

Project-based Learning in Developing Countries

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Abstract

Project-based learning in developing countries, which are among the underrepresented groups in engineering, often provides information that is a substitute for expensive consultancy that these countries cannot afford. This paper discusses the concept of global project-based learning in developing countries as it relates to engineering education at Worcester Polytechnic Institute (WPI). It argues that project-based learning is a pedagogical approach that focuses on learning by experience and emphasizes teamwork, communication and integration of technological and societal needs. With regard to teamwork the paper provides some facts relating to the way this teamwork has been expressed in partnerships between United States and African universities. It shows how this partnership has been promoted by the United States Agency for International Development (USAID) which funded a partnership project between WPI and Polytechnic of Namibia (PoN). The paper mentions several projects that WPI and other United States universities have undertaken in Africa sometimes in partnership with African educational institutions. It then describes a water management project that WPI students recently carried out in Africa. The project description is preceded by consideration of the major water resources in Africa and the management problems that bedevil these water resources. It makes recommendations that emanate from the study of the empirical data relating to Africa in general while other recommendations are based on the empirical data derived from the Worcester Polytechnic Institute (WPI) water project in Africa. The paper calls for collaboration among educational institutions, governments and industry for effective water management of the different African water resources described in this paper.

Introduction

This paper has a triple purpose. First, it is conceptual in that it delves into the notion of project-based learning which has in a measure defined Worcester Polytechnic Institute as an educational institution.

Second, it is empirical in that it has identified two types of empirical data. One type of empirical data is in the public domain in the form of journal articles, books, newspapers, magazines and internet. There is plenty of empirical data that has been accumulated on water in Africa over the years. The paper has used this empirical data that has largely been derived from geographical, geo-morphological, hydrological and other forms of scientific publications. In this

regard the paper has used the publications that have been involved in monitoring the collection of data on water resources in Africa, for instance the publications on the work of the European Space Agency (ESA). The other type of empirical data that the paper has used is the result of a water project carried out by the Worcester Polytechnic Institute (WPI) in Africa. The empirical data learned from this WPI project confirm what other empirical studies have shown, namely that management of water in Africa is crucial for its survival.

Third, the paper makes recommendations based on the findings of empirical studies and the WPI project. These recommendations have also been based on the examination of policy-oriented research that has been carried out in selected African countries by various research bodies such as the International Development Research Center (IDRC) based in Canada.¹

The paper is divided into four parts. The first part is this introduction. The second part considers the concept of project-based learning and how it has defined pedagogy at WPI, and in this context mentions a selected number of projects that WPI and other United States universities have already carried out in Africa in partnership with African universities. The third part describes a water project that was carried out by WPI students in Africa in 2004. We consider this WPI project to be a paradigm for the kind of collaboration that should be prevalent among the educational institutions and the business community in addressing the water problem in Africa. The fourth part of the paper is the conclusion and recommendations. Some of the recommendations emanate from the study of the empirical data relating to Africa in general while other recommendations are based on the empirical data derived from the Worcester Polytechnic Institute (WPI) water project in Africa.

Project-based Learning at WPI and Partnership with African universities

Project-based learning is a pedagogical approach that focuses on learning by experience. It emphasizes teamwork, communication and integration of technological and societal needs. In its April/May, 2004 issue *The Africa Journal* sponsored by the Corporate Council on Africa described Worcester Polytechnic Institute (WPI), founded in 1865, as “a pioneer in technological higher education.”² It noted that WPI students, working in teams at more than 20 project centers around the globe, complete professional-level work and that “this innovative, globally focused curriculum has been recognized by leaders in industry, governments and academia as a model for the technological education of tomorrow.”³

WPI’s Global Perspective Program plays a key role in the university’s project-based curriculum by overseeing society-technology projects at its global project centers. “These project experiences are unique among engineering and science universities because they require students to go off campus, including to remote locales.”⁴ The projects are overseen by faculty advisors and count as a full term’s academic credit. “No other university sends more engineering and

¹ R. Yates, T. Woto, and J. T. Tlhage, . “Solar-powered Desalination: A case study of Botswana,” *International Development Research Center*. Ottawa, 1997 (Updated 10 November, 1998).

² *The Africa Journal* April/May 2004 issue, p. 19.

³ Ibid.

⁴ Ibid.

science undergraduates overseas.”⁵ *The Africa Journal* notes that WPI’s newest project center is in Africa. It opened in Widhoek, Namibia in early 2002.

