COMPARISON OF SAFETY CULTURE IN VARIOUS SCIENTIFIC LABORATORIES OF SELECTED UNIVERSITIES

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ABSTRACT: The current study was designed to examine the perceptions of science students for actual practice of health and safety in their laboratories. This study was conducted in three departmental laboratories: 1-Agriculture, 2-Environmental Sciences, 3-Microbiology in Two universities of Pakistan. Questionnaire (Annex-1) was designed for study where sample size for each university was 240 to evaluate the safety perception on nine parameters (Annex-2) by using analytical tools: Five-point Likert Scale (FPLS) which was further associated with Parker's Framework. Safety culture considered as dependent variable depending on four independent parameters. Analytical work was done on SPSS by using Mean square and regression model. Responses were received from each university. The safety culture assessment response rate was 3.68992, 3.5067 of university-A and University-B respectively. The University-A average value applies from 3.50 to 3.75 on the other hand university-B all factors Average values apply from 3.40 to 3.51 which proves that the university-A mean of parameter is greater than the mean of all parameters from university-B. It is also noted that the parameter values increase as the safety culture is positive. R square shows that the safety culture of university-A and university-B is 98.0% and 98.6% respectively dependent on the remaining four parameters which were selected for this study. It is concluded by the survey of university-A in all department's students have positive behavior towards their safety rather than university-B. It is observed that there is a need to work on proper awareness about safety practices by the administration of university-B through arranging seminars, practical trainings and proper enforcement of Laboratory Safety rule.

Key Words: FPLC, Lab Safety, Safety Culture and Safety Behavior.

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INTRODUCTION

Safety culture is built to control the accidents at work site. However, many scientists have tried to develop authenticated 'measures' of safety culture, which clearly link cultural traits with actual safety practices (Cooper, 2019). It is workers response in terms of shared attitude, perceptions and beliefs related to safety to promote behavioral norms committed to the safety (Gutiérrez, 2013). It is also a common aspect of occupational health and safety, OHS encompasses the social, mental and physical well-being of worker that is the "complete Person" (Feisel, 2005; Koretsky, 2011). In other words, it refers to organizational groups' common attitudes, beliefs, and perceptions about safety, with the assumption that safety culture is both an invention and an inventor of risk-related activities (Tear,2020).

The quantity of data about chemical safety is increasing, but more data has to be collected and publicized. Academia and business are now unable to conduct research in the chemistry subdiscipline of chemical health and safety (Fivizzani, 2016). Institutional safety culture is described as an organization's common workplace safety principles, assumptions, and beliefs. Or, to put it another way, it's the importance of safety inside the company in comparison to other objectives (Miller, 2019). Educational institutions like Universities and Colleges present for excellence in education, but their labs are snot following the standard operating procedures due to which we could not get the desired goals. The place of experimental work in laboratories has always assumed a high profile at all levels of chemical education (James, 2006). It is approximately 160 years since laboratory work courses were first formally introduced by Liebig at the University of Giessen (Morrell, 2013) and by Eton at the Rensselaer Polytechnic Institute (Menzie, 2016). The first teaching laboratory in chemistry in Britain was

established by Thomas Thomson in the University of Edinburgh in 1807. It was the first institutional laboratory in which students were intentionally trained for membership of a highly effective research school by means of systematic research experiments (Morrell, 2013). Practical work at this time played a vital role in confirming the laboratory safety. (Hodson, 2015). Towards the end of the twentieth century, more sophisticated alternatives had been introduced to facilitate effective learning in university laboratories. These included pre-laboratory experiences, films, video experiments, computer-based pre-laboratories, post laboratory exercises and computer simulations (Carnduff, 2003).

