OPEN ACCESS

International
Journal
Of Modern Engineering Research (IJMER)

Cultivating the Culture of Ethics in Engineering Education

Ms. Mini Thomas
Affiliation& Email: Research Scholar, Masters in Engineering (Electrical),
Indian Institute of Technology Bombay (I.I.T.B);

ABSTRACT:- *Engineering Ethics is emerging to be a critical topic in engineering profession. Despite of its increasing importance, engineering ethics is not much focussed in engineering education. This paper attempts to achieve the objective of analysing the current practices of teaching engineering ethics in education with a diverse sample of Asian and North American Universities and Colleges. The paper draws on qualitativeinvestigation that were based on interviews, focus group, and survey of educators, students and administators of undergraduate electrical, mechanical, computer and civil engineering programs at seven universities or engineering colleges in Asia and North America. The paper reports the findings of the investigation on the impact of enginering curriculum upon the ethical behaviour of engineering students. The findings highlighted a major disconnect in the teaching of engineering ethics in the curriculum and the ethical outcome. The paper concludes with recommendations for cultivating the culture of ethics through out the engineering curriculum to develop the students to make decisions with highest ethical and professional conduct in consistent with the safety, health, and welfare of the public.*

KEYWORDS:- *culture, engineering education, ethics, program outcome, course work, , team work, ethical behaviour, ethical development, undergraduates, qualitative IEEE,NSPE, ABET,SEED.*

I. INTRODUCTION

As we stand embracing the great achievements and technological developments of the 21st century we are challenged with professional ethical values. One of the first professional ethics known was for medical doctors followed by code of ethics for lawyers, journalists, engineers and so on.

Ethics, The rules or standards governing the conduct of the members of a profession is a term widely used in most profession. Engineering Ethics is a obligation of engineers to their profession to act and serve with responsibility in safety of the public and profession. Most Engineering curricula has atleast one course on Engineering Skills and Ethics taught in the Freshman or Sophomore year. However, how much of it is carried forward through the junior , senior years and exhibited and lived after graduation and in profession is something to ponder about.

Engineering Ethics is not something which can be taught and finished in a course, but is essentially a component which should be given the scope to practice since inception. The engineering education should support, cultivate and breed the culture of engineering ethics throughout its program in course work, homeworks, exams, quizzes,projects and Lab works.

This paper attempts to achieve the objective:

1. To analyse the current practices of teaching engineering ethics in education
2. Recommendations on integrating the ethical component throughout the life cycle of engineering education.

II. ENGINEERING ETHICS

While Engineering may seem to be mathematical dealing with equations and principles of nature, Engineers are involved with interpretations of facts and data that has ethical connotations. Engineers are responsible to identify a problem and take actions. The engineers action can have good or bad impact sometimes which are intentional and sometimes unintentional. Therefore it is very essential an engineer understands both the sides of the matter and takes action ethically.

Ethics, According to National society of professional engineers(NSPE), is Professional engineers taking seriously their responsibility — not just for the quality of the jobs they work on — but for the safety and well-being of the public at large. The Institute of Electrical and Electronics Engineers (IEEE) have laid down ten point on code of Ethics for the engineer to make decisions with highest ethical and professional conduct in consistent with the safety, health, and welfare of the public.

Engineering Ethics range from micro ethics to macro ethics. Micro ethics is concerned with smaller groups in the engineering profession while Macro ethics involves ethical issues affecting larger segments of the society. A good example of bad macro ethics was displayed by the designers of Titanic, when the world witnessed the disaster of the seemingly untrue claims, that the ship was unsinkable.An example of micro ethics is when an engineer needs to maintain confidentiality in matters dealing with the work organization,colleagues, social circle, professional groups or committes.

As technology is advancing everyday, the ethical content on decision making for engineers is also increasing rapidly and will continueto aggravate with time. It is therefore very important to teach and train the future engineers with a great sense of accountability and responsibility.

