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Abstract

Technology transfer is a critical process to advance national technology capabilities and social development. This paper presents a proposed initiative at Tshwane University of Technology on technology transfer that is linked to ongoing work on appropriate technology. The initiative focuses on technology transfer through research in energy, water and industry. However, technology transfer is identified as a research area in itself and technology transfer is assessed based on outreach to communities; jobs and enterprise creation and research dissemination. The potentials of appropriate technology and technology transfer are investigated for the South Africa Post Office. This serves as an example for other industry sectors. The conclusion addresses particular recommendations to the post office and broad recommendation to the government and universities. Recommendations to universities address partnerships and curriculum development. The final section provides an example of curricula options for a program on 'Big Data'.

Keywords: technology transfer, public policy, appropriate technology, national planning

Introduction

Appropriate technology is primarily concerned with empowering people and communities. The International Network on Appropriate Technology (INAT) has organized international conference, local symposia and a website to advance appropriate technology. The first biennial conference was held in 2004 in Bulawayo, Zimbabwe. Since then five additional conferences have been held across Africa. The 7th ICAT is scheduled to be held this November in Victoria Falls, Zimbabwe.

Tshwane University of Technology (TUT) is planning a Flagship Initiative, which is a major university project centered on Technology Transfer. This project will involve science, engineering and business academic staff and research across several campuses and will have several industry partners including the South Africa Post Office. The Flagship Initiative is designed to heavily involve community infrastructures and serve as a model to help develop national policy, to address job creation and manufacturing and service development, by connecting appropriate technology and technology transfer to the needs of local communities.

Forward thinking national planning must take into account future demographics and encourage innovation and community engagement to achieve the needed industrial development and job creation that are the key measures of societal advancement. National planning must address policies that will facilitate the implementation of appropriate technologies and the transfer of technologies from universities to communities, designed to empower the most inpoverished and disadvantaged communities and individuals.

Methodology

This study examines the relationship between technology transfer, appropriate technology and national policy planning. Each of these three are presented as a system with components and relationships. How national policy planning can utilize technology transfer and appropriate technology is then constructed as a framework linking the roles of the university, international organizations and national government.

Results and Discussion

Technology Transfer

Ramanathan (2013) indicates two types of technology transfer: 1) a vertical transfer of technology from basic research to applied research, then on to development, and production; and 2) a horizontal technology transfer where technology used in one place or context is transferred for use in a different place or context. This research initiative addresses both perspectives.

Starting with basic science research in water and sanitation, energy and industry, the challenge is to use design and engineering principles to produce prototypes, products, and production processes that address the vertical transfer of technology. This requires a critical collaboration between researchers in Science, Engineering and Technology (SET). Research, in TUT's Industrial Engineering Department, on engineering design and manufacturing systems serves as a bridge in this process of vertical technology transfer. A Fabrication Laboratory is proposed, based on the FabLab model developing at Massachusetts Institute of Technology (FabFoundation 2016). This will be combined with existing TUT labs to facilitate prototype and product development, key to technology and skills transfer.

The challenge of horizontal technology transfer is how to take products, services and processes developed at TUT to industry and local communities such that the transfer leads to successful technology diffusion and contributes to job creation and community empowerment. This will require industry partners committed to assisting in the technology transfer process. It will also require the university's commitment to support the community outreach needed to make this successful.

TUT's Flagship initiative also addresses the challenge of extending the research conducted at TUT to a wider number of academic staff and departments. Technology transfer by its nature is multidisciplinary. Starting with research in water and energy and linking to engineering we are drawing on TUT's strong research subject areas. TUT's top ranked subjects in terms of number of publications are chemistry and engineering (Munda 2015). The test of quality research is not only publications and patents, but also conference presence and web presence. This initiative will address all four.

There are various contexts of technology transfer. In the global context, South Africa is concerned with transfers from developed countries as well as transfers within developing countries. In the national context South Africa is concerned with transfers between Small and Medium Enterprises (SMEs), academic institutions, government institutions and large-scale industry. Ramanathan (2013) examines the role of various institutions in both the global and national context and examines alternative approaches to technology transfer and develops a comprehensive model referred to as the TTLC (Technology Transfer Life Cycle) approach.

"The TTLC approach takes a holistic view of a TT project from its 'conception' right up to its "conclusion" and is based on the recognition of the fact that a life cycle of a TT project can be looked at from a process perspective as consisting of six major stages as follows.

- Identifying the technology needed and making a business case to obtain corporate approval
- Searching for possible technology sources and assessing offers

- Negotiating with short-listed suppliers and finalizing the deal
- Preparing a TT implementation plan
- Implementing and assimilating
- Assessing the impact of the TT project" (Ramanathan 2013, 16)

Another challenge is developing the academic entrepreneur in the TUT research environment. Rorwana and Tengeh (2015) speak to the importance of the entrepreneur at the University of Technology. This final challenge is instrumental in linking the academic researcher to the community entrepreneurial process and the industrial innovation process.

Together these challenges speak to the importance and complexity of technology transfer as well as the difficulties in effectively achieving it. The evaluation of the technology transfer process and the particular projects associated with the process must be a critical component of this initiative. In the spirit of empowerment, characterizing the mission of TUT, social relevance must be a key measure in assessing the outcome of technology transfer.

The vertical transfer of technology stimulates a cross-disciplinary research environment that will empower more staff and students to engage in research. A wide range of disciplines will be encouraged to participate by initiating the project with a team of the most productive researchers from science and engineering. Starting with the critical areas of industry, water and energy focuses on the university's strengths in basic science while allowing the mentoring of young academics in a range of subjects. The outreach and mentoring of less experienced academics will be a structured part of the Initiative and will build on the Early Career Academic capacity development programme at TUT.

Various engineering disciplines focus on taking the research from basic science to development and production. The Initiative will build on existing work on Engineering Design that involves Management, Engineering and ICT Faculties at several universities across Africa. It will be extended to address the transition from basic science research to production that is required for technology transfer of various projects at TUT. This will include the development of intellectual property in the form of physical artifacts such as our reconfigurable manufacturing equipment, as well as software artifacts and processes.

National Importance

Access to the latest technology is critical to national development. The transfer and diffusion of technology is key to increasing productivity in manufacturing as well as service delivery. "Developing countries criticize industrialized nations about their failure to transfer cleaner technologies and are emphatic about the paltry levels of financing to facilitate international technology transfer" (Gallagher 2014). This requires that national priority be given to developing the technology transfer process internal to South Africa. TUT can play an important role in this process.

The empowerment of people rests squarely, on their access to basic needs. Herein lies the importance of appropriate technology that addresses access to water, energy, food, shelter, education, health and communication.

> "Water, energy and food systems are inextricably interconnected. Water and energy are needed to produce food; water is needed for almost all forms of power generation; energy is required to treat and transport water. The relationships and trade-offs within this triangle of resources are known collectively as the water-energy-food nexus." (REEEP 2015)

This reinforces the importance of TUT's focus on energy and water. The third focus of industry complements our research on energy and water by supporting the horizontal technology transfer from basic science through engineering design to production, implementation, service and technology support.

Regional Importance

TUT enrolls more than 50 000 students annually. Its student body is one of the most demographically representative in South Africa with regard to both race and gender. With almost 22% of contact students accommodated in residences, the University is by far the largest residential higher education institution in Southern Africa. TUT is the largest university of technology in southern Africa. Its geographic footprint covers four provinces Gauteng, Mpumalanga, Limpopo and the North-West Province. In Gauteng, The TUT campuses are located across Tshwane (three in Pretoria, two in Soshanguve and one in Ga-Rankuwa). This geographic placement combines with its role as a University of Technology to make it the ideal candidate to champion technology transfer in the Gauteng area.

Community Centered Technology Transfer

The national emphasis placed on technology transfer resulted in universities across South Africa establishing offices of technology transfer. They have understandably worked primarily on intellectual property issues. Universities have encouraged academic researchers to embrace the entrepreneurial spirit and convert their ideas into patentable products. TUT intentionally extends the focus of technology transfer to an emphasis on community empowerment. This is in line with TUT's long-standing theme "we empower people" as well as the national and regional needs of skills development, job creation and SME development.

This Flagship Initiative calls on the creation of Research and Technology Outreach Centers. These centers will provide skills development for TUT students and community members. Exchange programs and collaborations between university and community members will also be a vital activity of the centers. Centers will serve as a critical location for our students to get the hands on project-based experience that is mandate of our science, engineering and technology curricula. Direct contact with various communities across Gauteng will allow students and their departments to identify socially relevant research making the work more meaningful and the technology transfer more beneficial to South Africa.

Collaborations and Partnerships

Technology transfer implies collaboration and partnership. The need for job creation in South Africa requires the university to organize initiatives that create needed skilled workers and opportunities for new job creating business ventures. Technology transfer from the university to established industries such as automotive and rail manufacturing, and energy and postal services will prepare graduates for jobs while enhancing the operations of these established industries, thereby leading to the creation of more jobs.

Technology transfer from the university to the communities through work with municipalities will lead to improved services and the creation of new enterprises. Collaboration with universities in South Africa can multiply the impact of technology transfer in South Africa, while collaboration with top international universities and global agencies will aid in the technology transfer from developed countries to TUT and more broadly South Africa. Collaborators and partners fall in the following categories.

- Industry partnerships in South Africa
- Community partnerships in South Africa
- Academic Partners in South Africa
- Academic Partners elsewhere in Africa
- Academic Partners outside of Africa

- Standing MOUs that TUT has internationally

Technology transfer Framework and Focus Areas

In the TUT Flagship Initiative, technology transfer is presented as a research concern in itself, but is primarily meant to facilitate technology transfer in the three focus areas: water, energy and industry. The three themes addressed within technology transfer are Outreach, Jobs and Enterprise creation, and Research Dissemination. This technology transfer model is displayed in figure 1 below.

"Technology transfer is the essence of technology flows; mainly three types of knowledge flow.

1) The physical flow of knowledge in terms of the products, parts and components, equipment, and manufacturers
2) The invisible flow of knowledge in terms of know-how, patents, and other information, including technical data, documents, standards, technical manuals, service contracts, and maintenance manuals
3) Macro and microflow of information in nations, and regions, business organizations, and individuals, because this knowledge cannot only be clearly written in the form of text, but can also be operated in practice to understand and master." (Lui et al, 2010, p.13)

It has been shown that university spin-offs make an important contribution to economic development. The TUT Flagship effort builds on documented successful universities' technology transfer policies, practices and structures. (Allen and O'Shea 2014; Speser 2011). Appropriate technology, engineering design, and ICT-based research dissemination are addressed as cross-cutting themes that impact all research focus areas.

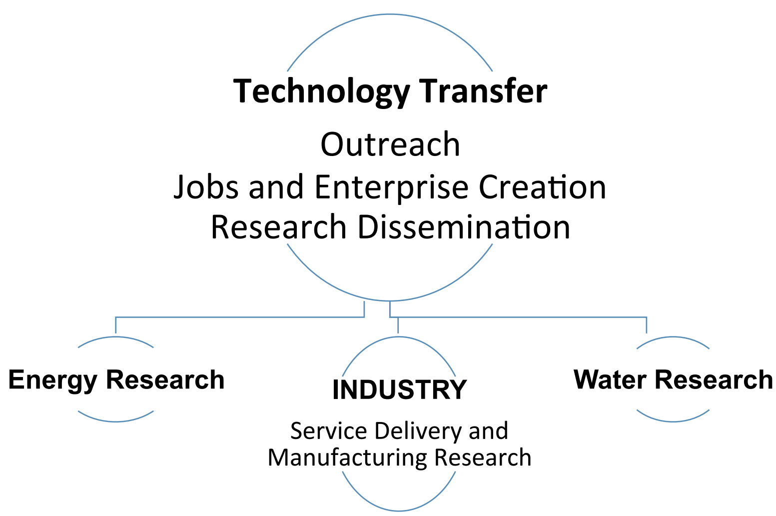

Figure 1. Technology transfer Framework and Research Focus Areas

Water research

Feature (2015) points out that more that half of humanity lives in urban areas and the 100 largest cities transfer 3.2 million cubic meters of water 5700 km daily through artificial channels. As cities grow this presents a number of problems. With Gauteng receiving its water from Lesotho 600 km away, water management justifiably is a major regional concern.

The water research focuses on science and technology for poverty alleviation and local/regional innovation, including sustainable rural development. It is driven by a research strategy, which promotes innovative research for the economic development of the country. Through various activities, rural and poor communities in the country will gain access to innovations that will provide safe drinking water using cost effective technologies. The water research effort intends to: 1) Contribute towards equitable and sustainable development of South Africa; 2) Strengthen the already existing research culture in the institutions; 3) Ensure the sustainability of resource management and usage by informed and empowered societies; and 4) Ensure community development through dissemination of knowledge about waste composition and appropriate handling practices. The scope is therefore captured under the following headings:

- Municipal water and wastewater treatment (Biological and/or Chemical).
- Industrial wastewater treatment and pollution preventive measures.
- Purification of drinking water
- Water hygiene and sanitation and water quality management.
- Water resources management and governance
- Capacity building and technology transfer.
- Social acceptance factors and development of strategies for the adoption of appropriate technologies

This effort has the potential to strengthen the research and capacity development in the critical area of water and wastewater management through the already existing intra and inter-disciplinary approach within the institution, as well as through collaboration with various research institutions and government departments.

Water Research in this project will be divided into the following research activities:

1) Decentralised water treatment technologies - development of cost effective strategies to secure adequate clean and safe drinking water to communities.
2) Social acceptance factors and development of strategies for the adoption of appropriate technologies for safe drinking water.
3) Impacts of nanomaterials on the microbial population and process performance of wastewater treatment systems.
4) Adsorbent-based water and wastewater treatment technology.
5) Solar radiation – ozonation coupled system for disinfection and removal of organic and inorganic pollutants from water sources using nanoparticles.
6) Neutralization and desalination of Industrial Effluents.

Energy Research

The energy system in South Africa continues to operate close to capacity (Lalk 2015). Occasionally demand outstrips available supply leading to load shedding. Energy research will focus on providing sustainable energy solutions aimed at relieving the national grid of unnecessary load and ensuring that acceptable reserve margins are maintained at all times, while paying particular attention to the environment and cost. This will involve the development of techniques for deployment of reliable energy systems – both renewable and conventional, with emphasis on rural communities in the region.

The energy system activities include the following areas:

1) Microgrids: energy management and optimization of microgrid systems. The management of energy supply and consumption in small systems, with different combinations of renewable

resources and storage, isolated or grid connected. Supply security, cost and environmental impacts of such systems are some of the main points to be considered.
2) Energy efficient buildings and intelligent buildings using the Internet of Things (IoT): This is a multidisciplinary effort with researchers from Engineering and ICT faculties.
3) Biodiesel technology systems: This includes the design of efficient systems, study of alternative biodiesel fuels, and minimizing waste generation and disposal.
4) New materials: This includes nanotechnology, natural fiber/polymer and nanocomposites that are used in energy systems, for example in fuel cell applications.
5) Complex systems: This is applied to the development of energy systems and the monitoring of energy delivery. Energy system loss minimization and condition monitoring strategies will be investigated and tested in real-life community systems.
6) Refrigeration systems environmental impacts: The focus of the work here will be on hydrocarbon substances for domestic and commercial refrigeration systems, with minimal ozone depletion potential (ODP) and global warming potential (GWP).
7) Fabrication of energy efficient domestic appliances using locally available materials. This links to the research focus on Industry.

Industry Research - Service delivery and Manufacturing research

Technology transfer in both the service and manufacturing sectors of industry will be key to Africa’s development in general and community empowerment in particular. This research focus builds on ongoing projects in manufacturing and services. Current work on service optimization and innovation with the Post office (Trimble and Keeling 2013; Trimble, Chilumanoi and Sibangiso 2015; Trimble 2016) will serve as a start to study service delivery in other sectors like water and energy. Research on Reconfigurable machines can be applied in different manufacturing and mining environments.

The Housing project initiated by Industrial Engineering is an example of applying reconfigurable machine research. The demand for better housing in South African communities has grown remarkably over the past few decades. With the fast increasing population in cities and urban areas, more and more people are in search of affordable housing at low taxation rates. The annual worldwide production of bricks is about 1.391 trillion units, and demand for bricks is expected to continue rising (Zhang, 2014). To deal with this demand, local brick manufacturing businesses are a fundamental cornerstone in reaching a large number of people across various communities. The sizes of manufacturers of house delivering machinery also tend to vary from micro, small, medium and large manufacturing machinery. The reconfigurable, adaptable, changeable approach to production system designs has been applied in various areas like machining, pressing and screening but has not been extensively applied to the brick manufacturing industry. Early investment into technology and innovation is essential to equip local brick manufacturers with knowledge and skills to enhance their productivity, while at the same time creating employment opportunities and ensuring economic growth within those communities. The aim of this research is to develop innovative strategies that will enable local brick manufacturers of different sizes to improve their businesses and enhance their productivity in meeting the varying needs of the people in urban, rural and informal settlement communities. As discussed above, the innovations and technologies that will be developed aim to address the three critical stages/units of the brick manufacturing business using a reconfigurable approach which allows for growth, customized production and optimized SMME competitiveness as a function of varying customer needs. These units are described and explained below:

a) **Adjustable Sand screening unit**: this is the customizable machine used to separate sand into various sizes (i.e. undersize, medium sized and oversized sand particles).
b) **Changeable Cement and sand mixing unit**: this is the unit responsible for mixing varying quantities of the correct samples of cement and sand to insure that all bricks are consistent with their quality.
c) **Reconfigurable Brick setting unit**: this is an adaptable machine responsible for molding different shapes of bricks depending upon customers' orders.

Cross-cutting Themes

Entrepreneurship in Engineering Design - This will build on previous work in engineering design practices across Africa, Intellectual property and engineering design and internationally best practices in engineering design (Muchie 2015; Trimble 2015). Topics that will be addressed to assist the focus areas are: engineering design ontology, Key Success factors for engineering design, engineering design for appropriate technology, and design for technology transfer.

ICT based Research dissemination - The Information and Communication Technology Faculty (ICT) will provide researchers to assist the three focus areas in designing computer-based approaches to connecting researchers and sharing research results. At the same time the focus areas will serve as an information source for fulfilling the ICT related research niche areas of ICT for education, ICT for development and intelligent distributed systems.

Innovation Economics - TUT's Institute for Economic Research on Innovation (IERI) provides in-depth analysis of systems of innovation, science and technology policy and local economic development. It focuses on local, provincial and national levels. Technology Transfer must be informed by an understanding that the solutions to the local problems of economic development should be embedded in the local context. By concentrating on challenges facing local municipalities, IERI researchers can provide insights to assist the three focus research areas in delivering technology that empowers the community.

Appropriate Technology - All focus areas will be guided by the mandate to provide 'appropriate technology' that fosters community empowerment, utilization of local natural and human resources, ecological and economic sustainability and cultural sensitivity. The International Conference on Appropriate Technology will serve as an important avenue for making international connections for our Flagship Initiative. This research effort draws on the rich historical experience of the global appropriate technology community to make critical selections on technologies and techniques to emphasize and transfer to the community (Trimble 2013)

Role of Appropriate Technology

In the broad framework of Technology transfer, the TUT Flagship Initiative considers appropriate technology to be a vital cross-cutting theme. It plays a long standing role in the author's ongoing research (Trimble 2013, Trimble 2015).

The task of the African intelligentsia in all disciplines is to seek to develop a revolutionary agenda of action that uses their skills, resources and infrastructures to empower people and move us closer to a society where communities control their natural resources and direct the distribution of the outputs of all industry. Appropriate technology has been identified as technology aimed at empowering people. It first looks at meeting the basic needs of people while utilizing local resources and remaining accountable to sustaining an ecological balance.

