THE USE OF INTERNATIONAL DEVELOPMENT TYPE PROJECTS IN CDIO PROGRAMS

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Abstract
Design projects are a key element of a CDIO program. These projects may involve students working in groups to design a device or process that meets certain requirements or may involve case studies of existing designs. Most such design projects involve devices geared to the needs of so-called “developed” countries. However, there appears to be good academic reasons to expose engineering students to the special considerations that must be taken into account when working in or with “developing” countries in the design of devices or processes to meet the needs of such countries. Projects for this purpose can illustrate the particular difficulties and constraints involved in engineering related problems in “developing” countries. They can be useful in developing an understanding of the importance of using indigenous knowledge and in illustrating the need to work with people from other professions. In preparing students for work with “developing” countries it is necessary to have available a series of projects and case studies. The present paper discusses some of the considerations that enter into the selection of suitable projects and cases and describes a few typical examples. Some discussion of how these can be incorporated into an undergraduate engineering program is also presented.

Keywords: International Development, Projects, Developing Countries, Case Studies

Introduction

At some time during their professional careers, a significant number of engineers from so-called developed countries will be involved in some way with a project that entails working in or with a so-called developing country. If engineers are to be successful in such work it is important that they clearly understand that the constraints and techniques required in this type of work can be very different from those that apply in the typical situation encountered in their developed home country. For example, it is important to understand the constraints placed on a design by the local availability of materials, by local atmospheric conditions, by the availability of spare parts, by the availability of health care services and, often, by the culture of the country involved. To be successful in this type of work, it is also important for engineers from a developed country to realize that while they can bring modern design techniques to the project, the inhabitants of the country involved have a wealth of practical experience under the conditions actually existing in the area involved, i.e., have a wealth of indigenous knowledge. The inhabitants of the country or area involved will also have a knowledge and understanding of the restrictions that will be placed on the design by local ethnic and religious traditions. Therefore, a successful project involves, wherever possible, cooperation between the workers from developed countries and workers from the area where the device is to be used or where the work is to be undertaken. Each group should clearly understand and respect the strengths and experiences that the other brings to the project. It is also important for an engineer working on a project in a developing country to understand that other professionals such as medical doctors and other caregivers may have to be involved in the project. In undertaking work in developing countries, it is also important for an engineer to be aware of the difficulties that can sometimes arise in living and working in such countries. Design projects and case-studies related to developing countries can be used to illustrate the range of considerations beyond those of a purely technical nature that must be taken into account in most design work involving developing countries. With these considerations in mind, it seems important that engineering students, particularly those in a CDIO program with its strong emphasis on design, team work and an understanding of the interaction between society and engineering, should be given exposure to design projects for developing countries in their undergraduate programs. Such projects are not just of interest to those students who end up doing work for or in developing countries. Projects of this type highlight considerations that can be as important in design work for developed world applications.

Exposure to developing world projects can be obtained by including in a program some design projects that are concerned with such problems, and/or by introducing suitable examples of this type of work into existing courses and/or by introducing case studies of developing world projects into the curriculum. Of course, added exposure to developing world work for a limited number of students can be achieved by introducing a separate, probably elective, course on this subject into the program. Whatever approach is adopted, it is necessary to have available a series of projects and case studies that illustrate the particular difficulties and constraints that are involved in engineering related problems in developing countries. The present paper discusses the considerations that should go into the selection of suitable projects and case studies, gives a few examples of typical such projects and cases and discusses some possible methods of incorporating these projects and cases into a CDIO undergraduate engineering program.

Selecting the Cases

Design projects and cases involved with engineering in the developing world need to be carefully selected to highlight some of the factors discussed in the Introduction. The following are some of the considerations that enter into the selection of suitable such projects and cases [1]:

1. Projects and cases should be selected that encourage the student to develop an understanding of the true meaning of “appropriate technology”, i.e. an understanding that the devices must be designed with the real needs of the potential “customers” in mind [2], with a true appreciation of the constraints imposed by local conditions whether they be environmental, social or political, and with a thorough knowledge of the level of maintenance that can be expected. The students must learn to appreciate that appropriate technology does not mean low technology. In fact, the design of a device for use in a developing country may require the application of highly sophisticated methods because of the very severe restraints placed on the design by local conditions. Large amounts of money have been squandered in the past by workers from so-called developed countries thinking that no real engineering knowledge was required to design devices for developing countries, which is seldom true.
2. Projects and cases should be selected that develop in the student not only an appreciation of the vast experience and knowledge that the inhabitants of the country or area involved can bring to the project but also the realization that a successful project involves, wherever

possible, cooperation between the workers from the developed country and workers from the area where the device is to be used or where the work is to be undertaken. Since much of the experience in certain areas of work rests with the village women in a developing country, an attempt should be made to develop in the student an appreciation of the particular problems faced by this group.