III. CURRICULUM AND PEDAGOGY

The Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC-ABET) now requires theaccredited engineering programs must demonstrate that their graduates have an understanding of professional and ethical responsibility. ABET has established a requirement that all engineering graduates should have a formal ethics course included in the study plan. Most engineering curricula have atleast one course on engineering ethics and the framework for teaching engineering ethics includes engineering codes of ehics and application of moral theories. Teaching engineering ethics can help in achieving the ABET outcomes c,f,h and j:

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
(f) an understanding of professional and ethical responsibility.
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
(j) a knowledge of contemporary issues

Common approaches in teaching engineering ethics include:

1. Theoretical: This approach emphasize on studying of general principles, codes and rules of ethics. It emphasizes on studying of moral theories, understanding the professional societies, and development of analytical skills. The assessment methods in this approach are through exams, quizzes and assignments.
2. Case Method:This approach deals with practical cases. Different types of cases are presented to the students in class , cases may be real or fictional. It emphasizes to strengthen students ethical reasoning to identify ethical issue and express ethical opinions. The assessment methods in this approach are through group discussions, debates and presentations.
3. Problem Solving: This approach is exposing students to real life practical experiences through lab experiements, projects, research, national- international competition, summer training and company visits. The emphasis in this approach is that students apply their analytical skills in group/ team work, analyze and understand the practical context of the profession and make realistic ethical decisions.

IV. RESEARCH FRAMEWORK

Although significant progress has been made in the teaching of engineering ethics,this area of learning and teaching continues to be changing meaninfully as the world and technology is evolving. It is a therefore highly challenging on the engineering faculty to develop the future engineers with knowledge and experience on the societal and ethical implications on engineering.

In this paper, aresearch was conducted to analyze the effectiveness of the different teaching approaches for engineering ethics.In order to measure the effectiveness of the ethical education offered for engineering students in higher education institutes, qualititative approaches were utilized. Since the opinions of educators, students and administators were important for this study, qualitative methods particularly focus groups, interviews and survey were employed and ideas were developed from the survey on engineeirng ethical development (SEED). The Qualitattive method, though extensive was prefered for the research study since it allows you to refine the researchprocess, to explore and gather in depth understanding. During interviews and focus group discussions new areas were explored or investigated, as it appeared necessary and the data collection process were at times narrowed to focus on a particular area. The research was conducted in two different regions: United States and Asia. To understand both learner and teacher perspective on ethical development, the following protocol was considered:

- ✓ Focus Group: Students from the Electrical, Mechanical, Computer and Civil Engineering programs were part of this group. Focus groups were conducted inPhilippines, Qatar , Mumbai and Texas. Separate Focus groups for males and females were conducted in Qatar, however in while in Mumbai, Philippines and Texas

the focus groups were not gender restricted. Teaching Assistants, Lecturer and Instructors were part of the Focus group.

- ✓ Leader Interviews: Chairs of the Electrical, Computer and Mechanical Engineering departments, associate dean of student affair and assistant dean of academic affair were interviewed in Qatar and Mumbai. Also, Project leaders and administrators from the universities in Singapore, Malaysia, Pakistan, and Philippines - participants at the Shell Eco Marathon Asia (SEMA) held at Philippines , Manila, 2014 were interviewed.
- ✓ Paper Survey: Third and final year students from the universities in Asia and North American regions were asked to answer a two page survey forms. The students who participated in the survey were group of students enrolled in a particular course.

A total of 62 malestudents, 40 female students and 12 Instructors/ Teaching Assistants participated in the focus group and survey. 7 Administrators / Chairs and 5 Project Team Leaders were interviewed. Specific Questionnaire's were prepared for focus group and interview.