> "Appropriate Technology (AT) is technology that is culturally sensitive yet ecologically sound and economically sustainable. To fully embrace AT, one must be driven by compassion for humankind and Mother Earth and philosophically rooted in the belief that humanism, collectivism and egalitarianism are abiding human characteristics that heighten a collective conscience across society globally." (Trimble and Muchie 2015)

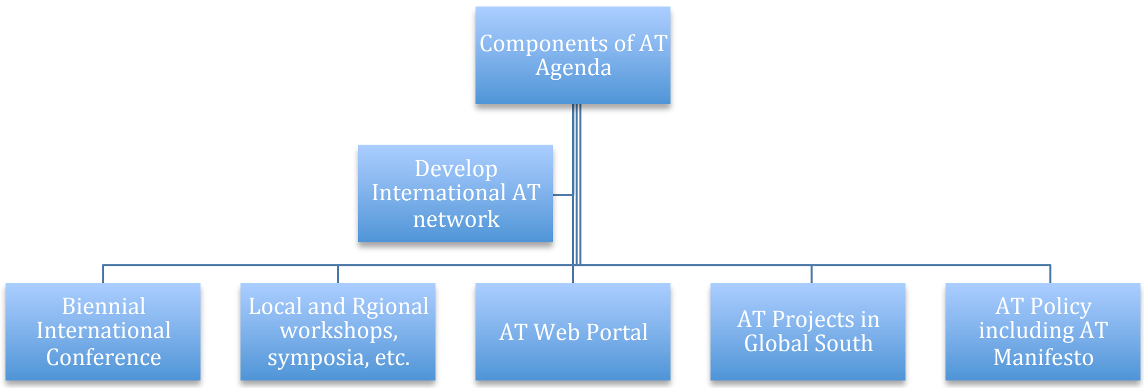

Figure 2. Current Appropriate Technology Agenda

In 1998, an appropriate technology agenda emerged from efforts based at Howard University with African students. This agenda expanded internationally leading to the International Network on Appropriate Technology (INAT), which now engages African, as well, and non-African technology-focused academics and practitioners in appropriate technology research and dissemination. INAT has organized a series of international conferences on appropriate technology. All the conferences have been held in Africa because Africa is most in need of technological advancement. More underdeveloped and developing countries are in Africa. The table below indicates the years, focus/themes and location of the ICAT conferences from 2004 through 2016.

Table 1. International Conferences on Appropriate Technology (ICAT)

Year	Focus	Location
2004	Land-based projects	Bulawayo, Zimbabwe
2006	Health related appropriate technology	Bulawayo, Zimbabwe
2008	Energy solutions in the Era of Climate Change	Kigali, Rwanda
2010	Water and Sanitation	Accra, Ghana
2012	Linking education, research & practice to inform policy	Pretoria, South Africa
2014	Technological Innovation to Empower Africa	Nairobi, Kenya
2016	Bridging Theory with Practice	Victoria Fall, Zimbabwe

While each conference has a focus, all conferences included a wide spectrum of technology projects and research efforts. The categories covered at the 2016 7th ICAT are listed in Table 2 below. ICAT provides an opportunity for collaboration on academic research and practical projects.

Table 2. Appropriate technology (AT) categories and topics

AT categories	**Some Research and Project Topics**
Green Economy and Innovation	Manufacturing, small scale industry, mining and mineral processing, socially relevant computing, economics of technology, textile technology, recycling, social business, appropriate technology innovation, ecological economics
Energy	Hydro power projects, alternative energy systems, renewable energy, distributed power, rural electrification, solar
Water and Sanitation	Water supply, storage and sanitation, water scarcity, water quality, water stress and recycling, toilets, waste management
Health	Indigenous medical technologies, food preparation/processing, technologies addressing malaria/TB/HIV/AIDS related issues, pharmaceuticals
Construction and Infrastructure	Appropriate architecture, appropriate construction, appropriate transportation, sustainable building materials
Environment and Agriculture	Environmental impact, irrigation projects, forestry & wildlife, agricultural technology, climate change, air quality, remediation of contaminated environments
Knowledge and Technology Transfer	Education and training, knowledge engineering, knowledge management, community development, indigenous knowledge, people's science
Policy, Ethics and Standards	Technology policies, technology standards, ethics, culture, quality assurance, responsible wellbeing

The appropriate technology agenda includes much more than the biennial conferences discussed above. There are plans to extend the website (www.appropriatetech.net) into a web portal that can serve to connect academics and practitioners with community activists and organizations. The portal would share global information on ongoing projects, potential projects and policy strategies designed to use technology to empower oppressed people and underdeveloped nations. The International Network on Appropriate Technology (INAT) engaged in regional conferences in Trinidad and Tobago and Washington DC. INAT assisted in an International Knowledge Management Conference in the Sudan and participated in radio and TV interviews in Guyana. INAT intends to extend their work geographically and most importantly, increase involvement in AT projects (Trimble 2013a). Figure 2 highlights the relation between the components in the AT Agenda.

AT can only be escalated when national and international technology policies are redirected to foster technology for the people. In 2011, INAT initiated an AT Manifesto. It called on individuals and organizations to support the shift of resources away from military and space technology toward meeting basic needs of people globally. This was part of a broader project, to develop a series of documents researching science and technology development and its impacts on people and the environment. This deeper research effort will be accompanied by the development of a series of Appropriate Technology declarations that can be examined and embraced by educational institutions, worker and professional organizations, and civil society organizations.

Once a larger audience's consciousness is heightened with respect to the global human-centered technology needs of our world, a more extensive Appropriate Technology manifesto can provide details on how to redirect our planet's resources toward Appropriate Technology. This manifesto can be the tool to get organizations to reallocate resources to this people-centered cause and communities to call on their governments to set policies in line with AT (Chomsky and McChesney 2011). Reallocation of resources will allow detailed demonstration of the validity of Appropriate Technology as a solution to impoverished and disempowered societies

National Planning

South Africa, like most developing countries, faces a major problem of insufficient employment opportunity. Increasing employment through economic growth has been given a priority in the National Development Plan 2030 (National Planning Commission 2011). This growth can come from both manufacturing and service industries, and from startup enterprises to large established businesses. Growth, in startup enterprises, as well as established industries, is driven by technology

There is a need to address effective skills development for large enterprises, such as Gibela Rail Transport, Passenger Rail Agency of South Africa (PRASA) and the South Africa Post Office. It is difficult to establish new production processes and technology to increase manufacturing productivity and jobs. At the same time, the service sector must optimize service delivery while developing new and innovative service options in order to maintain global competitiveness.

Increasing employment through economic growth also requires creating new opportunities through community engagement and entrepreneurial endeavors. The TUT Flagship Initiative will engage the community through planned activities on the various TUT campuses as well as through the SAPO at various locations where space will be provided for demonstrations, workshops and training. This will involve Post Office Researchers, TUT academic staff and students and community members. These efforts of technology transfer are designed to foster job creation and community empowerment through the promotion of appropriate technology. Appropriate technology highlights the use of local resources, with the priority on basic needs and most importantly the empowerment of individuals and communities.

Industry Development and Planning

Klaus Schwab has been organizing the World Economic Forum (WEF) for the past 45 Years. This annual meeting held in Davos Switzerland hosts the global political and economic leaders. In 2016, the theme was the Fourth Industrial Revolution. The organizers of the WEF venture that this 4^{th} Industrial revolution will bring leaps in productivity in manufacturing and services. The increased role of capital and technology will come at the expense of jobs. Millions of manufacturing and service jobs will be eliminated. This industrial revolution is possible because of the technology advances in computing, telecommunications, information science, robotics, material science, genomics, and artificial intelligence. Schwab cautions "the great beneficiaries of the fourth industrial revolution are the providers of intellectual or physical capital – the innovators, the investors and the shareholders, which explains the rising gap in wealth between those who depend on their labour and those who own capital. It also accounts for the disillusionment among so many workers, convinced that their real income may not increase over their lifetime and that their children may not have a better life than theirs" (Schwab 2016).

The recognition that the 4^{th} Industrial Revolution will lead to further wealth disparity and potential worker unrest is important. Recommendations of the WEF are designed to ease this tension, further stability and increase wealth and power of the wealthy. After all, the WEF is set up to benefit them. The opposing perspective questions the validity of using technology advances to benefit the wealthy. The call for appropriate technology (AT) champions technology that empowers communities and workers. Socially relevant computing is a critical sector of AT (Trimble 2013). The fact that the wealthy control the finances and factories needed to develop technology on a large scale is undeniable. What is challenged is their right to dictate the direction of technological development. If the technology of the 4th Industrial Revolution is inevitable, at least it should be used to benefit people. People should be given priority over profits. In public sectors such as the post office, it is possible to address this priority.

Universities must plan with insight into the impact of this 4th Industrial Revolution. Curriculum innovation must take into account the 4th Industrial Revolution and uses these advances to prepare students to use the latest technology to advance appropriate technology, technology transfer and community empowerment.

Service Development and Planning

The private and public service industries are growing faster than both the agricultural and manufacturing sectors. National planning must take this into account in setting policies and addressing job creation. The post office is a unique example of a service industry. It has a long tradition and sizable infrastructure and workforce. However, the post office is undergoing significant changes due to technological advancements. The problems and potentials of the post office offer the opportunity to examine policies and innovation with appropriate technology and technology transfer in mind.

Postal service as an example

Globally post offices started as a service to citizens, organized and financially supported by the government. In recent years, many countries have decided to privatize government structures such as the post office. This restructuring in all cases has reduced the service workforce and weakened their labor movement. African governments must act to create jobs not eliminate jobs. The evidence presented at Davos makes a clear case that the technologies of the 4th Industrial revolution will be transformative (Schwab 2016). Previous research made recommendations to the post office and universities on how to collaborate on an ICT based research agenda (Trimble 2014). These recommendations were addressed to postal operations and universities across Southern Africa through the Southern Africa Postal Operations Association (SAPOA). The response to these recommendations has led to the establishment of the SAPOA postal-university research council. This was initiated in July of 2015 as the result of a workshop where academics and postal service leadership were invited from Southern African Development Community (SADC) countries. The research council was tasked with addressing postal research needs beyond the ICT based research agenda. The workshop established six thematic areas to be addressed by the Research council, two broad crosscutting areas: the PO role and Research development, and four distinct areas: business opportunities; Trust; Delivery and Governance. When the chairperson of the Research council presented the structure to the general management of SAPOA at their annual meeting, a seventh thematic area was added – Transformation. This crosscutting theme is important because the future of the post office hinges on its ability to adopt transformational innovations. Table 3 provides a brief explanation of the coverage.

Table 3. SAPOA Research Council Thematic areas

Role of Post Office – Universal Service Obligation, Connecting people and communities, mail/parcel delivery, logistics, Community enterprise hub, financial & government services.			
Research – Existing research results, Ongoing research efforts, Embedding research in curriculum, New research topics, Research structures and Research methodologies			
Transformation – Innovation strategies, Reorganization strategies, Building a learning organization structure,			
Business Opportunity: operational environment, diversification, unregulated and regulated services, skills development	**Trust:** perception, marketing, image, work ethic, and government expectation	**Delivery:** collection, sorting, tracking, transport, reception (last mile), and ICT utilization	**Governance:** public policy, legal framework (local and international), management philosophy, accountabilities, and responsibilities

This study recognizes that post offices in general and SAPO in particular are losing their competitive edge. Transformation is needed to regain this edge. Post Office research must take into account the need for traditional postal operations to accept transformation in order to survive and grow the post office. The UN has recognized the importance of big data by initiating the Global Pulse initiative. Its indicated objective is the "harnessing of big data for development and humanitarian action" (United Nations 2016). In 2013, the Universal Postal Union (UPU) decided to join this initiative recognizing that "the UPU has the biggest harmonized physical data that is real time in the world" (Mirza 2013:15). The UPU is a global postal organization representing 192 countries. In this instance, it is important that African governments and postal operators follow the lead of the UN and UPU and acknowledge the importance of big data and the IoPT.

The success of these postal research plans, depend on national support for the SA Post Office. One test of the effectiveness of the TUT Technology Transfer Flagship Initiative will be the ability to impact national policy to support appropriate technology and technology transfer. At the same time the flagship initiative must continuously draw on developments in appropriate technology and technology transfer and include these developments in curriculum enhancements as well as ongoing research. Figure 3 highlights these relationships.

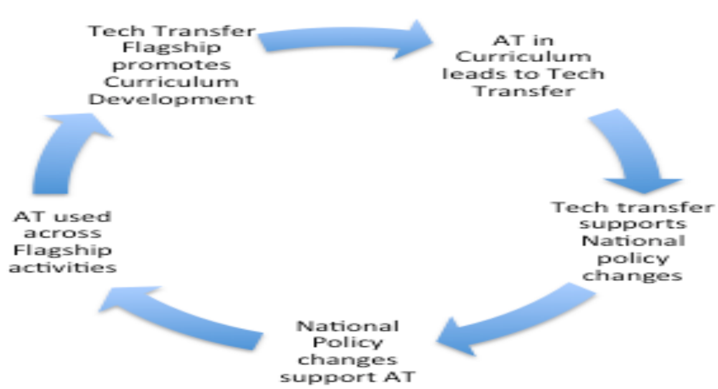

Figure 3. Linking AT, Technology Policy and Curriculum Development

Conclusions

The TUT Flagship Initiative serves as an example of how industry, government and a university can engage in a technology transfer partnership to foster the advancement of appropriate technology, local industry and job creation. The success of a bold initiative of this nature requires consistent national planning and support to expand and duplicate this initiative. In Davos 2016, the World Economic Forum recognized that the 4th Industrial Revolution is having a global impact and needs a global response. Developing countries like South Africa, must realize the global environment requires the South African government to look and work beyond its national borders. In conclusion our research offers three levels of recommendation. The specific postal recommendation serves as an example of how to impact a particular service industry. The broader government recommendation focuses on national policy, particular technology policy. The third recommendation addresses particular curriculum changes that can be embraced by any universities, but should be of particular interest to national universities in developing countries.

Recommendations related to Postal Services

The South Africa Post Office; Southern Africa Postal Organizations Authority; Pan-African Postal Union and the Universal Postal Union can all benefit from the following recommendations. The 4th Industrial Revolution mandates that the post office focus on key technologies in order to thrive. These key technologies include: big data, the Internet of postal things (IoPT), and various approaches to analytics including machine learning, artificial intelligence and information visualization. Industry leaders advise the post office to act now regarding the use of big data or risk being left behind (Rubens 2014). Postal operations should follow the recommendations presented earlier (Trimble, Chilumani, and Sibangiso 2015) and coordinate the research conducted by their employees with the universities, particularly in the case of post office employees working on advanced degrees. Also the post office should involve university students in research internships and bring in university researchers as consultants to team with PO researchers. These are all approaches used by other industries such as Telecommunications to stay competitive. The fact that the SAPO has continued to support human capital development (including its graduate program), despite the difficult financial times, is a good indication of its commitment to university relationships and research (SAPO 2016).

In order to maintain the relevance of the post office and expand its workforce governments ought to invest in a strategic information system plan that allows for the capture and extensive utilization of big data. The South African government can do this by investing additional funding in the SAPO, but also by making big data and analytics a priority with the National Research Foundation (NRF). The NRF should be given a mandate to pursue the IoT in general and the IoPT in particular. One way of assisting this effort is for the governments of SADC to empower the newly created Postal Research council to escalate their research by providing the council with resources.

The Post Office research serves as an example. Policy decisions that encourage appropriate technology and technology transfer must extend to all manufacturing and service industries. National governments across Africa must empower the African Union to better coordinate collaboration across borders to maximize benefits to all communities.

The collaborative research agenda created by the SAPOA Research Council lays the groundwork for a comprehensive collaborative research agenda. As this agenda is given detail and resources, it is important to take into account the driving force of the 4th Industrial Revolution in making priorities on what research projects to pursue. This brings us to the importance of an ICT-based research agenda to make the Post Offices across Southern Africa truly competitive (Trimble 2014). The Post Office must develop an Information Systems Strategy (ISS) that invigorates all its current activities. This ISS must recommend innovative new activities that take advantage of 4th Industrial Revolution technologies. The expansion of the SAPOA Research Council should be open to all university and postal researchers across southern Africa. However, ICT-based research in general and big data related research in particular must be sought out. This is needed to guarantee that this research collaboration focuses on the technologies and support systems that will most effectively generate innovation in postal operations.

Recommendations to Government

The South African government has several structures responsible for promoting technology and innovation. The National Research Foundation (NRF) is a major research funding source for universities. Government policies can direct the NRF to increase their focus on appropriate technology and technology transfer. The Department of Trade and Industry (DTI) coordinates funding that promotes innovation and development in both manufacturing and service industries. DTI can be instrumental in assisting in community centered small and medium enterprises (SMEs) that support appropriate technology and job creation. South Africa’s Technology Innovation Agency (TIA) works with university and community organizations in promoting innovation. TIA sponsored projects can involve different levels of research, as well as development and production. There are other organizations and agencies in South Africa that promote appropriate technology and technology transfer. The AT agenda must be promoted across all levels of government from local municipalities to the national level.

These are broad recommendations that should be replicated and expanded in other African countries, as well as developing countries outside of Africa. As the leading industrially developing countries in southern Africa, South Africa has obligation to take the lead in this important agenda of appropriate technology and technology transfer.

Recommendations to Universities

The university must recognize the potential for ongoing research in collaborating with service industries, such as the Post Office. As indicated by the structure of the Postal Research Council, the research is interdisciplinary and includes technical, social science and management fields. Legal frameworks are being researched by Law Faculties, while the IoPT is a serious concern of Engineering and ICT Faculties. Memorandums of Understanding (MOUs) including the Post Office, Universities, as well as the Ministry of Higher Education and the Ministry of Telecommunications and Post is a good starting point to indicate the seriousness of this effort.

MOUs initiated at the university can be used broadly to promote AT and technology transfer. The TUT Flagship Initiative plans to utilize the MOUs to engage a number of institutions in technology transfer across its focus areas of energy, water and industry.

Curriculum development is needed to promote AT and Technology Transfer. One approach is the infusion of relevant material in existing course. Extensive new course development is required. The list of proposed courses includes – Critical thinking; Appropriate Technology; Technology Transfer; Community Centered development; and Big Data Analysis.

Big Data curriculum recommendations

The big data curriculum, recommended Trimble (2016), provides the skills needed to advance innovation in the postal industry. These skills are not only needed for Post Office big data research but are the skills needed in any big data and analytics environment. This curriculum may be placed in Mathematics, Computer Science, Statistics, Information Systems, Operations Research or Engineering departments. The curriculum may reside in Faculties of Science, Engineering or Management or may be interdisciplinary. Table 4 indicates the recommended modules and tracks.

The TUT Flagship Initiative will encourage curriculum innovation in connection with its ongoing research agenda on technology transfer in energy, water and industry. The cross-cutting themes, particularly innovation economics and appropriate technology, will facilitate linking curriculum development to technology transfer.

