Productivity-centered, Service-learning:
Pedagogy for the Sustainable Development of the Province of the Galápagos

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ABSTRACT: This paper advocates for strategic investments in Productivity-centered, Service-learning (PCSL) in the Province of the Galápagos to self-generate revenue for education finance. PCSL curriculum can support student research and build market services for a proposed Renewable Energy Applications Laboratory of the Galápagos Archipelago (REAL) and the future Galápagos Ecological Observatory (GEO). The international donor community, especially institutions that advocate bridging the digital divide as a global strategy for improving the human condition in impoverished nations, can support and sustain innovative partnerships to aid the Province in the transition to an information economy.

INTRODUCTION / BACKGROUND

From 1999 to 2001, SolarQuest® applied the principles of PCSL to projects with governments in sub-Sahara Africa and Latin America under a partnership with the White House Millennium Council and various departments of the Government of the United States, including the United States Department of Energy, the Department of State, and United States Agency for International Development. This partnership demonstrated the efficacy of applying PCSL utilizing advanced Information and Communications Technologies (ICTs) and renewable energies to deliver human capacity building services leading to the sustainable economic development of communities isolated from the electricity and telecommunications grids.

After the tragedy of the oil tanker *Jessica* on January 16, 2001, the e7 Network for Expertise on the Global Environment (e7) requested the assistance of SolarQuest® to provide the PCSL pedagogy to address human capacity building for the sustainable economic development of the Province of the Galápagos. The e7 provided initial funding for SolarQuest® to support energy monitoring services for the proposed wind turbine farm on San Cristobal and for PCSL projects now operating under the MicroSolar Distance Learning Programme (MicroSolar). MicroSolar projects are expected to self-generate revenues for long-term financial sustainability based upon the identification of sustainable economic development opportunities and the formation of strategic partnerships between SolarQuest® and key institutions in the Province.

In 2003, SolarQuest® established broadband Internet services to several institutions – the Galápagos National Institute (INGALA), Empresa Eléctrica Provincial Galápagos, S.A., (EEPG), Colegio Tecnico Ignacio Hernández (CTIH), and Colegio Nacional Galápagos (CNG) – to provide infrastructure to support MicroSolar PCSL projects. In 2004, SolarQuest® launched the Action, Communication, Technology and Science (ACTS) curriculum at CTIH as a PCSL pilot project. This paper argues for the international donor community and key stakeholders in the Province to support the development of an expanded MicroSolar PCSL project – the Conservation Corps of the Province of the Galápagos Archipelago (Corps) – in order to prepare a new generation of knowledge workers for employment in an emerging information services

economy. The Corps will provide training and employment for youth ages 18 – 25 to support the development of a proposed Renewable Energy Applications Laboratory of the Galápagos Archipelago (REAL) and the future Galápagos Ecological Observatory (GEO). Revenues from the proposed REAL and the GEO will self-generate revenue for education finance.

MEETING THE CHALLENGE OF EDUCATION FINANCE WITH PCSL

Consensus among economists, educators and politicians worldwide is that improving the performance of the education sector at all levels is necessary to advance socioeconomic development.[1] Nevertheless, meaningful education reforms often fail to be approved or implemented for political and/or financial reasons – principally heavy debt burdens – which in developing countries continue to draw precious government resources away from critical investments in education.[2] PCSL represents an investment strategy and pedagogical practice that is independent of political constraints. Through productivity-driven research and parallel economic development activities, PCSL can supplement public sector education finance by self-generating revenues.