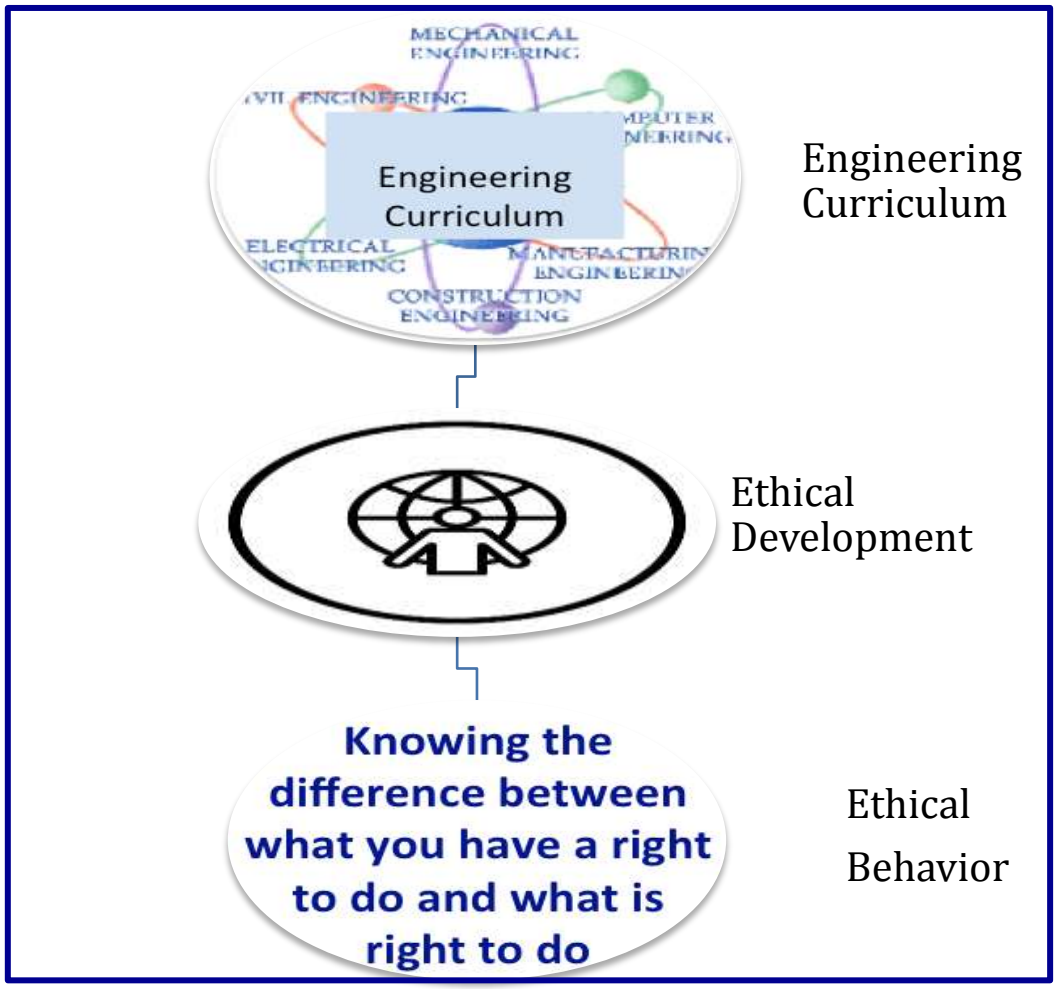

Figure 1 Research Framework

The research framework shown in Figure 1 was used for the investigation. The purpose of the research was to fully comprehend the impact of engineering currculum on students. The impact on students was measured with the outcome of ethical behaviour in professional context. Four dimensions of engineering curriculum, considered in this paper are:

- ✓ Academic Curriculum: The subjects intentionally providedby the college/university for the completion of the program and mandatory to the student. Example: courses, seminars, projects, trainings etc.
- ✓ Co-Curricular Activities: These activities are provided by the college/university for their students. These activities fall outside the formal academic curriculum and are not usually mandatory, but they are intended to complement the students learning experience. Example: Sports, Music, Media, National-International Competitions etc.

- ✓ Co-op Experience: Co-operative (Co-op) is a type of internship program that enables college/university students to receive career training with pay as they work with professionals in their major fields of study. Co-op experience is a compulsory part in some university programs, while it is optional in most others. Examples of Co-op services: students working as technicians/ research assistants in companies, graduate assistants, administrative services in university etc.
- ✓ Voluntary Experiences: These are activities where the student provides services within institution (College/University) of study or outside, for no financial or academic gain. Volunteering is completely optional but helps in skill development and benefits the society.Examples are volunteering in hospitals, emergency rescue, education etc.

