

Development of Survey Instrument to Assess Freshmen Engineering Students Understanding on Engineering Ethics

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Abstract: Academic dishonesty among students, also known as cheating, has become a severe problem at undergraduate universities. According to study, engineering students are more likely to cheat in academia, and this is related to unethical conduct in profession. When this relation is viewed in the context of higher levels of academic misconduct among engineering graduates, the situation becomes even more significant for engineering instructors, experts, businesses, and community. To examine this concern, this study was conducted to analyze perception of ethics in freshman students with five factors: ethical environment on campus, impact of technology, ethical influence on faculty and education, importance and awareness of ethics, attitude towards cheating. In this study, a survey instrument was designed to hypothesizing the five factors listed above. The survey instrument was administered to freshmen engineering students at affiliated autonomous college in south India Hyderabad Institute of Technology and Management (HITAM) during spring 2021. An exploratory factor analysis was conducted to validate the factor structure of the survey instrument. The analysis revealed five factors as hypothesized with a minimum and maximum loading of 0.56 and 0.90. The internal consistency reliability index Cronbach's α ranged from 0.81 to 0.89, representing a strong consistency. This survey instrument can be used in any education institutions to assess students' understanding related to engineering ethics.

Keywords: Freshman engineering students, engineering ethics, ethics education, ethical environment, cheating.

1. Introduction

Owing to rapidly changing technology and environment around, ethics is and should be the core of engineering.

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Engineering ethics is the field of system of moral principles that apply to the practice of engineering. The field examines and sets the obligations by engineers to society, to their clients, and to the profession. Engineering ethics comes under branch of applied ethics.

Engineering ethics as a subject has risen in popularity in the last decade, and it's evolved in a branch of teaching and research known as engineering ethics. [1]. Over the last decade, the area of engineering ethics has advanced dramatically. In the literature, a range of methodological approaches for teaching engineering ethics have been investigated and explored. [2]. The ethical decisions and moral values of an engineer need to be considered because the decisions of an engineer have an impact on the products and services they provide for the benefit of the people [3]. Contrary, engineering failures due to ethics are not new.

From the sinking of Titanic in 1912 to the Fukushima Daiichi nuclear disaster in 2011, engineering failures have been caused by problems in design, construction, and safety protocol. The blame can often have learned from the wrong ethical decisions that were made [4].

Due to unethical behaviour of the employees, serious consequences for both individuals and organizations could be easily witnessed. Engineers must act and behave under a standard of professional behavior that requires adherence to the highest principles of ethical conduct. The guiding principles that an individual or a firm has created in the workplace are skill competency and ethical values [5].

Employers should be aware of how college students view ethics in their undergraduate courses so that they may better select potential employees who will be able to make moral decisions in the actual world when presented with ethical dilemmas. As a reason, it's simple to see why many organizations currently place a high value on the ability to make social choices in the real world when recruiting employees [6].

Decision making is an important part in ethics irrespective of the discipline or field. Some of the common examples of decision-making used in the engineering education which do not directly relate to ethics involve some sort of optimization techniques, which requires to eventually make decisions based on different attributes [7-12]. However, ethics in engineering is not as evidently present as other decision-making methods in engineering. A few exceptions include engineering ethics courses established by National Society for Professional Engineers, IEEE, Accreditation Board for Engineering and Technology (ABET), and at Texas A&M university where they address the need for ethics in the engineering curricula [13].

Furthermore, many engineering programs are under stress to train learners for the inevitable ethical dilemmas that will arise in the workplace. Through teaching, classroom discussions, investigations, institutional practice guidelines, and active social conscience, many international institutions have continued to foster a moral conscience, transparency, social responsibility, and environmental sustainability. [14]. Recent study has addressed on the impact of moral behaviour on ethical education. The challenge is to understand, is this sort of education beneficial or not. Eventually affecting the behaviours of future engineers [15].

Because the tech community expects such ethical responsibilities or knowledge in its future workers, study into the influence of ethics education on youths' values and integrity [16] appears logical. The present study is focused on design and development of a survey instrument to investigate different aspects of engineering ethics in freshman engineering students.

