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Engineering the Skill for Rural Development in Papua New Guinea*

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The teaching of engineering in Papua New Guinea is challenging as incoming students generally lack exposure to technical activities. However, the need to gain lost technical ground is a serious endeavour of the government and people of Papua New Guinea. The universal wish for equality of opportunity and services also meant a special attention towards appropriate technology. This paper describes student projects which directly assist in electricity generation in remote places in Papua New Guinea, as an example of appropriate engineering education.

INTRODUCTION

PAPUA New Guinea is an independent nation in the South Pacific located north of the Australian continent sharing a common border with Indonesia's Province of Irian Jaya. Geographically, it has a formidable chain of mountains running from the north-west to the south-east, reaching up to 6000 metres above sea level. The main mode of transportation is by third level air network, although several daily jet services connect major centres. The longest surface connection is an 800 km road linking Lae, the second largest town to centres in the Highlands and the seaside resort of Madang in the North. The population is made up of more than 700 tribes each having a distinct language. The main language used in commerce in the major centres is English although the use of Pidgin and Hiri Motu is quite widespread (UPNG, 1977]. As 75% of the population lives in rural villages spread across large distances, the logistics of supplying services such as electricity from a centralized source is unrealistic and exorbitant. Fortunately, the existance of tall, albeit rugged mountains, gives rise to waterfalls the potential power of which can be harnessed through small-scale hydro-generators, popularly known as 'micro-hydro schemes', to produce electricity for the use of whole villages. Such electricity generators normally produce between 2 and 20 kW of power.

Electricity has been considered to be the key to rural development in Papua New Guinea. In its endeavour to answer the call for appropriateness, the Department of Mechanical Engineering at the Papua New Guinea University of Technology (Unitech)) consciously involves its senior students in projects associated with micro-hydro schemes—from concept initiation to design, building and installation in the remote villages. Such involvement is possible as one of the compulsory subjects in the Final Year of the Bachelor of Engineering (Mechanical) course at Unitech is ME 404 'Projects'. This subject requires students to select Projects offered by staff of the Department and to work them over the whole year. The formal staff–student contact time for this is two hours per week although in practice students may spend up to six or seven times this contact period at some time during the year. At the completion of the Projects, a Project Report is presented by each student. In the case of an authentic project where a group of students are involved, each member of the group will present a Report on an agreed part of the Project, without losing the overall thrust of the Project. All students must pass this subject in order to graduate.

PEDAGOGICAL BENEFITS

Although Unitech has produced a comparatively large number of engineers during the past twenty years, the present students are still coming from a generation which had little or no contact with technology. There is still no railroads in PNG (Papua New Guinea). The traditional teaching of engineering history using Watts and Brunel and therefore railroads precludes comprehension by these students. The first challenge facing engineering educators is therefore finding an authentic and yet understandable avenue to illustrate the practice of engineering. At the moment the micro-hydro scheme appears to adequately satisfy this requirement for Mechanical Engineering students at Unitech. The provision of clean water for personal consumption and consistent supply of water for irrigation are two other real community needs that can become areas answering this challenge.

The micro-hydro scheme, however, provides the

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most educational value among the above three possibilities. The development of the micro-hydro unit involves many aspects of flow theory as well as energy conversion. The involvement of students in the design and building of the unit, exposes them to tangible examples of flow theory, such as the relative velocities concept, as well as to the need for precision manufacture and assembly. The latter is so important, because repair due to manufacturing and other faults will be expensive and difficult after the unit has been installed. In addition it would mean an interruption to the electricity supply so valued by the village community.

The calculations of theoretical values and their comparison with those resulting from measurements in the field provide the mechanical engineering students with opportunities which in the past have eluded them. Civil engineering students for example may be involved in real measurements and placement of roadways or bridges etc.

Although the educational value of laboratory work is not questioned, for students whose background has not included exposure to simple technical activities, the educational value of involvement in authentic projects identified to be purposeful to their community has proven to be highly significant, as measured by their distinct enthusiasm and enhanced understanding of such theoretical concepts mentioned above.