Laboratories are one of the characteristic features of education in the sciences at all levels. It would be integral to find any science course in any institution of education without a substantial component of laboratory activity. However, very little justification is normally given for their presence today (Reid and Shah, 2007). The improvement of safety culture research is grounded in accident causation research and born out of a need to understand the causes of accidents in terms of root causes and system failures. The development of accident causation research has advanced historically in a number of stages. The first stage, the 1940s to 1960s, focused on machine and hardware improvements, due to the rapid development and implementation of new machinery and automations in the workplace when many accidents were attributed to mechanical malfunctions (Cooter and Luckin, 2012). The second stage from 1960s to 1980s, focused on human factors and human machine interactions. During this period employees were perceived as the weakest link in the system (Hilton, 2006 and Gordon, 1996). The third stage from the 1970s to 1990s, considered the interaction of human and technical factors (Cooter and Luckin, 1997). The most recent stage from the 1980s onwards considered the infrastructure and organogram of any laboratory have a great influence mentality of people for observing the status of laboratories safety. (Cox and Cheyne, 2000). Our duty as instructors is to provide our scholars with the skills they'll need to succeed in their chosen industry. This must contain the knowledge required for working safely in the laboratory and teaching the next generation of chemists (Sigmann, 2018). Although the students had greater safety training than others, we were far from perfection, as the incidence happened in in our lab. This article appears to have aided the establishment of a safety culture in our research laboratory, based on my personal experience (Denlinger, 2018). Theoretical and Applied Implications defined safety climate as 'a summary of molar perceptions that employees share about their work environments which acts as a frame of reference for guiding appropriate and adaptive task behaviors. Now a days there are different types of laboratories which are working for the testing of different parameters like Soil Sampling, fertilizer sampling, pesticide sampling etc. at departmental level. Occupational health and safety must be the obligation of every person in an organization or institution, irrespective of their job status and specification. Safety culture study or surveys are suggested as significant tools for estimating, evaluating and quantifying the efficacy and enhancement of safety programs direction at departmental laboratories. The objectives are as under:

- Comparison of inter university laboratories by selected departments (Agricultural Sciences, Environmental Sciences, Microbiology).
- To assess the level of compliance of occupational health and safety practices by undergraduate students.
- To investigate the type of organizational culture prevailing in the Laboratory.

MATERIALS AND METHODS

There are different types of tools available to measure the culture of safety in an organization. The tool used for present research is Likert Point Scale. Five-point Likert scale is depending on 1 to 5 points these are strongly disagree, disagree, neutral, agree and strongly agree. It is most common tool used for the assessment of safety levels at any organization. Mostly surveys are conducted by making a questionnaire by using Likert scale. (Stuart, 2019). In the present research, the safety culture of departmental laboratories (Environmental Sciences, Agricultural Sciences and Microbiology) is studied with a topic "Comparison of Safety Culture in Various Scientific Laboratories of Selected Universities". The research study is performed in two prestigious sciences universities (university-A and university-B) from Punjab region, Pakistan.

The comprehensive study was undertaken in laboratories of Environmental Sciences, Agriculture Sciences and microbiology of both universities-A and University-B by self-administrated questionnaire containing different questions about safety culture by using Analytical tools. The concerning data was gathered over and done with precise questionnaire based on safety culture study (Annex-1). The questionnaire is divided among the students of selected departments of both universities. The involved population for present research in each science department was 80 which makes sample size from one university is 240. The questionnaires were divided randomly to the students and collected at the time. Respondents were also asked which approaches they considered most effective in developing their lab's safety culture. Conducting informal group-wide safety talks was the most successful approach of promoting safety culture, according to the majority of graduate students (Armstrong, 2019).

The raw data were collected containing 480 questionnaires from two universities. The collected raw data were then arranged on excel sheet in order to quantify the response of all questions for each university. Two hundred and forty questionnaires response from each university was obtained by adding 80 responses from three departments of each university and whole data were entered in the SPSS software for quantitative analysis. The dependent variable for the present research is "Safety Culture of Laboratory" which depends on the various factors. Such as the questions forming dependent variable are related to basic definition of safety culture. The independent variables are formed by other questions too. These independent variables have great influence on the dependent variable. Annex-2.

RESULTS AND DISCUSSIONS

On the basis of selected department from both universities a comparison was conducted between University-A (Faisalabad) and University-B (Lahore). Analyzed the data with SPSS software using linear regression model which give the descriptive tables and r2 values.

