Supporting Hands of a Tutor towards Activity-Based Education

Emmanuel Emem-Obong Agbenyeku, Edison Muzenda and Innocent Mandla Msibi

Abstract**—**Tutors generally play a vital role towards the academic success of students at the University of Johannesburg (UJ), South Africa, with specificity of this study on engineering students. As such, UJ continually invest in the drive of tutors through the Academic Development Centre (ADC) towards activity-based education of students or interaction (ABE/I) with students. In most cases, the activity-based interaction between tutors and engineering students may differ amongst tutors however, one common element remains the teaming/grouping of students with one or more tutors as head of the team in different subject/module. Nonetheless, it is emphasized that tutors do not act to assume or supposedly function as lecturers to students. Notwithstanding, the exact role of a tutor in activity-based education is somewhat indistinct to both tutors as well as to students. Nevertheless, to streamline and better inform the tutors of their role and performance as well as help them improve, the study opted for open and closed item questionnaire aimed at appraising the supporting hands/performance of individual tutors in one active semester term. Tutors responses to the open item questions informed the study about their strengths and weaknesses. While responses to the closed items provided insight to the supporting hands of a tutor with respect to the functional operation of a team/group, individual learning processes, the progress of the activity/task, the approach of the tutor to activity-based education and the tutor's role in imbibing in the students development of critical thinking and problem solving skills.

Keywords**—**Tutors, Activity-Based Interaction, Questionnaire

I. INTRODUCTION

THE main initiative of the activity-based education/interaction (ABE/I) is geared towards the emphasis on student-centred learning, the early contact of students with real-life problems and the development of transversal proficiencies like communication skills, time management skills and improved integration of contents by working on open edged problems in teams/groups through the assistance of trained tutors. Through this interactive approach between the tutors and the engineering students in question, a gap is bridged in the teaching and learning process. This is such that, via the consistent interaction of the students with their tutors, their self-confidence and interactive competence gradually grows to points where they communicate and interact more effectively and freely with their mates but most especially with their lecturers. The tutors serve as intermediates between specific modules and the team/group, as against an individual student. As such, facilitating the learning process of the group of students trying to develop competencies in areas that the lecturers may have outlined and the tutors are familiar with. This initiative is quite new in UJ yet it is fast gaining grounds and yielding positive results as tutors are quickly understanding and executing their roles effectively. Furthermore, since lecturers are often used to roles that are directly related to their expertise and are less used to roles that emphasize the support of students working in teams/groups, the supporting hands of tutors come in handy to narrow that gap. A number of tutor roles as recorded by [1] can be differently identified in a module activity, beginning with:

- The lecturer setting out an activity/exercise and handing it out to a tutor to administer or a tutor being the setter of the activity;
- Deciding on the form and content of the activity may in this case also be the tutor's role; and
- Being the stimulator of the students by showing interest, asking about the why, how and when of the activity, encouraging them to go in-depth with the exercise and helping them to get through difficult periods likely to manifest over the long lasting activities;
- A tutor can also be a monitor of the ABE/I learning process- a role whereby learning through team/group effort is encouraged and the tutor supports the growth of cooperative effort to execute various functions essential to effectively and successfully accomplish the activity.

The study therefore, posits that a tutor could serve as a technical expert and as an evaluator bearing in mind the importance of recording and reporting every stage of task concluded to the lecturer concerned. The lecturer in turn may not entirely propose specific roles to a trained tutor, however, may recommend likelihoods for a tutor to engage in one or more of the roles described above [2]. In most instances, the tutor's role relies on the nature of the module activity that is pursued as well as the nexus of ideas between the lecturer and the tutor.

Manuscript received March 0, 2016; revised March 0, 2016; submitted for review April 15, 2016.

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Considering that an exercise is based on certain activity (ies) which occur within the boundaries of a specific topic in a module, and in this case the lecturer and the tutor responsible for the subject area approach it with a nexus of ideas, the degree of interdisciplinarity in such an instance is narrowed down.

In a case where the exercise is based on the component of an activity involving more than one subject area with a higher degree of interdisciplinarity, lecturers and tutors from different areas will be required to narrow the gap through a synergy of ideas.

Whereas, for an integrated subject area involving certain parts of the curriculum to execute an exercise, the exercise is no longer isolated from the subject area but the subject area becomes partially or wholly replaced by the exercise. At this point, tutors do not automatically assume the positions of lecturers of the specific subject areas represented in the exercise/activity, but are however, selected by lecturers as heads or group leaders of one or more student teams/groups. It is nonetheless noted that, based on the characteristics of the exercise/activity certain roles may or may not be appropriate for a tutor to administer and thus, should be properly addressed by the lecturer.