2. Literature Review

The supporting literature for this study explores the freshman engineering students' perceptions of ethics using different dimensions of ethics in engineering. Ethics is described as "the profession concerned with what is right and wrong, as well as legal conscience and obligation" in this study. It is difficult to teach ethical standards or to inspire students on ethical values seriously [17].

It is recommended to teach ethics for undergraduate students in four aspects of academic dishonesty, punctuality, judgment, and behaviour. It further explores the impact of gender and academic disciplines on these four moral processes [18]. The writers also explored the apparent correlation, or other connections, between race, age, engineering degree and ethical judgments. In engineering education, codes of ethics play a vital role in establishing moral principles [19]. In other measures, if students believe that certain codes of ethics are adequately implemented, they will regard them as beneficial and put high moral standard on the educational institution's ethical culture and individuals. However, it has been discovered that enforcing a code of ethics is not the sole factor that determines people's ethics judgments.

The numerous instances teachers and students talked about

ethics in engineering, the more confident students were in their capacity to make morally smart choices [20]. Similar

findings from research [21] support the value of ethics education, concluding that students' ideas of ethics evolve over time and are significantly impacted by ethics teaching. Their research centered on two widely held ethical theories: ethical egoism and utilitarianism.

To give an example, when a person picks the outcome that provides the most personal gain, such as the CEO who accepted unfair compensation, he or she is following the ethical egoism theory. When an individual picks an outcome that benefits most people, on the other hand, he or she is operating in accordance with the theory of utilitarianism [22].

On the other hand [23], contradicts the findings, indicating that ethics instruction has no substantial impact on students' views towards cheating. Cheating on tests in college has been related to other deceptive conduct. Students who cheat in academia are more likely to cheat in higher school and participate in immoral behaviour in the workplace. According to research [24] engineers are accountable for the public's health and physical welfare, therefore much more than the credibility of the academic process is at issue in this instance.

Furthermore, the authors [25] claimed that academic dishonesty is linked to immoral behaviour in the workplace. However, impact of technology on students' ethical behaviours were totally neglected in the past research where they conducted traditional classes. Although there is mistrust among college professors that technology could make cheating easier and more creative, there is limited research to back this up. [26] With the rising use of educational technology and the accessibility of online courses, it is critical to investigate this relatively unexplored part of the picture. According to author [27], college students believe that cheating in an online exam is more acceptable than cheating in an offline class. In a subsequent study, the author explored the implications of employing TM (Troy Remote Proctor) tools to track exams for their undergrads [28]. According to their study, technology can help students cheat less in the near term, although students rapidly devise inventive and efficient countermeasures. While most engineering students have a fundamental understanding of ethical concepts, they simply require more experience understanding and dealing with the complicated and intricate difficulties of professional obligation in engineering before they face ethical issues in the practical world [29].

Further emphasizing this issue, researchers concluded that ethics teaching can be learned and has an influence on students' own ideas and actions. Teaching ethics is not a required course in many undergraduate programs. Engineering students, on the other hand, must prove that they are professionally and ethically rooted. Engineering instructors must demonstrate that their graduates have a

considerate moral and legal duty, according to ABET's engineering standards 2007, yet teaching engineering ethics is still not a high emphasis in engineering degree. [30]. Despite these important advances and lack of research in this direction, this study attempts to examine the

perceptions of different components of ethics at freshman engineering level.

3. Methods

Based on the literature study the survey instrument was developed [31] few modifications were done basing on sample population during spring 2021 by the author. The instrument comprises of five factors as shown in Table 1. The factors in the instrument align with the dimensions or constructs of the participant's opinion and are intended to capture student impact, beliefs, experiences, and attitudes related to their ethical environment in engineering campus. The instrument also includes a separate demographic section with questions about students' personal background characteristics such as gender, discipline, board of study and highest qualification of parent. The author developed

26 interdependent items for the five factors to determine freshmen students' perception of ethics, requesting data on students' opinions of cheating as it pertains to themselves and their peers, as well as faculty perceptions and the influence of education on personal morals and ethical judgement abilities.