3. Projects and cases should be selected that foster in the student the understanding that the constraints and techniques that are required in this type of work can be very different from those that apply in the typical situation in a developed country.
4. Projects and cases should be selected that develop in the student an awareness of the difficulties that can sometimes arise in living and working in developing countries.
5. Projects and cases should be selected that foster in the student an appreciation of the problems faced by the developing countries and their inhabitants.
6. Projects and cases should be selected that enhance student appreciation of the environmental consequences that can result from engineering decisions.
7. Projects and cases should be selected that increase student understanding that the solution to most problems in developing countries involves such complex and interrelated issues that it will seldom be possible for the engineer alone to solve the problem. Instead, engineers have to interact with experts from many other fields, developing multi-disciplinary teams appropriate to each problem.

In selecting cases it seems important to choose those that, in some way, deal with the following:

- Production and processing of agricultural crops
- Provision of an adequate water supply
- Provision of an adequate energy supply
- Meeting health and related needs
- The interaction between development and environmental considerations
- The development of a manufacturing base

These areas have been selected because so much of the engineering work undertaken in developing countries is concerned with them.

Using the Projects and Cases

As previously mentioned, exposure to developing world projects can be obtained by having some design projects in a program that are concerned with such problems, and/or by introducing suitable examples of this type of work into existing courses and/or by introducing in various ways case studies of developing world projects into the curriculum. Of course, added exposure to developing world work can be achieved by introducing a separate course on this subject into the program. In this case, it is extremely important to ensure that, as well as being technically very competent, the person teaching the course should have experience, in some way, of working in a developing country. It is preferable that the instructor be currently involved in development work and it is also important that this person feels comfortable in leading the unstructured class discussion that is involved in teaching using the case-study method. Such an instructor can also act as a resource person for instructors and students in other courses into which developing world considerations are being introduced.

In any course in which design projects or case studies involving problems from the developing world are introduced, it is usually necessary to present, using a lecture type approach, some of the following material prior to considering the projects or cases:

- An introduction to the developing world and to the social, political, educational and technological conditions existing in various developing countries in Africa, Asia and South America.
- A broad discussion of some of the problems commonly faced by developing countries.
- A discussion of some of the special considerations that must be taken into account when performing work for or in developing countries.
- A discussion of some of the difficulties that can be encountered when working in developing countries.

When utilizing case studies, the following procedure can be adopted. First, each case is briefly discussed and some background material is provided to the students. After this material has been studied by the students, several relatively informal class discussions of the problem, the constraints on the solution, of relevant past work, of socio-economic and environmental aspects, and of possible solutions are held. The class is then split into smaller groups to work on various different aspects of the case. Finally, the groups are brought together to discuss their findings and, where possible, to discuss solutions. Typically, each case would take about three weeks to complete.

Typical Projects and Cases

As mentioned previously, it appears that there is much to be gained by having some of the design projects and case studies in an engineering program involve problems in developing countries. These projects and cases should be concerned with the development of a device or process for use in a developing country and with which engineers trained in a developed country have been or could have been involved. The following examples are of the type that it is believed are suitable for this purpose and which can be treated either as student projects or as case studies. Space does not permit a detailed discussion of these cases and the selection of the cases discussed here may be very much a result of the personal experiences of the authors. Some background material for these cases is provided in References [2] to [7].

Case 1 - Pumping of Water from Deep Wells in West Africa

Much of the water available to villages in certain West African countries is now in wells that are much deeper than those that have traditionally been used. Obtaining the water from such wells takes much more time and physical effort than required with the older more shallow wells. The traditional method of drawing water from a well was to throw a bucket tied to the end of a rope down the well and then to haul the filled bucket out of the well by hand. There is a need to replace this procedure with one that is more appropriate to deep wells. Many solutions have been proposed, ranging from simple wooden winch systems to photovoltaic cell powered pumping systems. In presenting the case, the basic problem is introduced and the reasons that have lead to the problem will be discussed. The social and environmental conditions that exist in a typical village in this part of the world will be described and the implications that these conditions have for the solution to the problem will also be discussed. Various possible solutions will be presented and the advantages and disadvantages of each will be discussed. A solution will be selected and a detailed design of the device will be undertaken, the effect of local conditions and the availability of local materials on the design being strongly emphasized.