Table 4. Tracks and Modules for Big Data Curriculum

Computing Track	Engineering Track	Management Track
Core Subjects		
Data structures, algorithms, databases, Ethics of information, Appropriate technology & Socially relevant computing	Data structures, algorithms, databases, Ethics of information, Appropriate technology & Socially relevant computing	Data structures, algorithms, databases, Ethics of information, Appropriate technology & Socially relevant computing
Depth subjects		
Operations research: Linear Programming, Non-Linear Programming, Dynamic Programming, Integer Programming, Stochastic Processes	Operations research: Linear Programming, Non-Linear Programming, Dynamic Programming, Integer Programming, Stochastic Processes	Operations research: Linear Programming, Non-Linear Programming, Dynamic Programming, Integer Programming, Stochastic Processes
Knowledge management: acquisition, representation, and assessment	Knowledge management: acquisition, representation, and assessment	Knowledge management: acquisition, representation, and assessment
Modeling, simulation and information visualization - including discrete, agent-based and system dynamics simulation	Modeling, simulation and information visualization - including discrete, agent-based and system dynamics simulation	Modeling, simulation and information visualization - including discrete, agent-based and system dynamics simulation
Specialty subjects		
Advanced algorithms: Artificial Intelligence, Machine learning	Microprocessor, Sensors, Data communications	Information System strategies, Human resource management, Communication and Organization Theory

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How Sugar Oriented the Caribbean 1640 to 1892

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Abstract

Caribbean intellectual C.L.R. James wrote in 1962 that the African people of the Caribbean began their historical existence in modern industry. That industry is sugar. That beginning was seventeenth century after the genocide of the original Caribbean people by European invaders. First, the Europeans established farmsteads to feed themselves in their 'New World'. Farmsteads then changed to plantations cultivating the sugar cane and manufacturing sugar which was exported back to Europe. The cane plants originated from tropical habitats in Brazil and then Hawaii. The factory design came from Arabs who Europeans saw making sugar in the 12th century. Labour came from enslaved Africans. Sugar is at the foundation of the decline of African civilizations from the 16th century, the political revolution in Haiti (1791 to 1804) and scientific and industrial revolutions in Europe. Several key pieces of equipment in modern industry owe their development to the sugar industry including the roller mill, filter press, centrifuge and evaporation in a vacuum. This paper provides a discussion on technology and human orientation before and after the Haiti revolution. Sugar impacted on science, engineering and politics in the Caribbean, Africa and Europe. Case studies are presented from several Caribbean countries.

Key words: Caribbean, Sugar, Orient, Science, Century, Industry

Introduction

In the sixteenth century European farmsteads in the Caribbean tried to grow tobacco, corn, ginger, cotton, indigo, sugar, ground provisions, fruit and much more for export back to Europe. These are crops of the tropics; and it was difficult for Europeans to get economic yields of these crops from the strange soil and climate. Tobacco consistently was of poor quality and could not compete with the Virginian tobacco from America. Cotton needed large land space which many islands did not have. The black mold of Barbados supported indigo better than the soils of St Kitts. However, the ecosystem of all islands supported sugar cane.

In the seventeenth century, Dutch invaders in Pernambuco, Brazil learned the art of cane cultivation most likely from Africans who were already there - Wolof, Fulani, Malinke, Temne and urbane Timbuktu dwellers. The Dutch passed on this knowledge to the English and French roaming the Caribbean. Cane needed a high steady temperature and adequate rainfall. It exhausted the soil only after many years. On combustion only a minute quantity of ash is obtained. In 1637 and 1639 Dutch seafarers ferried to English and French in the Caribbean the sugar cane from Pernambuco. By 1650, the way to boil the juice to make sweetened drinks and sugar was passed on to all Europeans in the Caribbean by the Dutch.

Besides temperature, rainfall and ash quantity other influences established sugar in the Caribbean. First, the islands were wooded and wood served as inexpensive fuel for processing from juice to sugar. Second, demand for sugar in Europe was rising because of new beverages coffee, cocoa and chocolate which had been introduced there by exploring Europeans. Third, technical information was gradually passing between Mohammedans and Christians. In 1642, Dutch seafarers sold rollers, coppers and other equipment and learned Africans to Europeans now settling in the Caribbean and the first crystals of raw sugar were manufactured.

Sugar oriented Europeans in the Caribbean away from general farming between 1642 and 1650. Historian Ligon in his book, 'A time and exact history of the island of Barbados (London 1659) wrote "At the time we landed on the island (Barbados) which was at the beginning of September 1647 we were informed by those planters we found there, and partly by our own observations, that the great works of sugar-making was but newly practiced by the inhabitants there". Then 1648, "the plantation contains 500 acres of land, with a faire Dwelling-House and ingenio (factory) in a room 400 feet square, a boiling house, filling house, cisterns and Still house, and a curing room 100 feet long and 40 feet broad, with stables and Smith's forge, and a room to lay provisions of corn and bonavist (greens). Houses for negroes and Indian slaves, with 96 negroes and 3 Indian women with their children, 28 Christians, 45 cattle for work, 8milch cows, a dozen horses and mares, and 11 assinigoes (asses). In the plantation of 500 acres there was employed for sugar something more than 200 acres, about 80 acres for pasture, 120 acres for wood, 20 for tobacco, 5 for ginger, as many for cotton wool, 70 acres for provisions viz corn, potatoes, plantains, cassava, and bonavist; some few acres of which were for fruit viz pines, plantains, melons, bananas, guavas, water melons, oranges and lemons". From the beginning, Europeans used West Africans on sugar plantations and not native Indians!

Plantations of this model produced sugar after 1650. Sugar monoculture spread from Barbados to other Caribbean centers as suitable soils of sand and clay mixture could be found in all Caribbean territories. Before the end of the century the monarchy in Europe ruled Caribbean sugar colonies.

What is a colony? A colony is a source of food stuff for the mother country, a source of raw materials for the mother country, a source of cheap labour, a market for industrial goods from the mother country and a military base for the mother country.

Some Technical Factors

The sugar cane is a perennial grass of the class triandria digynia and the genus saccharum officinarum. It has a fleshy stalk divided into nodes and internodes covered by a rind. Two varieties are mentioned in this discussion. Brazil cane is tall growing to 7-9 feet, and having more nodes than Hawaii cane whose internodes are usually eight or nine inches. Another difference is that Brazil cane took twelve to twenty months to mature while Hawaii cane matured between ten and sixteen months.

The sugar cane contains three principal sugars — sucrose (a disaccharide), glucose and fructose (monosaccharaides) dissolved in its sap. In mature canes 80 % of the juice is sucrose sparingly mixed with other bodies. All three sugars give a sweet taste. Glucose is a normal constituent of ripe canes but fructose is usually the product of inversion of sucrose in unripe and overripe canes. Also, there is pectin, organic acids, and mucus, which are important because they play a necessary part in the sugar crystallization. Sugar manufacture employs the following stage (1) Liberation of juices from plant (2) Clarification and Evaporation of juices (3) Crystallization (4) Separation of molasses.

Brazil cane and Africans 1640 to 1793

Brazil cane and West Africans from the Guinea coast were shipped to the Caribbean in the 1640s for cane cultivation and sugar manufacture. The relationship between Africans and this cane ended at the Haiti revolution in the 1790s. African victory in Haiti ended shipments to enslave Africans in the 1790s. Europeans turned to the Hawaii cane in the 1790s. This is now discussed.

The orientation of Africans from Guinea to produce sugar for Europeans was directed by two phases of labour activity known as 'crop time' and 'out of crop time'. The latter was the months of planting and caring the plant to maturity. The former was the months of harvest and processing to sugar and rum. Planting was done by field slaves. The field slaves were cultivators and regulators. Technically, plants grew from slips of cane stems put into the earth and they produce ratoons which are cane suckers of the underground stem.

Learned Africans with cutlass cut and burnt the bush. They then prepared the land by digging parallel holes with hoe. These holes were 15 to 18 inches square and from 8 to 12 inches deep depending on the soil. Slips of cane stem were put into the holes and covered with manure for the plant to grow. In Haiti where the soil was a favorable sand and clay mixture, the holes were seldom required – just manure around the stem. Plantations with stiff heavy soil required holes two feet apart in rows three feet apart. In Guyana's alluvial soil trenches three feet apart were made instead of holes to allow the excess moisture to run off by the surface drains. About a fortnight after planting young sprouts appeared and this was the signal for earth that had been heaped up on the dam to be sprinkled around the young shoots. This activity was continued for about four to five months until the canes were strong enough to withstand rain and winds. All this time hoeing and weeding routine was carried in a military manner. The caring of ratoons was not as arduous. For ratoons, the enslaved would place humus and manure at the root of the parent plant and loosen the earth around it with the cutlass or hoe.

Apart from the above, weather was a serious factor in cultivation. In the early plantation years canes were planted just before the rainy season commenced and harvested in the dry season. Then, Europeans began rainfall measurements and the strategy of planting shifted to take place when moderate rainfall commenced. This was already the practice in West Africa. Walter Rodney in A history of the Upper Guinea Coast 1545 to 1800 wrote, "In July when the first rains had already moistened the soil the seeds were sown" in discussing rice growing there.

Harvesting was the art of the skilled cane-cutter. Canes were cut not less than two joints from the primary bud except in canes maturing in dry soils. The reasons were four fold. First, at the bottom of the stem is the greatest concentration of sucrose (the sweet disaccharide). Second, if a large stump is left the development of ratoon is affected. Third, glucose at the top of the stem will increase the risk of fermentation when the juice is being processed because as a reducing sugar it has an aldehyde isomer that can be reduced to alcohol or oxidized to acid. Fourth, the maximum weight was wanted so as to obtain the maximum possible yield of sugar. The skilled harvester also performed another function. With his knife he judged if a cane has reached maturity. If the pith was soft it was not ready for harvest. If it was hard and white particles appeared then he judged it to be ripe. Cut canes were bundled and transported to the mill by mules, carts or foot. In Guyana, punts navigated aqueducts. Harvesting signaled that phase of plantation life when the factory processes were put into motion to make sugar and rum.

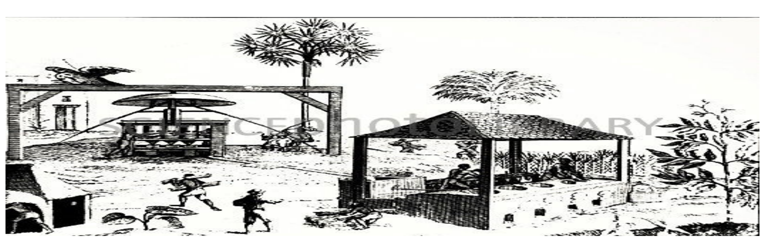

Fig 1: Caribbean sugar factory (1694) Cattle at mill. Africans crystallizing the syrup

The manufacture of sugar took place in three buildings – the mill where the vertical rollers crushed the canes, the boiler where the juice was clarified with lime and egg-white and skimmed, the curing house where the syrup was crystallized. Singer in his 'History of Technology Vol 3' (London 1948) wrote, "The West Indies became in the seventeenth and eighteenth centuries the main source of supply of sugar for the European market, the factory being built on the Egyptian model". What he meant was that the mill used vertical rollers made of wood encased with iron. It was on higher ground than the boiling house. The curing house had two chambers – the upper had raw sugar and into the lower chamber dripped molasses. This factory was known to Africans in the seventeenth century (see 1694 illustration) because the trans-Saharan trade preceded the trans-Atlantic trade. The Edo made swords and 'Benin bronzes' for the trans-Sarahan trade. The Akan town of Elmina was called Al-mina (Arabic "the port) during the 1400s according to Ato Ashun in Elmina, The Castle and the Slave Trade (2004). Others included in technology transfer during the trans-Sarahan trade include Akan, Mossi, Hausa, Ewe, Fan, Yoruba and Ibo.

All peoples of the globe have processes for production of spirits. Making rum was not arduous. Distillation of gregs, scum, molasses, raw juice with yeast added produced rum. These were left to ferment in cisterns for five to seven days then transferred to the Still before acetic acid is produced. Jamaican Stills prevented fermentation by placing a basket of limestone in the cistern.

Energy and Industry

Petit-Guien (children of Guinea) in Haiti under the command of Desalines stopped the slave trade during the 1790s. Warriors from other Caribbean islands recited African oaths and journeyed there to fight waves of Christian armies. Sugar technology and inspiration had oriented enslaved Africans towards struggle and strikes. In Haiti sugar technology was most advanced. In Haiti, disrespect for African faiths and racism supplied energy for the rebellion and revolution. The first direct shipment of Africans to the Caribbean took place in 1518. The first direct shipment of Africans for sugar servitude took place in 1642. These peoples had myths and prayed in shrines as outlined in Edo Cultural Voyage (2006) by Omorodion Uwaifo. Shipments of Africans stopped in the decade of rebellion and revolution (1793 to 1803) when that power-house of African energy unleashed itself on the European armies.

There are illustrations that show mills turned by cattle between 1650 and 1694. As Noel Deer wrote in History of Technology (London 1948) the Barbadian planter Littleton who was also an official of the Royal African Company erected this signboard in 1690 "our negroes work at it like ants and bees". At this time cattle worked at grinding and African provided the brain-power for clarification and crystallization. The plough was introduced in Jamaica in 1774 but productivity and profits continued to depend on the energy of the learned Africans. In Jamaica, Worthy Park estate was made up of three properties: Worthy Park proper, Spring Gardens – a cattle location and Mickleton – a rum and sugar bond from where boats sailed for Kingston the capitol. In 1792 the proprietor bought 30 men, 32 women, 16 boys and 16 girls – all Congolese. Congolese were sent to do sugar-work. He also bought 51men, 30 women, all aged between 18 and 22 – mostly Coromatis. These were retained as supervisors. In Haiti however, according to L.G. Ragaty in The Fall of the Planter Class in the British Caribbean 1763-1834 (New York 1963) irrigation was long practiced. Harnessing the forces of nature was more advanced in Haiti than in other Caribbean islands.

Against the above, we can look at technology practices in Africa between 1640 and 1793. I believe that the spirit of a people comes first and then technology. Who were the Africans in the Caribbean in the eighteenth century? What were their faiths? What skills did they bring from Africa? They were religious Africans – that's the first factor with agriculture, mining and industrial skills. According to Norman E. Cameron in his book '150 Years of Education in Guyana 1808 – 1957 (Guyana 1968) "On the fourteenth February 1818, the first five deacons were ordained. Among the number were two, Romeo and Jason. Romeo was a Mohamedan and one of the first to be baptized in November 1808; and was then registered by Mr Post as fifty two years old. He died in March 1835". Also, "Thomas Lewis was formerly Toby a Mohammedan boy who had been taught in Africa to read the Koran before his capture and sale into slavery. Mr Howe, Wray's successor at Hanaver, Berbice, was so impressed with Toby's intelligence and zeal for learning that he arranged for Toby to go to England where he was freed by the agency of a Rev. Thomas Lewis in 1836". The two quotations are attempting to illustrate the learning and faith of a corps of Africans men and women in the eighteenth century who were transported from Africa and enslaved as sugar-men and sugar-women throughout the Caribbean.

As an example of agriculture skills we look at the cultivation of rice on the Guinea coast. Walter Rodney in A History of the Upper Guinea Coast 1545 to 1800 (Oxford 1970) is instructive. Rodney is a native of coastal rice growing and bauxite and gold mining Guyana. Rodney wrote that on the Guinea coast in the sixteenth century there was in cultivation 'wet rice' and 'dry rice' further inland. "On the Gambia the residents were growing their crops on the riverain deposits and by a system of dykes had harnessed the tides to their own advantage. The system of irrigated farming extended south to the river Cacheu, that is to say throughout the territory of the Djolas". This was wet rice cultivation. On 'dry rice' cultivation Rodney wrote, "In July when the first rains had already moistened the soil the seeds were sown. They used a simple hoe culture. The ripening of the grains attracted large flocks of rice-birds and it was the job of the children and old people to scare them off". These techniques of planting in Africa were transferred to the planting of sugar cane.

Mining and refining salt was a vast industry in West Africa. Salt was exported to Sudan and traded to the first Portuguese. Rodney wrote, "Investigations disclosed three methods of obtaining salt in Sierra Leone: firstly, the collection of salt deposited on the leaves of the mangrove; secondly, the direct evaporation of sea water; thirdly, the extraction of salt impregnated soils. Salt manufacture was linked to the daily tidal pattern. The water from the sea or nearby river was collected in large shallow ponds at high tide and evaporated. The thin crust which remained was scraped up with a portion of earth to a depth of ¼ inch and dissolved in warm salt water to which a quantity of wood ash was added. (Below this thin crust was a concentrate of potassium nitrite which is an ingredient of gun-power and 'only if' the salt-farmers had captured this chemical their fate may have been different). The solution was poured into a conical strainer of palm leaves, at the apex of which straw was placed to prevent earthy matter from passing through (filtration). So the salt water and the soil were separated by percolation and the salt finally evaporated to dryness in specially constructed clay ovens, covered with tin or iron basins". These methods of clarification and crystallization in an oven were transferred and used by enslaved Africans doing sugar in the Caribbean.

As an example of industrial skills we turn to Margaret Trowel in 'African Design' (London 1960). She wrote of Benin cloth making about 1590: "cloth made from cotton wool very curiously woven and cloth made from the bark of palm trees". Then she goes on, "But the finest examples of African skill in printing on cloth are the Adinkira stamp-printing cloth made by the Ashanti. The stamps are cut from small pieces of calabash and a very large number of various motifs are used. The cloth used is woven cotton, sometimes left white, sometimes dyed russet brown with the bark of a tree. The black dye used for printing is prepared from another kind of bark which is cut up and boiled for several hours together with lumps of iron slag. After 2/3 of the water, has evaporated the remainder is strained off and the dye which is left is of the colour and consistency of coal tar. The cloth is spread on the ground and stamped". Weaving, stamping-making, printing, dye making from vegetable matter, evaporating and straining in the making of cloth is now called 'knowledge management'. This was transferred to sugar making in the Caribbean in the seventeenth and eighteenth centuries.

Hawaii Cane and the Scientific Revolution in Europe 1790 to 1892

The political revolution in Haiti and the halt by Dessalines to Africans being shipped to the Caribbean was trumped by the scientific revolution in Europe. European seafarers were studying nature all over the globe. Europeans were travelling the world recording unknown plants, animals, minerals and the stars in the sky. Many European minds were into science and nature. Europeans reacted to the end of African shipments with new inquisitiveness. One inquisitive person was the Frenchman Cossigney. He travelled to Hawaii in 1782 and discovered that canes there yielded 1/3 more juice than the canes in the Caribbean. He also discovered that this cane because of its thick stem and woody fibers furnished more fuel that those in the Caribbean. It made more sugar and hence more money per land space. He sent it immediately to the islands of Mauritius and Reunion and later caused it to be sent to the islands of Guadeloupe and Martinique. Another inquisitive person was the seafaring Englishman Captain Blight. He sailed to St Vincent with the Hawaii cane in 1793. This period then is the period when the Hawaii cane replaced the Brazil cane in the Caribbean.

Not only the African shipments ended but enslavement of Africans was coming to an end. Europeans continued to crave for sugar and revolutionary changes took place more in the manufacture of sugar than in the cultivation of the sugar cane. Strategy changed - a scientific approach was adapted led by two Frenchmen Marquis de Cagand and Dutione La Couture.

Cagaud was a sugar-man having been born and brought up in the Caribbean island of Grenada. He submitted a paper to the Royal Society of London, 'Account of the Method of Cultivating the Sugar Cane' (Philosophic Transaction, London 1779). Here he discussed the root system and ratoons. He tabulated the rainfall of Grenada for 1772 and 1773. Subsequently he linked rainfall to the distribution of the crop. He studied the effects of drought. Cagaud also experimented on the flower of the cane and published accurate drawings of its anatomy. According to Noel Deer by experimenting on the flower of the Brazil cane he failed to obtain seedlings because the Brazil cane was sterile. For many years after, the belief arose that all varieties of cane are sterile.

Dutione la Couture was a trained medical doctor who went to Haiti before 1785 to study cane manufacture. There he found old methods and a backward routine of centuries. He worked on the plantation of a Mr. Deladebate and set about modernizing it. First, he changed the layout of the factory into two sections. Section one had to do liberation of the juice, evaporation, clarification and filtration. Section two had to do boiling juice to syrup, striking for crystals and separating sugar from molasses (purification).

In section one Dutione introduced the Baume hydrometer, the balance to weigh lime, 'sample test' for complete clarification, sulphuric acid or oxalic acid for over limed juice, density measurements to end evaporation at 24 Baume and cotton wool stretched over a fine wire gauze to end clarification by filtration. He introduced a laboratory with appropriate equipment, chemical reagents and materials such a cotton wool to control evaporation and clarification.