These projects often require collaboration with overseas universities. The Association Liaison Office for University Cooperation in Development (ALO) works closely with the United States International Development Agency (USAID) in promoting leadership in higher education through the formation of partnerships among U.S. universities and universities in Africa.

With regard to Africa, ALO has promoted a variety of partnerships⁶ including the partnership between WPI and Polytechnic of Namibia. There is a good number of other partnerships. For instance there is partnership between The Ohio State University and Sokoine University of Agriculture in Tanzania in developing a practical agribusiness management program through links between the educational partners and the private agribusiness sector. Furthermore, the Texas A&M University, Corpus Christi-Lamar University/Insituto Tecnologico de Saltillo U.S.-Mexico Training, Internship, Exchange, and Scholarships (TIES), conferred with several colleagues from Africa and Asia with similar concerns regarding providing research training and education programs in water scarcity, and inadequate water resources management. Partners also discussed the possibility of applying technology derived from TIES Mexico partnership to remove arsenic from water in other geographic areas. There is another partnership among the Oregon State University, Debub University, and the Ethiopian Agricultural Research Organization to expand and improve training in natural resource management in Ethiopia by developing sound research to investigate food security and natural resource concerns for current and future generations. An improved natural resources management curriculum prepares professionals to better manage existing natural resources.

In its pursuit of partnership with overseas universities, WPI signed a Memorandum of Understanding with the Polytechnic of Namibia (PoN) and Kenyatta University of Kenya in May 2002. In some cases a PoN student and faculty person became part of WPI project team. As a result of the combination WPI-PoN partnership some projects have been strengthened. An example was a project done with the wood carvers in Okahandja and with the fisheries in Swakopmund. An outcome from this objective is that outreach work at PoN is expected to continue and grow and will impact many students.

Other examples of projects that WPI has carried out in Africa include the project called Desert Research Foundation of Namibia (DRFN) because WPI worked in collaboration with DRFN. This project studied the issues that relate to the sustainable management of the Kuiseb River watershed and developed recommendations about how to successfully involve all stakeholders in the management of this ephemeral river basin so that an equitable and sustainable decision-making process is put in place. The project required that the students understand the specific ecology of the Kuiseb River Basin and also how to successfully involve a range of stakeholders in a decision-making framework for solving water management problems of this region that will result in fair and long-term solutions. The stakeholders included the government, ranchers/farmers, town dwellers in Walvis Bay and Swakopmund, industry, and the Topnaars, a poor tribal group living in this area.

⁵ Ibid.

⁶ The partnerships described here are found in “Synergy in Development 2004,” *Higher Education Partnerships*, New York: The Association Liaison Office, 2004.

Another WPI project, entitled City of Windhoek, Department of Economic Development, Tourism & Recreation, established the tourism and cultural attraction base that is available in Windhoek, including the Katutura Heritage Route, in order to help the city develop its tourism infrastructure and activities that will attract and keep tourists in Windhoek for a longer stay than they currently spend. This project determines the interests and needs of tourists who come to Namibia and how they can be met by the development of attractions in and around Windhoek.

In addition, a WPI project known as Renewable Energy & Energy Efficiency Bureau (R-3-E) helped to plan and design an energy efficient off-grid housing cluster (50-100 dwellings) in an informal settlement area of Windhoek. Housing will accommodate 3 levels of income, business premises, stand-alone electricity provision, communal recreational area, passive solar designs, etc.

Another WPI project called Township of Okahandja carried out a feasibility study for the township on the potential for the use of solar energy in supplying the various needs for power that exist within its jurisdiction. The customers for the electricity include people living in informal settlements, regular residential neighborhoods, businesses and even industry.

Finally another WPI project entitled Renewable Energy & Energy Efficiency Bureau, Desert Research Foundation of Namibia (& Stuart Scott Consulting Engineers) identified the key issues and a national strategy to conserve biomass (e.g., wood) fuels and manage and encourage their sustainable utilization in Namibia.

WPI Water Project in Africa⁷

Before delving into the WPI Water Project it is worth noting the water potential of Africa so that institutions that may wish to undertake project-based learning as it pertains to water in Africa may know the wide range of possible water projects that they might undertake.

