Safety Perceptions in University Teaching Laboratory

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Abstract

The numerous cases of laboratory incidents make it clear that safety in laboratories become an important issue to be discussed. This research investigates the safety perceptions of students on using University teaching laboratory. This study is concentrated to the students who are regularly use chemicals substances in teaching laboratory. Regression is used to get the correlation between safety perception and safety behaviour among students in the teaching laboratory activities. The result showed that respondents have good perceptions on safety in university teaching laboratories but there's still improvement needed to raise a good perception of threats in order to increase safety behavior.

Keywords
Safety Perceptions, Occupational Health and Safety, Teaching Laboratory, Safety Risk, Regression Analysis

1. Introduction

There are numbers of accidents involving chemical substances all over the world. The Centers for Disease Control and Prevention (CDC) recently released that there were 57,975 incidents involving hazardous chemical substances and 4,621 of those incidents resulted in 15,506 persons being injured (Hill, 2015). The U.S Chemical Safety and Hazard Investigation Board (CSB), who respond to only the most serious chemical related accidents, has reported 120 laboratory accidents resulting in 87 evacuations, 96 serious injuries and three deaths since 2001 (Mulcahy *et al*., 2012 on Jorgensen, 2017). Langermann (2011) and National Research Council (2014) stated that, in addition to the incidents reported by the CSB, students and faculty working in research laboratories experience the pain and suffering of minor accidents injuries and illnesses (Jorgensen, 2017).

Association of Public & Land-Grant Universities Council on Research Task Force on Laboratory Safety (2016) has encountered the critical need for increased safety in research laboratory since the accidents have negatively impacted the students and faculty staffs (Jorgensen, 2017). Hill (2015) stated that most of the accidents happen in chemicals usage caused by human and this unsafe behavior of human is caused by perceptions based on Health Belief Model and Theory of Planned Behavior (Rosenstock et al., 1988, Ajzen, 1991 on Ying Ni *et al*, 2017). However, there are just few research discuss about human's perception on safety (Schröder *et al*., 2016). So, the new insight which this paper develop is to get to know the safety perception on University Teaching Laboratory.

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2. Literature Review

Since the late 20th century, the approach of laboratory activities has improved, with greater focus on safety due to a number of legal, ethical and educational reasons (Walters, *et al*., 2017). Implementing safety and health policies in the workplace should not only be confined to industries but should also be taken into consideration by educational institutions, specifically the state higher education institutions (Sumadsad and Ruiz, 2013). Many studies have demonstrated a positive impact on organizational safety climate and safety culture on safety outcomes, (Griffin and Neal, 2000; Huang *et* al., 2006; Neal and Griffin, 2006; Varonen and Mattila, 2000; Zohar, 2000 on Schröder *et al*., 2016), however little is known how researches compare in their safety perception and practices (Schröder *et al*., 2016).

2.1 Safety Perception

Health Belief Model (Rosenstock, 1974) suggest that in deciding whether to engage in protective behavior, one factor that individuals take into account is their perceived suscpetibility to the danger, in addition to the perceived efficacy of the behavior, perceived barriers to the behavior and perceived severity of the risk (Taylor and Snyder, 2017). Based on the Protection Motivation Theory, severity of hazard, the likelihood that harm will occur, and the effectiveness of the protective mechanism influence the likelihood that a person will engage in a protective behavior (Rogers, 1975 on Taylor and Snyder, 2017). From the theories can be concluded that higher perception of safety risk will be related to a greater likelihood of behaving safely (Taylor and Snyder, 2017). Based on Health and Safety Executive (2005), the psychological component consists of shared values, attitudes, perceptions, and beliefs that drive decisions and behaviors regarding safety (Kim, *et al*., 2017).

Risk is the possibility of suffering harm or loss which have two main components, the probability and the severity of a consequence (Hussin and Wang, 2010). It is important to understand the perceptions of safety in order to pave for better ways to manage the exploitation. Based on Şimşekoğlu, *et al*. (2012), Sjöberg (1999) concluded that perceived risk may be relatively in line with objective statistical accident distributions, especially when the risk sources are overall well known in a community.