Table 1 provides information about the item development for each scale, including, the intended meaning of the factor and example items. Response options for all factors asking students to response were arrayed on a Likert five-point scale from 1 (strongly agree) to 5 (strongly disagree) [32]. The researchers were able to assess the students' opinions on cheating or whether they believed that a bachelor's degree may have a substantial impact on their ethical behaviours based on the results of these survey.

Table-1 Overview of factors within the survey instrument

#	Factors	Definition of factor	Example items
1	Influence of ethics on faculty and education system.	Students' views on the influence of ethics and role of faculty and education system in instilling moral values in them	<ul style="list-style-type: none"> • Are educated people are more ethical • Faculty help students develop values in their classes
2	Attitude towards Cheating	Students' perspectives regarding cheating as it relates to themselves and their peers	<ul style="list-style-type: none"> • Cheating on homework assignments working on an assignment with others when the instructor asked for individual work. • When I see other students cheat, I feel compelled to report.
3	Impact of Technology	Students' perceptions of how easy it is to cheat in an online or hybrid class, as well as how easy it is to cheat when technology is employed	<ul style="list-style-type: none"> • In a course requiring computer work, copying a friend's program rather than doing your own • Is online education more conducive to cheating
4	Importance and awareness of ethics	Student's perception on how they perceive the importance of ethics in their lives and education.	<ul style="list-style-type: none"> • Ethics education should be taught in engineering curriculum • Ethics in engineering play a major role for influencing your behavior.
5	Ethical Environment on Campus	Student's perception on how faculty and peers play a major role in creating ethical environment in campus.	<ul style="list-style-type: none"> • Campus ethical environment plays major role in four years of engineering education • I consider the faculty and instructors in my major to be ethical human beings.

Factor-1: Influence of ethics on faculty and education system

It includes six items; each item is intended to assess students' perceptions about their faculty incorporating ethical values into their career through training and correlating with ethics education for playing a major role developing these values at freshmen engineering and how they consider the impact of ethics on educated people.

Factor-2: Attitude towards Cheating

It includes five items intended to examine student's perception on cheating at high school and college levels. Do they accept to cheat in non-major class and homework assignment working in groups when asked to submit individual report and to know if they report to faculty if they see someone cheating?

Factor-3: Impact of technology

It includes 5 items which focus on student's involvement in cheating online or hybrid class more compared to regular class and copying material for assignment when technology or online tool is provided and to know students' perception is online education is more conducive in cheating.

Factor-4: Importance and awareness of ethics

It includes five items which speaks about students' attitudes on how they think they hold ethics in their career. Does ethics play a major role in influencing their behaviour, do they keep themselves at same ethical standards as they hold others and most importantly should ethics be taught in engineering curriculum to be aware of ethical situations around them.

Factor-5: Ethical Environment on Campus

It includes five items to know students' approach towards having an ethical environment in campus and play a key role in their engineering education and considering faculty/instructor to be ethical human beings having an impact positively on their surroundings.

4. Data Analysis and Research Findings

After the survey questions were conducted, information was collected, categorized, analysed, and appropriate

descriptive statistics of the selected respondents were retrieved using the SPSS software program. The data for this study was collected from freshmen engineering students at an affiliated institution in south India. The evidence for the face validity of the survey instrument was obtained by asking three potential participants to review the questions on the survey and provide their feedback on wording and phrasing of the questions. The students did not find any unfamiliar words or confusing phrasing of the survey questions. Hence, the survey instrument did not require any revisions. A total of 281 participants responded the survey and an after cleaning the data 269 participants remained in the final dataset. Participants who did not respond to more than 50% of the questions on the survey were not included in the data. Also, participants who selected the same option for all the questions were deleted from the data. The missing data was handled using group mean substitution method. Table 2 presents the participants' demographic information including gender, engineering discipline, board of study, and parent's qualification. The data was collected during spring 2021. The participants provided their consent before starting to respond to the survey. In total, the survey takes approximately 8 minutes to complete. A five-point Likert type scale was used in the survey – strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree. The students were sent a reminder after 3 days to complete the survey if they had not already completed.