The salient water resources in Africa are as follows: First, Africa is surrounded by the Atlantic Ocean to the West, the Indian Ocean in the East, the Red Sea in the North East, and the Mediterranean in the North. The existence of these oceans and seas point to the fact that desalination of water in Africa is an option. Over the last few decades desalination technologies have been used increasingly throughout the world to produce drinking water from seawater. Over half of the African population is without clean drinking water and two-thirds lack the means to safely dispose of waste.⁸ Various types of desalination technologies have been developed to cope with the need to transform salty sea or ocean water to safe drinking water in South Africa, Namibia, Botswana, Mauritania, Morocco, Algeria, Libya, Tunis and Egypt.

Second Africa has groundwater as a resource. Thirty percent of all fresh water is underground, most of it in deep, hard-to-reach aquifers.⁹ In southern Africa, especially in the arid and semi-arid areas, groundwater is a strategic resource of national and international importance. Groundwater recharge is a key factor in determining the sustainable management of groundwater resources. Systems for Analysis, Research and, the World Climate Research Program and

⁷ This research project was supervised by Arthur Gerstenfeld, and Susan Vernon-Gerstenfeld. The students involved were Justin Braga, Jacob Castiglione, and Joseph Higgins.

⁸ Trade Development Authority (TDA) Update, Volume 6, Issue 3, Fall 1991

⁹ Fen Montaigne, "Water Pressure," *National Geographic*, September 2002, p. 13. This is a global statistic which more or less represents the African water conditions

Training (START¹⁰), which is co-sponsored by the International Geosphere-Biosphere Program the International Human Dimensions Program on global environmental change is addressing the need to develop a user-friendly framework for determining groundwater recharge in Southern Africa for region-wide application in groundwater management. This START effort has identified four themes that relate to groundwater management:¹¹ groundwater recharge, including artificial recharge; value and economics of groundwater; groundwater vulnerability mapping and catchment area studies.

Third, lakes and rivers, soils, wetlands, biota and atmospheric water vapor constitute additional water resources in Africa. Together, lakes and rivers contain just a little more than one-fourth of one percent of all fresh water.¹² Lakes have most of it. Lake Victoria, Lake Albert, and Lake Edward empty into the White Nile. Lake Tanganyika and Lake Kivu both empty into the Congo River system. There are about thirty principal rivers in Africa each more than 1000 km long. Virtually all African rivers are shared among different African countries. Soils, wetlands and biota which contain all the dirt, mud, swamps, plants and animals of the Earth contain just under one-tenth of one percent of fresh water.¹³ Although atmospheric water vapor (which includes water in clouds) holds just four one-hundredths of one percent of all fresh water, they still have six times more water than all the world's rivers.¹⁴

The task of developing most of the above water resources is rendered urgent in view of the fact that the current population of Africa is 800 million and is continuing to grow. An example of the contribution of education in finding out the water resources in Africa is the Tiger Initiative offer to make European Space Agency (ESA) satellite data available for monitoring African water resources. There are already four separate ESA projects operating under the TIGER umbrella, reflecting the TIGER priority topics to date of wetland monitoring, food security, epidemiology and groundwater resources management. There is provision of satellite data on 15 African wetland sites – which are important for protecting biodiversity, moderating flooding and maintaining water purity - with ten different African governments among the project users. ESA's TIGER Initiative is all about generating sustainable Earth Observation services for integrated water resources management in developing nations, its main focus on Africa¹⁵

We carried out our water project in Namibia, a country in southern Africa, in 2004. Indeed southern Africa has one of the most arid climates in the world. Rainfall in the region is very limited due to topography, ocean currents, and global air circulation.¹⁶ Mountains along the south-western coast force precipitation from the clouds as the clouds gain altitude, in addition to creating impediments to global air circulation. Moreover, cold ocean currents from the Antarctic provide little moisture for air currents to absorb and carry inland. The small amount of rainfall that does occur is quickly evaporated because of prevailing dry air. As a result, there are few

¹⁰ START. {See a description of START in Reference section [10]}.

¹¹ *Systems for Analysis, Research and Training (START)*. "Africa Groundwater Initiative," Washington, D.C. 2002

¹² Ibid.

¹³ Ibid.

¹⁴ Ibid.

¹⁵ European Space Agency (ESA) Portal, "TIGER Workshop puts focus on space for African water management," http://www.esa.int/esaCP/SEMUV0A90E_index_0.html, Copyright 2000-2004. Retrieved on December 4, 2004.

