Environmental Education and Socioresponsive Engineering

Report of an Educational Initiative in Hyderabad, India

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Keywords: environmental education, ethics code, socioresponsive engineering

ABSTRACT: *A recent initiative at Muffakham Jah College of Engineering and Technology, Hyderabad, India, has resulted in setting up a program called Centre for Environment Studies and Socioresponsive Engineering which seeks to involve undergraduate students in studying and solving environmental problems in and around the city of Hyderabad, India. Two pilot projects have been undertaken – one focusing on design and construction of an eco-friendly house, The Natural House, and another directed at improving environmental and general living conditions in a slum area.*

The paper describes our attempts and experience of motivating our students to take interest in such projects. In an interesting development we invited a member of a student-faculty team at Massachusetts Institute of Technology (M.I.T.) that is doing a project in Nepal on safe drinking water. We report in our paper how the presentation by the guest from M.I.T. served as a catalyst for generating interest among civil and mechanical engineering students in our own projects. The paper includes contributions from one of our students and the M.I.T. staff member, reporting on their experiences related to the slum development project.

We also discuss the Natural House project and its international and educational significance as a means of inculcating sensitivity and interest in nature among engineering students. We propose a pledge for engineers similar to the Hippocratic Oath for medical professionals.

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1. Setting Up the Centre and Initiating the "Maqta" Project

The first two authors of the paper – two senior faculty members from mechanical and civil engineering departments, respectively, at Muffakham Jah College of Engineering and Technology (MJCET) – have long had a passionate interest in, and commitment to, social responsibility of engineers. Ours is a small private, primarily undergraduate college, overseen by a vast and highly regimented university system. As such, we have no direct control over designing our own curriculum. The curriculum laid down by the university has a very small environmental education component (virtually none in mechanical engineering). Similarly, social issues related to technology, especially in the local, regional and national context, are nowhere considered.[1]

Given these constraints, it seemed logical to us to set up our own "extra-curricular" program to undertake not only environment-related studies in and around Hyderabad but also to help improve the living conditions of economically weaker sections of society through simple engineering inputs. That is how Centre for Environment Studies And Socioresponsive Engineering (CESSE) came into existence. We took inspiration from a lecture by the U.S. National Science Foundation's Deputy Director, Joseph Bordogna, at the M.I.T. Club, which includes the memorable line: "Engineering is not just about doing things right, but also about doing the right things."

We were able to form a small group of civil and mechanical engineering students to work under our direction and decided to initiate two projects – one for the direct social benefit of residents of a low-income area near us, known as Maqta, and the other related to energy-efficient and climate responsive building design. The second project, designated as the Natural House Project, seeks to model the cooling and heating systems of a house on the lines of those observed in natural systems.

The low-income community, Maqta, is among those worst affected by environmental problems due to extremely fast industrial growth in this metropolis of five and a half million in south-central India. Hyderabad, known until a decade ago mostly for its historical monuments and rich cultural heritage, has become the home of many high profile software companies and a host of multinational and big national corporations and industries. This has led to a spurt in construction activity and tourism development projects. One such recent project is the Necklace Road, an exquisitely landscaped, expensively built road that skirts a lovely lake in the middle of the city, called Hussain Sagar. On the other side of this new road is the low-income residential area, Maqta.

Some of the members of our group had observed high standing water in parts of Maqta during the monsoon season and general squalor and very poor living conditions. A detailed study of the area by students and faculty members revealed the source of the monsoon flooding problem. Prior to the construction of the Necklace Road by the government in 1999, rain water used to drain slowly but naturally into the lake. Necklace Road, a tourism draw and part of the city beautification scheme, was constructed as a high road, overlooking the lake and banked on the other side by a tall retaining wall to hide the slum area from view. This has aggravated the flooding

problem in the monsoon season. We discovered that as many as two hundred homes are affected, causing the residents to sometimes vacate their houses during heavy rains.

The underprivileged residents of the area are beset with innumerable difficulties including contaminated bore wells, poor sanitation, in some cases open sewers, broken handpumps, and an inadequate drinking water supply. We spoke to a doctor who has a clinic there and were told that many health problems of the residents are directly attributed to water pollution and general lack of hygiene, caused partly by inadequate water supply.