V. FINDINGS AND CONCLUSIONS

Data from all the three methods namely focus group, interviews and survey were collected and analyzed together to see the impact of engineering ethics education in curriculum, co-curriculum, co-op or voluntary services. Analysis of the data revealed some dominant and consistent results:

1) Well Covered but not Strongly emphasized:

a) The observations from most of the Focus group, revealed that most programshave a dedicated course on Engineering Ethics and the course is covered with ellaboarte discussions, case studies, study of codes and rules.The interviews with the instructors and leaders revealed that the course outcomes for the ethics were met in most cases and student performance in the course was above average in Qatar and United states.

b) However, both the focus group and interviews mentioned the central fact that though the principles were taught in a theoretical point of view no emphasis was made to apply the principles through the curriculum. The Instructors and Leaders during the Interviews, mentioned that while issues such as plagiarism, and reproducing others work are continously monitored through out the program curriculum , there is a definite lack amongst the students in acknowledging professional ethics for the safety and well-being of the public at large.

c) Students in the Focus group mentioned that while co-curricular and voluntary experiences are open venues for them to demonstrate professionalism and ethics, they find it very difficult. A project Leader at SEMA stated “International competitions such as Shell Eco Marathon is a very promising experience students can have, not only to prove their technical and soft skills but also a a place where students are expected to demonstrate high standards of professional ethics. But unfortunately we struggle in the area of engineering ethics. He added, “Making professionally ethical decisions are more than challenging at times and we feel we lack training in this area”.

2) Initiated but not Strictly continued:

a) The survey revealed that in most program curriculum the course in Engineering Ethics is truly an eye opener. More than 90% students who filled the survey, reported this fact. Discussions in the focus group revealed that the course in ethics uncovers truths of ethics through case studies and presentations. Most students echoed the fact that its probably the first time they hear about some good and bad real life examples of ethics and the course inspires them to be model engineers setting good examples in macro and micro ethics.

b) However, all three research methods revealed that though a good beginning is given through the engineering ethics course very less effort is taken by the faculty to discipline and encourage the students to develop good ethical behaviours. Students in the focus group were of the opinion that, since engineering ethics is new component which most of them come across in the freshman or sophomore years, its not naturally easy for them to mature in it. A Electrical Engineering Female student stated, “a good amount of deliberate disciplining will help the students to produce excellent ethicalbehaviour and this seems to be lacking in most of our programs”.

c) In a Interview conducted, the associate dean student affairs, mentioned “A very clear indication of poor ethical behaviour is evident from the engineering co-op service reports”. Very little but similar opinion was obtained about the ethical behaviour at voluntary services of this group of engineering students.

Compilation of the results from all the three methods gave a clear picture of the existing situation in the teaching- learning of engineering ethics in college and universities. While most programs do very well in teaching the course on ethics blending in the traditional method with case studies and problem solving, it does not seem to continue. In other words, it seems that the course is taught and left, whereas it should have a continuous ripple effect to develop the student to be a professionally ethical engineer. The impact of Engineering Cirriculum on the Ethical behaviour of the student is constructed in to a venn diagram as shown in Figure 2. The curriculum per se, does not seem to have impacted the student ethical behaviour as noted from the

outcomes in co-curricular, co-op or vountary experiences. The course and its outcomes seem to be mutually exclusive or have very little in common.