For a lecturer, being the setter, a technical expert or an evaluator of an activity, requires content specific knowledge. On one hand, this cannot always be expected in the case of tutors who are mostly appointed as facilitators without necessarily being related to a specific subject/content area. On the other hand as recorded by [3], the role of a tutor in stimulating cooperative team/group work, encouraging motivation and monitoring individual and group learning processes becomes more important in an integrated and extensive interdisciplinary exercise. This is further emphasized by [3], positing that teams/groups that do not display equal input of all members, need extra effort from their tutors which is something only tutors might have time to indulge in. According to [4] the roles of tutors can appear ambiguous in the eyes of both the lecturers and the students thereby, expecting unrealistic outputs from the tutors. Nevertheless, as students have certain expectations of their tutors so do tutors have expectations of their students as well as ideas about their tasks and responsibilities which often times never correspond. The following identified functions executed by tutors were gotten as feedbacks from a survey among tutors at the Faculty of Engineering and Built Environment (FEBE):

i. permanently monitoring the group while reaching project goals
ii. partake in exercise assessment (reports and presentations)
iii. establish a close relationship with the student team
iv. monitor the progress of the activity/exercise
v. partake in individual assessment of team members
vi. communicate problems to the coordinators/lecturers
vii. contribute to the organization and coordination of the exercise
viii. function as a privileged communication channel towards the group
ix. identifying organizational problem within the team
x. identify personal problems that reduce individual performance as well as guide and refer students to the relevant lecturer.

The tutors also highlighted some actions inappropriate for them to discharge:

a. disclose confidential information to lecturers or public
b. interfere in the content of the activity/project
c. disagree with or dispute staff/lecturers
d. help the group/team with specific content related to the lecturers specialization
e. break/betray the confidence of the student team.

In this light, the functions identified by the tutors were born out of their experiences from the multiple interactive sessions with the group/team of students involved in the ABE/I in FEBE.

II. BUILDING BLOCK

The UJ through the ADC and with specificity, the teaching staff of the FEBE invest in tutors as facilitators of learning. This is basically geared towards the insistent academic improvement of the engineering students amongst other things. However, the success of the activity/project via the supporting hands of tutors in all facets, including the performance of the tutors is of immense interest. For this reason, the tutors have been recognized to play a pivotal role in ABE/I as they have the closest contact with student teams/groups, possess a more comprehensible view on what students are doing, the failures and successes they are facing related to their academic goals and pursuits as well as from a group interactive and communication perspective. However, one challenge remains the lack of clarity on the roles and functions of a tutor among lecturers generally. To better understand the roles of a tutor on the one hand and on the other hand evaluate the tutor's performance (supporting hands) towards ABE/I thus, became the intentions of this study carried out at the FEBE, UJ. Vast number of 1st and 2nd year engineering students partook in the study from the different engineering departments.

III. APPROACH

In accordance to [1] questionnaires were developed based on the tutor roles combined with information from the experiences of tutors involved in the ABE/I at the FEBE, UJ. Often times, studies have revealed that the roles of a tutor involve problem-based learning rather than activity-based learning, usually more aimed at the group/team process and less at the activity goals needed to be actualized [5]. The first type of instrument was ran at the Chemical and Metallurgical Engineering Technology which saw the exclusion of a scale- on assessment. This was because lecturers and students established that tutors should not partake in the assessment of their group/team. Considering that the reliability of this scale was 47, the entire scale was better excluded. This led to the reformulation of other items, particularly those that denoted the tutor as a content expert, as they were found to confuse many students as was also the case recorded by [6]. However, the role of the tutor in achieving the set-out goals, which distinguished a tutor in problem-based learning from a tutor in activity-based learning were included in the first and the second type of instrument. More to this, the second type of instrument comprised of six scales and the first scale denoted knowledge of the ABE/I having 3 items. The second scale pointed to the attitudes of a tutor towards the set goals- which involved 11 items aimed at reflecting the attitudes of a tutor with respect to ABE/I, the tutorials and the interaction/communication between students and the tutor. The third scale relates to the progress of the student group/team in an activity- this involved 10 items intended to analyze students' thinking about the manner in which the tutor monitored the progress of the activity. The fourth scale contained 4 items benched on the development of critical thinking and problem solving skills. The fifth scale called the penultimate scale, had 7 items involving the group functioning of the student team, including, items on the interaction/discussion of peer and self-assessment results amongst others. The sixth and last scale possessed 3 items tied to the learning process of the individual student. Outside the 35 closed items, two open items were included to aid specific comment on the supporting hands/performance of tutors. Also, a last general closed item was included for a general quantitative evaluation of the tutor on a 10 point scale. In total 60 students indulged in the tutor assessment exercise. 40 students were 1st year and the remaining 20 students were 2nd year all from FEBE, UJ. The latter group consisted of an equal distribution of the Chemical Engineering students, Metallurgical Engineering students, Civil students and Mining Engineering students. The student teams for both the 1st and 2nd year included 6 students. The questionnaire was applied at the end of the term in the last activity week. The tutors of the 1st year were designated in the study as- tutor U to Z and were all trained and experienced tutors who had served as tutors in two or more ABE/I experiences. Two of the tutors for the 2nd year also tutored the 1st year, both from the Chemical Engineering Department. The two other tutors- tutor A and B were new tutors from the Department of Civil and Metallurgical Engineering respectively.