- Comparison of safety culture of both universities.
- Safety reliability at both universities and their comparison
- Describe the r2 values of selected universities

Safety assessment and comparison of university-A and university-B: The findings reveal that, despite a high level of knowledge, there were gaps in identification of hazards and emergency response. With a modest association between these two factors, attitudes and behaviors were acceptable but might be improved (Walters, 2017). In past work all issues were discussed about safety culture and safety web in which all three safety culture models covered key features. For example, Guldenmund's (2000) 'assumptions, behaviors and artefacts', Cooper's (2000) psychological, behavioral and situational aspects, and Reason's (1998) reporting, learning, informing & just cultures. As such, as a secondary exercise, the outcomes of the safety culture practices give minimum chances to instantaneously gain insights into the theoretical rationality of each model (Cooper, 2019). For the assessment of safety culture at university level study needs to compare the selected department's results of both universities. So, for this purpose 240 questionnaires were collected by each university to assess the safety culture for the university departmental laboratories 80 questionnaires were collected by each department (Agricultural, Environment and Microbiology) in which 15, 20, 20, 25 questionnaires are filed by the 1st year, 2nd year, 3rd year and 4th year students of the department. The facts and figures of Safety cultures of both universities are discussed in table-1.1, table 1.2, table 1.3, table 1.4 and table 1.5 respectively and their graphs are also drawn. This comparison is based on selected departments.

Table 1.1: If I accidentally do something unsafe, I share it with the group to prevent future incidents.

Response	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
University-A	20	29	39	78	74
University-B	27	44	35	70	64

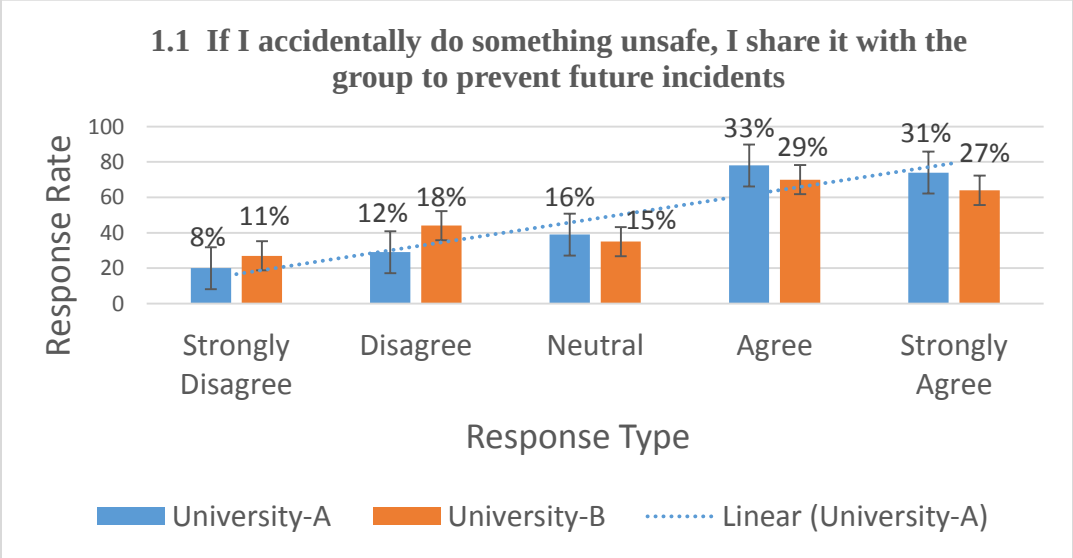

Figure 1.1 Comparison of both universities on the basis 1st component of safety culture

Comparison-I: Graph showed that less students were Strongly disagreed and dis agree of university-A rather than university-B, by the question which was first component of the safety culture on other side there are greater percentage of students who strongly Agree and Agree with the same question. It showed that in case of table-1.1 university-A have positive safety culture than university-B.

Table 1.2: When a change occurs in my experiment (chemical, process, etc.) I assess safety issues that may arise.

Response	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
University-A	20	27	41	105	47
University-B	26	44	39	78	53