¹⁶ Pallet J. (Ed) (1997). *Sharing Water in Southern Africa*. National BookPrinters, Windhoek, Namibia. Desert Research Foundation of Namibia.

perennial rivers or longstanding bodies of water. This also means that water supply and water demand are crucial issues to the survival of the region.

Among the countries in southern Africa, Namibia is considered the driest.¹⁷ Its capital, Windhoek, is located in the middle of the country on the Central Highlands. It is 700 km from the nearest perennial river located near Namibia's border in the northeast. Windhoek is supplied with water from local boreholes, dammed ephemeral river surface reservoirs, and reclamation of wastewater from sewage effluent.¹⁸

Organizations such as the Desert Research Foundation of Namibia (DRFN) have done studies on water demand management (WDM), but it is only recently that residents have been concerning themselves with the issue. It was not until 1994 that a water demand management policy was passed by the city council of Windhoek (Der Merwe, 1999). In 1998, NamWater was created as a subsidized company by the government to supply bulk water to municipalities and other authorities such as Okahandja. NamWater is determined to sell water in order to recover its full operating costs. As a result, they are hesitant to implement water demand management practices until times of drought. They believe if there is ample water to supply the city, then the water should be sold, claiming that water that stays in the dams for extended periods of time will eventually evaporate or leak out and be lost. The municipality, which buys water from NamWater, also hopes to achieve full cost recovery. This leads to further complications in developing and implementing WDM policies and practices within Windhoek. In contrast, experts at the DRFN and African Centre believe that water demand management should be practiced at all times. They calculate that there will never be a time when Namibians can simply use water as they please.

The goal of this project was to develop and recommend innovative improvements to the Water Demand Management (WDM) plan of Namibian cities. To accomplish this goal, the primary objective was to analyse past and present problems and successes in Windhoek's Water Management. Several methods were used to accomplish the objective. First, we undertook archival research of WDM reports, water management studies, and assessments of the water situation in Windhoek to gain knowledge of WDM practices and policies in Windhoek. Second, we conducted several interviews. We interviewed experts in water management to gather information on what was being done regarding WDM today and where WDM was likely to be most effective in the future. We also interviewed residents, students, and school employees to learn about their water use practices and knowledge of water conservation with legible school poster competition themes such as these: 'Wash cars with a wet cloth and a bucket of water'; 'Recycle washing water to water a garden,' 'Report burst water pipes,' and 'Put a bucket under a tap that leaks.'

The third method that we used was field research to acquire first hand knowledge of how Namibians use water daily and if they practice water conservation techniques. To gather this information, we installed advanced water meters in nine volunteer households. These meters recorded the amount of water used every fifteen seconds over a period of three days. In addition, we investigated two hardware stores to examine the availability of water-saving devices. Finally, we took a tour of Windhoek to study the landscaping practices around the city, where we looked for evidence of whether or not people were conserving water.

¹⁷ B. Van Der Merwe, (ed.) (1999). *IUCN Water Demand Management Country Study – Namibia*.

¹⁸ Ibid.

We observed that the block tariff system, which charges residents based on the amount of water used, has been the most successful policy in lowering domestic water use. Moreover, wet industries, especially Namibia's beer breweries, have become more water efficient. The breweries reuse grey water (wastewater other than that containing human excrete such as sink drainage, washing machine discharge, or bath water) within their facilities to reduce their water consumption and only use four litres of water per litre of beer. Most breweries in the world use six to eight litres of water per litre of beer.¹⁹

Another successful system the city developed is a dual pipe system. One pipe is used for delivering potable water, while a second is used to deliver semi-purified effluent. Semi-purified effluent is treated wastewater that is not suitable for drinking but sufficient for irrigation (grey water). Now large irrigation schemes, such as municipal gardens and sport fields, are watered using the treated wastewater. This saves a considerable amount of drinkable water for the city.

Unfortunately, some practices and policies have not been effective. For instance, gardens are not supposed to be watered during the middle of the day, pools should be covered when not being used, and households should have showerheads limiting flows to ten litres a minute. These are all things that are hard to regulate and are not enforced by the city. Part of the reality is there are no certified people to enforce such regulations. We believe that a stronger water management education program is needed.

