Software Engineering A Profession: Indian Perspective

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Abstract:*Software engineering consists of foundational theories, body of Knowledge and special skill set with methods and tools to apply software engineering knowledge as a mature profession. Software is not confined by geographical constraints or bound to a particular jurisdiction. India needs to upgrade both educational and professional infrastructures to make software engineering a profession. This paper explores from conceptual to application domain of software engineering;lack of theoretical foundation; software as a global phenomenon and all the aspects needed for establishment of software engineering as profession in India. This paper identifies and scrutinises the entities required for the job.*

Keywords:*Software Engineering profession; Global Software; India;Profession.*

I. INTRODUCTION

Software engineering is an engineering discipline concerned with foundational theories, body of Knowledge and special skill set with methods and tools to apply software engineering knowledge. Software has become a driving force for modern societies;driving economies of nations; a pervasive entity. Software has applications beyond boundaries, not confined by geographical constraints or bound to a particular jurisdiction. Software's runs allsectors of society like health, finance, law entertainment industry, personnel, defense, education, transportation and many other systems which drive our society. Software engineering implicates broad accountabilities and extensive ethical responsibilitiesbesides technical skills.Software has a direct and critical social implications, so with technical proficiency, the worth of software products depend on the ethical and professional behavior of the engineers that develop them. Software engineering in India as a discipline and profession is relatively in its infancy and a rigorous effort is required to establish it as a profession in India.

This paper explores all the aspects needed for description and the notion of professionalism of software engineering in India from theoretical foundation to application of Ford and Gibbs's (1996) model of profession adopted by the ACM and IEEE joint steering committee. This paper will discuss globalization aspect of software and sums up international Accordswhich India need to sign for entering into next level. Ford and Gibbs eight infrastructure componentsare also discussed for the establishment of software engineering in India as academic and professional discipline.

II. WHAT IS NEEDED ?

Software engineering as a mature discipline need to have three tier Pyramid architecture; Stable foundation; Knowledge base; practices and applications[1, p. 55].
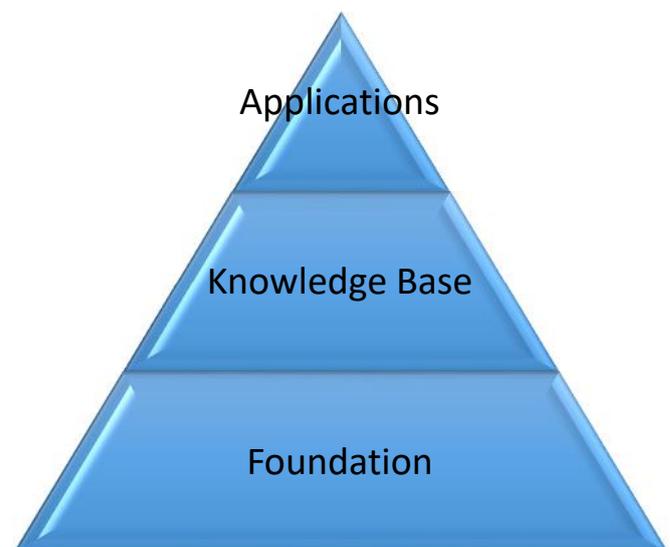

Figure 1. Software Engineering Architecture.

To Establish Software Engineering as a profession in India we need to have following considerations:

1.   Conceptual and theoretical framework;
2.   Why we need it;
3.   What domains to consider;
4.   Who's job is this;
5.   Globalization.

1.   Conceptual and theoretical framework

In India Software engineering is based on application domain; whole emphasis is on technicalities driven by industry orientations. Theoretical, conceptual and foundational aspects are ignored: strengthening of these is the first step for making software engineering as profession in India.
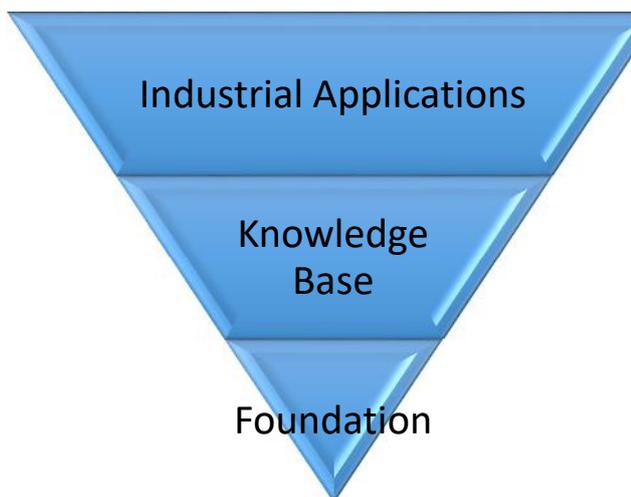

Figure 2. Indian Software Engineering Architecture.