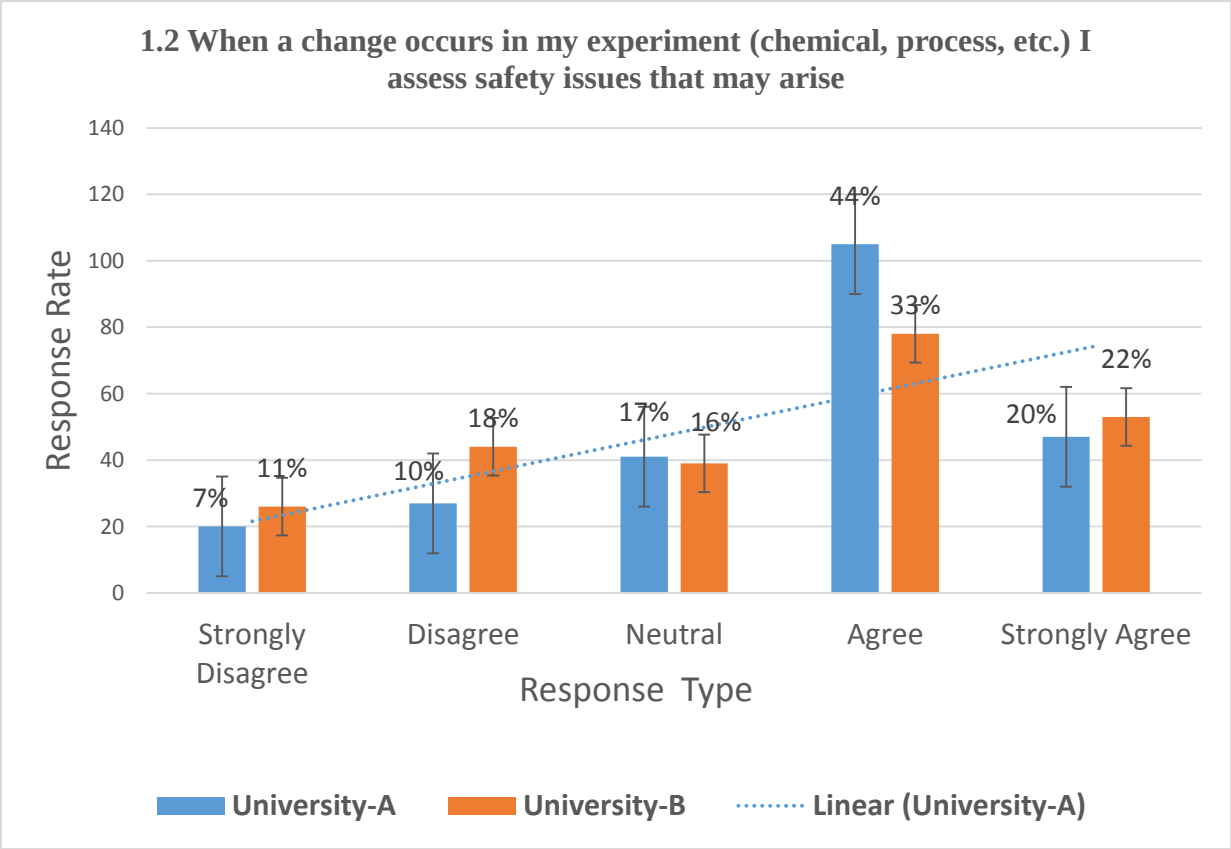

Figure 1.2 Comparison of both universities on the basis 2nd component of safety culture

Comparison-II: Graph 1.2 showed that the response rate of university-A had positive safety culture than university-B. It is also stated that table 1.2 again have the positive safety culture towards university-A. here percentage of strongly agree and agree students are discussed that is 44% agree and 20% strongly agree of university-A whereas 33% agree and 22% strongly agree to the asked question from university-B.

Table 1.3: In my lab, safety concerns are a legitimate reason to stop any experiment in progress, even if it might have impact on planning.

Response	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
University-A	13	21	55	112	39
University-B	16	31	60	95	38