IV. OUTCOMES

A. Results and Findings

The internal consistency of the seven scales of the Tutor Evaluation Questionnaire was estimated by the Cronbach alpha coefficient as described by [6] and was generally considered to be satisfactory. Table 1 presents the questionnaire reliability analysis. The reliability scale on critical thinking and problem-solving was observed to be low. This may have plausibly been due to the abstractness and extensiveness of items of this scale as was closely observed by [6].

TABLE I
Questionnaire reliability analysis

Properties/Scale	Item No.	Mean	SD	Cronbach alpha
Knowledge of ABE/I	3	11.98	3.15	0.71
Attitudes	11	43.63	4.97	0.78
Project progress	10	37.75	4.75	0.87
Critical thinking-problem solving	4	15.49	1.53	0.62
Group/Team Functionality	7	25.87	4.16	0.74
Individual learning	3	10.42	2.15	0.68

From the findings and results of the questionnaire for the 1st year students presented in Table 1 and 2, the scores on each scale reveal the tutors strengths and weaknesses. A lot of variations can be seen from the outcomes of the respective tutors however, some general comments can be made. The ABE/I knowledge scale was found to have the highest score in four groups while the attitudes of tutors with regard to ABE/I and the drive for critical thinking and problem solving skills are also seen as the strengths of tutors. The support for individual learning processes was however, not positively evaluated. It is observed that in seven out of ten student groups, it appeared to be the weakest point of the supporting hands/performance of tutors. In this light, the 1st year students were observed not to differ from the 2nd year students. Moreover, a low score was observed in both groups in the aspect of individual learning.

TABLE II
Outcomes of 1st year Chemical engineering students

Properties/Scale	Min.	Max.	Mean	SD
Knowledge of ABE/I				
Tutor U	11	13	11.34	0.983
Tutor V	10	14	12.34	1.66
Tutor W	13	13	13.00	0.02
Tutor X	9	14	11.25	1.53
Tutor Y	9	13	9.34	0.698
Tutor Z	12	14	13.15	0.983
Attitudes				
Tutor U	37	48	42.21	2.14
Tutor V	37	48	44.17	3.76
Tutor W	37	41	39.53	1.65
Tutor X	39	50	45.54	2.26
Tutor Y	35	38	38.79	1.12
Tutor Z	48	52	49.34	1.69
Project progress				
Tutor U	28	41	35.2	3.56
Tutor V	35	44	39.3	2.75
Tutor W	29	33	30.45	1.24
Tutor X	31	47	37.87	3.16
Tutor Y	28	41	32.6	3.57
Tutor Z	45	48	46.85	1.11
Critical thinking-problem solving				
Tutor U	12	17	14.56	1.35
Tutor V	12	17	16.12	1.87
Tutor W	13	17	16.12	1.05
Tutor X	13	16	14.74	0.85
Tutor Y	12	16	13.87	1.32
Tutor Z	15	18	17.34	1.21
Group/Team Functionality				
Tutor U	25	31	27.35	1.76
Tutor V	23	29	27.13	1.83
Tutor W	21	25	22.56	1.12
Tutor X	16	30	24.87	2.54
Tutor Y	14	27	23.98	3.28
Tutor Z	29	33	30.93	1.09
Individual learning				
Tutor U	7	11	10.3	1.32
Tutor V	7	12	10.42	1.56
Tutor W	5	9	7.89	1.11
Tutor X	6	11	9.34	1.86
Tutor Y	7	13	9.65	1.61
Tutor Z	12	13	12.54	0.44