A group of civil engineering students, including many women students, undertook a detailed house-to-house survey of a random 10% sample, using a questionnaire which covered many facets of day-to-day life, such as family size, house area, availability and usage of water, literacy, income and employment data etc. Water samples were taken of municipal water, as well as those from the two open wells and a number of bore wells. These were tested for water quality. It was discovered that water in the open wells is unfit for drinking. It was also found that homes in some parts of Maqta have virtually no municipal water supply, even though they have water connection, and the women have to walk a fair distance and carry water in pots.

We decided that a comprehensive plan of improvement of living conditions is needed in order to tackle the complete chain of interrelated problems. The plan includes arranging vocational training courses for women and unemployed youth. Some notable features of the plan are discussed below by Professor Ashfaque Jafari, Head, Civil Engineering Department, who has supervised the civil engineering student group associated with the project.

2. Professor Ashfaque Jafari's Report

The Maqta uplift project, which was initiated by the first two authors along with about a dozen undergraduate students, has been extremely stimulating because of the myriad facets that have surfaced during the course of fieldwork. It wouldn't be an exaggeration to say that it has touched a raw nerve and thrown up issues much wider than we had anticipated. It is disturbing to accept that in some ways the field realities have shaken my firmly entrenched beliefs in environmental conservation.

Work on this project was commissioned due to two reasons; firstly, our firm belief that engineering undergraduates should be exposed to environmental issues. Secondly, they should be made to discharge their social obligations towards the underprivileged stakeholders of society.

It's an undisputed fact that for several years universities in India have been producing engineering graduates who hardly have any formal education/training in ecological and environmental issues. For many of them, technological advancement overrides environmental concerns. Does the engineering curriculum try to inculcate material-energy-environment conservation among the students? Most of the time, the answer is negative. It is no surprise that frequently engineers come up with new products and designs that are academic innovations but environmental disasters. In order to avoid such occurrences it is imperative that environmental issues be built into

the course curriculum and engineers be made to develop a positive attitude towards nature and its conservation.

Experience shows that being responsive to environmental concerns is more easily said than done. This is so because issues pertaining to the environment and its pollution tend to slide along the hierarchy of human priorities within a much larger economic and social milieu. They are pushed up to the top of the list during periods of peace and affluence, and are thrust down during periods of turbulence and hardship. The fact that it takes tremendous physical and financial effort to reclaim any contaminated soil, water or air body does not weigh on the minds during such times.

The house-to-house survey which was conducted in the Maqta area threw up something similar to the above-mentioned realities. This part of the paper describes in brief the problems of the Maqta area, the strategy adopted by the investigators and the continuous redefining of the goals and strategy, which was necessitated in response to the people's reactions.

Background of the Maqta area:

The Maqta area is a middle and lower-middle class residential locality spread over 160,000 square meter area. It has about 1500 dwelling units and the population is estimated to be a little over ten thousand leading to a density of about 50,000 per square kilometer. The entire locality is interconnected through narrow lanes and bylanes. The road network consists of cement concrete, bitumen and water bound macadam (WBM) segments in various locations. The condition of the roads varies from bad to worse due to lack of maintenance and haphazard trenching for water supply and/or sewer connections. The water requirements of the area are met through municipal supplies, bore wells and open wells. There is an underground sewerage system in the locality.

Goal statement of the Maqta Project:

To begin with, the investigators formulated a simple goal statement for the Maqta region, which may be stated as below:

- Improving the environment scenario of the area through a multi-pronged strategy targeting
- Safe Water Supply
- Effective Sanitation
- Solid Waste Management Strategy

After a few field visits, the goals were modified to include:

- Addressing the socioeconomic problems of the residents by instituting self-help schemes in association with local Non-Governmental Organizations.
- Leading a literacy and awareness drive on environment and health aspects for improvement in the quality of life.