In section two the clear syrup was stored in a holding container so that the whole of the boiling could be done in the day-shift under export supervision. The night shift was left to a 'negro commandant' i.e. watchman. This was the boiling house and here Dutione introduced the thermometer. The thermometer made crystallization less ambiguous. Dutione advanced the syrup to concentrate using the thermometer. Temperature measurements prevented burning to cassareep instead of sugar. Temperature measurements also allow grading of sugar. For example at 228 Fahrenheit raw sugar is the product and at 230 Fahrenheit clay sugar is the product.

In 1830 R.G. Porter published 'Practical Directions for the Culture of Sugar Cane and the Manufacture of its Products' (London 1830) and sugar was oriented to chemistry away from African labour. Words such as molecules, salts and crystallization on cooling began to be used in the industry. Dutione not only changed the lay-out of the sugar factory, he revolutionized the interior of the sugar houses. He introduced laboratory operations and could separate molasses from crystals in three or four operations instead of five or six – and retrenched labour.

Another milestone was reached in 1858 when according to Noel Deer "The fertilization of the cane seeds was definitely established in May 1858 when an employee of Highlands estate, Iran Aeus, of African ancestry, saw and recognized cane seedlings growing in a field of ratoon canes. He called it to the attention of the owner James W. Parris who put on record the observation in a letter to Barbados Liberal of date Feb 8, 1859". After the sighting of seedlings, individual researchers gave way to European experimental stations in the Caribbean. At an experimental station in Guyana in 1892 the Demerara seedlings D74 and D95 displaced the Hawaii cane.

In the second half of the nineteenth century manufacture activities meant bigger factories but never refineries. The vacuum pan was introduced and two other grades of sugar were made in the Caribbean – brown and yellow. Progress in chemistry was to orient cultivation and manufacture of sugar to natural science laws. The concepts of super saturation, seed-grains, 'crystallization by agitation' influenced manufacturing. 1870 saw the first idea of a theory of molasses formation. In the sugar industry was invented or developed the roller-mill, evaporation in a vacuum, the filter press, the centrifuge and the new mental discipline of chemical engineering.

This paper provides a discussion on factories, process technology and human orientation before and after the Haitian revolution. It showed that sugar culture had a significant impact on science, engineering and politics in Africa, the Caribbean and Europe as indicated by the case studies.

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Smart Community Development Framework (SCDF): An Approach to Empower Vulnerable Communities Movement Towards Sustainable Development

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Abstract

The Smart Community Development Framework (SCDF) is a methodological frame that combines several other approaches such as Permaculture, Sustainable Livelihood Approaches (SLAs), Community-based Social Marketing (CBSM), Environmental Impact Management (EIA) and project management tools to effectively design and introduce appropriate technologies for and with vulnerable and poor communities worldwide, ensuring permanent and sustainable changes. A community in Guatemala was used as a model to list and evaluate the framework parameters because of its vulnerability condition, aggravated by the effects of climate change. This framework tries to integrate several approaches to systematically guide developmental projects to empower vulnerable communities, support poverty reduction, and sustainable development. The SCDF model is a workflow model to establish the vulnerability level and identify the problems; select the target actions, determine resource availability and major obstacles; an optimized permaculture design strategy incorporating specific appropriate technologies and social programs; an environmental impact assessment and implementation plan; an empowerment impact analysis, and power transfer guidelines. Local leaders, environmentalists, project managers and policy-makers can use the SCDF model to collaborate in the formulation of effective action plans worldwide.

Keywords: community development, empowerment, SCDF, smart community development framework, sustainable development, vulnerability

Introduction

Community development in vulnerable and poor communities is a complex and multidimensional study. Vulnerability and poverty levels of communities are dependent on economic, political, social, cultural, environmental, technological and time-response aspects. Several studies have highlighted the importance of community empowerment in sustainable development and poverty reduction. Though many approaches have been developed to address some of the global issues in a sustainable way, they lack integrative approaches to effectively guide the development of vulnerable and poor communities.

Maslow's Hierarchy of Needs categorizes the types of common needs ranging from physiological and safety (basic needs), to love, belonging and self-esteem (psychological needs), and self-actualization (being needs) (Cao et al. 2013, 170-190). One community empowerment method for addressing multiple societal and educational limitations that is grounded in Maslow's Hierarchy of Needs (and similar taxonomies) is the collaborative design and implementation of permaculture systems. Permaculture systems are a holistic design that provides basic and social needs by integrating nature, people, traditional knowledge and modern science (Veteto and Lockyer 2008, 47-58). Permaculture systems support the implementation of appropriate technologies, that is, products and systems that include social and cultural aspects and are affordable and appropriate to local needs and skills (Sianipar et al. 2013, 1007-1016) in order to improve environmental quality, sustainable food supply, equitable access to clean water, energy and shelter, and informal education.

However, there is a great debate on how best to define priorities regarding basic needs. Bradshaw's classification of needs determine four aspects of human needs: felt need (subjective), expressed need (communicated), normative need (determined by someone) and comparative need (determined by comparison) (Carver et al. 2014, 76-82). The nature of a specific need and how vulnerable people perceive it influences the importance of such need. Moreover, there are concerns on establishing and addressing the root causes of these needs, not just to mitigate the issues caused by the needs not being met. The present work tries to fulfill this gap creating a framework that attempts to guide intervention projects to address the root causes of vulnerability, poverty and inequality, by focusing on local perspectives. The Smart Community Development Framework (SCDF) combines several approaches such as Permaculture, Sustainable Livelihood Approaches (SLAs), Community-Based Social Marketing (CBSM) and project management tools to effectively design and introduce appropriate technologies in vulnerable and poor communities worldwide, ensuring permanent and sustainable changes.

A community in Guatemala was used as a model for this project assessment and to both list and evaluate the framework parameters. Guatemala is a country with much potential, but many challenges as well. There are a variety of ecosystems, affluent rivers and a rich cultural diversity. However, significant challenges related to widespread poverty and malnutrition, gender inequities, and low education attainment levels lead to significant community vulnerabilities, particularly with the impact of projected climate change continuing to erode prosperity and environmental quality.

In the Union Victoria Community, in the municipality of Pochuta, Guatemala, 400 families live their lives based on agricultural work, mainly coffee, and are subjected to lack of electricity, piped water and sewer service. Medical care access is limited and the population suffers of chronic malnutrition, with a basic diet based on beans and corn. Although there are close water birth, fertile soil to grow variety of vegetables and fruits and enough land and favorable climate to install proper energy, water and waste management systems, the lack of knowledge and financial resources to create and implement them is the major obstacles. Thus, an intervention that builds knowledge, engage the vulnerable population in new and sustainable behaviors and implement appropriate technology systems using local resources and cooperativism is essential to tackle those problems.

The work that the NGO *Comunidades de la Tierra* has done in the Union Victoria Community, along with the problems experienced by both the local community and the project team, inspired the development of the SCDF. Like Union Victoria, many other communities around the world have struggled with the lack of resilience, poverty and inequality. A generalized approach was taken and verified in the literature to allow worldwide applicability. It is important to note that this article does not aim to describe the examination of the village, but simply state that the analysis of the Union Victoria Community served to help the development of this comprehensive model.

Methodology Discussion and Evaluation

The SCDF proposed is composed of six major steps, each one with specific tactical actions and recommended resources (Figure 1). The framework deployment is approached in sequence and described in the following sections.

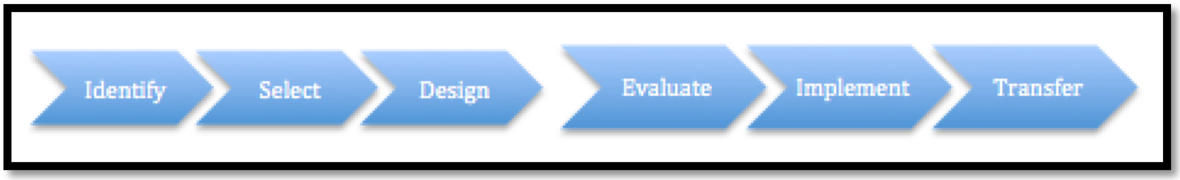

Figure 1. Smart Community Development Framework (SCDF)

Identify

The starting point of the project flow is to precisely identify the reasons to design and implement an intervention project. Vulnerable communities often have a multitude of problems that differ from one another depending on the political, economic, geographic and cultural environment they are subject to. It is during the contextual analysis of the community that the needs and influential forces are defined. The information gathered is used to explore opportunities and alternatives that will both reduce vulnerability and improve livelihoods, lifestyles and welfare, moving towards a more sustainable planet.

The identification process starts with a baseline assessment to identify current data with respect to:

(i) Access to basic needs (water, energy, food and shelter);
(ii) Environmental quality (water, air and soil);
(iii) Health and nutritional level;
(iv) Education attainment;
(v) Income security & employment;
(vi) Existing conditions (geography, natural resources, local infrastructure and accessibility); and
(vii) Existing local aid programs.

Then, it is important to understand the means of subsistence and pattern of life in the community, and so, a lifestyle and livelihood analysis is applied. This second step is an adaptation of Sustainable Livelihood Approaches (SLAs), which, through several tools and observations, tries to identify the assets and capabilities of community households, and the institutions, processes and vulnerability contexts that shape livelihood strategies and outcomes, as well as influence lifestyles (Scoones 2015). According to this author, SLAs bring into consideration valuable elements. First is the idea that there are five different capital assets: human (skills and knowledge), physical (shelter, water, energy and other systems), social (networks), natural (environmental resources) and financial (capital). Second is the concept that there are structures and processes that transform the daily life in the community such as governments and NGOS, legislation, social norms and environmental changes. The awareness and understanding of these elements help to select better strategies to foster sustainable behaviors and design sustainable systems in the community.

Based in the work of Scoones (2015), this framework proposes some questions to guide the livelihood and lifestyle analysis:

- Identifying ownership of assets and resources: *Who owns what?*
- Identifying social divisions and differentiation: *Who does what and gets what?*

- Identifying livelihoods and lifestyles: *What do they do with it?*
- Identifying social networks: *What are the institutions and social classes, and how do they interact with each other?*
- Identifying resilience: *How do environmental changes shape livelihoods and lifestyle?*

Furthermore, it is essential to consult the community to identify perceptions of current needs and importance rate, as well as community history (social, cultural and political factors). There could be differences in the collected data from what the community perceives to be a major problem or wishes to be firstly addressed. This action will ensure the bottom-up perspective from local people. This phase is based on an intercept survey guided by two questions (McKenzie-Mohr 2011):

- Identifying perceived problems: *What, if anything, makes it difficult or challenging to have a better quality of life?*
- Identifying perceived solutions: *What, if anything, do you see as beneficial or worthwhile to have a better quality of life?*

Finally, combining all of the information from previous actions to identify vulnerability levels and major problems in the community will provide an accurate panorama to guide the project design.

Select

No matter the context and problems a community is subjected to, a wide array of necessary changes and actions can be established. These changes might include physical changes (incorporating new systems or modifying existing ones), behavior changes (adopting new practices and attitudes) or, as is usually the case, a combination of both. These options lead to the desired goal of improving the quality of life in a sustainable way, making it necessary to target those that are most valuable and worthwhile within the context (McKenzie-Mohr 2011). It is necessary to list and prioritize the options when considering the context assessed in the previous phase, the resources available and the likelihood of making and sustaining them. This involves analyzing the following questions:

- *What are different actions and their potential to bring about the desired change?*
- *How often the actions are likely to happen and in which context?*

McKenzie-Mohr (2011) suggests that the selection be based on the best combination of impact, probability and penetration for better results. Once the target actions are selected, the next step is to identify the barriers that prevent the implementation. This involves analyzing internal and external barriers:

- *What are the contextual barriers (physical, technological, political, legal and economic) that prevent the implementation of the desired changes?*
- *What are the internal barriers (behavioral, cultural, social, and skills) that prevent the target population from engaging with the desired changes?*

Knowing which factors are major obstacles to implement the target actions is an essential step in developing engineering and marketing strategies.

Design

Having the target actions selected and the barriers established, it is time to design the project to implement the target physical systems and to promote the target behavior changes in the community. To address the physical systems, a permaculture design is recommended. The permaculture planning must incorporate engineering problem-solving and appropriate technologies in order to create or enhance food, water and energy systems, sanitation & health, infrastructures such as shelter and public spaces, transportation & accessibility, and landscape.

(i) Information Map: a map that overwrites the information from soil & vegetation, hydrography, rain & wind, natural resources, local regulations and local infrastructures to strategically plan the area (Aranya 2012);
(ii) Zoning: the division of the land in accordance to the information map to help position the systems and technologies and optimize space, access and movement (Aranya 2012);
(iii) Design & positioning of the engineering systems & the appropriate technologies.

The technological features may be co-designed with local people to ensure the satisfaction of their needs and may be as environmental friendly and simple to operate as possible. To address the behavior changes, social marketing strategies are an excellent tool to ensure they are permanent. They motivate local people to engage in different actions and promote changes in their livelihoods and lifestyle, fostering sustainable behaviors. Recommended strategies include public commitment, social norms, social diffusion, prompts, incentives and convenience (McKenzie-Mohr 2011).

Evaluate

Any intervention in the infrastructure of a place is likely to affect the natural ecosystem. Depending on the type, complexity and location of the project, an Environmental Impact Assessment (EIA) is required. EIA is a process used to assess and evaluate impacts of major development projects in order to get implementation approval from local bodies (Carroll and Turpin 2011). According to Carroll and Turpin (2011), a standard EIA process consists of eight steps:
(i) screening;
(ii) scooping;
(iii) terms of reference;
(iv) baseline studies;
(v) impact assessment and significance;
(vi) mitigation;
(vii) application; and
(viii) monitoring.

Consultation is also part of every step. This paper does not focus on deploying this process because interventions using permacultural designs and appropriate technologies are pro-nature and usually small. However, some projects may face regulatory obstacles and so an EIA is used to address the issues. If this is the case, the literature has plenty of work in the field that can guide interested parties through the process.

Regardless of the need for an EIA, a simple risk assessment is useful to develop a prevention, mitigation and monitoring plan to ensure human and environmental safety. It provides the likelihood of the occurrence of unacceptable risks and strategies to manage or avoid the consequences (Carroll and Turpin 2011).

Implement

At this point, the project, the intervention strategies and the impact management plan are designed, and so the implementation phase starts. The goal here is to implement the project cooperatively (a co-building process) while evaluating the community empowerment and other community-based impacts, such as perceptions, values, knowledge and behaviors changes, either during or post-building.

Power Transfer

The end of a project always finishes with an evaluation of the achieved goals and comparison with initial proposal, and with a review of trials and errors. All these findings must be reported in a technical review to serve as basis for future projects. As a developmental project focused in empowerment, this framework encourages planning the power transfer from the intervention team to the local people, that is, enabling local ownership. This plan should ensure that local people have the capacity, knowledge and input necessary to operate and maintain the new systems and behaviors, considering all of the partners, resources and support required, along with ways to access them.

The previous discussion deployed the six key steps of the SCDF into several actions, which are summarized in the Table 1. Also, Table 1 is enriched with a toolbox that suggests best resources and tools to support each action. There are many other tools that could be added here, but the important thing to consider is how appropriate are them for each context (Scoones 2015). This framework is not prescriptive, thus both the lineage of recommended actions and the suggested tools must be adapted to integrate the particularities of each context.

Table 1. Resources and Tools for Actions

ACTIONS	RESOURCES AND TOOLS
Action 1: Baseline assessment	Existing statistical and information databases; government and NGOs documents and literature review.
Action 2: Lifestyle and livelihood analysis	Surveys (social, income/expenditure, asset ownership); ecological, social, organizational and activity mapping; seasonal calendars; life histories; GIS analysis.
Action 3: Community consultation	Community meetings and focus groups guided by the intercept survey.
Action 4: Combining information	Group discussions; Mapping; Gap assessment analysis; problem tree; affinity diagram; mind mapping.
*Action 5:*Selecting specific changes	Brainstorming; technical/case reviews; expert surveys
Action 6: Identifying barriers	Observation; focus group; technical/cases reviews; expert surveys; vulnerability matrices; force field analysis; problem tree.
Action 7: Optimized permaculture design	Permaculture frameworks; Appropriate Technologies databases (e.g., Banco do Brasil Foundation); review cases, expert consultation.
Action 8: Social marketing strategies	Community-based Social Marketing (CBSM) framework, review cases, expert surveys.
Action 9: Identifying environmental impacts	Environmental Impact Assessment (EIA) frameworks; technical/cases reviews; expert surveys; vulnerability matrices.
Action 10: Pilot the project	Issue log; communication and motivation tools; project management frameworks (e.g.: PMI, PMD Pro)
Action 11: Implementation phase	Issue log; communication and motivation tools; project management frameworks (e.g.: PMI, PMD Pro).
Action 12: Evaluating community-based impact	Observation; community meetings and focus group; outcome measurements; impact surveys.
Action 10: Project transition	Transition planning matrix; check-lists; social marketing frameworks.

Several challenges may emerge anytime an intervention is planned and executed, such as incorrect evaluation and comprehension of needs, barriers, resources and systems involved; and changes in the schedule and budget due to unpredictable forces, for instance, natural disasters, inflation and sickness. Thus, a great integration between engineers and designers and the local people, along with resilience building, will provide the adaptive response needed in these unpredictable situations.

Conclusion

Vulnerable and poor community development is a complex and subtle issue that requires a holistic, bottom-up approach. More than that, it requires techniques based on Psychology and Marketing sciences that ensure endurable and sustainable changes while empowering the local population. This study proposes a holistic approach to implement appropriate technologies and address real needs.

The Smart Community Development Framework (SCDF) is a resource to efficiently implement appropriate technologies and foster sustainable behaviors in order to reduce vulnerabilities and create a sustainable community. It is a flexible frame, meaning that not all steps need to be addressed and the order can also be changed, depending on the community context. The combination of recognized approach and the flexible design is what allows its effectiveness on enhancing livelihoods, lifestyle and life quality of vulnerable and poor people

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The Use of Innovation by SMMEs to Tackle Social Challenges in South Africa

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Abstract

Innovation has become a critical point of discussion due to factors such as slow economic growth, commodisation and global competition. The national system of innovation (NSI) approach has been largely adopted by policy-makers, including those in South Africa, to understand and describe the structure of the innovation process. The NSI is defined as, the network of institutions in the public and private sectors within a nation whose activities and interactions initiate, import, and diffuse new technologies.

There are two distinct and complementary modes of innovation: (1) Science, technology and innovation (STI), which focuses on promoting research and development (R&D), utilising and creating access to explicit codified knowledge; and (2) Doing, using and interacting (DUI), which focuses on innovation strategies typically involving organisational frameworks, improving knowledge sharing among employees and promoting interactive learning. Due to the 10-Year Innovation Plan of the Department of Science and Technology (DST), a number of legislations and policies have been introduced to remove obstacles that weaken South Africa's NSI and obstruct growth in South Africa's STI capacity.

The research problem is to analyse the modes of innovation used by small, medium, and micro enterprises (SMMEs) in South Africa and to identify the potential for SMMEs to use their business innovations to tackle social challenges faced in South Africa. The method used in this study was a quantitative analysis by means of an online survey questionnaire sent to SMMEs in the Gauteng Province.

The results indicated that 85% of the SMMEs used DUI-modes of innovation compared to the 15% who used STI-modes of innovation. Furthermore, 65% of the firms indicated that their business activities could be used to tackle at least one of the social challenges outlined in the National Development Plan (NDP to a high extent), with 49% indicating that their innovations could tackle more than one social challenge. Policy-makers need to direct more effort into increasing STI-modes of innovation within South African SMMEs and using the innovation activities within SMMEs to tackle social challenges faced in South Africa.

Keywords: Innovation; SMME; social; NSI; DUI; STI; DST; NDP.