Considering the scores in the 2nd year group shown in Table 3, it is clear that Tutor A shows the highest scores at every scale as against the other tutors. Tutor V however, showed the second highest scores on each scale while Tutor B and U were either third or fourth on each scale. Furthermore, it can be seen that more experience as a tutor does not inevitably mean a better impact on student performance of a tutor, as tutor A and B were inexperienced in ABE/I whereas, U and V had several years of experiences. It is therefore noted that the outcomes of Tutor U and V reveal variations in the assessment of their 1st and 2nd year student groups. In line with the open items of the questionnaire, it can be said that the 2nd year students left either one or both questions blank. Those who responded to only one of the questions always chose the first one on the positive aspects of the tutor. The 1st year students displayed a similar pattern as 20 left one of both questions blank, and in case of one unanswered question, it was always the one on expectations that were not yet met. These outcomes were much similar to those reported by [6] although, upon analysis of the responses to the open questions of the 2nd year students, it appeared that they would like the tutor be more present at meetings and for longer durations. This observation was made by a number of students who also were of the opinion that tutors should pay more attention to identifying students in group who contribute more.

TABLE III
Outcomes of combined 2nd year students

Properties/Scale	Min.	Max.	Mean	SD
Knowledge of ABE/I				
Tutor U	8	13	10.34	1.57
Tutor V	9	12	11.34	1.06
Tutor A	11	13	13.00	0.52
Tutor B	7	13	10.65	1.53
Attitudes				
Tutor U	33	44	36.21	4.88
Tutor V	38	59	38.17	4.76
Tutor A	47	51	44.53	2.17
Tutor B	35	48	34.54	2.26
Project progress				
Tutor U	29	45	35.2	3.94
Tutor V	32	46	39.3	3.72
Tutor A	37	47	45.45	2.05
Tutor B	27	37	33.87	2.16
Critical thinking-problem solving				
Tutor U	10	17	14.56	1.95
Tutor V	13	16	15.12	1.12
Tutor A	15	18	16.12	0.25
Tutor B	11	16	15.12	1.54
Group/Team Functionality				
Tutor U	19	28	24.35	2.96
Tutor V	21	30	26.13	2.73
Tutor A	29	32	32.56	0.25
Tutor B	15	28	22.87	3.54
Individual learning				
Tutor U	7	10	8.78	1.02
Tutor V	8	11	9.65	1.14
Tutor A	9	13	11.43	1.16
Tutor B	4	10	7.54	1.89

From the perspective of the 2nd year students, motivation, availability, answering questions, interaction, believing in the team's ability were considered vital contributions of the tutor to the outcome of the student groups. Whereas, the 1st year students showed a more varied pattern of answers to the open questions, they also noted that their tutor kept them on track when they felt lost, that the tutor gave valuable information on how to attempt and answer questions, format reports and presentations, that they got vital feedback on their reports, got help with critical analysis when necessary and that the team spirit was held high by the tutor as part of the tutor's important contribution. Nonetheless, the 1st year students barely made any clear comment on expectation that had not yet been met but suggested increased representation at meetings, slightly tougher activities and the tutor being more thorough happened to be the peak of their opinions.

V. Conclusions

The study was directed towards recognizing the supporting hands of tutors in the education of engineering students at the FEBE, UJ. This basically involved addressing the role of the tutor in ABE/I which was subjected to the administering and analysis of questionnaires targeted towards evaluating the tutor performance/supporting hands of tutors. The outcomes of the questionnaire being applied in two different groups having experienced and inexperienced tutors revealed wide variations between the 1st year tutors and a wider variation between the 2nd year tutors. The questionnaires provided useful information on the supporting hands of the respective tutors and a clear indication of their respective strengths and weaknesses. The outcomes further revealed that having more experience from years of tutoring did not guarantee a better performance with respect to the student groups. This offers room for more investigations as one would rather expect the outcome of an experienced tutor to best the outcome of an inexperienced tutor. From this study however, the tutor with the highest scores of the 2nd year was a first time tutor/inexperienced tutor as against the tutor with the lowest scores of the 2nd year being a very experienced tutor with over two years of tutoring experience. The tutors who served both in the 1st and 2nd year groups had higher scores in the 1st year, although the variations were seen to be higher for tutor U than for Tutor V. The seven scales initiated in the study showed aspects of tutor performance that clearly differed from traditional tutor performance. The outcomes may aid respective tutors recognize their strengths and weaknesses, but may also offer a starting point for learning amongst the tutors.