Employees who perceive their jobs as safe tend to be involved in fewer accidents that employees who perceive their jobs as relatively more dangerous (Guastello & Guastello, 1988; Harrell, 1990; Smith *et al*., 1992 on Hayes, *et al*., 1998). Employees who perceive their workplace as safe report lower levels of jobs-related anxiety and stress, and exposure to fewer environmental hazards (Guastello, 1992 on Hayes *et al*., 1998), variables that have been strongly linked to accident rates (Guastello, 1989, 1991 on Hayes *et al*., 1998).

2.3 Occupational Health and Safety

Occupational safety and health has been and still is a topic of intense research and practical developments. Globally, there has been a substantial improvement on occupational safety and health in the construction industry, at large motivated by the publication and ongoing implementation of the two most relevant standards in the field, the ILO-OSH 2001 and the BS OHSAS 18001, and increasingly stringent regulations (Sousa *et al*., 2014)

Based on WHO (2001), Occupational Health is risk oriented activity and defined as a multidisciplinary activity aimed at :

a. The protection and promotion of the health of workers by preventing and controlling occupational diseases and accidents and by eliminating occupational factors and conditions hazardous to health and safety at work
b. The development and promotion of healthy and safe work, work environments and work organizations
c. The enhancement of the physical, mental and social well-being of workers and support for the development and maintenance of their working capacity, as well as professional and social development at work
d. Enabling workers to conduct socially and economically productive lives and to contribute positively to sustainable development

Occupational risk and safety are terms that are correlated. It is important to manage occupational risk as this reflects the safety levels for employers and employees. In a survey conducted by the National Council of Examiners in Engineering and Surveying (formerly known as National Council of Engineering Examiners), it was concluded that nearly all disciplines of engineering as well as all kinds of engineering job industry had significant amount of health and safety responsibilities (National Council of Engineering Examiners, 1981 on Hussin and Wang, 2010). Therefore, it is in the engineer's responsibility to protect both the occupational and the public health and safety. Engineers must bear the important role of managing risk ensuring risks are kept to a minimum or acceptable level (National Academy of Engineering, 1970 on Hussin and Wang, 2010).

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Heinrich (1931) defines the reasoning of sequential models through the domino theory, in which an accident is the culmination of a series of events and circumstances (Sousa, 2014). The greatest contribution of this theory is to recognize that an accident can be avoided by removing any factor in the sequence leading to it (Sousa *et al*., 2014).

There is a control hierarchy to manage risks. The idea behind this hierarchy is that the control methods at the top of graphic are potentially more effective and protective than those at the bottom. Following this hierarchy normally leads to the implementation of inherently safer systems, where the risk of illness or injury has been substantially reduced (CDC, 2015)

Based on CDC (2015),

a. Elimination and substitution, while most effective at reducing hazards, also tend to be the most difficult to implement in an existing process. If the process is still at the design or development stage, elimination and substitution of hazards may be inexpensive and simple to implement. For an existing process, major changes in equipment and procedures may be required to eliminate or substitute for a hazard.
b. Engineering controls are favored over administrative and personal protective equipment (PPE) for controlling existing worker exposures in the workplace because they are designed to remove the hazard at the source, before it comes in contact with the worker. Well-designed engineering controls can be highly effective in protecting workers and will typically be independent of worker interactions to provide this high level of protection. The initial cost of engineering controls can be higher than the cost of administrative controls or PPE, but over the longer term, operating costs are frequently lower, and in some instances, can provide a cost savings in other areas of the process
c. Administrative controls and PPE are frequently used with existing processes where hazards are not particularly well controlled. Administrative controls and PPE programs may be relatively inexpensive to establish but, over the long term, can be very costly to sustain. These methods for protecting workers have also proven to be less effective than other measures, requiring significant effort by the affected workers.