THE BENEFITS TO ENGINEERING PRACTICE

As the case with enhanced understanding of theoretical concepts, this project has also impressed upon the students good engineering practice through the needs of proper components design, drawing and manufacturing. It is fortunate that the department of Mechanical Engineering at Unitech owns a CNC lathe and a CNC Workstation which allows the demonstration of highly accurate metal forming and cutting. In addition, the use of CNC machines magnifies the effects of errors in both design and machine programming. This therefore further demonstrates the need for practising good and precision engineering.

The involvement of a community at which the micro-hydro plant is to be installed again expands the dimension of engineering education. Expatriate engineering educators generally have inadequate mastery of the local language or dialect. As a consequence students also have the task of transorienting the community to the technology to be introduced. This task is the more real, since the community members, in some cases the whole community, are involved in the installation of the micro-hydro plant itself. Thus students are therefore required to develop and execute plans of work that will match the capability of the community, within time and budgetary constraints. It is not often that engineering students obtain such opportunity.

THE SIGNIFICANCE OF ELECTRICITY IN RURAL DEVELOPMENT

In rugged country such as PNG, especially when the majority of the population actually lives in the rural areas, the availability of electricity there will ensure telecommunication which is so vital politically for the government in Port Moresby as well as the Provincial governments. Although satellite and not transmitter repeaters are used to bring television and radio to the rural community, electricity is required to run the satellite receiver and distributing the programs to the community. The television set becomes the 'window' to the world for most if not all of the community members there. In order to ensure rural development, the simple exposure to the outside world is important, even if it is only to see the concern expressed by many people and organizations on pollution, land erosion and the like.

It is also generally true that in many villages where coffee is not grown, the means of earning money is extremely limited. The growing of cash crop without the product reaching major centres for sale, is defeating the purpose of growing it in the first place. The availability of electricity in the community will allow cold storage of produce until they are ready for transportation, most probably by air, resulting in the produce being available 'fresh' to the consumers.

It can be seen from the above, that a facilitating cycle will result in improving the economy of that community.

The availability of electricity for lighting in homes, allows better opportunity for students to use the evenings for studying. This will provide the potential for increasing literacy and education participation. In turn, this positively contributes to the development of the country as a whole.

CASE STUDY—TEPTEP STATION

In order to illustrate the extent of engineering involvement in these projects, the example of designing, building and installing a micro-hydro plant at TepTep station located as shown on Fig. 1, is used.

A feasibility study was initiated to determine the size of plant that can be installed there, the actual power requirements and the amount of available potential energy, such as the water head. The feasibility study also acquires financial commitment from the provincial governments as well as the TepTep community itself. A total of PNGK 30,000.00 (Kina is the currency of Papua New Guinea, approximately equivalent to US$) was obtained in addition to the provision of timber poles for power lines, timber for construction work, rubble, sand and unskilled labour free of charge. One must hasten to add that the cooperation triangle between the governments, the community and Unitech, is not purely financial.

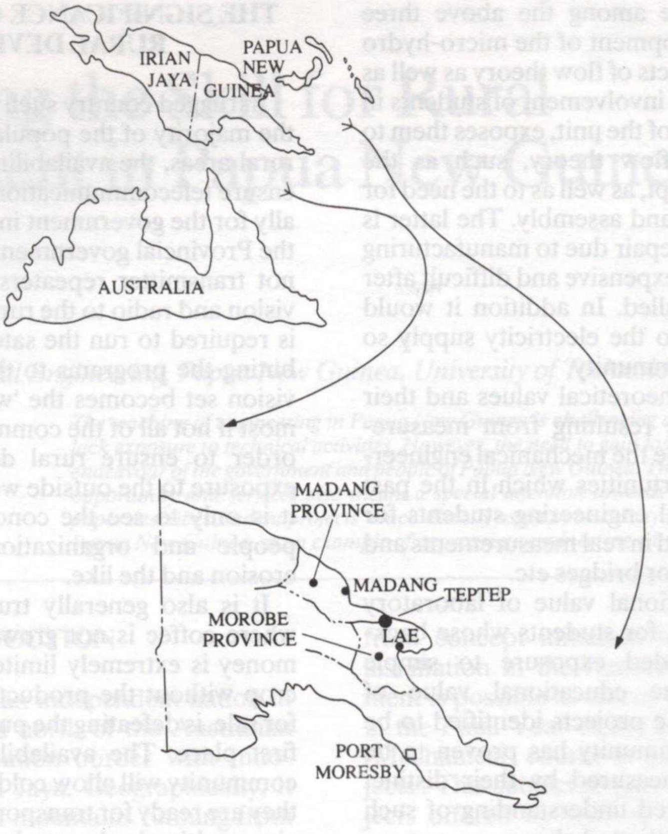

Fig. 1.