The items on problem solving and critical thinking need further attention and will perhaps need to be paraphrased for easier comprehension to the 1st year engineering students. The questionnaire focused on specific tutor functions like supporting group processes, monitoring progress and driving critical thinking and problem solving skills. These aspects of tutor performance is an instrument seen as a useful supplement to the standard questionnaire which may be deployed to other engineering departments to facilitate the improvement of their ABE/I learning experience. Considering the fact that ABE/I learning may be interpreted differently by in various modules and by various institutions, studies to further analyze the efficacy of the instrument in diverse framework would be vital. Prior to administering the questionnaire, tutors were unable to ascertain opinions of students with respect to their supporting hands/performance as tutors. However, they are presently receiving relevant information that can aid them assess and improve their performance. Nonetheless, it is common practice in most institutions to evaluate teaching performance and give feedback to lecturers, feedback on tutor performance is often or never included in such teaching evaluation processes. Thus, the instrument developed herein may can assist in analyzing the roles of tutors in ABE/I and improvement of their performance not limited to activities that can lead to developing certain proficiencies, but also to an acceptable end produce.

Acknowledgment

The Authors appreciate the University of Johannesburg where the study was done.

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Manuscript received March 0, 2016; revised March 0, 2016; submitted for review April 15, 2016.

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Prospective Inclination of Research and Engineering Education

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Abstract**—**The roles of Engineers are generally vital as their knowledge and expertise play a pivotal part in societal improvement, offer empowering ideas, innovations and initiatives that motivate financial and economic progress, enrich social and physical infrastructures, and also stimulate transformations that advance quality and standard of living. Concurrently, there are enormous challenges weighing on all facets of research and development (R&D), industry and manufacturing owing to globalization and circulated manufacturing. On this note, the corporate and commercial setting of manufacturing enterprises are categorized by incessant modification and growing intricacies. Most companies are in dire need of dynamic technical solutions as well as handling composite socio-technical systems geared towards substantially contributing to the sustainable growth and development of manufacturing and the environment. For this reason, in the ever changing industrial and business world of Engineering, Health delivery, Environment, Transportation, Logistics and Supply chain amongst others, researchers and graduates are profusely required once they display the ability to comprehend both composite technological processes and the resourceful arts and social skills. Thus, through the proficient technical and communication skills of engineering managers, various team-based activities are successfully supervised and executed. As such, aiming at the crucial role of engineering in solving simple to compound global problems make the career attractive to all gender of students.

Keywords**—**Sustainability, Engineering Education, Socio-technical systems, Researchers, Engineers

IV. INTRODUCTION

IT is very pertinent to note and admit that the global issues weighing on the diverse aspects of life today requires an even more diverse and composite framework of society, environment, economy and technology to resolve them. The chatter for sustainable growth, development, implementation and enforcement have been in the frontlines of events in almost every facet of industrial, sectorial and global pursuits in present times. More to this, economical sustainable production/manufacturing, high added value and knowledge-base are generally seen as basic drivers of industrialization diversification. It is generally known that engineering design and push-out production as well as the broader scope of engineering impacts fundamentally all areas of society. This implies that a large portion of the population are considerably involved executing the plans and designs of engineers. However, with all of these insistent global changes and challenges, one question is often asked by the general public: what then is the task of engineering in addressing and resolving the needs of society? As reported by [1] this question is persistently being asked with a greater tone of firmness by societies, considering what they have profited from massive improvements in technology, and on the other hand, all they have lost and experienced by technological association and involvement.

Nevertheless, it must be emphasized that the debates and questions about technology are often mixed up with questions about engineering. Regardless of the increasing database and literature on the respective connection of technology and engineering to the society, the mind of the public still perceives it differently. As earlier stated, the downsides, impacts and side effects of technology have come a long way yet continues to increase as it concurrently adds to the doubt of societies. In light of the fact that it may be inappropriate to fault the engineer for the seeming lack of interest by the broader society in understanding the technological process with all its limitations and prospects, it is however, expected that engineers can possibly do more to lessen societal doubts by way of open mindedness and active involvement. As recorded by [1] the National Academy of Engineering announced the following "Engineering Grand Challenges" to include the following:

i. Make Solar Energy Economical;
ii. Provide Energy from Fusion;
iii. Develop Carbon Sequestration Methods;
iv. Manage the Nitrogen Cycle;
v. Provide Access to Clean Water;
vi. Engineer Better Medicines;
vii. Advance Health Informatics;
viii. Secure Cyberspace;
ix. Prevent Nuclear Terror;
x. Restore and Improve Urban Infrastructure;
xi. Reverse Engineer the Brain; Enhance Virtual Reality;
xii. Advance Personalized Learning; and
xiii. Engineer the Tools of Scientific Discovery.

Human survival and existence relies strongly on some of the mentioned challenges as some will guard against human and natural threats but ultimately all of the listed challenges are targeted at advancing the quality and standard of living. An observation by [1] stated that all the listed challenges are

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multifaceted issues of global measures that also coincide as socio-technical composite structures.