"PCSL (Productivity-centered, Service-learning) is a teaching methodology in which a mutually supportive intentional group of inter-generational learners utilize a wide array of public and private resources – including traditional academics – to enrich the learning experience, and who are committed to a process in which they employ Information and Communications Technologies (ICTs) to acquire new information and relevant knowledge, and share that knowledge with other learners and the general public, in order to identify and solve critical social and economic problems for the betterment of their community with the specific goal to improve the general well-being of that community through the multiple benefits of increased economic productivity."[3] The key premises of PCSL are: i) that all participants are learners and the community is an extended classroom; ii) that learning results in outcomes measured not only by education standards but also by calculated productivity gains; and iii) that a portion of the productivity gains are reinvested in education. The ACTS 2004 pilot project provided meaningful insight into the potential for PCSL to contribute to the sustainable economic development of the Galápagos and to provide an incentive to invest – and reinvest – in education. The following is a summary of the ACTS 2004 PCSL project and its outcomes.

At the launch of the MicroSolar program in 2003, the e7 was planning a 2.5 megawatt wind turbine farm on the Island of San Cristobal in collaboration with the United Nations Development Programme (UNDP) and the Ministry of Energy and Mines (MEM) of the Government of Ecuador. Two key economic issues – energy efficiency and excess power generation – surfaced during the wind power feasibility study. These issues, which were not within the scope of the feasibility study, needed to be addressed in order to fully assess the potential benefits of wind power. In consultation with e7 companies American Electric Power and Enel, a decision was made to focus PCSL learning activities in 2004 on energy efficiency.

The Ministry of Education and Culture (MEC) and SolarQuest® subsequently developed ACTS as a curricular program for research on energy efficiency, and to meet community service requirements for level 5 students under national education standards. ACTS requires students to: i) demonstrate the capacities to use ICTs to collect and analyze data; ii) participate in activities that provide knowledge of and exposure to community economic issues; iii) conduct

original research identifying the potential to increase economic productivity; and iv) deliver oral and written presentations that communicate their knowledge.

To aid student research, SolarQuest® installed advanced power metering devices on diesel generators at the EEPG central thermal electric power plant and three buildings on the Island of San Cristobal by sector – commercial, institutional and residential. This "energy observatory" provided near-real-time data to model energy demand and consumption from representative structures in the Province. EEPG personnel, faculty and students were equipped with portable monitoring devices to measure the energy demand and consumption of individual appliances and to capture data at electric service meters. Instantaneous and archived datasets from the central power plant and monitored buildings were made available over the Internet in usable file formats, such as Microsoft® Excel. Instruments were deployed to collect relevant environmental data, including meters to measure the thermal performance of buildings and sensing devices to measure environmental conditions, such as indoor and outdoor temperature and solar insolation rates. Enel and SolarQuest® provided capacity building to EEPG on the principles of the Rational Use of Energy (RUE) – renewable energy and energy efficiency measures – and trained CTIH faculty and students to conduct comprehensive energy audits. Energy audits were conducted on 41 buildings selected by EEPG and posted to the SolarQuest® Virtual Schoolhouse. Enel engineers verified the accuracy of the audits utilizing energy modeling software.

After extensive analysis students determined that a significant portion of electricity demand and consumption in the Province is the result of domestic and commercial refrigerators failing to cycle off during twenty-four and forty-eight hour test periods. Consulting with Enel engineers and SolarQuest® support staff, students decided to conduct an island-wide refrigerator survey. Audits were performed over several months. Data from 500 refrigerators on the Island of San Cristobal were analyzed. By extrapolation, the results of the survey indicated that 36% of an estimated 6,000 refrigerators in the Galápagos were failing to cycle off. Students hypothesized that this represented: i) the consumption of 4.25 million kilowatt hours annually; ii) a demand of 486 kilowatts (base load) on the Province's four electric grids; and iii) consumer charges and government tariffs totaling USD 979,000. Students calculated that the potential to reduce 1.4 megawatts from the electricity grid would save consumers and government in excess of USD 1.5 million annually if energy efficiency refrigerators were combined with other high-value energy efficiency measures – compact fluorescent lighting, passive thermal water heating, high-efficiency air conditioning, and occupancy sensors. Using DSM industry standards, students assumed energy efficiency implementation costs at USD 3 million per megawatt avoided, 60% on a per megawatt cost basis of planned wind power installations for San Cristobal and Santa Cruz Islands, and 23% percent on a per megawatt cost basis of planned photovoltaic energy systems on Floreana, Isabela and Santa Cruz Islands. Based on various equipment replacement and financial scenarios, students generalized that a DSM program could be paid from energy savings over 3 years or less. A portion of the consumer and government savings during and beyond the requisite payback period could be reinvested in education.