Each component of that triangle benefits from the co-operation. Perhaps, the importance of this link is signified by stating that the Project would never have been possible without such a link being firstly established.

The overall costs are about one half of what other agencies have paid for similar plants. That is, the cost per kW paid by those agencies was around PNGK 8000, while the one under discussion is about PNGK 4000.

Design data were:

Gross head	12.3 m
Nett head	10.0 m
Flow rate	150.0 l/s
Shaft power	8.8 kW
Head race canal	109.0 m
Penstock	22.0 m

thus giving an 8.0 kW plant for the locality.

The nett head determines the final design of machines. In this case it reduces the choice to a Cross flow or a Francis turbine. At the outset it was decided that the use of imported components is to be reduced as far as possible. The existence of higher precision machines in the Department of Mechanical Engineering provides an opportunity for most of the components to be fabricated within the department. Commercial metal fabricators around Lae, although capable of producing to the required specification, will cost a lot more than fabricating within the department. From an educational point of view, fabricating components at commercial houses will deprive our students of their involvement, which is part of the exercise.

The exercise became very real for the students as they have to determine the capability of the various sections of the departmental facilities. For example, the Francis turbine design was rejected because the departmental foundry does not have the capability to manufacture the impeller involved. This left the project with the Cross-flow Turbine design.

Computer programs were developed and used to calculate the various parameters, such as speed, inlet angles, vane angles, outside and inside diameters, to produce overall theoretical efficiency. An efficiency of 84% was achieved through the above simulation of dimensions and rates. The final dimensions were selected by considering locally available materials, generator speed and the capacity of the machine tools in the Department. The last of these is so important, as engineering graduates particularly in PNG, will have to work within much more stringent constraints and limitations. This exercise exposed students to real-life situations, thus providing them with relevant preparation for their graduate careers.

The choice of load controllers gave students a real exercise also. On the one hand, electronic load controllers are cheaper and has the appearance of simplicity. In the environment of a community with little or no technological background, the susceptibility of equipment being treated roughly, however, must also be seriously considered. Experience elsewhere provides evidence of up to 30 years [Ranatunga *et al.*] useful life of mechanical governors. Such governors have also been found not to fail catastrophically but through wear and tear, thus allowing partial operation even if some parts were failing. Electronics components generally fail abruptly, thus not allowing time to prepare for component exchange without inconveniencing the community greatly. In this particular case, the project group decided to incorporate an hydraulic governor which was completely designed and manufactured in the department. This exercise provided the students with an opportunity to use the theory learnt in mechanics, materials and hydraulics. Through product testing and modification exercise in order to achieve the required performance, students were also shown the variation between theories and practice.

The installation, involving civil engineering work, exposed the students to managing unskilled but enthusiastic community members achieving what for the community is a very high-tech project.

Following the installation of the plant, a handover for the running and maintenance completes the Project. The Officer-in-Charge of the TepTep station took over the responsibility of running and maintaining the plant.

Students involved in this Project were also exposed to the real difficulties that have to be overcome in realizing such an undertaking. For example, as there is no road between Lae, where the University is located, and TepTep, every piece of equipment and tools had to be airlifted. This obviously presented a constraint that has to be taken into account long before the design stage. Such constraint may not exist in a country with different terrains.

CONCLUSION

This authentic project has allowed students from non-technical cultural background to obtain tangible understanding of engineering and scientific concepts, and at the same time contribute to the rural development of their country. The cooperation between two provincial governments, the particular community and a university, although tenuous at times, has shown to students real engineering in practice. The experience gained by students was highly relevant and would positively help in perpetuating practical engineers that PNG will need over the next decade or so.

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