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Proactive safety culture in Nigeria through engineering education: A key to the prevention of catastrophic incidents in the industry

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Abstract

Advances made in promoting a culture of preparedness through disaster risk reduction (DRR) initiatives are strong building blocks to promote more comprehensive changes at the policy level and strengthen resilience in the everyday lives of children, families, schools, and the communities they serve. Proactive safety entails constantly ensuring the safety efficacy of systems, procedures, and people. Process safety entails the identification and understanding of potential hazards, the evaluation of consequences, safeguards, and risks, and the addition of layers of protection to prevent and/or mitigate incidents. The purpose of this study is to review the proactive safety culture in Nigeria through engineering education as a key to the prevention of catastrophic incidents in the industry. A strong safety culture is required to protect employees, but it is especially important for protecting students and developing their skills and awareness of safety. A questionnaire was developed to obtain feedback from industry experts and other stakeholders on the appropriate contents of an undergraduate course on safety that will produce safety-conscious engineering graduates and ultimately a culture of safety in Nigeria. These questions were asked in the following areas: safety assessment in Nigeria, importance of safety education, and safety courses for engineering students. Based on the responses from the 250 questionnaires distributed and 208 responses, a safety course curriculum was suggested with a possible 30 course outlines that could support students at different stages in their development, and as such, it would be expected that students' safety skills improve as they progress through their degree.

Keywords: Proactive safety; Process Safety; Catastrophic; Safety education; Safety culture; Safety assessment

1. Introduction

All Safety is a positive value to any organisation as it prevents injuries, saves lives, and improves productivity and outcomes. When safety is actively practised and is regarded as a critical core value by organisational leaders, it instills a sense of confidence and caring in all of the people who work there. The safety culture of an institution is a reflection of the actions, attitudes, and behaviours of its members concerning safety. These members include the managers, supervisors, and employees in the industrial and governmental communities, as well as the faculty, staff, and students in the academic community [1].

Presently, calls for changes in the academic safety educational process and in the academic safety culture are becoming increasingly vocal both within and outside of the academic community. The requirement of a good safety culture that not only protects employees but also helps in developing the skills of students and their awareness of safety is essential.

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A strong safety culture also protects academic institutional reputations [1]. This culture emanates from ethical, moral, and practical considerations rather than regulatory requirements.

Academic administrators, faculties, and staff members have ethical responsibilities to care for their students' safety and to instill awareness about safety. They must teach students the necessary safety skills for working in on-campus and off-campus laboratories. Serious laboratory mishaps within an organisation are frequently regarded to be the outcome of a poor or insufficient safety culture--the incident's primary root cause. Devastating occurrences in academic laboratories, as well as widespread observations that university and college graduates lack solid safety skills, have raised worries about the safety culture in academia. Therefore, in a strong safety culture, students will acquire the skills to recognise hazards, assess the risk of exposures to those hazards, minimise the risk of exposures to hazards, and be prepared to respond to laboratory and other emergencies, as this can be the only way students and other members of academia can be proactive. This follows the Constitution of the Federal Republic of Nigeria, which places demands on the state to direct its policy towards ensuring, amongst other things, that the safety of all persons in employment is safeguarded and not endangered or abuse [2]. However, unemployment has made workers disregard compliance with safety practises by accepting risky jobs [3].

At present, many institutions are active in the attempt to implement a safety culture for both researchers and students. Industry still carries the lead with respect to developing and maintaining thorough safety systems [4]. There may be multiple reasons for this. Large-scale production facilities can potentially lead to very serious accidents causing multiple fatalities, and when accidents do occur, a frequently recognised attributor is the lack of a strong safety culture [5]. Hill postulated that the inherent obstacle to obtaining strong safety values in academia was that researchers are more prone to accepting risks [6]. This is due to a phenomenon described as the "normalisation of deviance [7]. Hill argued that, to counter this obstacle, safety education should be incorporated at all stages of education in order to confer a strong safety culture on students. From this industrial point of view, a young engineer should be well trained in the latest safety methodologies practised on real industrial projects, while the technical safety mindset of a safety engineer is formed based on a combination of profound safety education and intensive training [8].