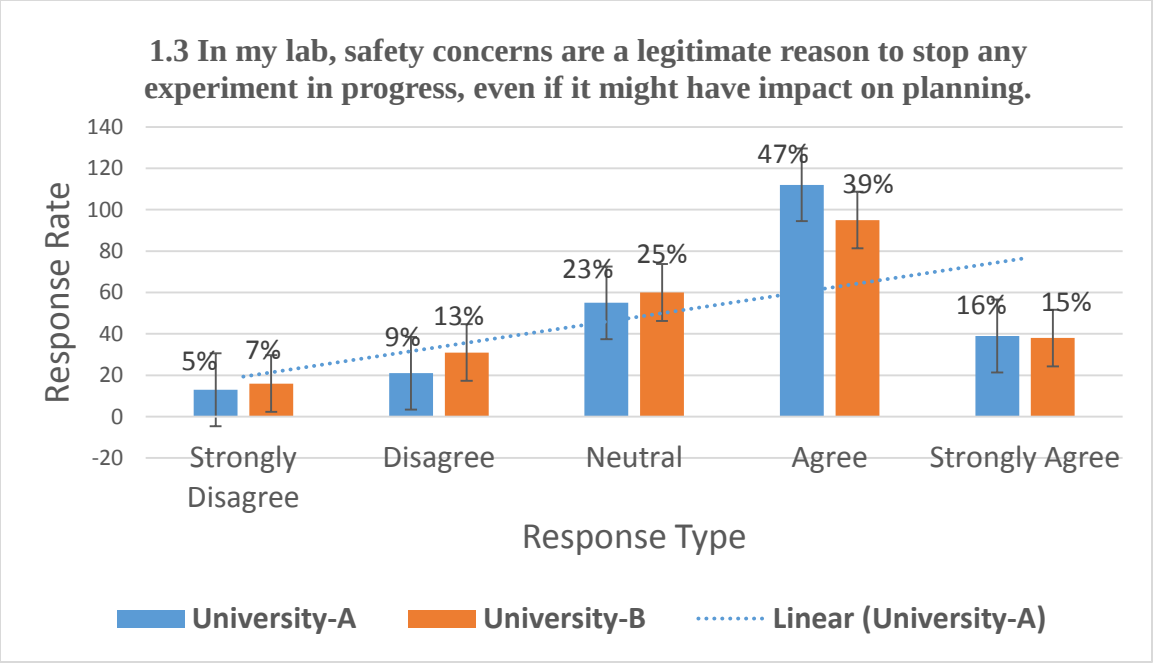

Figure 1.3 Comparison of both universities on the basis 3rd component of safety culture

Comparison-III: The figure 1.3 showed that the percentages of SD, D, SA, A are 5%, 9%, 47%, 16% and 7%, 13%, 39%, 15% of both universities respectively A and B. it is stated that more students agree to the said question makes the most the safety culture positive. So, in this case the percentages proved that the university-A has the strong safety culture than university-B.

Table 1.4: Safety issues can be discussed anytime with all the lab.

Response	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
University-A	8	16	37	100	79
University-B	11	24	50	78	77

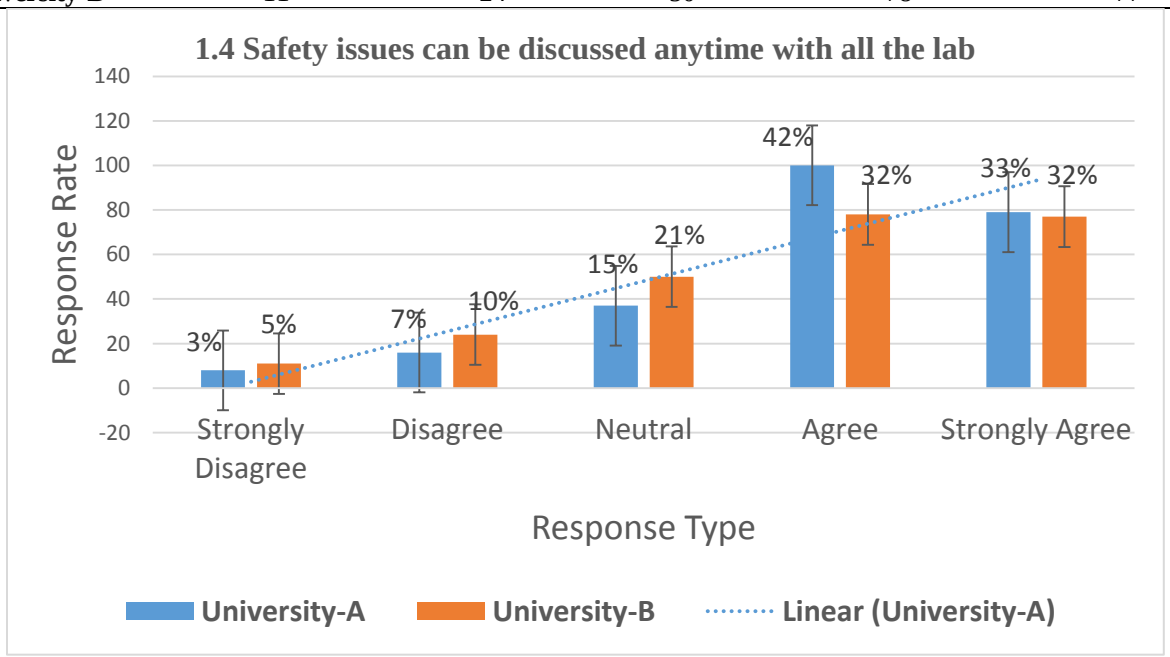

Figure 1.4 Comparison of both universities on the basis 4th component of safety culture

Comparison-IV: The question described in this graph also results the positivity if the most of the students agree to this. Graph 1.4 showed that less students were Strongly disagreed and dis agree of university-A rather than university-B, by the question which was forth component of the safety culture on other side there are greater percentage of students who "strongly agree" and "agree" with the same question. The table-1.4 showed that the university-A have positive safety culture than university-B.