Table 2. Demographic information of the participants

#	Category	n	%
	Total	269	100
1	<i>Gender</i>		
	Male	169	63
	Female	100	37
2	<i>Engineering discipline</i>		
	Electronics and communication engineering	31	12
	Mechanical engineering	22	8
	Electrical and electronics engineering	18	7
	Computer science engineering	44	16
	Artificial intelligence and Machine learning (AI & ML)	44	16
	Internet of things (IoT)	34	13
	Cyber security (CS)	36	13
	Data sciences (DS)	40	15
3	<i>Board of study</i>		
	CBSE(Central board of secondary education)	52	19
	SSC (Secondary school of education)	217	81
4	<i>Parent's qualification</i>		
	Below 10th grade	27	10
	10th grade	41	15
	12th grade	67	25
	Bachelor's degree	98	36
	Master's degree	32	12
	Ph.D.	04	2

Table 2 provides the demographic information of the respondents. When the survey was administered to the entire population, 269 students voluntarily responded, with 63% male respondents. The participants' class results were distributed equally among numerous undergraduate disciplines. (16% - CSE & AI ML 12% - ECE, 18% - EEE, 13% - DS & IOT, 15% - CS, and 8% - MECH). Demographic variation also categorizes the respondent's secondary education board of studies with maximum students from SSC (81%). The sample consisted diversity in parental qualification of maximum parents having bachelor's degree with 36% and minimum of Ph.D. constituting 2% of total population.

Table 3 provides the descriptive statistics of all the items used in the survey. An exploratory factor analysis was used in this study. Bartlett's test for sphericity was used to test the suitability of items for factor analysis ($p < 0.05$) and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was used ($KMO > 0.8$) was used to check the variance of the extracted factors [33]. The suggestions for factor analysis were considered through parallel analysis, scree plot and Kaiser's criterion. The parallel analysis and scree plot suggested five factors and Kaiser's criterion

suggested 3 factors. Five factors were chosen as it matched the hypothesized number of factors. As the correlations of the factors were greater than 0.33, Promax rotation was used [33]. The final factor loadings for all the five factors are shown in Table 4. Referring to table 3 three factors (items 5, 10, 26) had factor loading of less than 0.4 on at least two items and two factors (items 11 and 14) cross-loaded on more than one factor [34]. These five items were removed from the analysis resulting in a total five factors with of 21 items. The factor loadings for factor 1 ranged from 0.59 to 0.85, 0.61 to 0.84 for factor 2, 0.56 to 0.84 for factor 3, 0.61 to 0.82 for factor 4, and 0.71 to 0.9 for factor 5. The reliability coefficient for internal consistency (Cronbach's α) ranged from 0.81 to 0.89 showing a strong reliability of the factors [35].

Table 3. Descriptive Statistics of the five factors

#	Measure	Mean	SD
	<i>Influence of ethics on faculty and education system</i>		
1	Education should play a big role in teaching students about ethics	4.2	0.7
2	Faculty help students develop values in their classes	3.9	0.9
3	Faculty should incorporate ethics training into their classes	3.6	1.0
4	Faculty should enforce ethical standards onto their students	3.8	0.9
5	Educated people are relatively more ethical	3.4	1.0
6	There is a correlation between education and ethics	3.7	0.9
	<i>Attitude towards Cheating</i>		
7	I have never cheated on my schoolwork while in high school	3.0	1.2
8	I have never cheated on my schoolwork while in college	3.2	1.1
9	When I see other students cheat, I feel compelled to report	2.9	1.0
10	It is acceptable for me to cheat in a class	2.6	1.0
11	Cheating on homework/assignments by working on an assignment with others when the instructor asked for individual work is acceptable	2.7	1.0
	<i>Impact of Technology</i>		
12	It is easier to cheat in an online or hybrid class than a regular class	3.3	1.1
13	It is easier to cheat when technology is involved, e.g., access to online resources, calculator, etc.	3.4	1.0
14	Online education is more conducive to cheating	3.3	1.1
15	In a course requiring computer work, copying a friend's program rather than doing your own is easy	3.2	1.1
16	Copying material almost word for word from a written source and turning it in as your own work is acceptable	2.6	1.1
	<i>Importance and awareness of ethics</i>		
17	Ethics is very important to me	4.2	0.8
18	I hold myself to the same ethical standards that I hold others to	3.8	0.9
19	Ethics in engineering play a major role for influencing my behavior	4.1	0.8
20	I am aware of ethical situations around me	3.8	0.8
21	Ethics education should be taught in engineering curriculum	3.9	0.8
	<i>Ethical Environment on Campus</i>		
22	Students follow the ethical environment on campus	3.7	0.9
23	I consider the faculty in my institution to be ethical human beings	3.9	0.8
24	By the time people reach college age it is too late to teach them about ethics	3.3	1.1
25	Campus ethical environment plays major role in four years of engineering education	4.1	0.8
26	One can graduate without having ethical environment in their campus	2.9	1.1