In summary, the majority of what is known as safety today has been learned from mistakes or incidents. Using these incidents and the lessons learned as case studies throughout the undergraduate and graduate learning experience provides an opportunity to capture the interest and imagination of students while forcing them to think about how safety measures could have prevented or minimised these incidents. Idubor and Oisamoje argued that the performance and productivity of staff have to do with their level of expertise and skill gained from appropriate training and education [9]. It is an indication that if adequate safety training and education are not given, compliance with safety regulations will be affected. Tertiary institutions need to place more emphasis on empowering and developing students' safety skills than on the mere teaching of safety courses. thereby making them more knowledgeable beyond lecture halls [10]. This can be achieved, according to Pisaniello et al., by standardising students' training using a case study approach in teaching and learning occupational safety in tertiary institutions, because this will involve students' participation in safety practises and any lesson learned will greatly impact their understanding [11]. An important element of a strong safety culture is establishing a system for reporting and investigating incidents, identifying direct and root causes, and implementing corrective actions [1].

Therefore, the objective of this study is to provide a proactive safety culture in industries through engineering education. It is against this background that the following objectives would guide the study:

- To assess safety in Nigeria.
- To assess the importance of safety education and
- To suggest the safety course outlines that will encourage a proactive safety culture.

2. Material and method

Almalki affirmed that research could be exploratory, explanatory, or descriptive [12]. This study adopted a descriptive form of research to meet its objectives. This study was carried out through a questionnaire survey and interview sessions with academicians, engineering undergraduates, employees of industry, safety experts, and other stakeholders. The focus of this study is on the proactive safety culture of industry and academia. It also appraises the challenges confronting them in ensuring engineering safety.

The questionnaire, which was in Google Form, was sent to chat rooms of groups in WhatsApp and Telegram applications and other websites. In addition, 50 copies of the questionnaire were printed and administered by hand in the various departments of the Faculty of Engineering at the University of Uyo, Uyo Permanent Site, in order to reach out to those

students that could not afford data for browsing. This was a convenience sampling method because it was convenient, quick, and inexpensive. The questionnaire was used to collect data from respondents comprising engineering educators, engineering regulators, industrial stakeholders, professional engineering institutions, engineering students, and the informed public.

The location of the respondents was majorly in Lagos State with 10.10% (21) respondents, Rivers State with 9.60% (20) respondents, Akwa Ibom State with 59.10% (123) respondents, and Abuja with 0.04% (9) respondents, including nine other states plus the diaspora with 0.01% (2) respondents, as can be seen in Fig. 1.

The developed questionnaire for the study came up to 250 copies (as there were 202 online responses and just 6 responses from the printed copies) that were distributed to the respondents. 208 copies of the questionnaire were completed and returned, representing an 83.2 percent response rate. The questionnaire was broken down into three sections. The first section was to assess safety in Nigeria; the respondents did this to examine the level of compliance with safety rules and regulations. The second section was for the importance of safety education to individuals in their respective workplaces, and finally, the third section was to look at the suggestion of a proactive safety course for engineering students; this had respondents trying to suggest the course outlines that will encourage safety culture in the industry and academia.

The responses were analysed using SPSS version 27 and Microsoft Office 2016 Excel package analytical tools, such as mean item score, Likert scale analysis, and Friedman test, to present the data.