Based on the success of the ACTS 2004 pilot project, the PCSL pedagogy merits continued appraisal as an education finance strategy in the Galápagos and as a methodology to accelerate the sustainable economic development of the Province. SolarQuest®, in collaboration with the

UNDP and the MEM, will be examining the potential of PCSL to support the development of the proposed Renewable Energy Applications Laboratory of the Galápagos Archipelago (REAL). In collaboration with the INGALA, SolarQuest® will assess the feasibility of the Galápagos Ecological Observatory (GEO).

SUPPORTING RENEWABLE ENERGY INFORMATION SERVICES

PCSL curricula can contribute to the development of the proposed REAL. Two examples are cited: i) a real-time energy observatory to model renewable energy and energy efficiency projects, and ii) a geo-spatial mapping of primary renewable energy resources utilizing SWERA software developed by United Nations Environment Programme (UNEP).

Transformation in the energy sector is being led by the UNDP and the MEM under the project "*Ecuador: Renewable Energy for Electricity Generation – Renewable Electrification of the Galápagos Islands (ERGAL).*"[4] ERGAL is leveraging in excess of USD 33 million to integrate renewable energy technologies into the Province's four independent diesel-powered micro-grids. When ERGAL projects are complete, EEPG will be generating nearly 50% of its electricity from renewable energies – wind turbines and photovoltaic cells. Driving this transformation is a series of innovative public-private partnerships based upon the United Nations Foundation (UNF) – United Nations Fund for International Partnership (UNFIP) Climate Change / Sustainable Energy Programme Framework.[5] This framework, which aims to develop sustainable commercial approaches to deliver community-based renewable energy services modelled after the UNF's guiding principles of leverage and partnership, is premised upon the conditions established by the United Nations Framework Convention on Climate Change (UNFCCC) and the so-called Clean Development Mechanism (CDM).[6]

The CDM permits industrialized countries to pay for projects that reduce or avoid emissions in poorer nations. Under the CDM, project developers from industrialized nations are awarded with carbon credits that can be applied to meet their own emissions reduction targets. Beneficiaries in the recipient countries receive free, or substantially discounted, infusions of advanced technologies, allowing electrical generating plants to operate more efficiently and, hence, at lower costs and higher profits. ERGAL is an early stage adopter of the CDM and, as such, is a providing leadership for renewable energy development worldwide.

As a consequnce of ERGAL's success, the UNDP and MEM are proposing to establish an international, membership-based "Renewable Energy Applications Laboratory" (REAL). The proposed REAL will serve as a field laboratory, or "test-bed," for state-of-the-art renewable energy technologies and balance-of-systems components, and it will provide technical assistance to member nations on micro-grid development in order to meet growing demand for remote electricity services. The argument for the development of the REAL is compelling. The Electrification Scenario of the International Energy Agency (IEA) projects an added investment of USD 665 billion in order to supply 50 kilowatt hours annually to 1.4 billion people worldwide without access to electricity.[7] Strategies to provide expanded electrification include the construction of micro-grids. From a cost perspective, micro-grid development projected through 2030 represents 36% of the added investment – a potential micro-grid market of USD 239 billion over 25 years. This corresponds to nearly USD 10 billion annually in four international markets – Africa, South Asia, East Asia and Latin America. Latin America is

projected to achieve 90% of its remote power generation needs through micro-grid development, an average of USD 1 billion per year over the next 25 years.