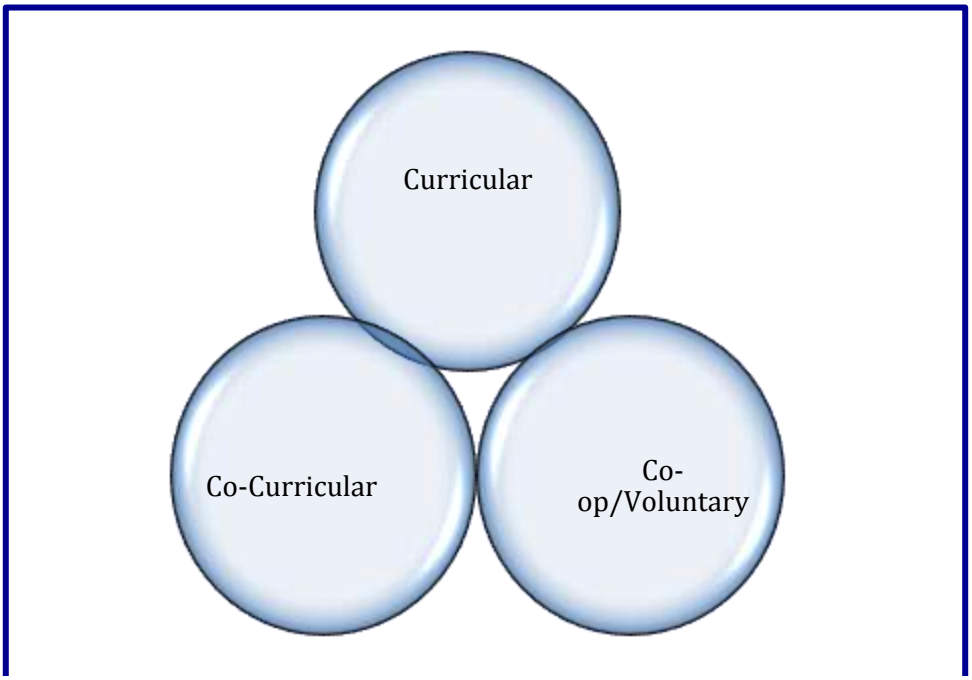

Figure 2 Impact of current Engineering Curriculum on the Ethical Behaviour of Student.

VI. RECOMMENDATIONS

The following Recommendations' are suggested on basis of this research study, bringing to surface some of the opinions by Faculty, Leaders, Support Staff and Students:

1) Ethics Policy in the Departments:

Developing a concise and precise ethics policy in each department, would help to shape the students to be more responsible and accountable engineers. The ethics policy shouldinclude the practical-real life situations taking in to consideration the culture, the laws and principles of the nation. Though it may seem like adding another set of rules amongst many others, implementing a policy of ethics in each department provides a basic framework for the faculty to nurture the students as ethically responsible engineers. It will also provide students of all years (from freshman to senior) to have a guiding document to refer as and when they need, rather than depending on vague and ambigous solutions offered otherwise.

2) Engineering Ethics Curriculum:

a) Ethics to be included earlier and to be a Pre-requisite: Most universities and colleges have atleast one mandatory course in Engineering skills/ethics embedded in their curriculum in the freshman or sophomore year, while some universities has the introductory course of ethics in the junior or senior year. Also, since engineering ethics is a course which usually has no pre-requiste or is not a pre-requiste to other courses, students tendto postpone the course until the final year. The general opinion of the students and faculty in this research was that the course on ethics should be at the beginning of the study plan (in the frehman or atleast in the Sophomore) so that the students gain an oversight of the ethical implications and will be able to apply the values in different situations through out the curriculum. Further, some leaders and faculty also suggested that, if the introductory course on Ethics could be set as a pre-requisite to a major course in the sophomore or junior , it would add more value to the course.

b) Flagged courses: Including one or more ethical outcome through selected course(s) in every term will allow the momentum to be build and a ethical behaviour well developed through the program curriculum. Flagged courses in ethics and skills should be intended to build on and reinforce the skills and critical thinking that students have obtained in the introductory course on ethics.Flags may be completed by major courses , or by elective courses.

3) Conducting special seminars:

Even as the engineering curriculum is not easy going , students try to avoid or keep away any activity that would put them in more pressure or demand more time. Conducting special seminars and talks by selected guests on current issues , specially arranged with student focus often seem to lack student audience. A good way

will be to include these seminars as a requirement in to the flagged courses and students may be required to present a report on the topics discussed. It may seem that the program is being very stringent but after all , disciplining costs. It may also be helpful in exposing some hidden truths and pull consciences to get the students thinking deeply of ethical values. William Marcy, executive director of the Murdough Center for Engineering Professionalism/National Institute for Engineering Ethics, teaches a course on engineering ethics to roughly 600 students per year at Texas Tech University. He says, "Making an ethical decision is thinking about the lifecycle of a project or product or design, not just assuming everything is fine. What may be OK in 2001 may not be fine in 2020 because technology, policies, and design methods can all change. An example he had students look at is the Tesla electric car. "It's very interesting because you would think about the responsibility of the safety of the car—but what about the batteries?" he says. "Some day that car will go to a landfill and how is that battery for the environment? If you think of the life cycle, does the company have a responsibility to properly dispose of the car—should that be part of the offering to a customer when they buy? After all, it may not be a factor for more than a decade. Making students aware of such practical examples gets students to visualize their careers ahead. There will be moments for advancement that could pull at their conscience. Decisions can be made that could literally decide lives." (Eric et al,2014)

4) Recognizing good ethical conduct: Recognition always encourages. If the department/college will recognize good ethical conduct per semester or year, it will motivate and encourage the students to develop good ethical behaviour which will be demonstrated through their works.