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Appropriate Technologies and Solutions for Disaster Management: Discovered and Applied Knowledge

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Abstract

Recently in 2013, with major floods that hit twelve states in Sudan, we saw the intersection of social organizing, the use of technology map the floods and affected areas, and the use of social media to spread the word and support organizations during the disaster. Disaster response and recovery efforts require timely interaction and coordination of public emergency services in order to save lives and property. In order to cope with such disasters in a fast and highly coordinated manner, the optimal provision of information concerning the situation as well as suitable communication information mechanisms that can both spread the information and process it as soon as it is received, are both critical.

In this paper, we will focus on Appropriate Technology contributions that can empower the use of applications for Disaster Management Systems. In addition, this paper discusses a case study of an application being used during the devastating 2013 flood in Sudan. Moreover, the paper analyses the capabilities that Information and Communication Technology can offer Disaster Management, in particular the use of Mobile applications for data communication, before, during, and after the disaster.

Keywords: Appropriate Technology; Disaster Management Systems; Information and Communication Technology; Free and open source software; Geographic Information System.

Introduction

"In disaster, one cannot wait for an accurate response from the field, which will take a long time." (BIDS, 1991), Climate change imperatives and increasing propensity to natural disasters, the world is becoming more vulnerable to disasters. For instance, Sudan faces frequent, and often devastating, river floods. Every year, thousands of Sudanese families face death, homelessness, and hunger (Tran, 2013). We need to mitigate the cost and suffering from disasters as much as possible. This can be facilitated by sharing information between the victim and the people outside the danger zone. One of the key shortcomings identified during these recent floods in Sudan is the lack of ICT solutions for disaster rescue and recovery. It was soon realized that without IT based solutions, it was difficult to coordinate the massive amount of information as well as manage the influx of relief. This highlighted the role of IT and telecommunication technology can play in transferring the information, and the realization that a duplex real-time communication medium can mitigate the intensity of disaster to a great extent. Chris Vein, the senior manager of the World Bank's ICT sector, said, "The World Bank's support is evolving to reflect new development challenges, and disaster risk management is becoming one of the key areas in which ICTs can make an exceptional impact." (Narimatsu , 2013).

According to Africa Mobile Network webpage, the coverage of mobile network in Sudan as of 2013, is approximately 67% of the population and 25% of the land area are covered by at least one of the 4 licensed mobile network operators (Zain, MTN, Sudani and Canar). By

2015, coverage is projected to increase to 60% population and 30% land area (AMN, 2014). Already, national statistics indicate that 76% of households own at least one mobile phone (MICS, 2014). Mobile phones are good examples of cheap technology due to the availability of low-cost pre-paid cards and cheaper handsets. The minimum air-time charge per second is about 0.03 SDG, making mobile networks more affordable and suitable for utilization during disasters. However, is good connectivity sufficient to implement a disaster management system?

According to UNESCO, a disaster plan usually involves four phases. The first phase, prevention, is about acting to reduce or eliminate the likelihood or effects of the disaster, while the second phase, preparedness, is about taking steps before the disaster to ensure effective response and recovery. The third phase, response, is about containing, controlling or minimizing the impacts of the disaster, and the final phase, recovery, is about minimizin disruption and recovery times (Bunmi, 1999).

For the promotion of a culture of disaster prevention management, researches have been conducted and knowledge produced on local disaster *preparedness* and *prevention*. These efforts have brought significant positive change. Although the number and frequency of disasters have increased, proper awareness of the potential disasters and their impacts can minimize the suffering from it notably. This can be achieved by developing a suitable warning system that uses an IT-based disaster preparedness and management *response*. While many disaster information systems are available, few would provide a robust system for data management to support the functionality for disaster management. Choosing an appropriate technology, or best solution, will be discussed in the rest of this paper.

Lina and Michal discussed three major types of social groups in emergency *response*. First, affected communities who may be immediately involved in activities, such as reporting what they see, taking pictures and videos, and transmitting to others information about what is happening at their locations. Second, professional emergency workers who would be equipped with capabilities to perform large-scale rescue efforts. Third, a large number of highly motivated volunteers who would contribute to the solution for humanitarian reasons (Lina, Michal, 2010).

Given the importance of using technology in disaster management, it is critical to consider the efficiency of these systems because in danger times one second delay might cost lives. Therefore, many mechanisms to prioritize assistance factor in and become crucial to provide maximum coverage of the area in the shortest possible time. For example, priority in terms of severity or by the number of people in danger can be identified through the selected software. One of the mechanisms for the "best system" might be according to its ability to determine the optimum route for the volunteers and rescuers to take in order to serve the most vulnerable. There a huge variety of ICT technologies that can be used for information exchange and collaboration in disaster management. The following subsections will explore different systems and explore their capabilities in dealing with disaster situations.

Disaster Management Systems (DMS)

In Massachusetts Institute of Technology (Patton, 2013), researchers have split disaster management applications that can potentially be used by people during a crisis into two categories. The first category, "Donation" applications (e.g. Donate-N-RequestApp) are used to match requests and donations during a disaster scenario, and the second category, "Reporting" applications (e.g. WeReport App) are used to report scenes and information related to the disaster. In this application, "WeReport", one may take a picture or record a video of the scene and add a “tag” and a “description” to the image. Likewise, the Japanese developed advanced technologies for disaster risk management, including for early warning (such as J-alert - a nationwide automated early warning system); emergency response, data analysis and decision making (e.g. tsunami arrival time, flood level and risk analysis); and information sharing (using mobile TV and satellite mobile phones) (Narimatsu, 2013).

In the developing world, open source solutions and the use of social media are popular. For example, the Philippines utilize Google’s Android operating system. Their disaster management system, an Android application known as MyDisasterDroid, determines the optimum route along different geographical locations for the volunteers and rescuers (FAJARDO, 2010). During Beijing’s flashes floods in July 2012, people used Twitter to provide information about the flooded areas and collaboratively developed a live crisis map of the floods impact using Google Maps (Patton, 2013).

On the other hand, Bangladesh’s Disaster Management Bureau (DMB) has a line of communication with other weather forecasting agencies. This application cycle starts with the weather forecasting agencies forecasting the disaster; cyclone for example, followed by a disaster warning, and then disseminates rescue and recovery information. The central coordinator will then write a Short Message Service (SMS) describing the weather report and necessary steps to be taken and send it to the mobile phone operators. Mobile operators disseminate this short message to all mobile phones in a specific geographic cell (Hossan, 2003).

However, the most popular app in the Asia is “Sahana” disaster management system, which was put into action during 2004 Indian Ocean Tsunami. Sahana uses free and open source software to create a number of functionalities. The success of these functionalities has contributed to the efficient and effective management of disaster relief. Although Sahana was initially meant to be a post-disaster management tool, it is now being modified to accommodate disaster preparedness functionality as well. It has the potential to address problems in coordination of relief supplies, manage camps, inventories supplies, find missing people and manage volunteers, In the aftermath of the Tsunami, 1 million people who were displaced and assets valued at US$ 900 million were destroyed. Sahana was able to provide an effective IT-based solution in the post-Tsunami relief and recovery phase. But also, it can be used for disaster prevention, preparedness, relief and recovery, through an interface to generate CAP (Common Alerting Protocol) messages. Its functionality include Messaging module that sends alerts through SMS or email to a group of people, pre-populating the organizational module in anticipation of disaster, registering respondents and volunteers and tracking them in advance, and pre-plotting and setting up evacuation points. Because of the success of Sahana system in alleviating human suffering during the Tsunami, it was adopted by Pakistan, Philippines, and Indonesia to manage their respective disasters. Besides, Lebanon and Ecuador are supposed to have adopted Sahana, although it cannot be confirmed (Zengpei, 2009).

Some experts advocate that low-income countries with limited resources and skills capacity could take advantage of Japanese technologies; others promote the use of local solutions such as that of Indonesia, where mosques’ speaker systems are used to disseminate early warnings information. Another example in Taipei, OS solutions did not appear stable or sturdy enough to handle the complexity of the disaster-prone island's data sets (120 to date), and in Sri Lanka they found that “ArcGIS is powerful enough to do the calculations and to integrate [the data] with satellite imagery, which cannot be achieved with Sahana," (Gutierrez, 2013). Due to the limited number of users (100) with rights to access the Arc-GIS licensed software in

Taiwan, local governments use their own commercial disaster management software (disaster risk reduction and response that are decentralized island-wide), and a number of NGOs and research groups have been trained to run Sahana. Locally, during Sudan floods, Facebook proved valuable for raising funds, coordinating volunteer groups, and disseminating information and alerts for the disaster areas.

As per above examples, we can argue that some scenarios fit specific countries while others might not. The next section will explore a number of technology options for Disaster management systems.

A Set of Appropriate Technologies for DMS

The following subsections focus on some of the popular technologies (described in the above case studies), that can be integrated to provide disaster management functionalities in different resources constrained settings.

Free and open source software (FOSS)

Free and open source software (FOSS) is increasingly being used in many spheres of ICT solutions including disaster management. Cheaper cost and vendor independence have been cited as the two key deciding factors in favor of free and open source software use. However, the issue with FOSS application is the stability and the support of the vendor, which can be granted by software companies. However, FOSS allies claim that Open source problem can be solved as you go by putting it online. Gutierrez (2013) sees “cheap and easy” as key criteria for FOSS. He argues that FOSS eliminates the need for servers and hosting facilities allowing the use of low-cost devices like smartphones and tablets that can gain access from any web browser connected to the Internet. In addition, FOSS would require less training, upkeep, and support, because it would have fewer options, less clutter, big buttons, and simple layouts. He notes that technical support personnel of community organizations can simply have a version of the software for free and be able to operate it easily.

Mobile technology

Mobile applications have sufficient capacity and capability to improve the quality of emergency preparedness and integration with sensor alarm systems. These “Apps” can assist in analyzing and finding suitable solutions during the disaster (Just-In-Time) by using GIS and web tools. The functionality of mobile technology can support the dissemination of pre-disaster warnings and post-disaster announcements. First, for pre-disaster warnings, mobile phones can disseminate information about impending disasters. For example, only 30 percent of the population of Bangladesh has access to electricity. They do not always have access to other media such as TV or radio, and if they have, they may not have it turned on during the emergency. However, mobile phones are widely prevalent and are ‘always on’. Second, for post-disaster announcements, governments and NGOs can send relevant announcements such as transferring helps to specific shelters or information about relief distribution after a disaster. This is crucial to deal with the aftermath, to receive information about relief needs, and to exchange information about health hazards. When people become homeless, without electricity, in additional to other dangers from the aftermath of the disaster, they can also be the move. During these situations, sending out announcements through mobile phones can be an effective means to keep people organized and run post-disaster operations smoothly (Hossan, 2003).

GIS, Satellite, and remote sensing

GIS can be used in carrying out search and rescue operations in a more effective manner by identifying areas that are disasters prone and zoning them accordingly to risk magnitudes (Vyas, 2007). Moreover, GIS and remote sensing can be used to manage drought relief, such as early warnings of drought, which can help planning strategies for organizing relief. On the other hand, satellite data can be used for mapping and monitoring of flood inundated areas, flood damage assessment, flood hazard zoning and after the floods of the rivers based on survey work and protection settings. Also, the data can be used to target sites for potential groundwater programmers include well excavation. This data can provide valuable insight for evaluating areas subject to desertification. Slides, photographs, and digital data can also be used to locate, assess and monitor the deterioration of natural conditions in a given area (Sapa, 2013).

Social networks

Social networks have proven critical in such severe situations because they are able to mobilize the necessary volunteers, to share information, and to manage networks or informal volunteers and coordinate their efforts. In emergencies, a key challenge is obtaining reliable, accurate, and timely geospatial data, especially in situations where disasters develop rapidly. It is extremely difficult for government agencies to send a sufficient number of trained people to the affected areas on time for mapping and data collection. However, when a disaster happens, professional emergency workers are rapidly overwhelmed and scarce emergency services may be quickly depleted. Social networks (e.g. Twitter, Flicker, and Facebook) can play two major roles in effective emergency management. First, information generated and disseminated over social networks is incredibly valuable for disaster response. Second, the study of the relationships, behaviors, and interactions in social networks may provide important insights for gathering information, planning evacuations and sheltering, and other rescue efforts. Nevertheless, few pieces of research have been done to investigate the effectiveness of using social-networking tools to disseminate information or to coordinate tasks by emergency managers during the response and recovery phases (Goodchild, 2010).

After analyzing different technologies that suit DMS, the following section will discuss their benefits to rescuers and the rescue, focusing on the knowledge generated in the disaster management process.

Discovered and Applied Knowledge in DMS

From the above it can be deduced that DMS will provide applied knowledge that can guide the users in two directions. First, Short-term direction as making it possible to make right decisions on time such as on evacuation areas or first aid basic information. Second, long-term direction that involves the data that the apps will collect, to inform national institutions and planning efforts, for example regarding mobility of people, catchment areas, road or building construction, and provide early warnings about Floods areas. In Sudan, for example, the above can be useful in determining residential areas, land distribution, and capacity building plans after floods.

Disaster management functionality involve providing a quick response and real-time solutions for basic disaster problems. It is preferable to be appropriate tool for communication and spreading the information to the right entities at the right time. Ideally, the disaster management process should yield a data repository, which can later be used for analyzing and developing strategic solutions as previously mentioned. It is noteworthy that advanced technologies cannot be considered in isolation whenever any disaster management mission is in operation, as advanced technologies have their own limitations. For many countries, these are expensive, inaccessible, and unavailable to a great extent. In addition, poor literacy levels can impede the ability of the population to become conversant with the application and utilize the technologies. On the other hand, indigenous and traditional technologies have many virtues and advantages, and could therefore, as Lindell (2003) suggests, be suitably integrated with their modern counterparts for maximum benefits in disaster time.

The example of Nafeer group in Sudan 2013 floods demonstrates the integration between sophisticated tools and local knowledge. That autumn, floods due to heavy rains have affected twelve States in Sudan with devastating effects on 232.135 people, or 46.427 families and more than 23.100 houses were damaged, and 45 lives lost, according to the WHO situation report on 14 August 2013. During the floods, a group of youth decided to help the flood victims by creating a page on Facebook and organized themselves into working groups to raise funds through hot lines. They chose the name Nafeer, after the traditional word for community assistance after a disaster. One group of volunteers took the task of helping the victims financially, medically, providing food and water to the communities most hit, while the other field groups and other members took care of the communication and organization among the volunteers and whoever raised a flag for need. Technical support group was mainly responsible for channeling all phone calls and field information into one system. This youth-led initiative was very effective and organized. Fund raising reached 55,660 SDG in one day on their Facebook page. According to Abeer Awad in TED talk 2013, the Nafeer group, worked in collaborations with the International Network of Crisis Mappers and other international organizations to build a crisis map (Figure 1) that provided instant graphic images of the type of need and locations of volunteers. This app used GIS, LBS, Satellite and VAS technologies to make a connection between first aid groups and victims. This setup was found to be a very effective where help was made accessible and available in a timely manner.

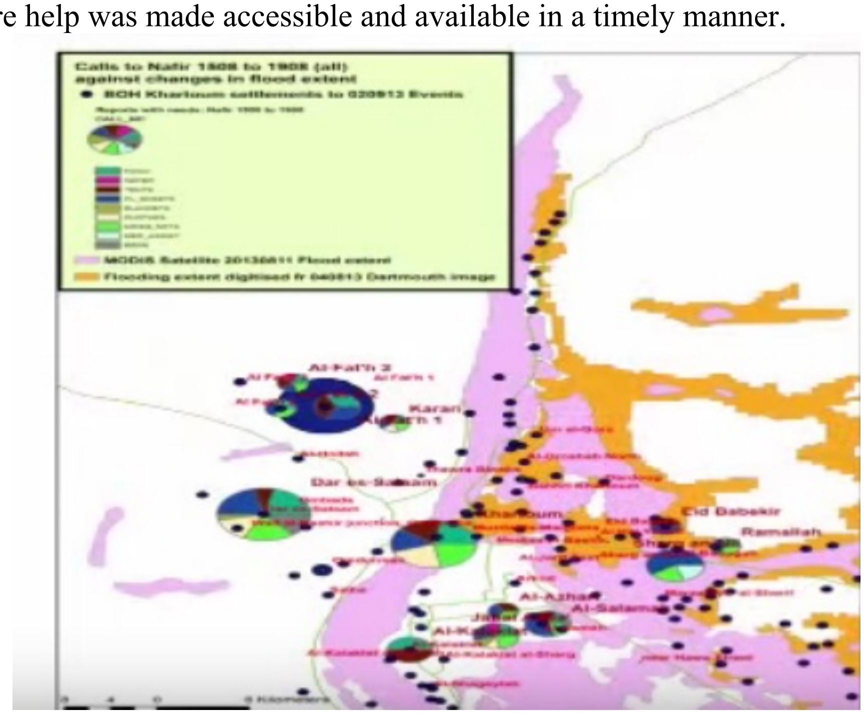

Figure 1. Crisis map during 2013 floods in Sudan (Nafeer TED TALK, 2013)

Whereas the Nafeer experience showed the role technology can play and how it can be applied in Sudan, Professor Fath Arhman Elgadi (2013) asked a very important question, "Why nonprofit organization by youth as Nafeer had successes in what the government couldn't achieve 1% of their achievement?" He thinks that the technology is the key word in the answer. Moreover, ELtahir (2009) noted that the government canceled any technical consultancies in the majority of crisis management and that is in fact, the root cause of how the country will always be behind.

Recommendations and Final Remarks

While the availability of free software and tools is seen as an enabler for countries with limited resources to develop disaster management capabilities, the private sector, particularly the mobile telephony providers, should be encouraged to play a role in disaster management as part of their corporate social responsibility. It is also necessary to create awareness amongst the public as well as decision makers for allocating resources for appropriate investments, public awareness and training, in information technology. Preparedness and awareness are both critical in mitigating the impact of future disasters, particularly in the developing countries who also suffer most from natural disasters.

There is a need to develop technology capability for dealing with local languages. The use of Bengali in Nokia's recent innovation in India is a very good example for DMS in semi or non-literate settings. Also, to have a specialized emergency network for disabled groups and people speaking different languages or from different cultures, is by and large, a human right. Enabling developers to quickly deploy applications that take advantage of key sources, fundamental for today's networked citizens such as Twitter feeds, Facebook posts; can also empower citizens involved in crises to contribute via crowd sourcing, and to communicate up-to-date information with each other and filter fake news and misinformation. While more research is required to explore the use of social media in DMS, youth interest in social media and software development, evident in Sudan, is an opportunity to tap into by developing the capacities of young software developers and exploring other country experiences rather than starting from scratch. The experience of Nafeer proved that a country like Sudan *can* indeed benefit from existing resources whether human or technologies.

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Service Learning in a Graduate Environmental Engineering Program – Community Engagement, Knowledge and Technology Transfer for Capacity Building and Sustainable Development

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Abstract

In this paper, we describe service learning (SL) activities developed for graduate students in environmental engineering working to prepare a Water Quality Atlas for Koratty Panchayath in GIS format and with full participation of the community. A women self-help group (SHG) water brigade was formed, provided training in water quality analysis by the graduate students of the Environmental Engineering program, and the SHG then trained the local community in water literacy. The student-driven and community based projects enabled students to engage in service while enhancing their engineering education and training and assisting communities. This paper reports outcomes of SL project activities: knowledge transfer to communities, enhanced student learning, empowerment of the communities, and the technology transfer that resulted in community capacity building. These experiences suggest a model for capacity building in communities, through the expansion of such SL pedagogical models across engineering disciplines and across academic grade levels. It is also possible to consider the development of service oriented student organizations, such as Engineers Without Borders (EWB) and more broadly link academic content to community service. Leveraging the teaching and learning of the young offers a mechanism for building capacity and empowering communities.

Keywords: *Service Learning, Project Based, Engineering, Education,Water Quality, Atlas*

This paper was accepted for publication in the African Journal of Science, Technology, Innovation and Development.