The Strategy Adopted

The following strategy was formulated to achieve the above mentioned goals:

Physical Surveys
- Preparation of the road network map of the area using the Global Positioning System (GPS)
- Locating salient topographic features on the map
- Locating the position of public taps, bore well and open wells on the map
- Locating the public trash bins on the map
- Locating the public services like schools, clinics etc. on the map

House-to-house surveys
- 10% Sample Size to be considered
- Random number generation technique to be adopted to identify houses for survey
- Physical survey to assess number of people in the residence, income level, education level and health conditions etc.
- Physical survey to assess the water supply and sanitation scenario through specific questionnaires

Municipal Water Supply and Ground Water
- Quantitative assessment
- Qualitative assessment

Sewerage and Solid waste management
- Review the sewer system for adequacy and recommend augmentation if required
- Formulate a solid waste management strategy

Review of Health Conditions
Assessment of the prevalence of waterborne diseases to be done through
- Feedback from Community Workers
- Feedback from at least two local clinics
- Feedback from local Schools

Progress of the work

The fieldwork was started with the active participation of about 10-12 undergraduate students of Civil Engineering belonging to MJCET. It was observed that 59% of the population of Maqta was male, 17% of the people were totally uneducated and 16% were high school graduates. About 73% of the children attended local schools. This shows that the dropout incidence is very high. Seventy-eight percent of the population depended on the municipal water supply, which was about 70 liters per capita on alternate days. The chemical and biological quality of the municipal water supply conformed to accepted potable water quality parameters. However, the open well water

samples tested positive for biological contamination and the concentration of iron was also high, making the ground water unfit for consumption. The residents complained that some of the areas were facing acute shortage of water. It was initially planned to augment the municipal supplies with treated local ground water for the benefit of those residents who had to make do with deficient municipal supplies.

At this stage, it was observed that although the residents were complaining about lack of civic amenities and adequate water supply, they were reluctant to participate in any action plan to mitigate the hardship. The entire responsibility was deemed that of the local government. The Center for Socioresponsive Engineering is willing to arrange funds for this project, but it is our firm belief that any improvement should be through community participation which, at this stage, is not forthcoming wholeheartedly.

The residents are aware about environmental, hygiene and health issues. However, as mentioned earlier, these have been pushed down to the bottom of their priority list, which is dominated by better education, employment opportunities, and augmentation of family income.

The Muffakham Jah College plans to have a long-term association with the Maqta area. In view of this, we took a conscious decision to put on hold our technical and environmental improvement programs until such time that the local residents would willingly participate in those programs. Meanwhile, to facilitate the upward movement of these issues in their list of priorities, we brought in a local volunteer group (Asha for Education) and a central government aided vocational training institute to offer vocational courses to the residents. It is hoped that this step will kindle their desire for better facilities and environmental quality and they would be willing to contribute towards its achievement. We at MJCET look forward to that day to put our plan into action.

3. Visit by Heather Lukacs of Massachusetts Institute of Technology

Our Centre had requested a faculty member of Massachusetts Institute of Technology's Civil and Environmental Engineering Department, Susan Murcott, to serve on its international advisory board. We discovered that engineering students at M.I.T. have been working with Susan Murcott since 1999 on a project to provide safe drinking water on a household level in a rural area of Nepal. We also learned that a member of that team, Heather Lukacs, a lecturer at M.I.T., was coming to India to present a seminar and workshop on their work. We invited Heather Lukacs to visit us and meet our students, which she was able to do in November 2002. She presented a seminar on the M.I.T. Nepal Water Project and also visited Maqta. Heather's account of her experience of meeting our students and faculty and visiting Maqta appears below, followed by that of one of our own students.

Heather Lukacs' Reflections:

I arrived at Muffakham Jah College of Engineering and Technology in Hyderabad, India with at least two important, interrelated goals. The first was to inform Professor

Ali Ansari and his students of the work that we have been doing at M.I.T. and in Nepal on appropriate (or intermediate) technology development. Focusing on clean drinking water provision to those in developing countries in general and Nepal specifically, members of our M.I.T. teams have the opportunity to experience how people actually live in places where their technologies are implemented. This international fieldwork promotes iterative technology design as students become conscious of user feedback and environmental constraints. My second, possibly more relevant, goal was to learn from those in the academic community in India. I was curious to hear of the most pressing issues through the eyes of those at Muffakham Jah College and elsewhere. I was interested to learn from those who live surrounded by and understand the great diversity of challenges posed to the engineers of the 21st century. Through correspondence with Professor Ansari, I was aware of student initiatives such as the Natural House Project and the potential for engineering outreach work to lower income peri-urban settlements, and had hoped to identify parallels between their projects and our own student-initiated projects at M.I.T.