Table 4. Final factor loadings of the survey instrument

#	Measure	F1	F2	F3	F4	F5
	<i>Influence of ethics on faculty and education system. ($\alpha=0.86$)</i>					
1	Education should play a big role in teaching students about ethics	0.85				
2	Faculty help students develop values in their classes	0.61				
3	Faculty should incorporate ethics training into their classes	0.59				
4	Faculty should enforce ethical standards onto their students	0.75				
5	There is a correlation between education and ethics	0.72				
	<i>Attitude towards Cheating ($\alpha=0.81$)</i>					
6	I have never cheated on my schoolwork while in high school		0.73			
7	I have never cheated on my schoolwork while in college		0.84			
8	When I see other students cheat, I feel compelled to report		0.61			
	<i>Impact of Technology ($\alpha=0.89$)</i>					
9	It is easier to cheat in an online or hybrid class than a regular class			0.65		
10	It is easier to cheat when technology is involved, e.g., access to online resources, calculator, etc.			0.77		
11	In a course requiring computer work, copying a friend's program rather than doing your own is easy			0.56		
12	Copying material almost word for word from a written source and turning it in as your own work is acceptable			0.84		
	<i>Importance and awareness of ethics ($\alpha=0.84$)</i>					
13	Ethics is very important to me				0.82	
14	I hold myself to the same ethical standards that I hold others to				0.67	
15	Ethics in engineering play a major role for influencing my behavior				0.61	
16	I am aware of ethical situations around me				0.72	
17	Ethics education should be taught in engineering curriculum				0.64	
	<i>Ethical Environment on Campus ($\alpha=0.82$)</i>					
18	Students follow the ethical environment on campus					0.79
19	I consider the faculty in my institution to be ethical human beings					0.68
20	By the time people reach college age it is too late to teach them about ethics					0.71
21	Campus ethical environment plays major role in four years of engineering education					0.90

5. Conclusions

The design and development of a survey instrument to capture the freshmen engineering students' perceptions related to different aspects of engineering ethics was presented. A total of five factors emerged from the exploratory factor analysis- ethical environment on campus, impact of technology, influence of ethics on faculty and education system, importance and awareness of ethics and attitude towards cheating. The evidence for face validity was collected. The factor had a minimum and maximum loading of 0.56 and 0.90 and Cronbach's α ranged from 0.81 to 0.89. This survey instrument could be used by any educational setting to understand students' understanding and knowledge levels related to engineering ethics. Based on the outcome of the survey, appropriate interventions can be made in the curriculum such as organizing a webinar on ethics, conducting workshops related to ethics, including elements of ethics in the curriculum, introducing elective courses related to engineering ethics, etc.

6. Future Work

In future, the author would like to collect evidence for content validation of the survey instrument. Examining the influence of the different demographic variables (gender, engineering discipline, board of study, and parent's highest qualification) on all the five factors could be a direction for potential future work. Collecting more data and conducting a confirmatory factor analysis to further validate the survey instrument could also be done in future. Future research would even involve students' quantitative survey to collect data from the students of all the four years of engineering and their ethical perspective in engineering education which will help to better understand how to incorporate ethics in curriculum [31-34]. Further research will be carried out by conducting qualitative interviews that can be designed to investigate deeper understandings and perceptions of ethics in engineering [35-38]. Lastly, qualitative research studies can also be conducted to investigate the perceptions/opinions of the faculty member's perspectives on engineering ethics. Concept assessment tools can also be created and used to assess students' understanding and knowledge in applying their learnings related to engineering ethics under different circumstances [39-42].

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