We also discovered there is a significant amount of wasted water throughout the city. For instance, Windhoek has many large green gardens that use a lot of water. Although many of these gardens use semi-purified water, this water could be saved by using indigenous plants that can be just as visually appealing and can survive on low rainfall. A different problem that is threatening Windhoek's water supply is leaks. Using our water meter studies, we discovered that some residents lose a significant amount of water through leaks and high-flow water fixtures. In one residence, over half of the overall household consumption was attributed to a leaking toilet. The leak costs the family US\$253 over the course of a year. Another residence had a leaking toilet, which constituted 81 percent of the total household water consumption. This costs that family over US\$398 a year. Therefore, one way in which people can limit their water use is through timely repairs of leaks and the use of water-saving devices. Upon visiting two hardware stores, we found that water efficient technologies were available and comparably priced to regular flow devices.

Although the study described above took place in Namibia, we believe our findings apply to all of Africa.

Conclusions and Recommendations

In conclusion, we have two sets of recommendations. The first set pertains to our empirical findings in Namibia. The second set emanates from our general study of the water situation in Africa. Regarding our experience in Namibia, we found there are successes and problems with the current Water Management practices and policies of Windhoek. Some practices, such as the block tariff system have been highly successful, but others, such as gardening regulations, have seemingly failed. Moreover, there are discrepancies that must be addressed among experts in water management. Nevertheless, from the research and analysis of

¹⁹ Der Merwe, Op. Cit., 1999).

the successes and problems of past and current water management practices and policies, we developed a prioritised list of recommendations for improving the water management plans of Namibian cities:

- To improve educational programs on water conservation both in schools and in local communities.
- To improve response and repair time of infrastructure breakdowns.
- To practice more accurate accounting of metered water use.
- To promote and increase availability of water-saving devices.
- To develop new clean water systems such as better filters, desalination, and water reuse.

With regard to the set of recommendations relating to Africa in general we have five recommendations. First, there is the need for Africa to work with international agencies to ensure it is in the cutting edge of technologies for water resource development, e.g. working with the European Space Agency (ESA) that can provide satellite data for monitoring African water resources. Second, there is need for African countries to exchange scientific knowledge and business expertise among themselves for effective provision of water to their populations. For instance, South Africa and Nigeria cooperate on the development of groundwater. Third there is need for African countries that share the same water resources such as lakes and rivers to develop water management policies that are based on transboundary, supranational considerations and agreements to avert the occurrence of “Water Wars”. The growing populations of Namibia and Botswana seem destined to put extreme pressure on the Okavango River and its magnificent inland delta, and risk bringing Namibians and Botswana into conflict.

Fourth, government policies need to emphasize conservation and sustainability instead of merely emphasizing exploitation for development. For example, in most countries there is no single agency responsible for wetlands management.

Fifth, there is the need for coordination of the numerous freshwater ecosystem resources in a given African country. To date it has been typical for a number of different agencies to be responsible for fisheries issues, agricultural concerns, industrial waste affairs, and drinking water problems.

References

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- [2] *The Africa Journal* April/May 2004 issue, p. 19.
- [3] Ibid.
- [4] Ibid.
- [5] Ibid.
- [6] The partnerships described here are found in “Synergy in Development 2004,” *Higher Education Partnerships*, New York: The Association Liaison Office, 2004.
- [7] This research project was supervised by Arthur Gerstenfeld, and Susan Vernon-Gerstenfeld. The students involved were Justin Braga, Jacob Castiglione, and Joseph Higgins.
- [8] Trade Development Authority (TDA) Update, Volume 6, Issue 3, Fall 1991
- [9] Fen Montaigne, “Water Pressure,” *National Geographic*, September 2002, p. 13. This is a global statistic which more or less represents the African water conditions
- [10] START is a non-governmental, non-profit organization that seeks to establish and foster regional networks of collaborating scientists and institutions in developing countries. These networks conduct research on regional

aspects of environmental change, assess impacts and vulnerabilities to such changes, and provide information to policy-makers. START acts to enhance the scientific capacity of developing countries to address the complex processes of environmental change and degradation through a wide variety of training and career development programs. START mobilizes resources to support infrastructure and research programs on environmental change within developing regions.

[11] *Systems for Analysis, Research and Training (START)*. "Africa Groundwater Initiative," Washington, D.C. 2002

[12] Ibid.

[13] Ibid.

[14] Ibid.

[15] European Space Agency (ESA) Portal, "TIGER Workshop puts focus on space for African water management," http://www.esa.int/esaCP/SEMUV0A90E_index_0.html. Copyright 2000-2004. Retrieved on December 4, 2004.

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[18] Ibid.

[19] Der Merwe, Op. Cit., 1999).

Authors' biographies

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