Towards a Core Curriculum for Civic Engagement on Appropriate Technology: Characterizing, Optimizing, and Mobilizing Youth Community Service Learning

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Young learners represent a source of renewable energy that could benefit communities worldwide. While there are a growing number of isolated case examples of successful community engagement projects led by youth and their educators from around the world, a gap remains with regard to the development of a core curriculum for civic engagement that can help to better organize, strategize, and standardize these initiatives. In this paper, we provide an overview of an international research project that is seeking to develop a core curriculum for civic engagement (CC4CE) to optimize worldwide school-led community improvement initiatives while supporting youth learning across academic disciplines at the same time. By integrating knowledge of research methods, best practices across differences of culture and context, and along local to global scales, the CC4CE is being developed to serve as both a standardized and customizable approach to community improvement through integration of traditional academic learning with civic engagement education research. With the CC4CE we seek to empower young learners with the skills and confidence they need to take-on the mounting social and environmental challenges of our time. The curriculum seeks to especially support those currently engaged in service-learning implementation of Appropriate Technology for healthier, more sustainable communities.

Keywords: Appropriate Technology, Civic Engagement, Collaboration, Education, Service learning, Teamwork

This paper was accepted for publication in the African Journal of Science, Technology, Innovation and Development.

Zimbabwean A' Level Subjects and Career Guidance Mobile Application

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Abstract

Ordinary Level (O' Level) Students in Zimbabwean educational curriculum tend to decide on which subjects to take at Advanced Level (A' Level) based solely on the results attained from their examinations. Most students pay little or no attention to their lifestyle and personality traits as part of the factors that should be considered when choosing the subjects to take. Some schools even create clusters for O' Level students. A' Level subjects are categorised into Commercials, Sciences and Arts, and students are added into these clusters purely on academic basis. The categories offer assistance to high school students in choosing suitable A' Level subjects' combination and determine a relevant career path to follow afterwards. In this paper, we propose the development of a mobile application that will assist in guiding the student based on his/her personality. The system will take full advantage of the mobile penetration rate in Zimbabwe. Its aim is to highlight the personality traits of an individual and use that as a basis for career guidance. The relevance of the system goes even beyond students to anyone whose intention is to know their personality traits in detail. The system achieves the aim by doing the following; it allows a user to take a personality test based on the Holland Codes, it classifies a user as being Artistic, Investigative, Realistic, Social, Enterprising or Conventional in terms of personality and then advises a user on whether he should take up Sciences, Commercials or Arts at Advanced Level. Finally, the system seeks to suggest to a user a list of proposed career opportunities that matches his/her personality traits and the local universities offering the suggested programs of study. The other advantage is this system follows the Do It Yourself principle.

Keywords: O' Level (Ordinary); A' Level (Advanced); Subjects; Career guidance; Holland Codes; Personality traits; DIY

Introduction

Zimbabwean junior education has two phases; namely the primary and secondary education. Students take a single examination at the end of their primary education which gives them passage into secondary school. In secondary school, they sit for the Ordinary Level (O' Level) and Advanced Level (A' Level) examinations. Ordinary Level examination results are used for admission into the Advanced Level stage. The Advanced Level is a very critical stage of the Zimbabwean educational system because it is the one considered for tertiary and indirectly the career path. Ordinary Level students tend to decide on which subjects to take at Advanced Level based solely on the results attained from their Ordinary Level examinations. Most students pay little or no attention to their lifestyle and personality traits as part of the factors that should be considered when choosing the subjects to take. Schools come up with career clusters for their students. These are categorised into Commercials, Sciences and Arts. Students are added into these clusters purely on academic performance. This approach has a downside in that later in life individuals realise that they are working in fields they do not enjoy and neither have natural ability in though they studied and passed an examination. Career guidance is a very complex exercise (Hinkedmann et al. 2003).

Although people behave in different ways, depending upon the circumstances you are in or the people you are with, you nevertheless have a personality that remains identifiable (Barrett, 2009). The late psychologist John Lewis Holland (1997) developed a school of thought on career paths. According to his Committee of Scientific Award winning work and research he says that "Personalities seek out and flourish in environments they fit and that job and careers are classifiable by the personalities that flourish in them." (Gottfredson and Holland, 2003).

Dr. Holland's Theory of Careers and Vocational choices had been revised and improved since its origins in the 1950s to produce a mature and robust method of linking personalities to career options. By the time the 1973 version of the theory was published, many reviewers' worries about its applicability to women, to adults, and to a wide range of youths were already being put to rest by evidence. The Vocational Preference Inventory data from 43,391 second and fourth Year College students was been used to test the hexagonal representation and to classify occupations. The population included both male and female students. Furthermore, job analysis data based on Position Analysis Questionnaire dimension scores (McCormick ,2001) and vocational interest data (Campbell & Holland, 2002) has also provided evidence that the Holland's code can be used for working adults who seek to bolster their careers.

Using the above philosophy, we developed an Android based Decision Support System that proposes a suitable set of subjects to take at Advanced Level. The application also gives suggestions of the career path(s) to pursue. A psychometric test is completed and personality is deduced from the results. The personality analysis is results and an input of person interests are used to classify an individual to one of the following interest types: Realistic, Investigative, Artistic, Social, Enterprising and Conventional. These classes are based on the Holland REISEC theory in the dictionary of Holland's Occupational Titles (Gottfredson and Holland, 2003). Since personalities are too complex to be described by a single interest theme, a code was developed that uses a combination of related interests (in order of importance). Having obtained a particular personality code associated to the particular individual the application then returns a set of career options that match the particular Code. The application also highlights to the user A Levels (set of subjects) required to pursue a particular career that they are interested in. An example would be the application assigning a user a code RIE, which means that he is Realistic, Innovative and Enterprising and the particular order means the Realistic trait carries more weight as compared to the Innovative and Enterprising trait. This code would be different from IRE although they are both composed of the same interest types. Since the application is designed to mostly cater for local students the application also suggests local universities that offer degree majors associated with the career(s) to even allow the user to make a more informed choice of subjects to take up for A' Level.

Materials and Methods

RIASEC Model and the Holland's Code

In its modern form, trait-and-factor theory stresses the interpersonal nature of careers and associated lifestyles as well as the performance requirements of a work position. Holland (1997) identifies six categories in which personality types and occupational environments can be classified: realistic, investigative, artistic, social, enterprising, and conventional (RIASEC).

According to prestige levels, investigative (I) occupations rank highest, followed by enterprising (E), artistic (A), and social (S) occupations, which have roughly the same level of prestige. The lowest levels of prestige are realistic (R) and conventional (C) occupation (Gottfredson, 1981).The theory of career choice propounded by John Holland more than 40 years ago is perhaps the most well-known and widely studied career theory in the history of Career Psychology. This is probably because the theory has yielded objective methods for the practice of career counselling.

At the heart of Holland's theory are three propositions: Firstly, it is possible, according to Holland, to classify people and environments into types. Type by definition, is a conglomeration of traits which can serve as a measure for categorising people into groups. In Holland's formulation, there are six types of people and work environment. These are the realistic, investigative, artistic, social enterprising and conventional (RIASEC).The realistic type is the person who is most comfortable being involved in activities that are concrete and based on clearly defined systems and norms. Conversely, the realistic type of person is not comfortable in social contexts that require interpersonal skills, expressive ability and situations that require the expression of emotional sensitivity. Engineers, machine operators and mechanics are examples of professionals who would fit into Holland's realistic type. The investigative type is analytical in orientation and enjoys drawing conclusions from systematic and objective observations. Repetitive and routine activities are likely to be avoided by this group of people. Researchers, doctors, detectives are examples of the investigative type.

The artistic type thrives on being expressive and original. This type tends to be unconventional and deeply sensitive to personal feelings, thoughts and ideas. Activities that are orderly and mechanical are likely to be unattractive to this group. Actors, designers, musicians, authors would demonstrate the characteristics of the artistic type. The social type is strongly oriented to human interactions. These people are sensitive to human needs, nuances of emotions, thinking patterns and other aspects of human behaviour. Activities that occur in non-human situations are likely to be avoided. Counsellors, nurses, teachers, social workers would fit into the social type. The enterprising type is typically self-driven. An individual from this group would enjoy organising people, objects and resources to create systems and structures for the attainment of goals and targets. The enterprising type is likely to be uncomfortable in work situations that are repetitive and do not allow for leadership or the expression and implementation of personal ideas. Sales people, managers, politicians are said to possess the characteristics of the enterprising type.

The conventional type tends to find the highest level of comfort in situations that are organised and predictable. They are likely to enjoy activities that require routine and repetition. Unpredictable, disordered situations and activities that require innovation are likely to be avoided. Accountants, bankers, receptionists would fall into the category of the conventional type. In an analysis of census data using the Holland codes, Reardon, Bullock and Meyer (2007) confirmed that the distribution across Holland's types is asymmetrical. They found that from 1960 to 2000 "the Realistic area had the largest number of individuals employed and that the Artistic area had the fewest number employed". The gap between the number of people employed in the Realistic and Enterprising areas shrunk during the five decades to where in 2000 there were approximately equal numbers of people employed in both areas.

Interestingly, the Investigative area more than doubled during this time whereas the other four areas remained relatively stable. Regardless of age, between 75 % and 85 % of male workers were employed in the Realistic and Enterprising areas; women were more varied and concentrated in Conventional, Realistic, Social and more recently Enterprising areas. Personal satisfaction in a work setting depends on a number of factors, but among the most important is the degree of congruence between personality types.

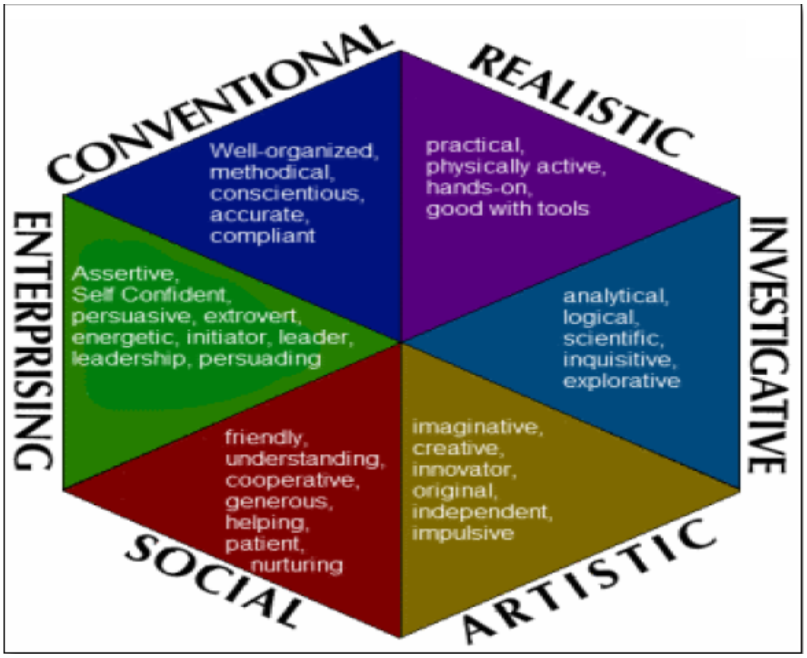

Figure 1. RAISEC Model (Holland, et al. 2001)

Research and Development Methodology Used

A research is a framework associated with a set of paradigmatic assumptions that are used to conduct research (O'Leary, 2004). In this paper, the two methodologies were used. One methodology is for the actual research and the other is for the application development. The two methodologies used are: the Design-build and the Incremental Prototyping.

Research was carried out on the functional requirements and before the application development; a single system design was done. The design was showing clear interaction of all the elements need for the Career Guidance Decision Support System.

The Incremental Prototyping model performs the Waterfall model in overlapping sections attempting to compensate for the length of waterfall model projects by producing usable functionality early in development. Developing systems through incremental prototyping requires first providing essential operating functions.

Properties of Incremental Prototyping development process:

- System is developed and delivered in increments after establishing an overall architecture.
- Requirements and specifications for each increment may be developed
- Users may experiment with delivered increments while others are being developed therefore, these serve as a form of prototype system.
- Intended to combine some of the advantages of prototyping but with a more manageable process and better system structure.
- Suitable for situations where it is too risky to develop the whole system at once:

The Incremental Prototyping method has a report back facility, resource management and early functionality. Progress is visible as early functionality can be realised. The methodology does not require a complete set of requirements from the start. It offers cost effectiveness on any change of scope and requirements. It is also easy to test and debug during a smaller iteration. The methodology offers an easy platform for risk management since functionality is added to the prototype and at each stage.

For the development of this application, the Holland Codes' six personally types were used as 'increments'. Each stage of Incremental Prototyping was marked by adding a personally and testing it. The testing was done through students and the exercise was also serving Turing tests. Interviews were carried out with professionals who do Career Guidance.

Analysis of Functional and Non-functional requirements

One of the objectives of the requirements phase in Incremental Prototyping is to identify the functions that are supported by the proposed application. The A Level Subjects and Career Decision Support System should:

- Allocate a user a unique code that represents his/her personality trait. This is made possible by use of a standardised personality extraction algorithm that is comprised of multiple sets of questions meant to test different personality traits in an individual.
- Present the user with a set of job opportunities to scroll over and choose from.
- Allow a user to view a gallery with images of a particular university chosen
- Display to a user a list degree majors that are aligned to a particular job option and recommend A Level subjects to pursue.

There are constraints on the services or functions offered by the system. They include timing constraints, constraints on the development process and constraints imposed by standards. (Somerville, 2009) The A Level Subjects and Career Decision Support System quality properties are abstract behaviours such as reliability, usability, performance and availability. The following qualities apply to the whole system architecture:

- User friendliness is achieved by the use of well-designed user interfaces. People get overwhelmed when they see too much at once. The system breaks tasks and information into small, digestible chunks hiding options that are not essential at any moment, and gets necessary psychometric details from the users as they go.
- Data integrity is maintained in databases and interfaces. Referential integrity with constrains is applied in designing the database such that anomalies in deletions and insertions are eliminated and recommendations given to an individual are as accurate as possible.
- Availability is increased because the system is internet independent therefore it can be accessed offline without internet connection.
- Responsiveness and reliability. Writing code that is performs exceptionally well but takes too much system memory is disaster in Android and often leads to an "Application Not Responding" (ANR) dialog. Potentially long running operations such database operations or computationally expensive calculations such as resizing bitmaps were done in a worker thread (or in the case of databases operations, via an asynchronous request).

System Design

The pooled system architecture was used for the architectural design. A pooled architecture is when computing, storage and networks are in separate resource pools consisting of blocks and orchestrated separately. System upgrade is through replacing blocks within a pool. System growth through adding blocks to a pool. The architecture is designed to enable efficient scaling and growth of multiple workloads.

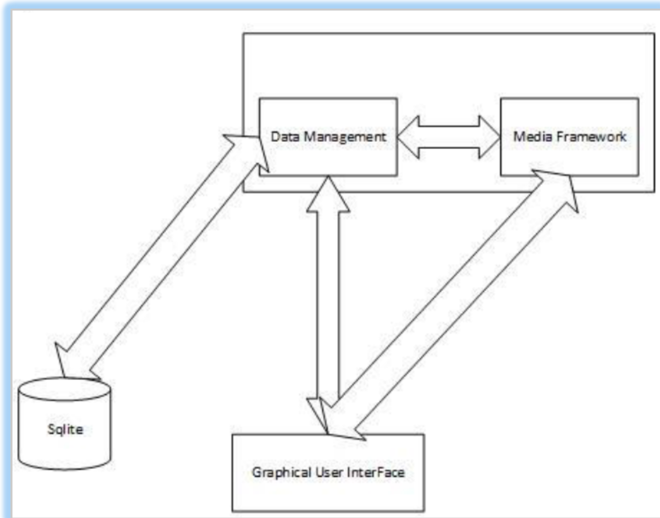

Figure 2. The Architectural Design

Figure 2 above shows the architectural design of the A' Level Subjects and Career Guidance Decision Support System. The architecture separates the conceptual designs into different sections. The architecture contains the media framework that is responsible for rendering different components, such as images, that as they are viewed by the user.

Implementation and Testing

Implementation Tools

Implementation tools are APIs and languages used in the development of the system. The tools used in implementing the A' Level Subjects and Career Decision Support System include XML, Android Studio, SQLite database and Java.

Implementation and Acceptance Testing

The user will interact with system through graphical user Interfaces designed in Android studio using XML. Figure 3 below shows the application start screen. The image at the centre shows an individual who is not sure of which path to follow and the system is responsible for helping the user make an informed choice in deciding subjects to do and also career path. The start button takes you to the career test and the not now button exits the system.

Figure 3. Application Start Screen (tilted)

Figure 4 below shows a screenshot of Personality Test. The screenshot shows a sample set of questions that a user is presented with. From that form an individual selects which ever statements best describe him and what he/she enjoys doing. Multiple options can be selected and in cases where there is no statement the user can go to the next screen by clicking on the next button. During the test if the user feels that he has to go back to a previous set of questions he clicks on the back button that is at the bottom of the screen.

Figure 4. Sample Personality Test Section

Figure 5. Personality Test Results

Figure 5 above shows the results after taking the personality test. The hexagonal diagram shows the six types of personalities. The code at the bottom of the screen it shows the personality code that has been generated by the system were each letter represents a particular personality type and the three letter code shows which personality types an individual comprises of.

Conclusion

Career Guidance programmes are organised by schools, colleges, universities and even by the government of Zimbabwe through the Ministry Of Primary and Secondary Schools. These programmes are run through huge budgets. This application is bringing all that to the student as a do it yourself (DIY) service. With the high mobile penetration rate being enjoyed by Zimbabwe and the rest of Africa this finds its relevance with the young people. Android is the operating system running on majority of smartphones and using this application will find a place in the market. Universities may also use the application as an advertisement and vacancy application platform. As further work, I would recommend that there be commercialisation of this application. Other models may also be used for Career Guidance.

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Designing a User Centered M-Health Application Interface to be Used for HIV/AIDS Management in Zimbabwe

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Abstract

Mobile Health (m-health) is the use of mobile devices in health delivery systems and it is a sub-segment of the broader field of electronic health (e-Health). This work seeks to bridge the gap between the mobile application designers and the expectations of the users by way of creating an m-health application which embodies the local identity of users living positive with HIV in Zimbabwe. The application is expected to provide the basis for which users can access healthy living information as well as foster community support. Ten individual in-depth interviews were done with peer educators living positively. Convenience sampling was used for the three focus group discussions that were carried out with HIV/AIDS support groups in Chinhoyi and Harare. The interviews and focus group discussions were done to gather information about the expectations from a user experience (UX), functionality and aesthetics point of view. The respondents identified the design considerations that would enhance the effectiveness for the HIV/Aids-specific m-health application. These responses, collected through the interviews and discussions, were the basis upon which the m-health application user interface (UI) was designed. The research also highlights how ubiquitous mobile technology usage has become a key practice in health management. The key emerging design features for the interface in this work are security, healthy living, home remedies, CD4 count management and how the application can be used as alarm reminder for taking medication or monitor the individual.

Keywords: mobile health(m-health), user-centered design, mobile application, design interface design, user experience

Introduction

Over the past decade there has been a rise in mobile technologies that have been aiming at the promotion of healthy lifestyles (Consolvo, Klasnja, McDonald and Landay (2009); Lin, Mamykina, Lindtner, Delajoux and Strub (2006); Long and Stevens (2004); Peng (2009)). In the developing economies one of the biggest challenges is the management of diseases as there is generally lack of resources. It is believed that the developing world, driven by the increased affordability of mobile devices, will produce most of the future growth, by adding a further 2.9 billion smartphone connections by 2020. Innovative mobile solutions being implemented in developing economies are assisting poverty stricken regions with the opportunity to overcome socio-economic challenges, particularly in the areas of financial inclusion, health, education and disaster response (Mobile Economy, 2015). Given that Zimbabwe had a mobile penetration of 90.8% in the first quarter of 2015, introduction of mobile health applications for use by the population will be to everyone's benefit in the future (POTRAZ, 2015). POTRAZ's first quarter report for 2015 notes that in Zimbabwe, internet and data services are on the upward trend against a decline of voice calls thereby supporting a growing user base for the m-health applications.

