategies specific to the laboratories in use at institutions and industries shows engineering students potential dangers should be assessed before the experimentation. If the policies are inconsistently followed by the faculty and staff of the department's then mixed messages are sent to the students resulting inconsistency between the safety, stress, behavior and knowledge of engineering students. However, neither the

industry leaders are concerned about safety and stress and changing behaviors of their employees nor they participate in caning curricula which leads towards the gap among the two sectors: education and industries. There should be steps take to collaborate with the two so that engineering programs can be structured to suit the needs of local industries.

6.2Research Contribution

Safety-related stress has not been employed in the academia due to which as in previous studies it lacks research and researchers are currently focusing on safety knowledge and safety motivation to positively portray a behavior that is accepted by the organizations but in universities there is requirement of education, safety-related stress, safety knowledge so that a positive safety behavior where there is compliance, participation and strong commitment is shown while performing in labs or in fields. Engineering education particularly is the solution to the challenges that we mostly are facing and is of high importance for to build a livable world. Engineers are paramount of the state and they are starters, facilitators, performers and achiever s to technological development for a state and has a direct impact on the well being of the state globally visible in all engineering fields stated in the demographics of the study in chapter 4. Engineers demand special care and attention and are expected to solve problems not technological social and economic as well for that safety- related stress should be reduced and safety knowledge should be promoted to have a positive outcome in term of behaviors.

SCT theory also suggests that our behaviors as a student needs to be corrected so that efficiently and effectively can be performed. As there is extant literature from the theoretical lens of SCT can be observed. The present research adds value to the approach used and paves a way for the researchers who can study that the stressors can affect students' behavior if properly safety knowledge is not utilized which leaves the case to the management to look for certain stressors, behaviors that are disruptive for now and later in organizations.

6.3Limitations of study

The current study sheds light on several limitations that present the need for future research. First, the study was conducted among 4 universities in which NUST is semi government, IST and PIEAS are public universities and GIKI is private university which shows that engineering students were reluctant and resistant towards filling the survey forms which created a barrier between the researcher and the universities.

Secondly, the use of safety studies focuses on final year engineering students, since they comprise the largest percentage of the research and field workers often work without faculty advisor being present. And participants were recruited through their teachers/instructors and data was collected during the class sessions, which may influence their participation and honest review. Third, the current study only concentrated on the safety-related stress, safety behavior and safety knowledge of engineering students, the second order constructs such as discussed in the paper role ambiguity, role conflict, safety training, safety participation, compliance and commitment effects were not used which also creates a hindrance in knowing the exact causes of the study and how it affects.

6.4Conclusion

The study aimed at examining the safety-related stress effect on safety behavior of engineering students through the utilization of safety knowledge. The study further aimed to test the model supported by theoretical underpinning of SCT to better understand the role of safety-related stress and safety behavior. All relations among the constructs have been confirmed and mediating role of safety knowledge on safety-related stress and safety behavior among the engineering students has been supported. The research study provides the clarity that safety and stress, safety behavior and safety knowledge are required to be studied in Pakistan which takes the study towards a new direction. Safety-related stress does impact the safety behavior of engineering students but by providing them the sufficient knowledge, the effect of safety-related stress can be reduced and a positive behavior can be depicted.

Future studies should examine the connection between other types of stress (such as academic, occupational, and personal stress) and engineering students' safety behavior. Overall, the paper emphasizes the necessity for a comprehensive strategy that integrates stress management skills with safety knowledge in the preparation of engineering students for high-risk industries. The research has been survey based and has not asked open ended questions that can provide a broader aspect to the understanding of the stressors and behaviors effect; therefore, a qualitative approach could elicit the information that may otherwise go unrecorded in the survey. Further future studies should combine faculty, staff and students collectively to find out how they educate future engineers for work at sites and at institutions. To raise the level of safety and safety behavior, an in-depth understanding of the motivational factors and barriers they face is required. The study

has shown that SCT has been proven to provide a better understanding of engineering students knowledge and behaviors to acting safe in the labs and future studies should utilize to understand the labs safety behavior and the safety-related stressors that affect their learning.

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Appendix A

Here is the list of top 10 Engineering universities of Pakistan according to PEC general rankings

1. Pakistan Institute of Engineering and Applied Sciences, Islamabad
2. National University of Sciences and Technology, Islamabad
3. Ghulam Ishaq Khan Institute of Engineering Sciences & Technology, Topi
4. University of Engineering and Technology- Lahore
5. University of Engineering and Technology – Taxila
6. Institute of Space Technology, Islamabad
7. KPK University of Engineering and Technology
8. Mehran University of Engineering & Technology, Jamshoro
9. NED University of Engineering & Technology, Karachi
10. Air University, Islamabad

Appendix B

NUST
NATIONAL UNIVERSITY
OF SCIENCES & TECHNOLOGY

Questionnaire

Safety-related stress effect on safety behavior of engineering students through the utilization of safety knowledge

Dear Participant,

My name is Maryam Wajid, and I am a postgraduate student at NUST Business School Islamabad. For my research, I'm examining the Impact of safety-related stress on safety behavior of engineering students through the utilization of safety knowledge. I am inviting you to participate in this research by completing the following survey.

This survey will take 5-8 minutes. Your responses will be kept confidential and only copies will be provided to research supervisor Dr. Ayesha Abrar. If you choose to participate, please respond to the survey honestly. Participation is strictly voluntary, and you may refuse anytime. The data collected will remain confidential and used solely for academic purposes.

Thank you for taking your time out in assisting me with this research. If you have any queries about this study or interested in the results of this study, you may contact us.