V. PUBLIC PERCEPTION OF ENGINEERING

Generally, engineers in/ by training as well as a large portion of society regard engineering as a mere form of applied science. Contrary to the general perception, engineering entails more as it is an integral part of society. As such, an education that highlights engineering and society, or better still, "Engineering Arts", as against the known conventional and traditional Engineering Science is what is required towards a paradigm shift. The functionality and sole existence of engineering is intertwined with society and as such one cannot be independent of the other as each is a required portion to feature and operate within reality. Hence, a better comprehension of what necessities and constrictions are laid on engineers by the rest of society including what role the engineer realistically can or should play in that society requires dire attention.

A. Socio-Technical Structures

The nexus between engineering and society is multifaceted gearing towards the core of impracticable expectations over conventional and traditional engineering, as on the one hand, social units are becoming more inefficiently organized to advance and utilize engineering effectually. While on the other hand, engineers unable to take their abilities and transform them to solutions of social/ societal problems or channel them towards the operative organization of the engineering enterprise are fast becoming frustrated. However, engineers should find the socio-technical structure an agreeable and more realistic leeway. This is because as engineers, and particularly field and production engineers for that matter, have to engage in active systems i.e., technical systems all the time and become conversant with how to design, analyze and oversee/ manage the process. In the case of the socio-technical model, the entire society is envisaged as an enormous unified system, having diverse social and technical areas of human activity as major networking subsystems. Engineering in this context feature as one of the subsystems. Hence, to examine the subsystems they must be split into sub-subsystems and sub-modules, components and even items; which are then analyzed independently with a view to recoupling the whole system. The idea of engineering as an adaptive socio-technical subsystem functioning within the adaptive socio-technical structure of society offers an even greater compound model to instrument. This comes closer to reality, although, than the model of engineering and society as different and discrete units.

B. Need for Socio-Technical Structures

In present times, it is more or less a cliché to express how any single technology can be utilized in multiple ways and applied to various unanticipated conducts. However, it is pertinent to note that, for every distinct application, the technology is imprinted onto a multifaceted set of new/ other technologies, procedures, people, physical surroundings etc., that collectively compose of the socio-technical structure. Therefore, only when this structure is understood can it be used to analyze the societal, ethical and environmental challenges and effects. More so, numerous ethical challenges are closely connected to the social/ societal and environmental structures. As such, they are socio-technical systems and the ethical challenges connected to them are founded in the actual combination of technology and social structure. Furthermore, it is the technology entrenched in the social systems that forms the ethical challenges. The major task/ dilemma presently is finding an equilibrium between the rights and freedoms of individual' and that of society.

C. Socio-Technical Structures and Inclinations

Social changes have over time evolved with evolving technologies. This includes the industrial transformation/ industrialization triggered by technology, together with the expansion and extension of cities and suburbs caused by the automobiles. In today's day and age, the computer-inspired century of information technology and wireless communication systems have transformed entirely everything around the globe. As such, through technology the truism about the world being a global village has been drawn closer to reality. As time continuous to progress, man and machine increasingly interact as the dependency on computer systems, information systems, social media systems and communication systems, on and off-line information systems, system weaponry etc., are insistently increasing and constantly being adapted and used in everyday life. Mass production of standardized goods born out of industrialization, caused to a great extent the limitation and/ or deprivation of freedom of choice of consumers.

The present jet age has allowed computers the potential to provide individuality, through flexible, reconfigurable computerized manufacturing that permit vast ranges of individualized products. Nevertheless, one essential remain of the jet age is the increase in complexity which includes; technological systems, business systems, and social systems complexities. These composites appear to illustrate a form of the second law of thermodynamics- Entropy, which is insistently increasing. This phenomenon is particularly displayed in large-scale systems such as global distributed manufacturing, transportation, the environment and the earth's ecosystem, as well as in the strategic defense and security systems. One vital question of whether the ability of computers to manage complexity and information, and decision systems can keep up with the persistent rise in complexity is forever on the lips of the general public and society. However, there seem to significant hope due to the influence of modelling, simulation and availability of supercomputers which may be deployed and harnessed to address socio-technical problems thereby, allowing a new and better understanding as well as offer the ability to deal with societal problems. Considering that the social and business systems have also been adapting to the information age, intellectual property has become a vital aspect of law which has added its own complexities to an increasingly divisive society. The financial system has new problems of stability and control, as exemplified by program trading and the increasing volatility of the market. More to this, the recent savings and loan crisis has shown the vulnerability of the banking system. The time constraints and turbulence in the economic system have also worked against the development of new science and technology, as business leaders are more engrossed in short-term profitability rather than the long-term investment required for stable research.