PCSL curricula can provide the foundation for the development of the REAL by training qualified technical personnel to support energy monitoring services planned for ERGAL projects. Under the CDM, financial incentives for emissions credits tied to renewable energy and/or energy conservation technologies are determined by three verification strategies. The level of financial incentives over the lifetime of a project can be negotiated on the basis of inspection, default, or monitoring, with financial incentives increasing from inspection (low incentive rates) to monitoring (high incentive rates). The REAL can deploy a pervasive sensing model or "real-time observatory" (such as SolarQuest® developed for ACTS 2004 student research) for CDM energy monitoring and evaluation. Engineers, faculty and students can develop the capacity for real-time monitoring of energy flows measuring production and consumption through a diversified data topology of the Province's four micro-grids. This represents a high-value technical assistance service and benchmark for internal and external project assessment. It provides the ability for policy makers, project developers, finance agencies, equipment manufacturers, and operations and maintenance personnel to evaluate project and/or product performance. And it can promote energy monitoring as a project finance strategy in the international micro-gird market. SolarQuest® offers a preview into this pervasive sensing and observatory concept designed for the ACTS 2004 PCSL project and the e7 CDM monitoring requirement.[8]

PCSL curricula can also provide the foundation for the REAL by developing the capacity for member training and site assessment utilizing SWERA, a solar and wind energy resource assessment software program developed by the UNEP. SWERA was designed to develop and access reliable and easily useable resource data essential for government and industry to identify in-country power generation potential from solar and wind, and to act on that knowledge. The UNEP identified two issues – the lack of primary energy information and the lack of institutional capacity to conduct relevant research – as "primary obstacles to both public-sector and private-sector investments in renewable energy applications in most of the developing world, including renewable energy projects and programs supported by the GEF."[9] The UNEP developed SWERA to aid developing countries with technical, economic and environmental assessments for broad scale development of solar and wind facilities, and to amplify their ability to attract private and public sector investments.

PCSL activities to develop training capacities utilizing SWERA would include deploying Geographic Information Systems (GIS) to obtain geographically referenced information on primary renewable energy resources. Data collected in digital formats would be comprised of spatial features and social attributes. Spatial features include elements that can be shown on a map, such as roads, rivers, population density, electric transmission corridors, meteorological stations, wind or solar resource distribution, temperature, wind speed and solar radiation values. Social attributes include elements that are associated with land ownership and use designations, such as forest, agriculture, park, residential, commercial, and industrial use patterns. Students can be deployed utilizing GIS technologies to obtain the requisite data to map these elements, maintain a SWERA database, provide data analysis and support training services. Through a PCSL project, the REAL can establish and maintain an international training center for SWERA technical skills development.

PCSL activities can also include the integration of SWERA with a real-time energy observatory based upon the ACTS 2004 model. A computerized map and a database within the same system (SWERA) integrated with the real-time measuring of energy flows (ACTS energy observatory) creates an interactive assessment tool that allows dynamic modeling, supports predictive analysis capabilities and aids in decision making capacities of all stakeholders in renewable energy development. SolarQuest® is providing concept development for the REAL in collaboration with UNDP, MEM and INGALA, and will assess the potential to design into the REAL a role for PCSL project applications.

PCSL AS THE FOUNDATION FOR SCIENCE INFORMATION SERVICES

The success of the ACTS 2004 PCSL pilot project stimulated discourse between SolarQuest® and key education stakeholders in the Galápagos – the INGALA and the MEC – on the notion that the skills acquired for PCSL application in the energy services sector could be readily applied to the development of an information economy based on the delivery of science education content to classrooms worldwide. From this discourse the concept of a virtual Galápagos Ecological Observatory (GEO) emerged as a vision for the sustainable economic development of the Province. The INGALA and SolarQuest® subsequently signed an agreement to develop a concept for the GEO as a principal strategy for biodiversity protection and the sustainable development of the Province.