Sincerely,
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Questionnaire

Section 1: Demographic Information

1.	Gender	□ Male □ Female□ Prefer not to say
2.	Department *(Please Specify)*	
3.	CGPA	
4.	City *(Please Specify from where you belong from)*	
5.	After your graduation, do you intend to join for employment any of the firms that fall in following industries	Petroleum (e.g. Oil and Gas firms) Electric Power Industry (e.g. WAPDA) Construction Industry (e.g. any construction firm) Transport and Logistics (e.g. NHA, NLC, Railway) Others (please specify)_____

Important Definitions: Following words have been used in this scale. Please read the meaning of these words carefully before you fill the questionnaire.

1. **Job/Work:** The practical/lab work or any other field work which is mandatory part of your degree
2. **Workplace**: The time you spend at your educational institution (classroom/lab/filed)
3. **Management**: The Educational Institutions/Engineering School/Department
4. **Co-workers/Others/Person**: All people whom you work with, or your class fellows, or the instructors

Section B: For each statement below please circle the appropriate response. Please fill this section carefully as certain statements have been made in reverse order and might convey an opposite meaning as compared to the one that you actually intended. Please indicate the extent of your agreement or disagreement with each statement after careful consideration:

1 = Strongly Disagree (SDA), 2 = Disagree (DA), 3 = Neutral (N), 4 = Agree (A), 5 = Strongly Agree (SA)

Safety Related Stress	**SDA (1)**	**DA (2)**	**N (3)**	**A (4)**	**SA (5)**
1. There are clear, planned safety goals and objectives for my job	1	2	3	4	5
2. I know that I have divided my time to ensure safety at work	1	2	3	4	5
3. I know what my safety responsibilities are at work	1	2	3	4	5

4.I know exactly what is expected of me with regard to safety at work	1	2	3	4	5
5. I have to ignore a rule or policy in order to carry out an assignment safely	1	2	3	4	5
6. I work with two or more groups who operate quite differently with regard to safety	1	2	3	4	5
7. I receive incompatible safety requests from two or more people	1	2	3	4	5
8. I do things that are apt to be thought of as safe by one person and not by others	1	2	3	4	5
9. I receive an assignment without adequate resources and materials to execute it safely	1	2	3	4	5
10. You get into arguments about safety with others at work	1	2	3	4	5
11. Other people yell at you about safety at work	1	2	3	4	5
12. People are rude to you about safety at work	1	2	3	4	5
13. Other people do nasty things to you at work	1	2	3	4	5
Safety Behavior	**SDA (1)**	**DA (2)**	**N (3)**	**A (4)**	**SA (5)**
1.I use all necessary safety equipment to do my job	1	2	3	4	5
2.I ensure the highest level of safety when I carry out my job	1	2	3	4	5
3. I carry out my work in a safe manner	1	2	3	4	5
4.I follow correct safety rules and procedures while carrying out my job	1	2	3	4	5
5.I encourage my co-workers to work safely	1	2	3	4	5
6.I voluntarily carry out tasks or activities that help to improve workplace safety	1	2	3	4	5
7.I put extra effort to improve the safety of the workplace	1	2	3	4	5

8.I always point out the management if any safety related matters are noticed in my company	1	2	3	4	5
9.In my workplace, management acts quickly to correct safety problems	1	2	3	4	5
10.Management acts decisively when a safety concern is raised	1	2	3	4	5
11.In my workplace management turn a blind eye to safety issues	1	2	3	4	5
12.Corrective action is always taken when management is told about unsafe practices	1	2	3	4	5
Safety Knowledge	**SDA (1)**	**DA (2)**	**N (3)**	**A (4)**	**SA (5)**
1.I know how to perform my job in a safe manner	1	2	3	4	5
2. I know how to use safety equipment and standard rules and procedures	1	2	3	4	5
3.I know how to maintain or improve workplace health and safety	1	2	3	4	5
4.I know how to reduce the risk of accidents and incidents in the workplace	1	2	3	4	5
5.I know what are the hazards associated with my jobs and the necessary precautions to be taken while doing my job	1	2	3	4	5
6.I don't know what to do and whom to report if a potential hazard is noticed in my workplace	1	2	3	4	5
7.Training provides adequate skills and experience to carry out normal duties safely	1	2	3	4	5
8. Adequate training is received when new procedures or equipment are introduced at my workplace	1	2	3	4	5
9.Regular training is provided to me for a range of emergency situations	1	2	3	4	5
10. I am confident that I could deal efficiently with unexpected events.	1	2	3	4	5

11. I can remain calm when facing difficulties because I can rely on my coping abilities.	1	2	3	4	5
12. I am confident in reducing the risk of accidents	1	2	3	4	5
13. I am capable of maintaining and improving the safety of my workplace	1	2	3	4	5

Appendix C

TOTAL, DIRECT, AND INDIRECT EFFECTS OF X ON Y

Total effect of X on Y

Effect	se	t	p	LLCI	ULCI	c_ps	c_cs
.0684	.0410	1.6675	.0963	-.0123	.1490	.1340	.0864

Direct effect of X on Y

Effect	se	t	p	LLCI	ULCI	c'_ps	c'_cs
.0880	.0371	2.3726	.0182	.0151	.1610	.1725	.1112

Indirect effect(s) of X on Y:

	Effect	BootSE	BootLLCI	BootULCI
SK	-.0197	.0181	-.0545	.0166

Partially standardized indirect effect(s) of X on Y:

	Effect	BootSE	BootLLCI	BootULCI
SK	-.0385	.0356	-.1067	.0318

Completely standardized indirect effect(s) of X on Y:

	Effect	BootSE	BootLLCI	BootULCI
SK	-.0248	.0228	-.0686	.0204

Level of confidence for all confidence intervals in output:
95.0000; Number of bootstrap samples for percentile bootstrap confidence intervals:
5000