Software engineering besides empirical knowledge incorporates broader theoretical multidisciplinary foundational knowledge; it inculcates concepts from "mathematics, philosophy, cognitiveinformatics, computation, sociology, and system science".Software engineering discipline is an offshoot of computer science, having at core, anextensive and multidisciplinary base ofknowledge.Theoretical core of software engineering can be derived from theoretical foundation of computer science and as a discipline it is evolving, so lot of work need to be done for its theoretical underpinning. Theoretical underpinning starts from Norbert Wiener who did not gave a metaphysical theory. Later many theories were proposed for its foundation. There has been an

intense and conflicting debate over it. Parker believed that inNo-foundation theory. Gotterbarn suggested a professional ethics, Krystyna Gorniak-Kocikowska proposed "global ethics". Deborah Johnson argued that there will be no foundation in future as it will disappear.Luciano Floridi proposed an ontological "Information Ethics" theory. Terrell Ward Bynum offered "flourishing ethics" theory[2]. (See Juneed, et. al., 2017, "Computer Ethics from Obscure to Ubiquitous").

2.   Why we need it

Software engineering has evolved as a society driven field. Every aspect of society: health, finance, defense, education, transportation etc. is critically dependent on it, giving rise to tremendous ethical issues. The software engineering professional who built these society driving artefacts need to keep social implications of these artifacts into cognizance with technical expertise to build these; moral framework is required to accomplish such requisition. Software Engineering has a potential to have direct and vigorous effect on individuals, societies and nations. Disregardingsocial context of software development can lead to disastrous consequences. India has become global leader in software development and has now more responsibility to build better software by practicing international standard design and development practices. Digital India Program by government of India is like a beacon pushing its software industry to go further up. India has an ecosystem full of elite technical institutes, technical manpower, well developed software industryetc.; this in turn demands ethical framework and professionalism. (See Juneed, et. al., 2017, "Ethical Aspects of Software Engineering: A wake up call for India").
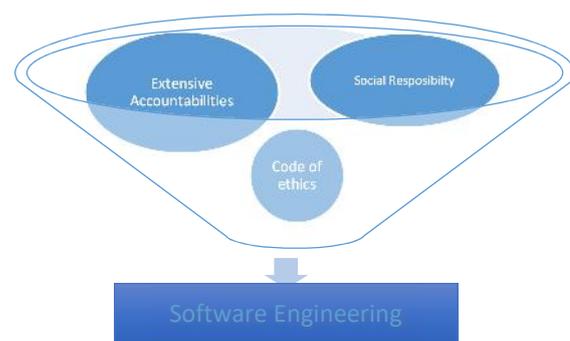

Figure 3. Software Engineering Concerns.

Software developed by unprofessional developers can lead to catastrophic consequences. History is full with such example[3]:
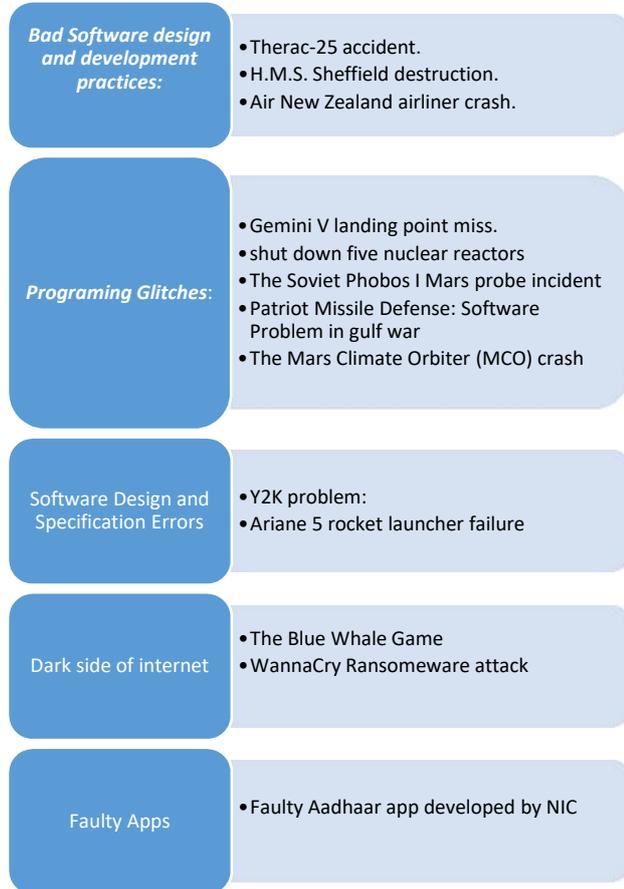
Bad Software design and development practices:	• Therac-25 accident. • H.M.S. Sheffield destruction. • Air New Zealand airliner crash.
Programing Glitches:	• Gemini V landing point miss. • shut down five nuclear reactors • The Soviet Phobos I Mars probe incident • Patriot Missile Defense: Software Problem in gulf war • The Mars Climate Orbiter (MCO) crash
Software Design and Specification Errors	• Y2K problem: • Ariane 5 rocket launcher failure
Dark side of internet	• The Blue Whale Game • WannaCry Ransomeware attack
Faulty Apps	• Faulty Aadhaar app developed by NIC