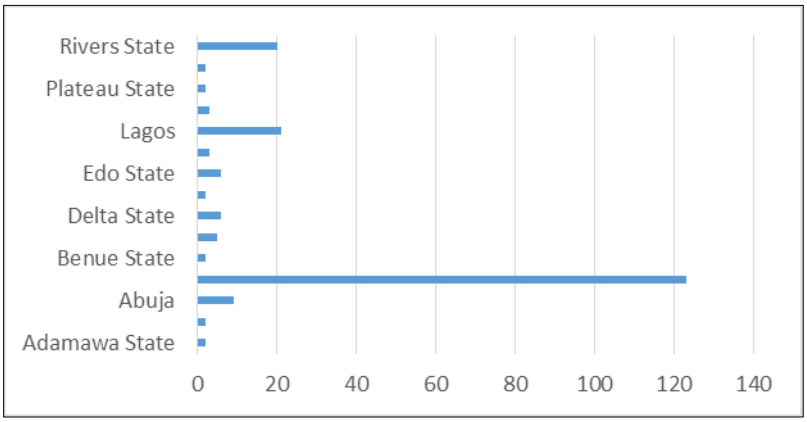

Figure 1 Locations of the respondents for this study

3. Result and Discussion

The data and results of analysis as obtained from the distributed questionnaire were presented under the following headings:

3.1. Background Information

Finding the challenges first by looking around the workplace rather than waiting for problems to happen is being proactive. This involves workers, supervisors, and managers observing jobs, communicating the hazards, making decisions on effective options, and then taking the necessary action. Four steps to an effective proactive action plan were reported. These included looking for potential hazards clues, assessing and prioritising identified hazards, making improvements to reduce or eliminate the identified risk, and following up to see if the new steps introduced are effective [13].

The background information of the respondents revealed that engineering students had the highest participation in the study with 107 (51.44%), which was followed by 36 (17.31%) industrial stakeholders, 21 (10.10%) engineering educators, 18 (8.65%) professional engineering institutions, 17 (8.17%) informed public, and 9 (4.33%) engineering regulators. A survey of the working experience of the respondents in the study showed that 75% had 0–5 years of working experience, 12% had 6–10 years of working experience, and 13% had over 10 years of working experience. The gender distribution showed that 166 (79.8%) were male and 42 (22.2%) were female respondents.

3.2. What do you think are the reasons for the poor safety culture in Nigeria?

When asked what they thought about the lack of safety culture in Nigeria, the respondents gave the reasons for the poor or lack of safety culture in Nigeria as follows: Lack of awareness, non-compliance with safety regulations, little or no safety education, negligence, and corruption as shown in Fig. 2. This is in agreement with other researchers [14], [15], [16], [17], [18], [9], [19],[20], [3], [21], [22].

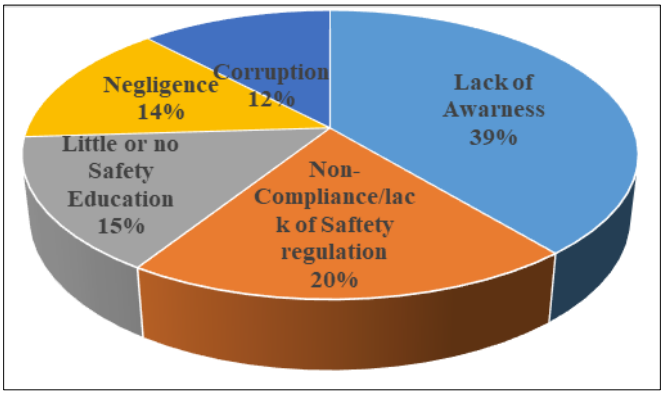

Figure 2 A representation of the lack of safety culture in Nigeria with their respective distribution in percentages

3.3. Likert scale test

The Likert scale test was undertaken to interpret the two hundred and eight (208) responses that were obtained from the research survey carried out. The observations contained in the questionnaire that needed responses are listed in Table 1 with their corresponding symbols.