Table 1.5: My lab colleagues exert a strong peer pressure on me to work safely.

Response	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
University-A	9	31	47	88	65
University-B	16	41	58	51	74

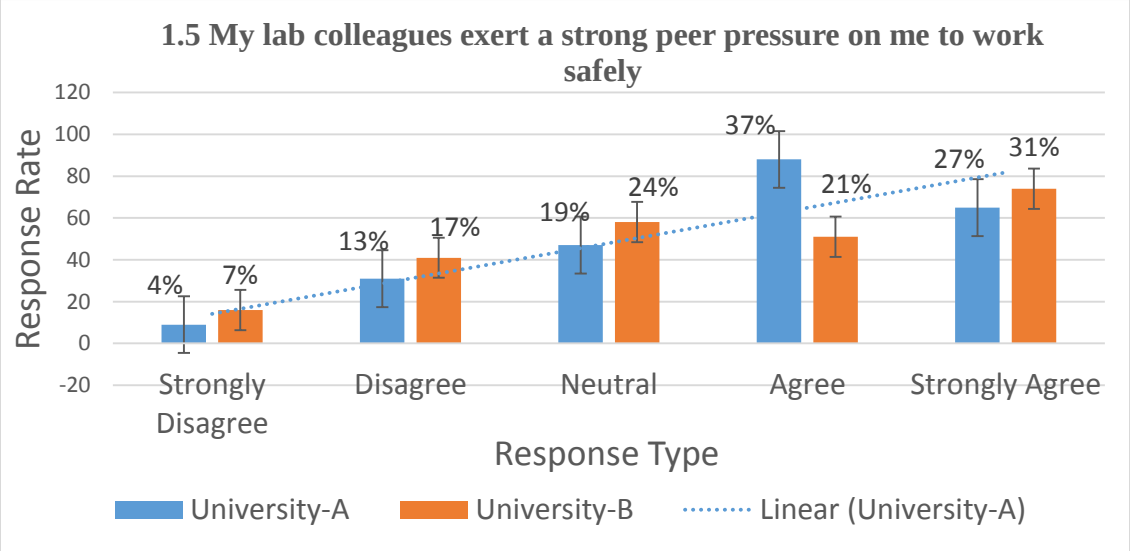

Figure 1.5 Comparison of both universities on the basis 5th component of safety culture

Comparison-V: The figure 1.5 showed that the percentages of SD, D, SA, A are 4%, 13%, 37%, 27% and 7%, 17%, 21%, 31% of both universities respectively A and B. it is stated that more students agree to the said question makes the most the safety culture positive. So, in this case the table 1.5 proved that the university-A has the strong safety culture than university-B.

Safety reliability at university level (Regression Model): Consistency of measurement is known as reliability. If the adopted technique is not consistent, it is not possible to define the field of interest e.g., safety culture (Cooper, 2019). Regression model was used to find the relationship of the safety knowledge, behavioral intention, and perceived behavioral control. It was an outcome of the safety practices in the institutional laboratories (Kean Eng Koo, 2013). Two hundred and forty questionnaires from each university whereas study has four independent variables and one dependent variable which were analyzed by SPSS using regression model. The descriptive statistics of university-A and university-B are given in Table-1.6

Table 1.6: Descriptive analysis of dependent and independent variables in University-A, University-B

Sr. No.	Parameters Dependent and Independent	University-A Mean	University-A Std. Deviation	University-B Mean	University-B Std. Deviation
1.	Safety Culture,	3.6892	1.08449	3.5067	1.19873
2.	Incident Reporting Investigations and Analysis, university	3.5021	1.15190	3.3677	1.23683
3.	Competency/Training Are Workers Interested?	3.6448	1.16055	3.4208	1.24149
4.	Who Causes the Accidents in the Eyes of Management	3.5115	1.15468	3.4604	1.25574
5.	Balance Between HSE and Profitability	3.7427	1.12860	3.4146	1.23092