According to Clifford and Clifton (2012), developing countries lack healthcare personnel as they usually migrate to the more developed economies for more rewarding employment thereby making use of m-health an important and timely intervention given that a lot of people can access these mobile devices. Mobile Health (m-health) is the use of mobile devices in health delivery systems and it is a sub-segment of the broader field of electronic health (eHealth). The mobile tools include mobile phone technologies used in disease monitoring and reporting, mobile computing tools such as wireless laptops, and tablet computers that provide easier mobility than more localised devices. Some of the key health related applications that can be implemented in mobile health include national disease surveillance and monitoring tools, patient information repositories, helpline, education and training resources ((Ministry of Health and Child Welfare, 2012).In emerging market economies interest has been particularly kindled in the arena of HIV healthcare, where the m-health could support the existing health infrastructure to reach out to rural and marginalized regions (Haberer, Kiwanuka, Nansera, Wilson and Bangsberg(2010); Lester and Karanja (2008)).

Lemaire (2011) states that Getachew Sahlu of the WHO identified the union of the following factors as the driving force behind the current rapid m-health growth in developing countries: (1) a rapid growth of mobile phone users, (2) rapid expansion of mobile networks, (3) the decline in mobile phone costs, and (4) the innovation in mobile technology. Generally, the world over, costs of acquiring mobile handsets are declining whilst the demand for mobile services is increasing and mobile networks are being rapidly expanded. M-health technology provides a cost-effective mode for peer support in stress amongst patients though it should come as a compliment to the usual face-to-face support (McColl, Rideout, Parmar and Aji, 2014).M-health applications allow patients to take responsibility and control of their own wellness by monitoring and tracking their health (Lising, 2013).

M-health has managed to develop due to a number of reasons and some which include user-friendliness, convenience and effectiveness of these m-health technologies have been acknowledged by both patients as well as healthcare providers as very crucial and important (Clifford and Clifton 2012). Some authors like Halko and Kientz (2010), do argue that the one-size-fits-all notion is usually not enough to meet the demands of users, especially with regards to health technologies. They go on to say, consumers are expecting more from technology providers across a wide range of fields, and these persuasive mobile technologies are no exception thus they should accommodate the needs of diverse users and sustain user interest over time, through consideration of the different personality types of their users. This view is also supported by Arteaga, Kudeki and Woodworth (2009), who state that there is some promise that mobile applications customized for an individual's personality type may achieve higher success rates in the future.

It is against this background that this research seeks to develop a user informed design for an m-health application specifically targeting the HIV/Aids. In communities where the resources are limited mobile phones can assist to induce a paradigm shift in healthcare delivery by empowering patients to stay connected to their specific healthcare providers, personalizing healthcare messages, facilitating collection of patient data and training rural professionals with health updates (Shet and De Costa, 2011). Mobile technologies do offer great potential to help patients keep track of their care, provide reminders, give patients greater access to health experts and this can be created by local talents within developing nations as they are more knowledgeable about their environments (Tablot, 2012). A good example of a developing nation that has embraced m-health is Kenya. Kenya has a population of 41 million and has seen a rise in the number of m-health applications being developed and used, some of the applications include *LIMITED LIFELINE, FACE OF AIDS, START ME UP, APP FOR THAT*, all with an aim of using mobile technologies in managing health related aspects of Kenya's population (Tablot, 2012).

Aim

To design a user interface for a mobile phone application to manage and promote issues related to HIV/Aids

Objectives

The study sought to:

- Establish the user expectations of an m-health application for HIV/Aids management and self-care
- Investigate the key features required for the functionality of the m-health application
- Recommend the best design interface features for the m-health application
- Design a user informed mobile health application interface

Literature Review

Issues on privacy of m-health

There is need to integrate health literacy into the process of developing m-health applications as this is critical in design (Broderick, Devine, Langhans, Lemerise, Lier and Harris, 2014). Conducting research to monitor the impact of health literate m-health applications on end users' attitudes, knowledge, beliefs, and behavior related to health information is also important. Broderick et al. (2014) also propose that a way to maximise the potential of m-health applications to improve health is by ensuring that these applications are designed to deliver health information that will be simple to understand, engaging, and easy to use for people of all literacy levels. Despite the huge potential of m-health application use, their biggest concern is lack of evidence and medical professionals' involvement in the application development phase, resulting in concerns about safety (Mobasheri, Johnston, King, Leff, Thiruchelvam, and Darzi, 2014).

One of the key issues which have a great impact on the development of mobile health applications is the effect they might have on the individuals' rights to privacy and personal data protection. Also in developing economies the disposable income is very low which might affect one's ability to smoothly have an internet connection so that the mobile application can work or more generally the ability to pay access fees charged by different mobile phone operators. The EU Charter of Fundamental Rights under Articles 7 and 8 tries to provide a guideline to privacy and protection of personal data of individuals. It also goes on to specify rules currently applicable to m-health so that processing of personal data must respect certain safeguards (Directive 2002/58/EC). The lack of trust in m-health by individuals will deter users from using very innovative solutions and this can prevent society from reaping the benefits of m-health. It is therefore of paramount importance for all players in m-health application development and use, to guarantee confidentiality and integrity of the individuals' personal data (Buttarelli, 2015).

M-health application design

According to Lemaire (2011) the success of a mobile health application is hinged on a lot of factors. These factors include performance of need assessments to identify real needs and demands of target beneficiaries, knowledge of local health priorities and to understand the local landscape in the area of implementation of the idea. The success of any mobile application is also dependant on the user experience (UX) it facilitates. In the case of m-health, the UX must be personal and designed to accommodate individual needs. Also one has to take into account the local conditions, environment, stakeholders and barriers identified through the assessment during the design stage and planning phase. Whenever design fails to engage the user the design is believed to have failed its objective. In m-health this can result in consumers often not returning to applications that do not immediately engage them, therefore undermining the intervention's potential effectiveness in health care (Verhoeven, Tanja-Dijkstra, Nijland, Eysenbach and van Gemert-Pijnen, 2010). Many mobile health applications are designed on the basis of existing healthcare system constructs and these may not be as effective as those that involve end users in the design process (Verhoeven et al. 2010). In some cases, the designers of these m-health applications often base their designs on assumptions that are not validated with any primary user input (McCurdie, Taneva, Casselman, Yeung, McDaniel, Ho and Cafazzo, 2012). Currently, many electronic health and mobile health interventions are designed on the basis of existing healthcare system constructs and may not be as effective as those that involve end users in the design process. Moreover, designers of these m-health applications often base their designs on assumptions that are not validated with primary user input. Due to these problems in designing the application designed might lack key features expected by the users and thus compromise its usage by the target population. User-Centered Design (UCD) plays a key role in achieving the user engagement, thus improving the likelihood of the intervention's effectiveness in health (McCurdie et al. 2012).

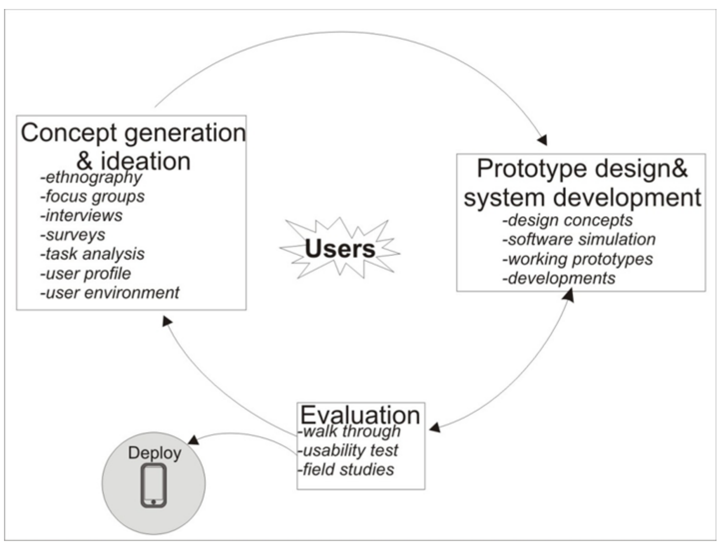

Figure 1. Conceptual framework on User-Centered Design Process (UCD) (*own source*)

UX required that the designers take human factors into account in an effort to empathise with the users and take a user-centric design approach so as to produce usable, intuitive and valuable interactive products. (Lising, 2013)

Methodology

The study was conducted in Harare and Chinhoyi. The ten interview respondents were chosen randomly from the available support groups, which help people living positively. In this study it was envisaged that using interviews was the best way of getting as much information from the respondents as possible. The respondents are people who have more experiences in the issues that face those living positively therefore are more knowledgeable on expectations. Given that there are issues to do with stigma focus group discussions were done on two occasions at two health institutions where participants were randomly picked irrespective of their status.

Results

The findings from the research unearthed key features that will define the success of the m-health application. The majority of responses highlighted their concern with the HIV/Aids-induced stigma that might arise from utilizing the application in public. This concern was addressed through the design in a number of ways namely adopting blue as the predominant colour and also naming the application LIVE **PLUS**. The name makes reference to the notion of "living positively" whilst maintaining some subtlety and is also alludes adding the number of years to the users' lives.

Figure 2. Loading Page

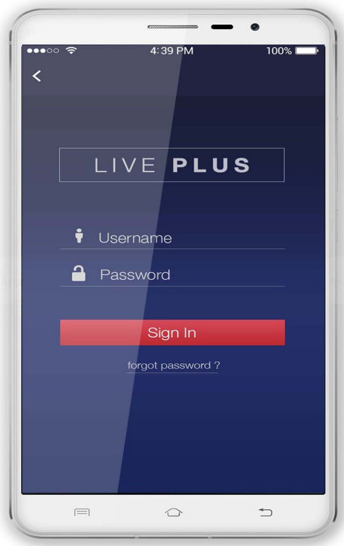

Figure 3. Profile sign in

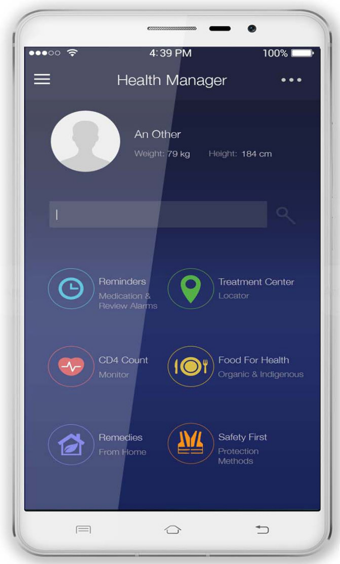

Figure 4. Health Manager

Figure 5. Reminder Alarms

Figure 6. Cd4 count

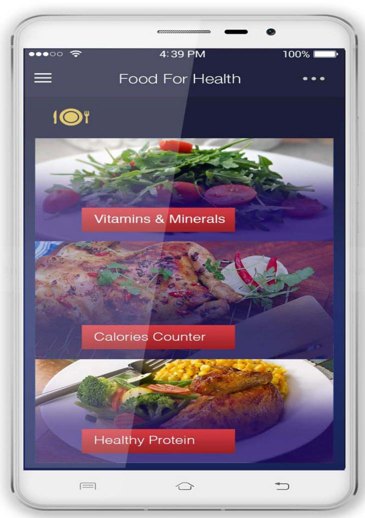

Figure 7. Food for health

Loading Page

The colour choice was suggested by some of the respondents citing that red was too obvious a choice. Blue is more discrete but red has been used as an accent colour in order to suggest the authenticity of being HIV/Aids health management product. The splash screen was designed with the users' concerns about privacy and security in mind in order to avoid the stigmatisation often associated with being HIV positive. Instead of making the predominant colour red, which is universally associated with HIV/Aids, blue was chosen so as to ensure the that application will be discrete and will not allow onlookers to deduce that the user is HIV positive. The name of the application, *Live Plus* plays on the word "plus" meaning living *positively* yet also suggesting that the usage of the application will allow the user to *add* more years to their life. This double entrendre embodies the positive use that is intended for the user. The Logo itself does not carry the plus symbol (+) itself, for the purposes of discretion but is derived from the minimalist design aesthetic which dominates modern user interface design as shown by Figure 2.

Security and profile management

The user's basic information is entered into the system. Their physical information like *sex*, *weight* and *height* will assist to keep track of their body mass index (BMI). The *Sign In* page as shown in Figure 3 is vital to protecting the privacy of the user. By virtue of this being a personal health application, the information stored and accessed therein is sensitive and it is crucial that access to the application is restricted to the user alone. The accent colour that was chosen for the design is red which subtly pays homage to the universal symbolism of HIV/Aids.

Health Manager

Physical information such, namely Weight and Height (as entered by the user) is stored. Should body mass index (BMI) indicate danger for the user, the application will generate an alarm notification. This feature can allow a user to monitor their BMI from home provided they have a scale and ruler with which to measure their weight and height. The search function allows the user to locate information and pages that will answer their specific needs quickly. The icons in Figure 4, (representing clickable buttons) are designed to be intuitively interpreted by the user and norms in UID were employed to create the *Reminders*, Treatment Centre *Locator*, *Food* For Health and Remedies From *Home* icons. The information was gathered through the focus group discussions as these were picked as the key issues important to someone living positively.

Reminder Alarms

One of the salient points to come out of the research on the feature that would be most helpful to people living positively was reminder to take antiretroviral (ARVs). To that end, a *Reminder Alarms* page was designed. This function will allow users to customise reminders for the various medications that they need to take on a regular basis. The page also has the special function of monitoring of remaining dosages of medication that are left based on the intake of the user. This feature will remind the user to restock on medication that is running out when the need arises as shown in Figure 5. Additionally, a countdown reminder will keep the user aware to the number of days left until their next medical examination or review as shown also in Figure 5. The use of alarm system to remind a user of times to take a certain medication or to watch their health patterns is very important. Having this feature integrated within the design was suggested to be a plus for the application as some users might forget to maintain the times set by the doctors in taking their medications.

Cd4 count

The CD4 Count Monitor is a key feature of this m-health application. It is vital for people with HIV to maintain healthy CD4 levels and the respondents highlighted that such a feature would be very useful to managing their health. This function allows the user (and their doctor) to track the CD4 levels over a given time. Through further research, in conjunction with medical practitioners and software development specialists, this feature will be able to actually count the users CD4s, thereby reducing the amount of physical examinations with a doctor that are necessary for the upkeep of their health.

Food for Health

This page gives the user access to recipes for health-boosting meals. The section gives access to web-connected content that provides recipes for meals rich in nutrients (for example vitamins and protein) which are key to managing HIV/Aids. This section is also not limited to the people living positively as it seeks to promote healthy eating and living amongst the whole population. The design aesthetic employed is based on minimalist design. Care was undertaken to ensure that the layout would be simple enough to appeal to the spectrum of ages and cultural backgrounds of the population infected by HIV/Aids, not just tech-savvy professional as alluded also by (Yee, 2015). The design utilized standard design conventions for the sake of ensuring intuitive navigation by user. Such conventions include the + sign on the top right corner of the *Reminder Alarms* Figure 5 and *CD4 Counter,* Figure 6. Search functions, which are familiar to mobile phone users, are also incorporated into Figure 7 which covers *Health Management* and also gives the user some *Home Remedies in case of getting sick at home* and also some specific common illnesses. Visual hierarchy and emphasis on elements some of relative importance was created through defined colours, fonts and sizes in the design (Yee, 2015). For instance, the *Reminder Alarms* page emphasizes the reminder of how many of the patient's tablets remain through the colour and scale of the number.

Conclusion

The mobile application design interface was informed by the users and further research on its user friendliness can be assessed after being on the market for some period of time. The idea is that the users can easily identify themselves with a design they have been made part of thus appreciate and use the application for the betterment of their livelihoods. The growth of the mobile phone usage in developing nations is the starting point for integrating technology into the ordinary people's lives such that these technological advancements can be of real benefit even to those in marginalised communities. Using mobile health applications for disease management, monitoring and control can be the solution for some of these communities and it also helps to do away with the shy individuals who might fail to ask for information from health professionals. Given an option that one can easily get the relevant information from the mobile application means the issues of stigma might be reduced and thus have a knowledgeable economy with regards to issues of health management**.** This research work gives an opportunity for the development of the full application and this can be developed by android developers then a validation of the design can then be carried out.

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An Assessment of e-readiness for IoT adoption in Zimbabwean Hospitals: A Case of Chitungwiza Hospital

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Abstract

Technology adoption in the health sector has been increasing tremendously in the past years. This has motivated innovators into developing and improving ways of conducting health processes through use of a variety of technologies. The main problem faced by hospitals in Zimbabwe is human error in handling of patient information and administering of treatment after a diagnosis. This is mainly seen in erroneous capturing of patient data, and in some cases in response delay between patient arrival at the hospital and the treatment of the same. Hospitals have tried to address the response delay by increasing the number of health workers and also consistently educating the health workers on patient care. Various technologies have also been employed to address these problems, but this has not been of much assistance as some processes are still done manually in most hospitals, particularly those in the rural areas. As part of its effort to promote e-health in hospitals, the Government of Zimbabwe selected Chitungwiza Central Hospital to be a pilot project in the use of e-health for its hospital information systems. This has seen the hospital implementing a number of e-health systems. This paper discusses the results of an assessment carried out on the readiness of Chitungwiza Central Hospital for IoT adoption as a component of e-health. Questionnaires and interviews were employed as data collection techniques and data was analysed. The results revealed that the e-health readiness for IoTs by the hospital is at its lowest level, requiring mediatory strategies if ever the Government's endeavour is to succeed.

Keywords: *e-readiness, e-health, Information and Communication Technologies, internet connectivity, Internet of Things*

Introduction

Information and communication technologies (ICTs), are now an integral part of everyday life globally. ICTs enable fast and efficient decision making in business and the society at large. With the global economic downturn, most governments are considering the reduction of their wage bill by employing ICTs to complement their reduced numbers of staff. Zimbabwe has not been left out in this. Such measures have been employed in the education, health and industry and commerce sectors to name just a few. In the health sector automation and business re-engineering have been employed successfully resulting in improved health delivery. The internet of things (IoT) technologies as a subset of ICTs, offer a great opportunity in the field of healthcare. IoT principles are currently being applied to improve access to healthcare, increase the quality of healthcare and most importantly reduce the cost of care and medical errors (Niewolny, 2013).

Various studies exploring the impact of IoT on academia, domestic settings and industry (Santucci, 2009) have been conducted. Following the introduction of the IoT technology by Kevin Ashton in 1999, tremendous developments have occurred in the area. By embedding short range mobile transceivers into a wide array of devices, communication has been made possible between people and devices (things) and between things themselves. IoT technology is projected to add a new dimension to the world of information and communication.

As the technology for collecting, analysing and transmitting data in the IoT continues to mature, more new and exciting IoT driven healthcare applications and systems continue to emerge. There is no doubt that the IoT is going to revolutionize healthcare by dramatically lowering costs and improving quality of health services (Niewolny, 2013). Wireless sensor based systems are currently used to gather patient medical data that was never before available for analysis and delivering care to people for whom care was not previously accessible. In these ways, IoT driven systems are making it possible to radically reduce costs and improve health by increasing the availability and quality of health care (Niewolny, 2013). IoT applications in the health sector include: use of wearable devices, interconnection of medical devices and staff support systems to locate both doctor and patient in a hospital at any point in time. The combination of sensors, Wi-Fi and other technologies come in handy in the monitoring of body temperature, blood pressure and heart rate (Dlodlo, 2013).