While visiting Muffakham Jah College, I was able to interact with various student and faculty engineering groups many of whom were female and/or of religious minority factions. I watched a student presentation on the Natural House design and toured the college campus. I also visited Maqta and observed firsthand the living conditions and separation wall described above by Professor Ansari. While I did indeed achieve my goals of information exchange, I find possibly greater value in the simple observations and reflections of my time spent in Hyderabad.

I was immediately impressed with how engaged the students are and their thoughtful approach to the real, pressing problems facing our world today. Unlike students in the United States who may not even know where their water comes from, every student at Muffakham Jah College has a deep level of understanding about water in general, concern for the sustainability of their water sources, and basic knowledge of water treatment. While this can partially be attributed to student interest, much of it is due to having a municipal water system that only provides water for a couple of hours every other day. This requires people to store and conserve water. Even though their curriculum may not explicitly require study of the environment, the professors and students that I met during my short visit confront many challenging environmental and social issues on a daily basis. Often removed from First World thought, these issues include real poverty, waterborne disease, hunger, water scarcity, and poor housing. In addition, cultural, social, and gender differences are much more apparent as they are part of everyday life at Muffakham Jah College. Women who are required to wear traditional dress (some of whom attend class with long dress and headscarf) only recently filled the classrooms. University doors are also open to rural village students and those of lower castes, and existing quota systems secure their places despite the expressed discontent of others. So, as raw sewage from newly built hotels runs down sidewalks past squatter shelters that are tucked into every available space and with living conditions in places like Maqta with 6 to 8 people often sharing a single room that risks being flooded in the rainy season, it is hard not to be aware of what the real issues are. Whereas in the US poverty and obesity are actually positively correlated, in

India poverty means stunted growth and early death due to lack of nutrition and waterborne disease – where poor people are significantly smaller in size than wealthy people.

In my opinion then if engineering education is to be sensitive to critical global issues we as educators need to engage students not only from all parts of the world, but also from a variety of social, economic, gender, and ethnic groups. Which is to say that if we truly want to unite the diverse elements of the international engineering education world we first must broaden the definition of "diverse". Colleges such as Muffakham Jah encourage their students to become educated, to speak, and to initiate projects. It then becomes a question of whether or not these diverse voices are heard and their words understood. It is only by listening to what such people have to say, by understanding what the problems they face really are, and by together helping to solve such issues, that real "progress" for all will be made. If our goal is really "engineering education" that addresses the real issues of today, let us be open to being educated by those who intimately understand these pressing problems.

Encouraging First World engineers to experience real life conditions in less-developed countries and by allowing engineers from these countries to come to places like North America and Europe, students themselves can identify the most relevant engineering challenges of today and of the future. This experience may lead some to question the importance of designing a new consumer good that will add to an already disposable society. They may begin to wonder if it is more worthwhile to assist, learn, and fund real, local initiatives that aim to help people who today thirst for what we take for granted. If we really want this process to be truly participatory, we need to have participation in all levels of international development – starting with engineering education – and creating socio-responsive engineers who understand the basic realities of the world we live in.

My academic experience consists of dual degrees from the Massachusetts Institute of Technology ('01,'02) where students come from all over the United States and world to study and learn together. While some are drawn by the fact that large salaries can be made upon graduating with an engineering degree, many are, in fact, drawn by the feeling that all seems possible when surrounded by many bright, like-minded, dedicated, inspired individuals. Many of these students desire to contribute to solving the many problems of our world today – and many, including myself, have sought out leadership within the academic community to help guide us in this process. Engineering students at places like Muffakham Jah College in India and M.I.T. in the United States are no different in that they want to solve these global problems; it then becomes a challenge to us as educators to funnel all this student spirit toward meaningful goals.

4. Zulfia Imtiaz Writes:

The concept of Socioresponsive Engineering as recently introduced at Muffakham Jah College of Engineering and Technology, is relatively new to most engineering students. In this fast paced world of dog-eat-dog and rat race competitions, it is

difficult for many of us to stay focused on the various responsibilities that we as human beings have towards the environment. Hence, it is a progressive step towards the birth of a more environmentally aware and responsible generation of students.