Based on a FPLS outcomes an overall ‘‘high level’’ perception of safety on these institutions. Similar results found on Perception 4 out of 5 on safety climate which was also equal to high perception of safety, it is reported in the previous study in the institutions of Taiwan (Gutierrez, 2013). Standard deviation shows the deviation in the mean data of university-A and university-B according to safety culture that is 1.08449A-1.19878B = 0.1142 it means that 0.115 deviation presents between both universities. It is also observed that safety culture is directly proportion to remaining all parameters which are discussed. The comparison between mean values of both universities was conducted and represented in the graph (Figure-1.6)

Description: The safety culture assessment response rate was 3.68992 and 3.5067 of university-A and University-B respectively. It clearly seems that the University-A average value applies from 3.50 to 3.75 but on the other hand university-B all factors Average values apply from 3.40 to 3.51 which proves that the university-A mean of combine parameter is higher than the mean of all parameters from university-B. It is also noted that the parameter values increase as the safety culture positive. The regression summary of this comparison is also drawn in Table-1.7

Table 1.7: Regression summary of the university-A and university-B.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
University-A	.990[a]	0.980	0.979	0.15566	0.521
University-B	.993[a]	0.986	0.986	0.14243	0.601

Predictors: (Constant), Balance Between HSE and Profitability, Incident Reporting Investigations and Analysis, Who Causes the Accidents in The Eyes of Management, Competency/Training Are Workers Interested.

Dependent Variable: Safety Culture: R square shows that the safety culture of university-A and university-B is 98.0% and 98.6% respectively dependent on the remaining four parameters which were selected for this study.

Conclusions: The objective of this study is to observe the key predictor’s undergraduate students’ performance and behavioral intention on working safely in the Science laboratories. Using Parker’s frame work and five-point Likert scale as a safety tool, based on the observed indication from the data, the research concludes that the university-A as a whole, has a positive craving to improve safety culture; and that there is a good understanding that safety culture can only be achieved if there is a good safety practices in the university. The summary of this study work is described by the following points:

- The projected method has proven to be useful in analyzing existing health and safety systems. The procedural tools displayed to be helpful in defining incompetence and evaluating the status of the Health & Safety measurements in the selected departmental laboratories.
- It is concluded by the survey of university-A student’s have positive behavior towards their safety.
- In university-B surveys, more work is needed for strong safety culture in all departments, the safety behavior is less developed compared to university-A.
- Based on the linear regression, four independent variables used were able to explain safety culture. Three same departments (Agricultural Sciences, Environmental Sciences and Microbiology) from university-A and university-B have participated, as combine result of a university-A ranged from 3.50 to 3.80 and university-B ranged from 3.30 to 3.50 on a Likert scale 1-5 in which 5 indicates high perception of safety; the standard deviation of each university is 0.980 and 0.986 respectively.

The value of this research lies in the potential to helping the university management and the government realize the highly co relation between the safety culture of different university and their laboratories. It will create a connection with the implementation of safety practices which results in decreasing the number of accidents. Another important goal of study is that students are learn, aware about the safety measures and wished it to be safe environment in the laboratory.