PCSL curricula can be instrumental in formulating and testing the feasibility of establishing the GEO as an archipelago-scale research instrument consisting of the following elements: i) a distributed electronic infrastructure networked via state-of-the-art ICTs; ii) cutting-edge laboratory and field instrumentation; and iii) computational, analytical and modeling capabilities linked via high-speed networks both within the Galápagos and distributed to facilities in the United States for distribution to global information markets. A GEO would modernize the research of the Charles Darwin Research Station, the Galápagos National Park Service and the international science research community. It would support the ecological monitoring goals established through the International Convention of Conservation Biologists (May 1999).[10]

A technologically advanced ecological observatory in the Galápagos would transform education and science research in client nations by enabling cooperation on global studies of major environmental challenges and evolutionary responses. Scientists and engineers would potentially use the GEO to conduct real-time ecological studies spanning macro- and micro-levels of biological organization and temporal and geographical scales within the Archipelago. Globally networked research partners would be supported by a communications and informatics infrastructure enabling collaborative, comprehensive and interdisciplinary measurements and experiments on ecological systems and their interface with human communities. The GEO's advanced computational infrastructure would sustain sensor-to-client synthesis, computation and visualization to aid predictive modeling and decision support services for international environmental policy and systems-wide interventions.

Over 126,500 primary and secondary schools throughout the United States are equipped with ICTs supporting distance learning on a variety of technology platforms, including web-interface and interactive video conferencing. Teachers and students in the United States would utilize

the GEO as a platform for experiential learning and biosphere literacy, integrating access to real-time data streams, marine and terrestrial observation posts, and live experiments broadcast from the Galápagos into their existing core science curriculum. Students would be able to participate in innovative learning environments that foster the integration of education with research conducted in collaborative with scientists in the field. Students and scientists would co-develop information services – science education content – as the principal intervention strategy to preserve the biological diversity of the Galápagos. Financial incentives would encourage local stakeholders, including small fisheries in partnership with the scientific community, to derive income from maintaining a pervasive electronic sensing network deployed throughout the Archipelago's ecosystems.

Transitioning to an information services economy in the Province premised upon a GEO model would require investments in terrestrial- and space-based broadband capacities, in networked sensing arrays and in sustained institutional capacity building services from international stakeholders. It would require an unparalleled cooperation between diverse sectors often in conflict. Most importantly, it would require a multi-sector commitment to workforce development focused on comprehensive education reform to train knowledge workers with cognitive skills in spatial thinking and proficiency in geospatial technologies.

SolarQuest® and the INGALA are planning a Community Informatics Committee for the Province of the Galapagos consisting of key stakeholders to guide the development of the GEO. Also planned is an International Leadership Council of the Galapagos Archipelago comprised of world leaders in environmental policy, education reform, and science and technology. GEO development efforts will commence with proposals for the establishment of the Conservation Corps of the Galápagos Archipelago (Corps) with technical assistance services from the California Conservation Corps (United States).

CONCLUSION

School facilities in the Province are in disrepair. Students are exposed to broken glass, sharp metal roofing and unprotected electrical wiring. Classrooms fail to provide adequate environments for teaching and learning. Chronic shortages of basic materials – desks, blackboards, textbooks and other teaching aids – persist at all grade levels. Classroom resources are virtually non-existent or outdated by decades. Salaries are inadequate to attract highly qualified teachers or to provide sustained professional development services for career faculty. Overcrowding is emerging as a critical issue and was the cause of a teachers' strike in Santa Cruz at the opening of school in 2006. These conditions persist despite the fact that education reform emerged worldwide in the 1990's as a top priority issue in both developed and developing countries alike.

Evidence does exist that this situation is improving with a concentrated focus on technology-aided education. Modern networked computer laboratories have been installed in primary and secondary schools on three islands. New classrooms – future computer labs – have been constructed at many schools. Schools without the benefit of a networked computer lab have at least one or more working computer(s). Community- and school-based, post-secondary distance education services are emerging under partnerships with institutions of higher education from the continent. Improvements, however, are unable to keep pace with increasing demands, and the requisite investment in education to accelerate the Province toward

sustainable economic development remains elusive. PCSL can be instrumental for the Galápagos to re-tool its educational infrastructure and emerge as a viable stakeholder in the global information economy within framework of the proposed REAL and the GEO.