Figure 4. Examples of Software based mishaps.

Digital India Program is acting as a catalyst merging together bunch of notions, beliefs, ingenuities and thoughts;making India a knowledge economy run by digitally empowered society; by nine pillars:

⟩ Broadband Highways ;
⟩ Universal access to Mobile Connectivity;
⟩ Public Internet Access Programme;
⟩ e-Governance – Reforming Government through Technology;
⟩ E-Kranti - Electronic delivery of services;
⟩ Information for All;
⟩ Electronics Manufacturing;

⟩ IT for Jobs; and
⟩ Early Harvest Programmes.[3]

India is evolving asa software giant making software engineering profession a prime concern owing to the following reasons:

⟩ Low wages of Indian developers attract companies all over world to hire developers and engineers from India.

⟩ Lower infrastructure buildup and maintenance cost saves huge money.

⟩ India is positioned on the other side of globe, thus giving opportunity for companies to work for a 24 hour.[3]

According to the Electronic and Computer Software Export Promotion Council (ESC) report on computer software export[4]:

Indian Software Export Estimation	
Period	**Software Export in US$**
Late 1980's	$50 million
1980 - 1993	$200 million
1994 - 2001	$6 billion
2014-2015	$118.53
2015 - 2016	$129 billion

Table 1. Indian Software Export Estimation

According to NASSCOM India is building itself as Digital Innovation Hub in a Digital ecosystem: "outreaching to newer markets - Japan, Germany, Middle East, Africa, and China with focus on Digital solutions, Industry 4.0"[5].

Figure 5.India IT-BPM Export Revenues.
Source: NASSCOM

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 1
January 2018

www.nasscom.in/sites/default/files/NASSCOM_Annual_Guidance_Final_22062017.pdf

India is evolving aggressively as a software giant in the world; India can sustain and grow further only by making software engineering a professional discipline and thereby software development a professional practice.

3.   What domains to consider

In India Software Engineering as an independent discipline is in its infancy, itis usually offered as computer science engineering. Software engineering has its own approach and its own set of applications which for the most part deal with software development and its applications. India to uplift its software industry at the international level has to upgrade it academically as well as professionally; industry, academia, and professional societies, need to make rigorous and concrete measures. India has to follow Ford and Gibbs's (1996) model of software engineering profession adopted by IEEE and ACM[6]. India has to consider following eight domains to establish software engineering as profession[7]:

• Initial professional education,

• Accreditation,

• Skills development,

• Certification

• Licensing,

• Code of ethics,

• Professional development and

• Professional society.

Initial professional education

India to match its Software engineering education with international standards need to make serious efforts in terms of:

⟩   Curriculum reforms;

⟩   Pedagogy reforms;

⟩   Sensitivity to changing technology;

⟩   Integrated professional practice module;

⟩   Ethics integration.[6]

India should considerThe Computing Curriculum Software Engineering (CCSE): the Software Engineering 2004 (SE2004) sponsored by the Association for Computing Machinery and the

IEEE Computer Society later revised to SE2014 which delivers recommendations for undergraduate education in software engineering such that Initial professional education enables (See Juneed, et. al., 2017,"Non-Existent Software Engineering Profession in India"):

1.   Design, analyze and manage development of a computing-based system, component or process and implementing new technologies to compete in the global environment;

2.   Application of well-defined engineering practices and use software engineering knowledge, techniques and skills to classify, formulate and solve software engineering problems;