Case 2 - Low Height, Short Range Mobility Device

There are still many persons in places like India who are unable to walk due to bilateral polio and other disabilities. Traditional "western" wheelchairs are often not appropriate for them as many traditional activities of daily living, such as cooking, eating, washing dishes and clothes and personal hygiene are on or near the ground. Such persons have often no other means of moving than to crawl on the floor which is awkward, slow and often dusty. There is, therefore, a need for a low height and short range mobility device that would allow such persons to move freely within and near their dwelling, and to be able to do daily chores. Moving along the road to stores and jobs would also be possible with such devices if the ground is dry and reasonably smooth. Such a device would have to be made with locally available materials so that it can also be maintained at the local level. This case requires not only an introduction to locally available materials and manufacturing techniques, but also an introduction to the pathology of polio and other diseases so that the students have an understanding of what would be required of such a device. This will allow them to come up with ideas that they can discuss with the instructor, and possibly build. They can use finite element analysis techniques to optimize such a device for performance and weight. Ergonomic design considerations will also make for a better design.

Case 3 - A Biogas Generator for the Himalayan Region

In many parts of the Himalayan region, significant numbers of livestock are kept in relatively small areas. The waste from this livestock can be used in a biogas generator to produce a gas containing roughly 60% methane. This gas can supply much of the cooking energy needs of such areas. While biogas generators have been extensively studied in many parts of the world, the particular conditions existing in the Himalayan region pose unique difficulties. For example, very wide ambient temperature variations occur and some biogas generators do no operate well at low temperatures. The presentation of the case will begin with a description of a typical Himalayan village. The operation of a biogas generator will then be reviewed and the efficiency of the device will be discussed. The amount of animal waste being produced and the cooking energy requirements will be reviewed. Separate groups of students will then look at the modeling of the effects of changes in ambient conditions on the operation of the generator, at the construction of such generators, at the economics of the generator and, at the ways in such generators could be used in the region. The groups would then work together in order to develop a proposal for a generator matching the conditions existing in the region.

Case 4 - A Village Scale Dehuller

Cereal grains such as Sorgum and millet are important food-sources in many parts of Africa. Dehulling, i.e., removing the outer envelope, is an important part of the preparations of the grains for consumption. Traditionally, this dehulling has been undertaken by the village women by pounding the wet grain in a mortar with a pestle. The resultant product is wet and cannot be stored for more than about one day. This method of dehulling is very time consuming and not suitable for producing a marketable form of the grain. Various types of mechanical dehullers have been suggested and produced but they have received only limited acceptance. In this project, the need for dehulling is discussed. The traditional method is then examined and the socio-economic constraints on a replacement of this method are discussed. Groups of students then examine various possible mechanical dehullers in light of the conditions existing in the villages where they are intended to be used. Particular emphasis will be placed on trying to decide on an optimum size of dehuller.

Case 5 - A Solar Rice Dryer

Drying is the major method of preserving food products in many developing countries. In a number of these countries, crops such as rice and corn are extensively dried by spreading them on a hard surface in the sun, i.e., by sun-drying. While a good quality product is usually obtained by using this procedure, quite high losses can be incurred during the process for a number of reasons. In order to reduce these losses, a solar dryer in which the crop is contained in some form of cabinet can be used. In this project, the drying of rice will be considered. The changes in the moisture content during the drying of rice and the constraints on the drying process such as maximum allowable crop temperature will be reviewed. The size of crop to be dried and possible local economic and social constraints will then be considered. A discussion of the various possible types of dryer will follow. The class will then be spilt into groups, each of which will study a separate type of dryer, e.g., indirect cabinet type, in detail. Then, a class discussion of the findings of each group will be held. The groups then produce designs of suitable solar dryers.

As mentioned previously, these are meant only as examples of suitable cases. Many other projects and cases dealing with, for example, the harvesting of crops, irrigation, improvements in wood stoves, generation of electricity, provision of health care related devices and desalination can be developed from available material.

Other Courses

Examples of developing world work can be introduced into non-design courses when discussing the applications of the material being covered in the course. For example, the design of simple hand pumps can be discussed in Fluid Mechanics courses and the heat transfer processes involved in solar crop drying can be discussed in Heat Transfer and/or Thermodynamics courses.

Conclusions

Project work and case-studies are important tools for preparing engineering students for work in international development. To be effective, the cases must be carefully selected. Some of the criteria for selecting projects and cases have been reviewed and some typical projects or cases have been described.

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Bibliographical Information

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