ERGAL demonstrated the feasibility of achieving energy sector reform based on partnerships with the international community. Proposals were written and investments secured. Projects are now under construction. As a consequence of ERGAL, the Galápagos is on an irreversible transition to a renewable energy economy. The rational strategy for the sustainable development of the Galápagos is to embrace this model of positive change through partnerships with the international information technology sector, and to invest in education reform in order to train a knowledge workforce – a Conservation Corps of the Galápagos Archipelago – and build an economy through value-added information services as unique as the Archipelago itself. Multi-billion dollar global initiatives addressing the so-called "digital divide" are emerging that can assist in this transition.

The Galápagos is hailed worldwide as the "Living Laboratory of Evolution" and birthplace of evolutionary science. To maintain its preeminence, it must engage the world to define the parameters of new research instruments that can aid in the emergence of an ecologically sustainable paradigm – for the Province and for the Planet. The critical challenges lie in building consensus and in building effective partnerships among international resource partners and galapagueños.

The Galápagos is at an historic threshold today much as it was when Charles Darwin first conducted research in the Archipelago in 1835. That threshold will not be crossed in the *H.M.S. Beagle* or its replica; rather it will be crossed in the interaction between cyberspace and human consciousness bridged by technological innovation and with leadership from a new generation of technologically literate galapagueños. This is the requisite pathway to protect the endemic biodiversity of the Archipelago and to achieve ecologically sustainable human development for the Province. Investment in education is the prerequisite.

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[1] Corrales, Javier, 1999. "The Politics of Education Reform: Bolstering the Supply and Demand; Overcoming Institutional Blocks." The Education Reform and Management Series, Vol. II, No. 1., p.7

[2] UNESCO, March 1990, World Declaration on Education for All, Jomtien, Thailand, "Meeting Basic Learning Needs, Preamble." [online] URL: http://www.unesco.org/education/efa/ed_for_all/background/jomtien_declaration.shtml

[3] Baer, Allan, 2005. "Productivity-Centered, Service-Learning; A Working Definition." Unpublished Manuscript.

[4] United Nations Development Programme, 2001, ECU/02G31. "Ecuador: Renewable Energy for Electricity Generation—Renewable Electrification of the Galápagos Islands." [online] URL: http://www.gefweb.org/Documents/Council_Documents/GEF_C18/Ecuador_Renewable_Energy.pdf

[5] United Nations Foundation for International Partnerships, 2001, "Interim Program Framework For Sustainable Energy/Climate Change," [online] URL: http://www.un.org/unfip/2004Website/docs/climateframework.pdf

[6] United Nations Framework Convention on Climate Change, 2001, FCCC/CP/2001/13/Add.2, Decision 15/CP.7, "Principles, nature and scope of the mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol." [online] URL: http://unfccc.int/resource/docs/cop7/13a02.pdf#page=20

[7] International Energy Agency, 2003, "World Energy Investment Outlook," Chapter 7, Universal Electricity Access, Pages 408-413. [online] URL: http://www.iea.org/Textbase/nppdf/free/2003/weio.pdf

[8] SolarQuest® Energy Observatory, ACTS 2004 PCSL, [online] URL: http://galapagos.solarquest.com/EEPG/

[9] United Nations Environment Program, 2006, "SWERA." [online] URL: http://www.uneptie.org/energy/act/re/fact_sheet/docs/SWERAInfosheet.pdf

[10] Bensted-Smith, R., Editor, 1999. "A Biodiversity Vision for the Galapágos Islands," published by the Charles Darwin Research Station and World Wildlife Fund; [online]URL: http://www.darwinfoundation.org/downloads/bio_vision_galapagos_eng.pdf