Such socially and environmentally responsive groups, though, are often subjected to ridicule at even the mention of the various environmental concerns. The source of such ridicule, is neither the capitalists nor any of the antipathy groups. Instead, it is most often the layman. This is quite understandable, since the roots of his worries don't originate with the pollution caused by a nearby factory or the next species on the endangered list, but from the thought of where his next meal, or the money for his children's much needed shoes, is going to come from. The younger student generation too would hardly stop to think if the factory they are going to start would be a cause for depletion of natural resources. The objective of material profits is what guides their use of personal energies.

In this scenario, people are almost always forced to think that environmentalists are a bunch of idealists with more time and money on their hand than they can manage. Such a viewpoint might sound cynical, but forms the base for the apathy people in general have towards such issues. On the brighter side though, there are a few for whom environmental concerns are crucial for the sustenance of the world. These people continue to try and reach a balance between technological development and environmental responsibilities. Engineering, being about innovation and its applications, can therefore play a key role in reaching this harmony in advancement. And this is exactly what the faculty members and a few students of this college have endeavoured to do.

At Maqta, we did the same by taking up the whole ill-facilitated area under the project called "Maqta Uplift Project". This project has two facets. Firstly, the area will stand to benefit from our long-term focus on its development. Secondly, the dissemination of social and environmental awareness among the local population as wll as the undergraduate engineering students at my college will be in the interest of development of healthy attitudes towards environmental concerns.

The project required us to initially conduct a social and physical survey of the area which gave us a general idea of the kind of conditions the residents lived in and the adequacy or inadequacy of the facilities provided by the Government. During the course of the survey my friends and I came across many heartrending scenes of squalor and indigence. The daily ordeals the residents face for the mere purpose of getting drinking water are enormous. In the face of inadequate municipal water supply, many residents are compelled to use ground water for their everyday needs of cooking, washing, bathing, etc. This ground water on examination showed high concentrations of unwanted effluents and organic waste. Moreover, the children are often victims of many water-related diseases and the casualty rates are shocking. Many families in the area have lost at least one child to this sad state of affairs. The educational institutions in this area, which can scarcely be called that, are few and ill equipped to serve the purpose of educating local children. Consequently most children drop out of school at a very young age.

In the face of such problems, people continue to live, unaware of better living conditions, adapted to this filthy environment and poverty with any hope for progress buried deep within their hardened personalities. After witnessing this side of humanity, that we, from our sheltered homes, see only in newspapers and television, the determination we had for doing something for this underprivileged society only further strengthened its roots.

Under the concerned guidance of our faculty members and their constant endeavors at molding us into better human beings, we have indeed evolved and are now more aware of the present imperfect world and our vision and goal of a new and better world.

5. Other Programs at the Centre for Environmental Studies and Socioresponsive Engineering (CESSE)

The Centre is still evolving. In addition to inviting and enabling interested students to participate in the Maqta Project, and later other similar ones, we plan to conduct a series of workshops on environmental literacy and environmental problem solving. We are working on a small booklet entitled, "What Every Engineer Should Know About Nature and the Environment".

One of the Centre's objectives is to integrate research, design and teaching at the undergraduate level. This is best epitomized by the Natural House Project. The design of the house uses simple principles of nature, such as transpiration or evaporative cooling occurring in plants, and geothermal cooling, which takes advantage of the presence of a very comfortable sub-ground earth temperature in our region (25C to 28C in winter and summer, respectively), to create a building that is thermally comfortable throughout the year. The design also uses the entire roof, which is curved and looks like a shallow dome, as a natural solar collector and directs the heat where it is desired, away from the interior in the summer and into it in the winter. Maneuverable screens, which are automated to open and close according to solar intensity, are used at different places to block direct solar radiation on the walls in summer and allow quick cooling at night.