Incorporating the above mentioned recommendations on the engineering curriculum for ethical education may reflect a cohesive patternand a relation of inclusiveness through the outcomes in curricular , co-curricular , voluntary and co-op experiences , as shown in Figure 3.

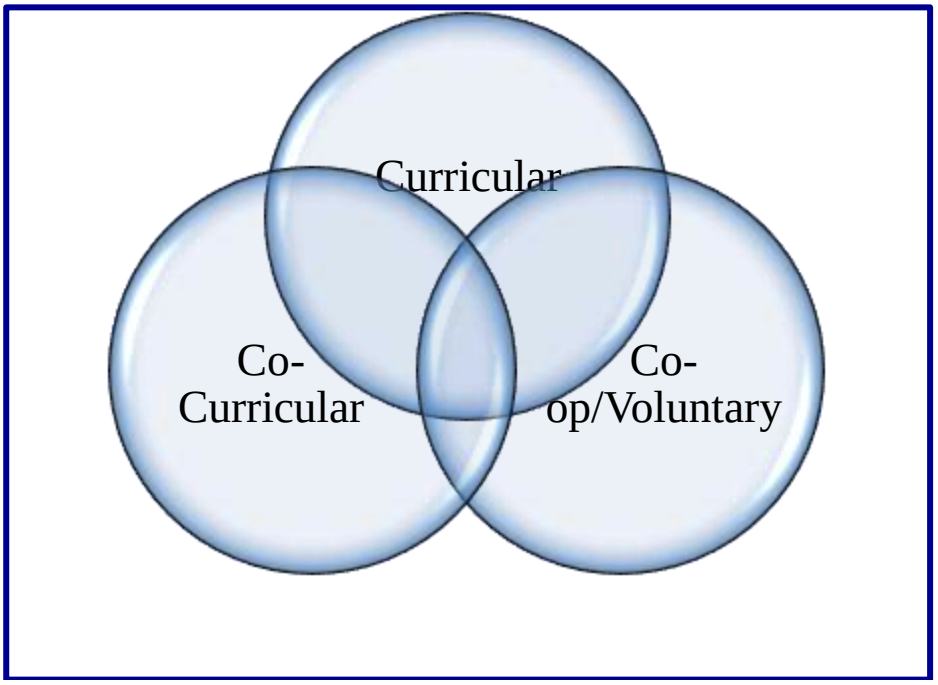

Figure 3 Reflection of the ethical education as per proposed recommendations

VII. CONCLUSION

The objective of this survey was to find out the impact of engineering curriculum on ethical development in undergraduate engineering education. Different pedagogical approaches were reviewed. A qualitative assesment method was implemented for the study. The study revealed the importance of engineering ethics in engineering profession.However the study also showed a lack of impact of the engineering curriculum on ethical development of the student. Recommendations are provided to improve the effectiveness of the engineering curriculum towards the ethical development of the student, so that they become future leaders in the comminuty, who know and understand well that, though many things may seem feasible or doable , not all of them are beneficial to the safety and benefit of the public at large.

REFERENCES

[1]. ABET, Criteria for Accrediting Engineering Programs, Accreditation Board for Engineering and Technology, http://www.abet.org.
[2]. IEEE Policies, Section 7 - Professional Activities, IEEE Code of Ethics, http://www.ieee.org/about/corporate/governance/p7-8.html
[3]. National Society of Professional Engineers, July2007, NSPE Code of Ethics for Engineers, http://www.nspe.org/sites/default/files/resources/pdfs/Ethics/CodeofEthics/Code-2007-July.pdf
[4]. Herkert,J.R 2002.Continuing and emerging issues in engineering ethics education.The Bridge32 (3), Open Document
[5]. C.J.Finelli, M.A.Holsapple, E.Ra, R.M.Bielby, B.A.Burt,D.D Carpenter,T.S.Harding and J.A.Sutkus, "An assessment of engineering students curricular and co-curricular experiences and their ethical development, "Journal of Engineering Education,vol.101,no.3,pp469-494,2012.
[6]. Eric Butterman, March 2014, "Ethics in Engineering", The American Society of Mechanical Engineers (ASME)
[7]. Gharabagi, R. 2007. Coverage of legal and ethical aspects in electrical and computer engineering curriculum. Paper presented at American Society for Engineering Education Annual Conference & Exposition, Honululu, HI