III. ENGINEERING EDUCATION AND SOCIETY

Understanding how engineering reacts to the needs of society requires critical assessment of its social and functional systems. For instance, most people who study engineering in North America have skills in higher physics, biology and mathematics while some have communication and social proficiencies. This seems to reduce their chances and involvement in politics as well as their success in communicating with the rest of society. In turn, an engineer is often seen by society as a narrow, conservative, numbers-driven person, unresponsive to subtle societal issues. The methodical study of socio-technical problems rarely features in engineering curricula as an important sphere of engineering activity. The curricula usually focus on man-made artifacts to the exclusion, except for specialized cases at the graduate studies level. This narrow focus has swayed engineering from not only a rich source of inspiration for specific technical achievements and knowledge obtainable by systems of great delicacy and complexity, but also a deeper understanding of environmental change.

According to [1] most high school students today do not view an engineering education as a path to success and prestige worthy of the sacrifices of a rigorous curriculum. Even bright young engineering students, upon graduation, switch to careers in business management, law, and medicine. Also, engineering continues to be a powerful tool for social mobility and advancement for immigrants and the poor. However, it is well recognized by most governments that in order for a country to prosper and compete globally, more engineering and science graduates are needed as they contribute immensely to a nation's wealth, growth and development. In various societies engineering offers most of the same outcome including; shelter, energy and communications, manufacturing, water supply, extraction and use of resources, and disposal of waste. There are societies however, where engineers carry out broader functions by virtue of the position they hold. In several European and developing countries, engineers head state organizations and major industry corporations, participate in government, and enjoy high social prestige. Although, in other parts of the globe like in most developing countries in Africa, engineers are absent from major positions of societal leadership, and only a handful serve in government, in Congress, in Parliaments, or at the cabinet level. The profession is, in a sense, handicapped in terms of serving society in a broader spectrum by a pecking order that prizes activities connected with the design of tangible products above the challenges of manufacturing, operations, and maintenance, or public service at large.

A. Social Requirements and Obligation

Manufactured products have generally advanced through the gradual process that has shaped man and other biological species. As such, there is a constant question of whether the technology being developed enhances the long-range survival of our species. It should however be noted that there is increasing body of research that use biological evolution as a metaphor for developing products and systems as recorded by [2]. An important determinant of how well engineering satisfies its social purpose is the breadth of engineering. Engineering in present time proceeds significantly to center on inanimate products or machines, as engineering school curricula worldwide continue to bypass socio-technology. The factory environment single-mindedly rationalized by the engineer F. W. Taylor discounted the effective integration of the worker, biological unit and the machine in the manufacturing/ production process. This is basically the case in virtually everywhere in the world, with Japan being in exclusion where a different social attitude created a more effective incorporation with humans, as well as the artificial version, known as artificial intelligence or intelligent robots. Another reason for the difficulty engineers encounter in dealing with social issues has to do with the various, and often conflicting, needs of social groups (educational, economic, environmental, health, public service, spiritual, and government) that engineering and technology may be expected to satisfy.

The recurrent conflict between advocates of independent and targeted research is an example and an inevitable result of the tension between short-and long-range needs. Nevertheless, such conflicts may cross the boundary between what is socially useful and what is out of control. Most governments in the developed world that fund research, including in developing Africa particularly South Africa, are at the edge with regards to this issue. A balance must be struck between short- and long-term needs. These projections both serve a useful purpose because it is impossible to have a strategy void of implementation and application. Equally, operating without a long term research base plan can have catastrophic impacts over time. For example, the health care system in most developed and developing countries, has increasingly engrossed a larger quota of gross national product, irrespective of the condition of economic prosperity. Also, it has continually become highly priced and more difficult to access to larger populace. More to the issues, the challenges of hunger, drought, poor crop yields etc., remains endemic in many parts of the globe regardless of advances in agricultural technology. In fact, where yield and production is high in some countries, produce and supplies are lost for lack of effective storage and distribution systems. At this juncture, the argument that engineers need to check their cultural responsibility and involvement to society as they contribute to transformation can be tabled. Therefore, as recorded by [3] effort must be initiated at university level and from professional societies towards educating prospective engineers as well as researchers. The following five guiding principles with some already rooted in the conscience of engineers were posited by [4]:

i. *Uphold the dignity of man*: - this is an essential value of our society that should never be violated by an engineering design. This could happen when the design or operation of a technological product fails to recognize the importance of individuality, privacy, diversity and aesthetics.
ii. *Avoid dangerous or uncontrolled side effects and by-products:* - this demands a rigorous development of a design or a technology considering all the functional

requirements and constraints whether social, political, economic, popular, or intrinsically technological.

iii. *Make provisions for consequence when technology fails*: - the importance of making provisions for the consequences of failure is self-evident, especially in those systems that are complex, pervasive, and put lives at risk upon failure.