What is exceptionally inventive and unique about the Natural House project from an educational point of view is that it brings together several diverse elements – thermal, structural, architectural, electronics, mechatronics, and controls, in a creatively challenging project, which reflects the seamlessness of the natural environment and life itself. The project allows students from many departments to work and learn together, so that each one develops the ability to integrate different elements of engineering to make an encompassing whole. This approach is similar to that proposed by many industrial ecologists. M.I.T.'s Ehrenfeld argues that "the university can and must play a central role in developing the concept of industrial ecology and institutionalizing its practice." He suggests that they must overcome strong disciplinary barriers, jealousies, and their own political dynamics to do this. Disciplines must be reconstructed to "mimic the seamless web" of the very world we are trying to understand.[2]

The Natural House Project enables students to "learn by doing" – an idea that some U.S. universities are also experimenting with, e.g. University of Tennessee's Engage Program for freshmen.[3] For our students the Natural House Project is fun – they can design and create their own "dream house", tackle the problems of energy, water, comfort, aesthetics, cost economy, environmental compatibility and so on in a down-to-earth, realistic framework, blending the roles of engineer, architect, builder, owner, urban community dweller and responsible planetary citizen. There could hardly be a better way to enjoy the "existential pleasures of engineering".[4]

6. Conclusion

As first author and someone with many years of teaching experience in the U.S. and India it is my privilege to add final thoughts to the issues raised here. I may be permitted to do so by making a reference to the medical profession. I have always admired the spirit of service and caring implicit in that profession. Although not every medical graduate around the world is obliged to take the Hippocratic Oath, and many may not even know what it is, it is understood that their obligation and responsibility is to help and heal to the best of their ability.

Is engineering a "service" profession?[5,6] If so, who are we supposed to serve? Most directly, of course, as employees we are obliged to serve our employer. It is assumed, as part of an unstated social contract, that the employer, such as a company offering engineering services, contributes to the good of the society and the checks and balances built into the social, economic and judicial system ensure the well-being of all, thus absolving the individual engineer from direct social responsibility. But, is this a reasonable and satisfactory assumption? What about conflict of interest?

In the early days of modern engineering practice, when industrial development and services such as construction of roads, bridges and dams, were unanimously considered desirable and beneficial to everyone, there were no particular complications. In India, for example, most engineers were employed by the government and were indeed "public servants".

The world in the 21st Century is strikingly different. Despite all the talk about the engineering profession's responsibility to protect the environment, the basic modes of engineering education and practice have not changed. In contrast to the medical, or other "helping professions", no one considers an engineer to be a helper and healer of either individual, or general, human suffering.

I am personally gratified to note many outstanding exceptions, two of them being the testimonies of Zulfia Imtiaz and Heather Lukacs. They give me hope and strengthen my resolve to be a part of the effort to "reconstruct" the goals and commitments of my profession. As Heather Lukacs has expressed, there are no boundaries to caring. The chasm between "First" and "Third" world (Global North/South) cannot be indefinitely sustained, nor can the illusion of profit and gain derived from narrow business interests. Rich and poor, developed or not, we are all sailing the same ship. You can't have one end going down and not the other. The engineer is obliged, for pragmatic as well as emotional reasons, to care.

Let me close by proposing a minimal equivalent of the Hippocratic Oath for engineers. I am aware that many engineering associations, especially those concerned with education, have formulated explicit codes of ethics and in recent times these have been revised to encompass protection of the environment, as well as service to society. The point, however, is that few engineering students during their study or at graduation are made aware of such a code and none are required to take a pledge to abide by it.

What follows is a tentative proposal for a pledge. I have kept it short, assuming that it may be elaborated, revised or rewritten, as needed, through peer discussion. There is, however, merit in keeping it short.

> *"I recognize and appreciate that the profession I am embarking on is a privilege that carries special responsibilities. I recognize and appreciate that the design, creation and use of technology has far-reaching consequences for the natural environment and human society and that as an engineer I must exercise care and consideration to avoid causing harm to either. I recognize and appreciate that the purity and quality of the earth's environmental systems comprising air, water and land are in danger of serious damage and I pledge to protect them when I can. I recognize and appreciate that the earth's natural resources must be used efficiently, effectively and equitably and that basic needs of people in all countries – adequate supply of water, food, fuel, housing and employment must be fulfilled through sustainable engineering practices. As a responsible citizen of the planet I pledge to use my knowledge and skills to further the interests of peace and cooperation and mutual benefit among the peoples of the earth."*

A pledge such as this, if adopted by an institution, could even be optional and still serve its purpose, directly and indirectly. The graduating student could be given the text of the pledge beforehand and be permitted to decide whether or not to take it. Either way, the issue of engineering responsibility would be brought into awareness.

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