3.   Application of software engineering in contemporary, global, business, environmental, economic, and societal context;

4.   Work effectively as team members in multidisciplinary projects; and

Engage in continuous learning, career improvement and adopt to changing professional and societal needs.[6]

Accreditation

Accreditation is the tool to guarantee and approve excellence of initial professional software engineering education and to analytically validate the institutions such that they are:

⟩ aware of the weaknesses and thereby improvement of the programme offered;

⟩ Constantly working for the quality and excellence;

⟩ Persistently updating curriculum, teaching and learning processes, faculty achievements, students' skills/abilities/knowledge;

⟩ Exceling among stakeholders. (Peers, students, employers, societies etc.);

⟩ Receiving of grants from Government regulatory bodies and institutions/agencies;

⟩ Accomplishing international recognition of accredited degrees awarded; and

⟩ facilitating the mobility of graduated students and professionals.[8, p. 9]

Accreditation in India should be in conformity with the Accreditation Board for Engineering and Technology (ABET) which recommends for software engineering graduate to have following attributes:

a) an ability to apply knowledge of mathematics, science, and engineering;

b) an ability to design and conduct experiments, as well as to analyze and interpret data;

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;

d) an ability to function on multidisciplinary teams;

e) an ability to identify, formulate, and solve engineering problems;

f) an understanding of professional and ethical responsibility;

g) an ability to communicate effectively;

h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;

i) a recognition of the need for, and an ability to engage in life-long learning;

j) a knowledge of contemporary issues; and

k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.[9]

Skills development

Software Engineering professionals need a well-defined skillset to implement and apply knowledge they have gained in their basic software engineering program. India need to impart skill sets to software engineering professionals as perindustry requirements. Software engineering curriculum guidelines SE 2014 which is based on SWEBOK and SWEEP helps in identification of different areas of skill set required by a software engineering professional .

Certification and Licensing

Certification and licensing is a mechanism to assure expertise of a professional software developer and helps in avoiding the risks of unprofessional practices. Licensing of software engineering professionals was initiated by IEEE. Certification is a voluntary process handled by profession to ascertain that the engineer has achieved a particular level of expertise of a specific body of knowledge. Licensing is a non-voluntary process controlled by the government agencies.

In India, licensing, and certification has to be introduced to ascertain that a software engineering professional is having a required level of competency; following is required for licensure:

) ABET accredited bachelor's degree ;

) Fundamentals of Engineering exam qualification;

) At least four years work experience under the supervision of a licensed professional engineer;

) Passing the Principles and Practices of Software Engineering (P&P) exam. [10]

To practice software engineering profession in international market Indian engineers require internationally recognised degree but also internationally recognised licensure. "Licensing will bring international recognition of India software engineers, as it indicates high competence. In India licensing can be offered at state level and also at national level by government agencies which then be mapped to international level"[6].

Code of ethics

Software engineering profession has to abide by the social norms and code of ethics is a mean of putting such constraints; assuring practitioners follow social norms; making them socially responsible and trustworthy. The software engineering code of ethics helps practitioners in decision making. Software Engineering has its own Code of Ethics adopted by both the ACM and the IEEE–CS. ACM's first code was adopted in 1972 and later after gone through an extensive review process, in 1992 ACM's latest code was adopted. "From 1992 till now, computer technology has drastically changed and has become so pervasive and ubiquitous that it has become life line of modern society. Computer technology has now integrating in our body which is making cyborg concept true — Bionic eye, Oculus earbuds, insulin pumps and pacemakers. Technology controls our communication, transportation, health services, education, wars and all areas of our lives. Computer technology has so radically changed in these 25 years that updating code of professional practices and its rules pertaining to society is sine qua non"[6]. The ACM council gave responsibility for update existing code to "Code 2018", to The Association for Computing Machinery's Committee on Professional Ethics (COPE). COPE has to complete three projects

up to 2018: "Updating ACM's Code of Ethics and Professional Conduct, revising the enforcement procedures for the Code, and developing new media to promote integrity in the profession"[11] . (See Juneed, et. al., 2017, "Computer Ethics from Obscure to Ubiquitous"). Code 2018 will work on following principles:

- The Code should continue to document the ethical and professional responsibilities and obligations of computing professionals.
- The Code should express the consensus of the computing profession on ethical issues.
- The Code should be used as a guide to decision making.
- The Code should educate both the public and aspiring professionals about the professional obligation of all computing professionals.[12]

India can be a part of Code 2018. Indian computer professionals from academia as well as industry should join ACM Special Interest Group (SIGCAS) that deals with social and ethical aspects of computer usage. SIGCAS members are specially invited to join the Code 2018 Task Force. India is now a major player in software development thus it has a greater role to play in providing its perspective of the fields which need to get updated. India has to provide inputs which reflects changes in technology and society, as draft 3 of the Code 2018 to be published on January 1, 2018 is under preparation[13]. India also need to set up a software council that makes it sure that software engineers adhere to the Code of professional practices and summons punitive hearings on mal-practicing software engineers.

