APPROPRIATE TECHNOLOGY AND APPROPRIATE DESIGN

the ability to design systems, technologies and equipment in an appropriate way

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Engineers and product designers have often been guilty of feeding on consumer wants rather than working to satisfy the basic needs of the global population. It is nothing short of scandalous that in the twenty first century, one-third of the world's population – two billion people – do not have access to safe drinking water, whilst expensive projects such as the Large Hadron Collider (estimated final cost £5.5 billion) occupy the attention of engineers. Large projects with no obvious benefits are easy targets, but on the individual scale, a survey carried out by insurer Cornhill Direct, found that the average UK teenager leaves the house with clothes, jewellery, watches and gadgets such as mobile phones worth £529.54; a value roughly equivalent to the Gross National Income per capita of sub-Saharan Africa (estimated by the World Bank as £590 in 2006).

Up to the mid twentieth century, engineering was usually a response to a physical need. For example, steam engines were developed by Newcomen, Watt, Trevithick and others, to pump water from mineshafts; Abraham Darby's efforts to refine iron production were motivated by the need for cheaper cooking pots; and the chlorination of water by John Snow was in response to the 1854 Cholera epidemic.

Maslow ranked human needs in a pyramid, with basic physiological needs such as the need to eat, to breathe, to sleep at the bottom of the pyramid. The next layer includes the need for safety and security. Next comes the need to belong, to love and be loved, which are topped by esteem and other higher 'self-actualisation needs'. With basic needs having been largely met in over-developed countries, engineers have been aimlessly 'innovating' and relying on a massive advertising industry to convince consumers that the resultant products will satisfy their higher needs. Buy these trainers and you will be accepted. Use this deodorant and you will be attractive to the opposite sex. Subscribe to our mobile phone network and your talk will be unlimited (see *Advertising Awareness*, this volume). In the twenty first century, consumerism, not necessity is the mother of invention.

The influence that technology can have on culture is discussed by Postman, who classified cultures into three types: tool-using cultures, technocracies, and technopolies. Until the seventeenth century, all cultures fitted into the first type. Tools were invented to do two things – firstly to solve urgent basic physical problems such as grinding corn, ploughing land, transporting water and so on, and secondly to serve the symbolic world of art and religion. The integrity and dignity of the culture was not threatened by the use of such tools. However, in a technocracy, tools play a central role in the thought-world of the culture. The very instruments created to meet the needs of society threaten to transform and indeed overthrow it. In Huxley's Brave New World, the revolution is complete – Technopoly eliminates alternatives to itself by creating a culture that seeks its purpose and finds its satisfaction in technology. The means to an end has become an end in itself.

The Indian theologian M. M. Thomas (1993) expressed these concerns in an address to the Christian Medical College at Vellore:

> There is no doubt that the scientific and technological revolution of the modem period has been a tremendous expression of human creativity, it has eliminated distances and created the global community materially. It has given us the knowledge necessary to produce goods and services in abundance. It has given us power for social, psychic and genetic engineering, to control disease and death as well as birth. But as we survey the world situation today, the general feeling is that along with many benefits, many of the promises of technology stand betrayed and there is evidence of a lot of technology having become instruments of exploitation of peoples, destruction of cultures and dehumanization of persons and pose a threat of destruction not only to the whole humanity through nuclear war but also to the whole community of life on the Earth through the destruction of its ecological basis.

As powerful marketing departments encourage consumers to switch their focus from one flashy technology to another, designers provide products to meet the latest fad, even though they know that the market for whatever it is they are producing will last perhaps a few years at the most. The rate at which technology becomes obsolete is increasing. For instance, it is estimated that mobile phones are replaced by users after eighteen months, whereas it takes approximately 1000 years for a mobile phone to decompose naturally (see *Materials Awareness*, this volume).

Too often, engineers have ignored sustainability and designed equipment, processes and technologies without taking into account local factors such as culture, environment, gender, local availability of materials and local production methods. Market economics has pushed engineers into coming up with mass-produced 'one size fits all' solutions, which may be inappropriate for some. This is particularly evident when designing for remote communities both in economically well-off countries and, acutely, for those with fewer physical resources.

Cook stoves make a good case study. Half the world cooks using wood as a fuel. With population pressures and climate change, it is becoming increasingly difficult in the twenty first century for populations around the world to find sustainable sources of wood for cooking, leading to widespread deforestation. In addition, with some designs of wood burning stove there are issues of indoor pollution. The developed world's response to these problems has largely been to come up with new technologies which are designed and tested at considerable distance from the communities they intend to serve. Often research is carried out in academic institutions away from where stoves are used and although the resulting stoves can be fuel efficient, the neglect of social factors is a major barrier to successfully introducing improved stoves into the homes of those living in remote communities.