iv. *Avoid supporting social systems that perform poorly and should be replaced*: - this runs much against the grain of most engineers. Short-run technological fixes can put lives at risk in the long-term. In the case of energy, for instance, technological or commercial fixes cannot mask the need to rethink globally the impact of consumerism and the interrelationship of energy, environment, and economic development.

v. *Participate in formulating the "why" of technology*: - *a*t present the engineering profession is poorly equipped to do so in South Africa and other countries around the globe. Few engineers, for instance, have been involved in developing a philosophy of technology. This separation of engineering and philosophy affects our entire society. Engineers, in shaping our future, need to be guided by a clearer sense of the meaning and evolutionary role of technology.

The great social challenges facing virtually the whole world today requires rethinking of the human-artifact-society interrelationship and the options it offers us to carry out a growing number of social functions using quasi-intelligent products to instruct, manufacture, inspect, control, and so on.

IV. PROSPECTIVE RESEARCH AND ENGINEERING

Present generation of students are better inclined with global issues and the need for new approaches than their predecessors. For this reason [3] discussed the future of engineering in detail. By focusing on the critical role of engineering in solving the most complex global issues, aspirations to make the profession more attractive to both male and female students, especially the latter is ensured. The new definition of engineering/ engineers according to [5] defined it as: "The enablers of dreams". Engineers play a vital role in societal development, contributing to and enabling initiatives that drive economic progress, enhance social and physical infrastructures, and inspire the changes that improve quality of life. Engineers are committed to helping provide the best possible quality and standard of living for all of society. Therefore, the aspiration that engineers will continue to be leaders in the drive for the use of wise, informed, economical and greener approaches towards sustainable growth and development in all facets of societal needs is very pertinent. However, this should commence from the grass root of educational institutions and be founded in the basic principles of the engineering profession and its actions. The objective for a future where engineers are prepared to adapt to changes in global forces and inclinations and to ethically assist the world in creating a balance in standard of living for developing and developed countries alike is paramount to paving way for a sustainable future.

The following resolve should therefore be targeted towards bettering the prosperity of societies going forward:

I. Deliver engineering innovation domestically and to the global community

II. Deliver specific engineering capabilities that will be needed in the future to improve health and safety, provide for a cleaner environment, and enable more sustainable development

III. Address areas in which advocacy by the engineering profession can lead to public policy development and directly contribute to an standard and quality of life

IV. Make educational improvements that will foster broader involvement in the profession by all segments of society and nurture innovation.

Also at a higher level, it must be acknowledged and ensured that the following are pursued going forward:

a. A larger collaboration across disciplines and professions
b. An increase engineers' influence and involvement in policy making
c. A re-assessment of accreditation processes
d. A transformation in engineering education and practice
e. An encouraged participation of all groups and peoples
f. An attractive and retaining environment especially for women in larger numbers.

Attention to sustainability and globalization issues should therefore be propagated towards educational objectives and key prospective inclinations that will aid redefine the future and interaction between engineering and society through the following:

- Challenges in developing secure and sustainable forms of resources, including energy and water
- The need to develop more sustainable practices in all branches of engineering
- Increased opportunities for technology to improve human health
- Globalization and its impact on industrial supply chains, education, research and the human condition

Furthermore, the Guiding Principles and Core Professional values of Engineering should include:

1. An innovative and stimulating learning environment where students can prepare themselves to excel in life
2. To achieve the next level in research outcomes and reputation by building on existing and emerging areas of excellence
3. To build an all-inclusive society with related and shared purpose
4. To be honest, mutually respectful, fair and involved
5. To foster a collegial, interdisciplinary and innovative work environment
6. To respect and reflect diversity in opinions, recruitments and the society under construction
7. To engaged in engineering according to the highest standards of professionalism
8. To act ethically and with integrity
9. To expect the best out of students and nothing less
10. To instill in students the desire to learn
11. To inspire students to see themselves as global engineers
12. To be stewards of the environment and execute social responsibility in research and education.

V. Conclusions

This paper was a medium to explore the nexus between engineering and education as well as other disciplines. The paper pushed to emphasize the stretch of engineering across and in connection to various subject areas including technology, inclined to the challenges facing society. The basic point here from is to encourage a leading integrated, interdisciplinary undergraduate engineering education for all engineering students, with great specificity to females. Such that, students interested in an educational experience that offers a rich mixture which balances technical matters/ subjects can possess a deeper sense and understanding of the role of an engineer in addressing sustainability and the challenges, and key socio-technical issues affecting our immediate society and the global hub at large.

Acknowledgment

The Authors appreciate the University of Johannesburg where the paper was done.

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