Professional development

Professional development is to attain special skills and knowledge by continuous education and training for professional practices after completion of initial professional education. The IEEE Computer Society published the first edition of The Guide to the Software Engineering Body of Knowledge (SWEBoK Guide) in 2004. The current edition, SWEBoK V3.0, was published in 2014[38]. In 2016, IEEE Computer Society started the next iteration work for SWEBoK Evolution[14]. According to SWEBoK V3.0, "professional development through training and study add skills and knowledge to the software engineer's portfolio; reading, networking, and experimenting with new tools, techniques, and methods are all valid means of professional development"[15].

Professional development in India is diffused, scattered in many areas and clouded. There is no standard protocol that software engineers can follow. We believe Indian professional societies like Computer society of India (CSI) should perspicaciously realize its importance and take concrete steps to set up standard guidelines for professional development. Software engineering skill set, knowledge and acquisition of certification or licensure will all be as per professional development guidelines. There must be well defined protocol making constant upgrading of knowledge and skill set of software engineers obligatory.

Professional society.

Professional societies provide a spaceby means of conferences, seminars, symposia, publishing journals, textbooks and reference booketc.for software engineering professionals to interact with fellow professionals for individual and professional development. Professional societies make software engineering profession and professionals flourish and it deals with:

- Define criteria for licensure
- Manage certification
- Development of standards
- Development of body of knowledge
- Define code of ethics
- Curriculum design
- Guidelines for professional development

Computer Society of India (CSI) is the main organisation in India representing computer professionals. In India CSI encourage students and It professionals; promotes Research, Knowledge Sharing, Learning and Career Enhancement [16]. CSI organizes national as well as International seminars and workshops; constantly for continuous education and professional development. CSI has a big role to play for making software engineering a mature profession in India; development and interaction of all components of software engineering profession is a prime concern. CSI has to take concrete steps to[6]:

- make the curriculum in Indian Institutions in conformance to the guidelines prescribed by SE2014;

⌡ play a role to the emergence of software engineering licensing;

⌡ Setup guidelines for certification programs as per body of knowledge SWEBoK v3.0;

⌡ establishment of standards for software engineering professional practices.

⌡ actively take part in the next iteration work for SWEBoK Evolution started by IEEE Computer Society;

⌡ inspire Indian scholars and professionals for contributing and becoming part of code 2018;

⌡ organize seminars, conferences and symposia for making software engineering a mature profession in India;

⌡ create a mechanism for development and improvement of guidelines for the professional development.[6]

4. Who's job is this

Establishing software engineering as a profession in India is a challenging job; academia, industry and government everyone has to play a vital role. Computer scientist has a major role to play by establishing theories, paradigms, code of ethics and setting standards[17]. (See Juneed, et. al., 2017, "Computer Ethics: Job of Computer Scientist". To establish Software engineering as a profession in India is broadly Job of following:

⌡ Indian Computer scientist

⌡ Universities of India

⌡ Accreditation agencies like NBA

⌡ Professional societies like CSI

⌡ Software development companies operating in India.

⌡ Government of India.

⌡ Researchers and scholars.

5. Globalization.

Software engineering and software development is a global phenomenon. Software is made in India and used in other countries. Software is not confined by geographical constraints or bound to a particular jurisdiction. Unprofessional software can harm people across borders.The fast growth of internet use in India ,smartphones, social media, cloud computing and large array of smart devices and applications gets with a global phenomenon and at the same time haveincreased the vulnerability to crimes which canharm a person, a society or even a nation. Modernsocieties live in a cyberspace run by Internet. India, is the second largestInternet users in the Asia[18]. India has become a mill for the production of software engineers who then have to work in international market; they need international recognition and expertise recommended by international organizations.