In Ethiopia and neighbouring Eritrea, the staple food *injera*: a spongy sour flatbread, is cooked on a large griddle on a *mogogo* stove. These inefficient, smoky stoves are made by individuals from a mixture of mud and clay, whilst the mogogo plates are supplied by the local ceramics industry. Two recently proposed "improved" stoves are not suitable for cooking injera. The CleanCook alcohol stove, made in Sweden from aluminium, has two small burners which are insufficient to heat a mogogo plate. The change of fuel and stove also has adverse economic effects on local mogogo plate manufacturers and firewood sellers. A stove from Aprovecho with a more traditional appearance but made from concrete failed to take into account the even temperature distribution required, so although testing in the USA by boiling pots of water appeared to show improved efficiency, when it came to cooking injira, the results were inedible. Although these attempts have some merit, their use requires Ethiopians to change their eating habits, threatens local economies and could thus be regarded as intrusive and colonialist. There is also a design of mogogo plate promoted by the Eritrean government – the ETRC (Energy Research and Training Centre) mogogo, but the cost of £28 places it out of reach of many Eritreans.

Alternative approaches involving local stakeholders have tended to be successful on a small scale, but are much more labour intensive. For example, on a recent trip with Engineers Without Borders UK to install wood stoves in a remote village in the Imbabura region of Ecuador, Nottingham University undergraduate Rob Quail found that although initially the villagers were rather shy, by involving them in the design and material selection process, they overcame scepticism. Returning to the village two weeks later, Rob found that the villagers had built two stoves from his design and had begun to experiment with modifying the stoves according to their own ideas.

It may be impractical to involve end-users at every stage of the process in the design of improved cook stoves, but it is vital that users' requirements are assessed carefully before solutions are proposed. For instance, stove users in rural locations are more concerned about the cost of a stove than fuel efficiency, since firewood is often collected free, whereas urban dwellers may have to purchase fuel and consequently are concerned with both initial cost and fuel efficiency.

An alternative approach is to tackle the problems of poor fuel economy and harmful emissions by modifying stoves which are currently in use rather than starting with a blank sheet of paper. Indigenous stoves will have undergone a natural process of evolution, with good stoves being imitated and bad ones replaced. Indigenous technologies can inspire us to find solutions to engineering problems of the twenty first century because they are addressed at solving real needs with limited resources. We must therefore exercise caution in defining the characteristics of good stoves. A project to replace smoky stoves in Nepal was successful in eliminating harmful indoor air pollution, but after six months, several dwellings collapsed due to termite damage; the previously used smoky stoves had been effective at killing pests whereas the new improved stoves did not fulfil this secondary (but essential) function.

Whilst the evolutionary approach to stove design is commendable for the way in which it builds up local communities, supports the local economy and fosters a sense of ownership, the process is frustratingly slow and costly in terms of the number of new stoves that have to be built and tested, many of which will not show any improvement on the previous generation. A novel approach is to make use of genetic algorithms and computer modelling. Traditional stoves are allowed to "mate" with stoves with good fuel efficiency, such as the rocket stove. The offspring stoves are modelled using Computational Fluid Dynamics (CFD) and assessed in terms of fitness. Fitness can be defined to include factors such as: fuel efficiency, temperature distribution, volume of material used to construct the stove (indicative of cost) and so on, although other cultural and environmental concerns, such as local availability of materials, may be harder to factor into the algorithms.

An excellent way to engender appropriate design is through project based learning. Learners have tackled the following problems: designing a wheelchair suitable for use in Kenya, producing a small-scale cardboard briquetting machine for use on the Isle of Lewis (to avoid cardboard ending up in landfill), designing medical equipment such as laryngoscopes and otoscopes which work without the need for replacement batteries in remote regions of Uganda, removing excess fluoride from drinking water using locally available materials in Ethiopia, designing a mechanical solar tracker for the Democratic Republic of Congo, and so on.

Working on projects designed with specific communities in mind encourages learners to develop communication skills, increases their awareness and understanding of the importance of cultural and social factors to engineers and promotes people-centred design. Involving users of technologies in the design and manufacturing process breaks down the barriers between learners and educators, and facilitates the discovery of solutions through mutual investigation and knowledge sharing.

Understanding the principles of appropriate design and technology is important not just for engineers but for everyone, since everyone makes choices about what kind of technology to employ in particular circumstances. As fossil fuels become scarcer and their use increasingly constrained, appropriate design and use of technology will become increasingly important, not only in remote locations which lack physical resources, but everywhere. Skills in appropriate design and appropriate technology will be essential in order to confront real problems of survival rather than the artificial problems of satisfying fleeting whims created by marketers.

Clifford, M. (2007) Engineering learning with appropriate technology. *Education for Sustainable Development: Graduates as Global Citizens, Second International Conference* 10th - 11th September 2007, Bournemouth University

Engineers Without Borders. www.ewb-uk.org [A student-led charity that focuses on removing barriers to development using engineering].

Practical Action. www.praticalaction.org [Originally the *Intermediate Technology Development Group*, this charity addresses issues of poverty through simple and extremely effective technologies that give determined people the power to change their lives]

Robinson, P. (1998) Microhydro in Papua New Guinea – the experiences of an electrical engineer. *Power Engineering Journal* 2:5:273-280

Schumacher, E.F (1999/1973) *Small is beautiful.* Dublin: Hartley & Marks

Thomas, M. M. (1993) *The Church's mission and post-modern humanism.* The Indian Society for Promoting Christian Knowledge http://www.religion-online.org/showchapter.asp?title=1448&C=1258

Appropriate Technology Research. www.nottingham.ac.uk/~eaxhtv/ATR [contains details of a growing number of student projects concerned with appropriate technology]