2.4 Teaching Laboratory

Safety considerations are an issue for everyone exposed to potentially hazardous substances, persons who routinely work with chemicals, for example students and persons working in laboratories, are particularly at risk (Walters, *et al*., 2017). Laboratory is the cornerstone of technological progress. Its safety education is an important part of laboratory management (Lawler, 2000 and Massie *et al*., 1995 on Li, *et al*., 2016), which is the key step to ensure the safety of laboratory because the perfect safety education system can improve personal knowledge and skills (Li, *et al*., 2016). Langerman (2009) concluded that most of academic laboratories are unsafe venues for work or study (Marendaz *et al*. (2012).

Based on Olewski and Snakard (2017), there is general perception that risks in laboratory universities are lower that industrial processes, but what highlighted in the literature is that :

a. Often researchers are within a few meters of the operating equipment and typically closer when collecting experimental data than industry personnel, who are typically several meters away or housed in control room;
b. Researchers in close proximity to the operating equipment for longer periods of time, more so than is typical for industry;
c. University research labs are often involved in the development of new technologies and do not have proven designs to build from; and
d. Due to the nature of using students to operate the research laboratories, the turnover of operating personnel is frequent, and the sharing of process safety knowledge during a formal handover often does not exist.

According to Marendaz, *et al*. (2012) the evidence is still serious concerns about safety in the laboratory and especially in academia probably due to the fact that they receive less attention compared to industrial production plants. Dramatic accidents happen regularly, most of them being only published in local newspapers but some are reported in literature:

a. (Blayney et al., 1997) Hanover (New Hampshire, USA). Fatal intoxication by a single skin contact with a drop of highly toxic compound.
b. (Sanderson, 2005) Southampton (United Kingdom). Major firedestroyed the university's unit of clean room complex electronic science. Damage was extremely important.
c. (Freemantle, 2006) Mulhouse (France). Blast in the University's chemistry building leading to one death and several injured.
d. (Wu et al., 2007) Taipei City (Taiwan). Blindness after a chemical experiment at University of technology.

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e. (Kemsley, 2009). Los Angeles (California, USA). Fire in a chemistry lab leading to one death.
f. (Kemsley, 2010) Lubbock (Texas, USA). Explosion of perchlorate in a University's chemistry building leading to one severe injured.

Chemical security and safety in laboratories has become an important issue at Universitas Indonesia, as there have been a number of chemical accidents including laboratory fire accidents, fatalities involving the use of hazardous materials and adverse health exposures (Lestari, *et al*., 2015). Chemicals used in the laboratories can be hazardous. Studies indicate laboratory chemists may have shorter life spans, more diseases (Belli *et al*., 1992 and Boxer *et al*., 1995 on Lestari, 2015) higher cancer incidence (Belli *et al*., 1992 on Lestari, 2015) and higher suicide rates particularly for females (Belli *et al*., 1992 on Lestari, 2015). Workers in biomedical and chemical laboratories have potential exposures to a variety occupational hazards.3 (Lestari *et al*., 2015).

3. Methodology

This study takes place in Universitas Indonesia since it has hundreds of laboratories and many of them, involving chemicals for the work. This study investigated some laboratories and focused on students as research object. Firstly we formulate the 5-Likert Scale questionnaire which would be used in the study, it was adopted from the questionnaire from Hayes *et al*. (1998) and is classified into five parts, susceptibility, threats, benefits, external factor, and safe behavior, and distributed to 65 students who use teaching laboratory. After receiving the filled out questionnaires, we processed the result using Minitab software to get description of safety perceptions in University Teaching Laboratory and linking the perceptions with safe behavior through regression analysis.

4. Results and Discussion

4.1 Examined Laboratories

There are numerous laboratories in Universitas Indonesia and some of them use chemicals in its teaching process. We have collected data from different faculties, such as Faculty of Public Health, Faculty of Pharmacy and Faculty of Mathematics and Science. The examined teaching laboratories are Taksonomi from Biology Department, Faculty of Mathematics and Science; Nutrition from Nutrition Department, Faculty of Public Health; Mikrobiologi, Farmasi Dasar, Farmasetika, Analisis Kimia Kualitatif, Analisis Kuantitatif, Kimia Farmasi Medisinal, Analisis Kimia Farmasi, Formulasi Tablet Farmasi, Fotokimia from Faculty of Pharmacy Universitas Indonesia. These eleven laboratories as a former data, hopefully could give some view about the perceptions in university teaching laboratories.