On 13th June 2014, India became the 17th member of the Washington Accord which is an international accreditation agreement for professional engineering academic degrees, between the bodies responsible for accreditation in its signatory countries. NBA changed its accreditation norms and procedure as per the Washington Accord. Washington Accord does not cover professional computing and information technology academic degrees, for that India will have to sign the Seoul Accord. The main objective of Seoul Accord is the perfection of computing education worldwide. It is a multi-lateral agreement among agencies responsible for accreditation or recognition of tertiary-level computing and IT-related qualifications. Software applications are of universal nature and software engineers are not bound by jurisdictional boundaries, thus software engineering professional need an internationally recognized knowledge and abilities. The Seoul Accord has established a mechanism for recognizing the equivalence of accredited educational qualifications in the development of computing professionals[6].

India to upgrade software engineering to International level has to :

⌡ Sign Seoul Accord.

⌡ Sign Sydney Accord.

⌡ Sign Dublin Accord

⌡ Sign Budapest Convention on Cybercrime.

(See Juneed, et. al., 2017,"Cybercrime in India: Trends and Challenges,").

III. CONCLUSION

Software engineering is evolving as a mature profession at global level consisting of foundational theories, body of Knowledge and special skill set with methods and tools to apply software engineering

knowledge. Software is not confined by geographical constraints or bound to a particular jurisdiction. India needs to upgrade both educational and professional infrastructures to make software engineering a profession; Introduction of solid theoretical foundation; signing International accords to compete with global software industry; better statutes to meet international standards; ABET recommended accreditation and strengthening of professional societies.

References

[1] F. A. Goodman, *Process-based software project management*. Boca Raton, FL: Auerbach Publications, 2006.

[2] J. Iqbal and B. Maqbool, "Computer ethics from obscure to ubiquitous," *Int. J. Adv. Res. Comput. Sci.*, vol. 8, no. 3, Apr. 2017.

[3] J. Iqbal and B. M. Beigh, "Ethical Aspects of Software Engineering:A wake up call for India," vol. 5, no. 8, pp. 53–62, Aug. 2017.

[4] "Indias Computer Software Export – Electronics and Computer Software Export Promotion Council."

[5] "IT-BPM Industry in India: Sustaining Growth and Investing for the Future," NASSCOM, Hyderabad, India, Jun. 2017.

[6] J. Iqbal and B. Maqbool, "NonExistent Software Engineering profession in India."

[7] G. Ford and N. E. Gibbs, "A Mature Profession of Software Engineering," CARNEGIE-MELLON UNIV PITTSBURGH PA SOFTWARE ENGINEERING INST, 1996.

[8] "ACCREDITATION MANUAL FOR PG ENGINEERING PROGRAMMES (TIER-I)."

[9] "Criteria for Accrediting Engineering Programs, 2016 – 2017 | ABET." .

[10] P. A. Laplante, "Licensing professional software engineers: seize the opportunity," *Commun. ACM*, vol. 57, no. 7, pp. 38–40, Jul. 2014.

[11] R. E. Anderson, D. G. Johnson, D. Gotterbarn, and J. Perrolle, "Using the new ACM code of ethics in decision making," *Commun. ACM*, vol. 36, no. 2, pp. 98–107, Feb. 1993.

[12] B. Brinkman, D. Gotterbarn, K. Miller, and M. J. Wolf, "Making a positive impact: updating the ACM code of ethics," *Commun. ACM*, vol. 59, no. 12, pp. 7–13, Dec. 2016.

[13] "ACM Ethics," *ACM Ethics*. [Online]. Available: https://ethics.acm.org/. [Accessed: 23-Nov-2017].

[14] "SWEBOK Evolution • IEEE Computer Society." [Online]. Available: https://www.computer.org/web/peb/swebok-evolution. [Accessed: 25-Nov-2017].

[15] P. Bourque and R. E. Fairley, *Guide to the software engineering body of knowledge*. IEEE Computer Society, 2014.

[16] "CSI INDIA." [Online]. Available: http://www.csi-india.org/AboutCSI.php. [Accessed: 03-Dec-2017].

[17] J. Iqbal and B. Maqbool, "Computer Ethics: Job of Computer Scientist," *Int. J. Adv. Res. Comput. Sci. Softw. Eng.*, vol. 7, no. 6, Jun. 2017.

[18] J. Iqbal and B. Maqbool, "Cybercrime in India: Trends and Challenges," presented at the !st International Conference on Advancements and Innovations in Engineering, Technology & Management(ICAIETM2017), Joginpally B.R.Engineering College, Hyderabad, India, 2017.

[8] "ACCREDITATION MANUAL FOR PG ENGINEERING PROGRAMMES (TIER-I)." NATIONAL BOARD OF ACCREDITATION, Jan-2013.