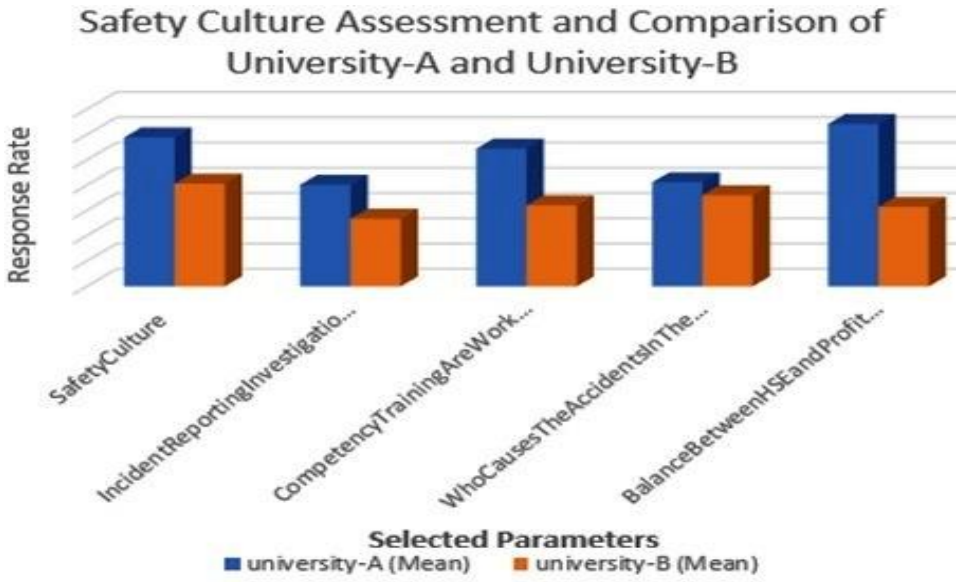

Figure 1.6 Results of university-A and B on the basis of Dependent and Independent variables.

Annex-1 Questionnaire Used in Study

Sr.#	PRAMETERS	SD	D	N	A	SA
	1. Incident reporting, investigations and analysis					
1	I think causal analysis of accidents should focus on workforce level					
2	When a safety-related incident occurs elsewhere on campus, it is communicated to me with causal analysis					
3	I have been told to report every incident, accident and near-miss to Safety Competence Center through the safety events manager					
4	1.4. In my opinion, reporting every small incident may be superfluous					
	2. Competency/Training – are workers interested?					
5	I willingly participate to safety training sessions to acquire new skills					
6	A good safety training is enough for new workers to ensure good safety behaviors in the lab					
7	My PI encourages lab workers to participate in training session					
8	I would like to propose specific training session in matters I'm concerned with					
	3. Who causes the accidents in the eyes of management?					
9	I am afraid to be seen as responsible of an accident in the lab					
10	In my opinion, most accident occur if people are disrespecting safety rules					
11	In my lab, PI get involved for any incident in the lab, even small ones					
12	My PI ensures maintenance of equipment is done as a preventive safety measure					
	4. Balance between HSE and profitability?					
13	I feel free to delay my work to solve safety issues					
14	Money is the major consideration when discussing safety improvements					
15	In my opinion, safety considerations may slow down researches					
16	I think I can reach better performances if I work in a safe environment					
	5. Safety Culture					
17	If I accidentally do something unsafe, I share it with the group to prevent future incidents					
18	When a change occurs in my experiment (chemical, process, etc.) I assess safety issues that may arise					
19	In my lab, safety concerns are a legitimate reason to stop any experiment in progress, even if it might have impact on planning					
20	Safety issues can be discussed anytime with all the lab					
21	My lab colleagues exert a strong peer pressure on me to work safely					

Annex-2 Dependent and independent variables

Dependent Variable Formation

Dependent Variable	Questions
Safety Culture	If I accidentally do something unsafe, I share it with the group to prevent future incidents
	When a change occurs in my experiment (chemical, process, etc.) I assess safety issues that may arise
	In my lab, safety concerns are a legitimate reason to stop any experiment in progress, even if it might have impact on planning
	Safety issues can be discussed anytime with all the lab
	My lab colleagues exert a strong peer pressure on me to work safely

Independent Variables Formation

Independent Variables	Questions
Incident reporting, investigations and analysis	I think causal analysis of accidents should focus on workforce level.
	When a safety-related incident occurs elsewhere on campus, it is communicated to me with causal analysis
	I have been told to report every incident, accident and near-miss to Safety Competence Center through the safety events manager
	In my opinion, reporting every small incident may be superfluous
Competency/Training – are workers interested	I willingly participate to safety training sessions to acquire new skills
	A good safety training is enough for new workers to ensure good safety behaviors in the lab Past accidents are the main reason that justify safety concerns
	My PI encourages lab workers to participate in training session
	I would like to propose specific training session in matters I'm concerned with
	I am afraid to be seen as responsible of an accident in the lab
Who causes the accidents in the eyes of management	In my opinion, most accident occur if people are disrespecting safety rules
	In my lab, Principal Investigator get involved for any incident in the lab, even small ones
	My Principal Investigator ensures maintenance of equipment is done as a preventive safety measure
	I feel free to delay my work to solve safety issues
Balance between HSE and profitability	Money is the major consideration when discussing safety improvements
	In my opinion, safety considerations may slow down researches
	I think I can reach better performances if I work in a safe environment

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