4.2 Data Analysis

The questionnaire which is used in the study is the one that adopted from Hayes *et al*'s Questionnaire. It is classified and is divided into safety perceptions and safety behavior. Safety perceptions consists of five parts, susceptibility, threats, benefits, external factor, and safe behavior

The chart below is described the percentage of each criteria measured on the survey

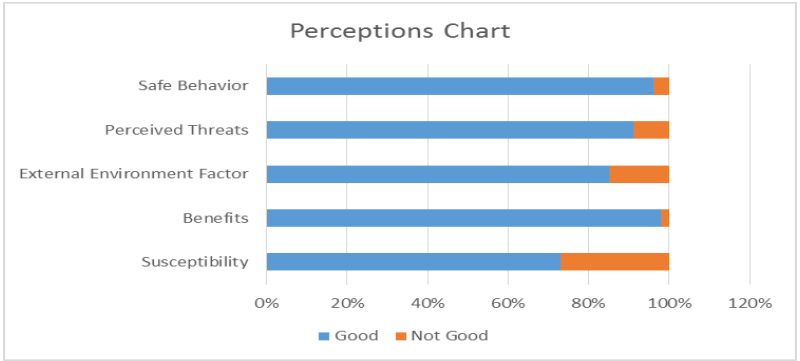

Figure 3. Perceptions and Behavior Chart

According to the chart above, there are 73% respondents who have good perception on self susceptibility while there are 91% of those respondents have good perception on threats. After that, there are 98% and 85% respondents who have good perception on benefits of preventive action and also discover that external

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factors influence them on behaving safely. Finally, there are 96% of respondents who have the likelihood of taking safe behavior when using chemicals in laboratory activities. Every part of the item showed on chart was elaborated to the explication below :

4.2.1 Susceptibility

Perceived susceptibility consist of consideration of users' perception of laboratory activities susceptibility, it's whether they feel it's safe, risky, unhealthy, scary, etc. Data has shown that the highest rank of perceived suscpetibility was taken by the criteria that state laboratory as the risky place. So it means that most of the respondents perceived laboratory as the risky place to work with chemicals because there are posters and signages in laboratory, eventhough not so many and most of them have already introduced to the basic safety and health in their curriculum so it makes the respondents have that good perceptions.

4.2.2 Threats

Perceived threats consist of the criterias of how people perceived their environment in the relation of their own self safety while using chemicals in laboratory and it was elaborated to three items, they are working safety of partner, laboratory team, and university management. The data have shown that about 91% of respondents feel safe with their working environment while using chemicals in laboratories. This means that respondents perceived that laboratory users, management team, and university management were already supported the safety implementation in laboratory activities.

4.2.3 Benefits

Perceived benefits consist of the criterias of how people perceived the benefits of treatment which lead to protect themselves from accident. From the collected data, it showed that 98% of the respondents perceived the programs applied by the university on avoiding accidents are good and useful.

4.2.4 External Environment Factor

Cues to action consists of the criteria of how external factors encourage people to act particular behavior. In this case, the external factor which is stated is data of accidents in chemicals usage in laboratories. The data showed that about 85% of respondents perceived that external factor like laboratory accident statistics become an encouragement to act safely in using chemicals in teaching laboratory activities. This means that most of the respondents will be more carefull on using chemicals in laboratory, evenmore they have willingness to literate others about safety in chemicals usage in laboratory.

4.2.5 Safe Behavior

This part consists of particular behavior that people will take when they work with chemicals in laboratory. The data have shown that about 96% respondents will behave safely when they work with chemicals in teaching laboratory activities. This described that most of all respondents are aware with the risks they meet on the laboratory when using chemicals, so they have willingness to take safe act as a preventive action on avoiding unexpected events on the teaching laboratory activities.