Table 1 The observations and their symbols for identification

Symbol	Observation
QA	Nigeria lacks a safety culture.
QB	Industries with safety culture do adhere to safety measures put in place
QC	There is a strong need to build a culture of safety in Nigeria.
QD	Engineers and engineering has a key role to play towards achieving a safer society
QE	Safety is essential in every industry
QF	The teaching of Safety should be encouraged for Secondary/Technical schools in Nigeria
QG	Teaching Safety in tertiary institutions (Safety Education) will help to build a safety culture in Nigeria.
QH	Every engineering student should take a course on safety while in the university.
QI	Safety conscious engineering graduates will help to build a safer society.
QJ	Establishing regulatory bodies to sanction institutions that don't comply to safety rules and regulations will go a long way to curbing poor work and safety ethics

The respondents were asked to rate the level of observations concerning safety and safety practises in society, as can be seen in Table 1, using a five-point Likert scale from strongly agreeing to strongly disagreeing, and their responses are presented in Table 2. The table shows that 60% of the respondents strongly agreed with the following observations: QC, QD, QE, QH, QI, and QJ, with a low mean score attributed to them ranging from 1.18 to 1.75.

Table 2 The mean score and the interpretation of the observations by the respondents

Observation	Mean score	Interpretation
QA	2.34	Agree
QB	2.09	Agree
QC	1.64	Strongly agree
QD	1.57	Strongly agree
QE	1.18	Strongly agree
QF	1.90	Agree
QG	1.81	Agree
QH	1.38	Strongly agree
QI	1.75	Strongly agree
QJ	1.55	Strongly agree

3.4. The Friedman Test

The Friedman test is a helpful nonparametric data analysis approach, particularly in human competence research. The Friedman Test was applied to the data in this study to ensure that two assumptions were met. To begin, the variables must be mutually independent, which means that the findings of one block cannot influence the outcomes of another. Second, the observations can be sorted by their mean values [23].

Table 3 The general descriptive statistics for all the observations by respondents in the study, showing the mean and standard deviations

Symbol	N	Mean	Standard Deviation	Rank
QA	208	2.34	1.085	1st
QB	208	2.09	0.942	2nd
QC	208	1.64	1.261	6th
QD	208	1.57	1.174	7th
QE	208	1.18	0.621	10th
QF	208	1.90	1.472	3rd
QG	208	1.81	1.278	4th
QH	208	1.38	0.714	9th
QI	208	1.75	1.265	5th
QJ	208	1.55	0.924	8th

Table 4 The general Friedman test statistics for the observations of all the respondents

N	**208**
Chi-Square	350.499
df	9
Asymp. Sig.	0.000

Table 3 and Table 4 show the general descriptive statistics and the general Friedman test statistics, respectively. It was observed in Table 4 that the Friedman Test statistics gave a p-value of less than 0.05, which made the analysis significant while ignoring the null hypothesis. As a result, the observations in Table 3 are significantly different, and they are ranked according to their mean scores.

3.5. Safety assessment in Nigeria

Descriptive statistics were carried out to find out if the null hypothesis held for the first section of the questionnaire that was distributed to the respondents. From Table 6, it was observed that the p-value was less than 0.05, which made the test significant, and as such, the null hypothesis was rejected. Table 5 shows that the four observations for this section were significantly different, with observation QA being ranked first with the highest mean score of 2.37, followed by QB with a mean score of 2.09, and then by QC with a mean score of 1.63. QD was ranked last in this section with a mean score of 1.57. QA had the highest mean score. This suggested that all 208 respondents supported the fact that Nigeria lacks a safety culture, which is in agreement with the reports of other researchers [24], [25], [15], [26].

Table 5 The descriptive statistics for safety assessment in Nigeria show the mean and standard deviations

Symbol	N	Mean	Standard Deviation	Rank
QA	208	2.37	1.089	1st
QB	208	2.09	0.943	2nd
QC	208	1.63	1.259	3rd
QD	208	1.57	1.172	4th

Table 6 The Friedman test statistics for safety assessment in Nigeria

N	208
Chi-Square	156.107
df	3
Asymp. Sig.	<.001

3.6. Importance of safety education

Table 7 The descriptive statistics for the importance of safety Education showing the mean and standard deviation

Symbol	N	Mean	Standard Deviation	Rank
QE	208	1.18	0.619	6th
QF	208	1.90	1.485	1st
QG	208	1.82	1.294	2nd
QH	208	1.38	0.713	5th
QI	208	1.75	1.282	3rd
QJ	208	1.55	0.923	4th