This result has shown that most of the respondents are already have a good perceptions in university teaching laboratory. This could be happened by some circumstances, such as :

a. Most of the respondents have already known the basic knowledge about safety and health
b. There are some posters and signages in the teaching laboratory
c. University management team has provided safety information in University Teaching Laboratories

Afterwards, we discovered the correlation of perceptions and safety behavior. It was drawn in the table below.

Table 1. Correlation Between Variables

Correlation	P Score	Interpretation
Susceptibility & Perceived Threats	0,025	Significant
Benefits & Perceived Threats	0,001	Significant
External Factors & Perceived Threats	0,000	Significant
Benefits & Safety behavior	0,068	Not Significant
Perceived Threats & safety behavior	0,000	Significant

The table above show that there is a significant relationship between susceptibility and perceived threats, benefits and perceived threats, external factors and perceived threats, and perceived threats and likelihood of behaving safely. But the study show that there is no significant relationship between perceived benefits and likelihood of behaving safely. It all was concluded from the regression calculation score compared to the alpha

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number. There is significant relationship when the score is lower than the alpha, and not significant if the score is higher than alpha.

From the data provided above, we can infer that to create safety in university teaching laboratory, we could manage the perceptions of teaching laboratories user. The good perceptions in university teaching laboratories can be raised by increasing the perceptions of susceptibility, perceptions of benefits, and also supportive external factors. These criterias can increase the perceptions of threats in every user and it will lead to safe act because it has a significant correlation to safe act or behavior.

The result of this study is in line with the Health Belief Model Theory which stated that perceptions has significantly impacted likelihood of behaving safely and also in line with Schröder *et al* (2016) which stated that risk perception motivates safety behavior. What makes this possible is that because in the current study, most of the respondents have good knowledge on risk, the environment is supported the likelihood of taking safe behavior, the university also have program to protect from accidents, and it all makes good perceptions among the respondents. When people have a good perceptions on university teaching laboratory usage, it will create a good safety behavior on laboratory users.

However, this result is a little bit contradictive with the conclusion of Safety and Health Perceptions in Work-Related Transport Activities in Ghanaian Industries (Atombo *et al*., 2017), the research was in the same interest but in the different scope, which stated that interventions to improve safety and health concentration has been on drivers' safety practice with less attention to safe driving environments and vehicle usage, while this study has shown that external environment and chemicals usage (susceptibility) have significantly affected the safety perception of threats and that leads to safety behavior taken by the users. This might be caused by on the previous research, there is a gradual raising of health and safety standards and increased awareness of the benefits of safety practices at the workplaces (Atombo *et al*., 2017) while in the current study, people's perception is significantly impacted by the environment and hazard susceptibility so when the environment is not supported, they might have lower perceptions and when they dont perceived hazard susceptibility, the same thing will also happen.

The future research that can be taken to reinforce what is written on this paper is quite about the more comprehensive discussion about the correlation of safety perceptions and safety behavior in university teaching laboratory and the elaboration of how safety behavior affects safety perceptions.

5. Conclusion and Recommendations

From the data analysis, we can conclude that most of the respondents have good perception on safety in using chemicals in laboratories and their perceptions have significantly correlated with safety behavior that they take in teaching laboratory activities. The good perception is caused by some reasons. Most of them has introduced to basic safety and health and this raised their awareness to the risk they will face on using chemicals in teaching laboratory. Then, the university management quite have supportive program to protect the laboratory users from accident, such as safety inspections. Also, respondents are mostly aware with their safety when knowing many cases related chemicals usage in laboratory. However, there still are some potential improvement, such as :

a. Update Hazard Identification, Risk Assessment, and Determining Control (HIRADC),
b. Conduct safety system management audit periodically,
c. Create faculty safety team and conduct monthly meeting to discuss safety issues,
d. Conduct emergency response simulation,
e. Conduct annual safety talks,
f. Enrich safety posters and signages,
g. Conduct regular safety training to asisstant laboratories and lecturers,
h. Provide more adequate protective equipments.

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