Table 8 gives the result of the Friedman test carried out, and the p-value was less than 0.05. This indicated that the test was significantly different and that the null hypothesis was rejected. Observations QE, QF, QG, QH, QI, and QJ are significantly different. Table 7 shows that QF was ranked number one based on the mean, and this means that the respondents were in support of the observation that the teaching of safety should be encouraged for secondary and technical schools in Nigeria. While QE was ranked last, the respondents were at least in support of the fact that Nigeria lacked a safety culture. The observation QG made was in agreement with various researchers that teaching safety in tertiary institutions (safety education) would help to build a safety culture in Nigeria [27], [28]. This was in

disagreement with Ayodele and Olubayo-Fatiregun, who concluded that the "Safety Education and Training for Workers' strategy is not effective in reducing accidents in industries [29].

Table 8 The Friedman Test statistics for the importance of safety education

N	**208**
Chi-Square	70.173
df	5
Asymp. Sig.	<.001

3.7. A safety course curriculum

Supervisors, safety educators, and engineers must realise that accidents do not happen by chance; they are caused and can be avoided. An industrial safety education plan will be ineffective unless efforts are made to develop a good safety philosophy, educate safety concepts, and dispel myths regarding accident causes [30]. The high number of industrial accidents has been ascribed to a lack of safety instruction, which has caused workers to run machines without a guard, drop objects on their toes, or cut their hands due to tool misuse [31].

In this research survey, only 204 out of the 208 respondents suggested possible outlines for a proactive course on safety. The respondents were allowed freehand to decide the outline for a safety course as they were guarded. The responses were not analysed statistically because the respondents suggested random outlines, which made analysis impossible. Only the relevant suggestions were selected; these resulted in thirty (30) outlines for the safety course that could be developed, as can be seen in Table 9.

Table 9 Suggested Safety Course contents for engineering students by respondents

Serial Number	**Safety outlines for proposed proactive safety culture**
1	The use of Personal Protective Equipment (PPE)
2	Permit to work analysis
3	Reporting and recording accidents/incidents
4	Process Safety
5	Principles of safety measurements
6	Safety rules and regulations
7	Introduction to security
8	Equipment management, lifting operations and stress management.
9	Importance of safety practices
10	Environmental Safety
11	Safety in the Workshop
12	Energy Management, Quality & Ergonomics
13	Best Practices in Safety Management
14	Product Safety and Liability
15	Basic first Aid training
16	Industrial Safety Analysis and Risk Assessment
17	Legal Administrative Framework for Industrial Safety Management
18	Cyber and Industrial Security Management
19	Introduction to incident investigation

20	Accident reporting and investigation
21	Simultaneous Operations (SIMOPs) - Guidelines
22	Introduction to Behavioural Based Safety (BBS)
23	Work at height - Guidelines
24	Industrial Fire Protection
25	Environmental Law and Regulation
26	Fundamental to occupational Safety
27	Safety Demand in Engineering & General Working Environments
28	Analysis of Degree of Safety
29	Design of Safety procedures
30	Technical Report on Operational Safety in Engineering Related Engagement

4. Conclusion

The study developed a curriculum of suggested course outlines needed to implement a proactive safety engineering culture in academia and industry. The study revealed that there is little awareness among engineering students and industry stakeholders about safety. With the level of awareness mainly in personal protective equipment (PPE) by engineering students. The exposure to PPE may be due to the compulsory industrial training (IT) programmes or Student Work Experience Programme (SWEP) engaged in their 2nd, 3rd, and 4th years in their various institutions.

The findings from research survey implied that engineering students are largely unaware of the core issues of safety. It was strongly agreed that there is a lack of safety culture in Nigeria. While the 208 respondents agreed that teaching safety should be encouraged in secondary and technical schools in Nigeria, It was also agreed that safety education is important.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors have declared that no conflict of interests exist.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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