Related Work

In healthcare, it is no longer just about using instruments to perform a diagnosis or treat a patient. IoT connected devices and sensors have helped to enable the measuring and performing of analytics on a more expansive array of variables for medical decision making.
Electronic readiness (e-readiness) is a measure of the degree to which a country, nation, community or economy may be ready, willing or prepared to obtain benefits which arise from ICTs (Dada, 2006). This measure is often used to gauge how ready a country or organization is, to partake in electronic activities such as e-commerce and e-Government. In the case of Chitungwiza Central Hospital, before it embraces IoT technology, there is need to assess the availability of the ICT infrastructure such as the number of computers per ward/offices, WI-FI strength per ward/office, existence of ICT policies and the staff knowledge of ICT. This addresses the most critical areas for IoT adoption. When considered together in the context of a strategic planning dialogue, an assessment based on these elements provides a robust portrayal of a community's/organisation's e-readiness.

Various studies have been conducted on e-readiness in general. e-readiness assessments towards the implementation of ICT projects in health sector are often neglected for political and other socio-cultural reasons (Touré, et. al., 2011). In most African countries where some health-related ICT projects have been implemented, e-readiness assessment studies have not been conducted and where they were conducted, results were not used to serve as a guide to the subsequent implementations. IoT is a new technology in the health sector and still faces challenges such as ethics, privacy and security. This normally impacts negatively on the adoption of this technology by hospitals. Also, one of the biggest challenges in trying to adopt these technologies is availability of finance for the required infrastructure. A number of developing countries lack certain basic infrastructure and policies for nationwide health-related projects (Touré, 2011). E-readiness assessment is therefore important, if government efforts to invest in IoT technologies in hospitals are to succeed.

Many frameworks have been created for technology adoption. The choice of these theories depends on the major variable that researchers want to research on. There are several studies that use theories on technological adoption at the individual level such as Technology Acceptance Model (TAM) (Davis, 1989), Theory of Planned Behaviour (TPB) (Ajzen, 1991) and Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003).

The factors influencing individual adoption of technology, differ significantly from the factors affecting an organisation`s adoption of technology, as there are several organisational internal and external factors that would influence adoption. Some of the organisational level theoretical frameworks on adoption are Diffusion of Innovation Theory (Rogers, 1995), Technology, Organisation and Environment framework (Tornatzky and Fleischer, 1990), Institutional Theory (Scott and Christensen, 1995) and Transaction Cost Theory.

This research employed the Technology, Organisation and Environment framework (Tornatzky and Fleischer, 1990) as it takes a holistic approach into the assessment. The framework is based on three pillars that determine adoption and implementation of a new technology and these are:-

i. Technology development – availability of the technology in and around the organisation to facilitate the adoption of the new technology;

ii. Organisational conditions, business and organizational reconfiguration – organisational scope of processes, top management support and culture and

iii. Industry environment - competitive pressure, business associates' readiness, socio-cultural issues, government support, and ICT infrastructure and human capital to support the technology under study.

This way the framework addresses both human and no human aspects of technology adoption, giving a holistic picture of the assessment.

Methodology

In this research the Convergent Parallel Mixed Methodology was used. Quantitative and qualitative data were collected and merged in order to provide a comprehensive analysis of the research problem. The data were collected simultaneously and then integrated to provide information in the interpretation of the overall results. This approach was chosen as it neutralises the weaknesses of each form of data (i.e. Qualitative or Quantitative). The research sample was Chitungwiza Central Hospital out of all the Zimbabwean hospitals as it is fully computerised supporting the use of digitalised systems like D hospital information system (DHIS), System application program (SAP), Hospital information system (HIS). Purposive sampling was used to select the doctors, nurses and top management to participate in the study. The sampling was conducted to select the 3 groups with a purpose to investigate the e-readiness of adopting the use of Internet-of-Things in hospitals for better treatment and reduction of medical errors. A total of 50 people were sampled to accurately represent the population. The sample comprised doctors and nurses (40) and executive management (10). Questionnaires and interviews were used as data collection techniques with the sample. Pre test questionnaires were distributed to a pre test set of respondents mimicking Chitungwiza Hospital. The response rate on the pre-test questionnaire was 88%, and this being in line with Hart's recommendation of 70% as the minimum response rate for a well structured questionnaire, gave us assurance that the questionnaire was well structured and ready for distribution. Hospital section heads were requested to distribute the questionnaires to the target population who were then asked to hand back the questionnaires to the section heads. The respondents were contacted by telephone, emails and other electronic means like facebook, google talk and skype to establish if they were interested in completing the questionnaire before they were sent to them. The respondents were given a week to answer the questionnaires and return them to the section heads. Questionnaires were then collected from the heads. This created convenience and accessibility for the respondents. Apart from accessibility, the section heads were in a better position to identify the people who did not hand back their questionnaires. This allowed the researchers to make follow ups to the respondents. Face-to-face interviews were carried out with executive staff that included the IT director of Chitungwiza Central Hospital. Interview questions were derived from unclear, thrilling or unexpected findings from the questionnaires which required more clarity.

Findings

A total of 50 questionnaires were distributed to participating individuals at the hospital and a total of 38 questionnaires were returned. This represented a return rate of 76% whilst a total of 12 questionnaires were not returned which represented a non-return of 24%. An assessment of the relevant indices shows the following results.

One of the important assessments on e-readiness is availability of infrastructure for the technology to be implemented. Important among the ICT devices for implementing IoT the health care are mobile devices such as tablets, smart phones and WI-Fi which are scalable and ubiquitous (Jara, et. al, 2005). This is a very fundamental requirement in distant monitoring of patients and to keep them connected in any time anywhere fashion. Table 1 shows the related technologies that are available in Chitungwiza hospital. Those intelligent medical devices stated by respondents to be available at the hospital were latter verified with section heads to physically exist. A visit to the hospital established the existing equipment to be as follows:

Table 1. Intelligent medical equipment available at Chitungwiza Hospitals

Equipment	Count	Expected	Chi Square
Digital scale	14	5.4	13.69
Digital BP machine	8	5.4	1.25
Glucometer	9	5.4	2.4
X-ray	1	5.4	3.59
Scan machine	2	5.4	2.14
CT – Scan	1	5.4	3.59
Dialysis machine	8	5.4	1.25
Vital organ monitor	4	5.4	0.36
e-Vent medical machine	2	5.4	2.14
Digital beds	5	5.4	0.03
Total	54	5.4	30.44

A Chi square test to reject or fail to reject the NULL hypothesis (H_0), that Chitungwiza is not ready based on the inadequacy of equipment was performed, with the results shown in Table 1. H_0 is rejected based on this Chi-square analysis where $16.919 < 30.44$ at 0.05 with degrees of freedom of 9. In this instance 16.919 is the level if significance and 30.44 is the Chi-square value. Therefore it is concluded that Chitungwiza Hospital is not ready to implement IoT. It should however be noted that no prior knowledge of the expected standard for the hospital was available, hence the expected values were derived from the data collected.

In measuring the availability of ICT skills needed to operate the relevant technology for IoT among the staff, 94.7% of the health workers indicated that they had the ability to operate the available intelligent medical equipment in the hospital as shown in figure 1. The hospital is currently on the pilot project for e-health, so such knowledge is available among most of the staff. 5.3% are not able to operate the equipment at a full capacity owing to the non availability of these in their sections.

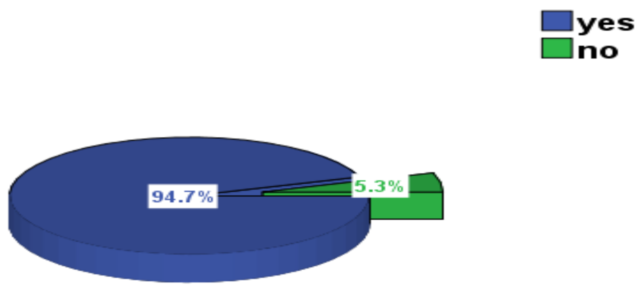

Figure 1. IoT skills levels for IoT technologies operation

In addition to the ICT technologies available in the hospital, results of the study show that the hospital has a comprehensive ICT Department responsible for the upkeep of ICT infrastructure and training.

Discussion

The research findings show that the hospital has relevant but inadequate equipment for the purposes of fully implementing IoT as shown in table 1. Health staff was trained to use these as stand-alone devices. However these aspects respectively address the concerns of infrastructure and skills availability, but with no interoperability. An ideal ICT infrastructure is the one where devices are fully connected, over which patients services, hospital management services and clinical services (Jara, et.al., 2013) are well defined in line with an ICT Health policy. Regarding the adoption of IoTs, it can be concluded that most of the health staff are aware of the existence of the technology and can comfortably use it. Also it was established that top management are willing to fund and support the IoTs adoption. However the ICT infrastructure setup does not guarantee the implementation of IoT.

Conclusion

From the findings of the research, theoretical review and empirical evidence; the following conclusions can be drawn; In relation to infrastructure as a component of e-readiness that will influence IoTs adoption, it can be concluded that the hospital is not ready to adopt these IoTs. While the hospital is regarded as a pilot project for the e-health by the Government of Zimbabwe, giving it an advantage of having a well-established ICT infrastructure, the project does not involve IoT implementation as a priority technology. Having reviewed the findings of the study, the following areas may need further study. Firstly there is a greater need for a formalised adoption framework for IoT technology in the health sector. This framework will be used to guide hospitals on the implementation of IoT in hospitals. Also future work could look into health mobile applications which are used in cell phones and interact with the health information system at the hospital while the patient is at home, this is another dimension of IoT that deals with Android software applications.

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Automated Monitoring of Call Activity and Usage for Cooperate Mobile Phones

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Abstract

Nowadays it is necessary for corporate organisations to minimise costs of mobile phone usage. Employees may misuse phones at the expense of the organisation. In order to circumvent misuse, automated monitoring can be implemented to monitor system usage and call activities. The automated monitoring generates call and usage audit trails. Furthermore, it assists in tracking the mobile devices in the event that they are misplaced or stolen. Mobile Network Operator companies are able to track mobile devices in the event that they have been stolen. However, the tracking has its shortcomings and may not be cost effective. It is limited to the devices using a particular mobile network operator. If the mobile network operator is changed on the devices, then tracking may be halted. Moreover, if the mobile operating system is flushed, then mobile device state and data is lost making it difficult to track and recover. This paper discusses the design and implementation of a custom phone system usage and call activity monitoring daemon for mobile phones. The automated monitoring daemon helps to record what the mobile device is used for and to track the location of a mobile device. It uses embedded data capture facilities designed to send data to a backend tracking system.

Keywords: Automated Monitoring; Call Activity; Mobile Phone; System Usage.

Introduction

The A mobile device has become one's close companion in this modern age due to the advent of the Internet (Erran, 2013). The need for constant connectivity in order to facilitate communication and sharing of information motivates users to carry their phones all the time. As such, information received and processed by these mobile devices need to be protected and in some cases monitored in terms of usage statistics and location in order to bring business value to the owners. According to Worldwide Quarterly Mobile Phone Tracker (www.idc.com), mobile devices running on Google's Android operating system have been predominantly used, taking up 70% of the mobile market share. The Android mobile devices are being used both at individual level for personal use or at company level for business. When the mobile devices are given to employees for business purposes, the employer needs a way to monitor the use of the mobile phones for the overall benefit of the company. In this regard, this paper is a discussion on the results of a research project for tracking and monitoring of activities on mobile devices. The technology assists in the event that a mobile device has been misplaced or stolen. In which case, the mobile device is tracked using its geographic position system (GPS) location. This software artefact empowers communities with a tool that promotes sustainable use of mobile phones.

The phone usage and system activity monitoring technology is designed with the capacity to frequently capture phone details and send to a remote server. It detects the unique mobile device identity known as the International Mobile Station Equipment Identity (IMEI) which identifies the hardware. The network Mobile Station International Subscriber Directory Number (MSISDN) being used by the mobile device is also detected to identify network provider and the unique subscriber identity module (SIM) card in use. It also captures the current GPS coordinates in order to identify the device's location at given times. In addition, the daemon is capable of capturing call logs and the text messages sent and received, as well as the mobile numbers of the sender and the receiver.

Literature Review and Related Systems

Literature and related systems were surveyed in order to elicit desirable characteristics and identify shortcomings of existing systems. There are tracking applications (apps) and techniques for mobile devices that are currently in use by organisations, individuals and some telecommunication companies. The literature review was important to reveal the concepts of how such a system for monitoring mobile device usage and system activities is built. Furthermore, techniques and matching design patterns were discovered from other research projects. The review of existing systems uncovered the general features desirable for monitoring mobile device usage and system activities. Confidentiality, reliability and availability are some of the salient features which guarantee security of client data which may involve applications signing to when deploying on mobile devices (Laverty, et al 2011). Other features are robustness and adaptability in the case whereby the number of phones to be monitored increase exponentially or when there is an increased workload. This allows for growth in terms of system usage or demand when the client base increases unprecedentedly.

Existing systems were evaluated in order to discover their strengths and weaknesses. There are research projects that focus on monitoring employees using mobile devices with the hope of increasing their performance (Mankar et al, 2015). Current systems from specific telecommunication companies facilitate tracking a mobile device if it is using the same mobile services operator. However, some do not have the capacity to track the device in the event that the mobile operator is switched through changing the SIM card number. (Mori et al, 2011) implemented, "A Self-Configurable New Generation Children Tracking System Based on Mobile Ad Hoc Networks Consisting of Android Mobile Terminals" which focus on children tracking. The system can be used anywhere in the world to assure parents that their children are safe. It encompasses ward safety, detecting suspicious actions and environmental mood/atmosphere. The system tracks the movement of a child going to and coming from school. The information pertaining to missing children or those who move beyond the coverage area is sent to a control room probably at a school as well as to respective parents/guardians. Another system has been developed, which uses "Autonomous Clustering technique" for managing groups of Android terminals attached to children in school (Yuichiro, 2000). HelloSPY is a cell phone tracking and monitoring software for smart phones and tablets running on different operating systems. If it is installed on a phone, the application is able to monitor and record all calls made and received, real time GPS location of the phone, track and record text messages (SMS). It also has access to the entire contacts list and photos stored on the phone and much more. HelloSPY application satisfies all needs for monitoring, tracking and backing up the data for any Smartphone (Kilmer, 2014). One of the most popular and user-friendly application for watching over kids, preventing theft, and supervising company employees' performance is named mSpy. The mobile monitoring software runs on the target device to track all activity including call log history, location, calendar, messages and browser history amongst other activities. It allows users to create their own personal online mSpy account which is used to log in to the account and view tracking data and reports.

Methodology

All studies require various steps adopted by researchers while studying a research problem (Rajasekar, 2010). This study requires a software methodology to manage and guide the development of the software artefact. The methodology includes process steps, methods and computer aided software engineering tools which help system developers in their task of implementing a new system. The aim of a methodology is to formalize what is being done, making it more repeatable (Ambler, 2013). In many cases software development failure is the result of either not using a methodology at all or using a wrong methodology. In this project, a simple project management technique was selected to track the time-line and manage resources required for the task of developing the phone usage and system activity monitoring system. The rapid application development (RAD) process model was chosen to guide the software development life cycle of the system. For project management, a Gantt chart was made to organise the tasks and resources required. The size (number of lines of code), complexity (module coupling and cohesion) and the limited time available to deliver a project justified the selection of the RAD methodology.

Four major stages of the RAD methodology were followed in this project. The specific stages were:

1. Requirements planning stage consisting of a review of the requirements associated with the proposed system.
2. Functional design stage whose objectives are to produce a detailed system analysis, to develop a system design and to prepare an implementation plan
3. Construction stage whose objectives are to develop and test the application software that implements the system design, to prepare documentation necessary to operate the proposed software application.
4. Transition stage whose objectives are to install the system in production operation and to identify potential future enhancements.

System Design and Implementation

The functional requirements were used to guide the sketching of user interface, the system analysis and the system design. The functional requirements explicitly state what the system should do and the system design details the interaction of the software components (Somerville, 2009). Guided by literature and similar system, this study designed and implemented the Phone usage and activity monitoring system with the following functional requirements:

1. Upon installation of the application for the first time, user is prompted to sign up to use the application. This is done once and after that the user needs authentication by logging in on the web application to view phone usage activities.
2. The application sends the phone usage and activities captured in real time to the web server, any new events are also sent automatically as they occur and the information is saved on the database.
3. The users can view their phone usage activities captured at a particular point in time as per user query.
4. When the user logs in on the web application, they should not be able to edit the contents on the web application.

The non-functional requirements specified for the phone usage and system activity monitoring application were of two categories, namely constraints and qualities. Constraints are off-limits and design trade-offs, unlike qualities they are not subject to change upon negotiation. On the other hand qualities are desirable properties or characteristics of the software system in order to please users or stakeholders and therefore may change upon negotiation. The non-functional requirements considered for this application include the following:

1. The design of user interface should be user friendly and easily understood by end users, that is the users should be able to install and signup on to the android application with ease.
2. The system must able to capture and send data to the server reasonably fast and should not affect the general performance of the Smartphone.
3. The response time should be within a reasonable interval time such that users are not kept waiting for a long time when querying usage ant activity monitoring results.
4. The application should be robustness in order to handle unexpected error and echo back with proper responses. An effective error handling and error messaging method should be used to deal with any unexpected error.
5. The system should restrict access to authenticated users and should not disclose information to third parties and unauthenticated users.

The activity diagram in Figure 1 visualises the process flows in the phone usage and system activity monitoring system. It defines the interactions between processes and data elements. The activities and actions are shown with their associated support for selection, iteration and concurrency.

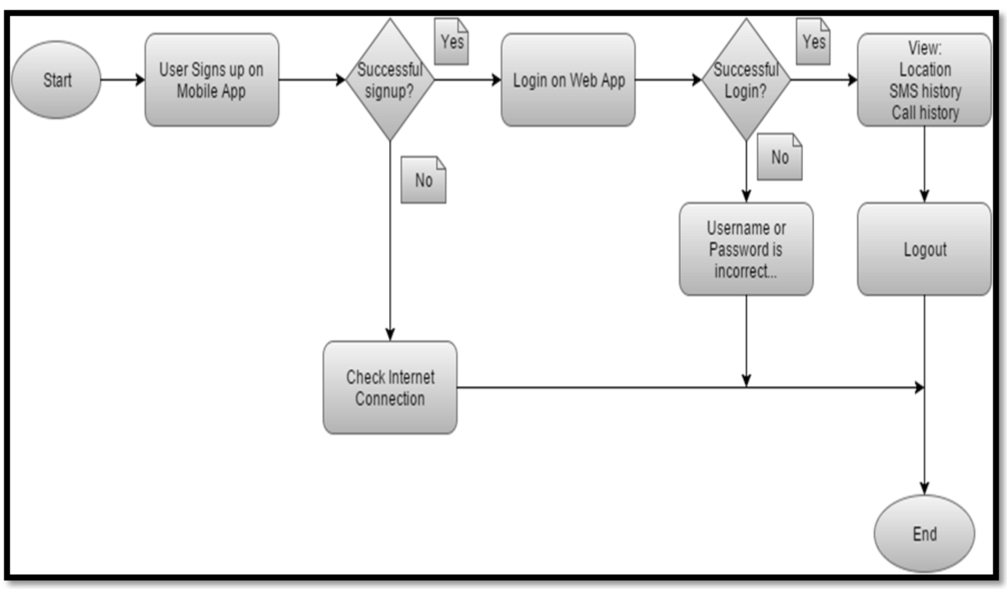

Figure 1. Activity Diagram for Phone Usage And System Activity Monitoring.

The application (app) consists of three components, namely the mobile application, the application server and a web portal for visualisation of the usage and system activity reports. The mobile application component is the client side responsible for capturing phone usage and system activities. It records mobile device message logs and device location for registered users. On the application server, the logic of the system is encoded and mobile device content is uploaded to the database. User credentials are also uploaded on the database to enable user login and verification on the web visualisation application. The web portal is a component where users can login using their registration credentials to be able to view mobile device usage and activities that have been captured and sent to the app server by the mobile app. The users' credentials are matched with the user data in the database in order to authenticate the user.

The architectural design shown in Figure 2 is depicts the overall structure of the system. It shows the relationships and distribution of the main components.

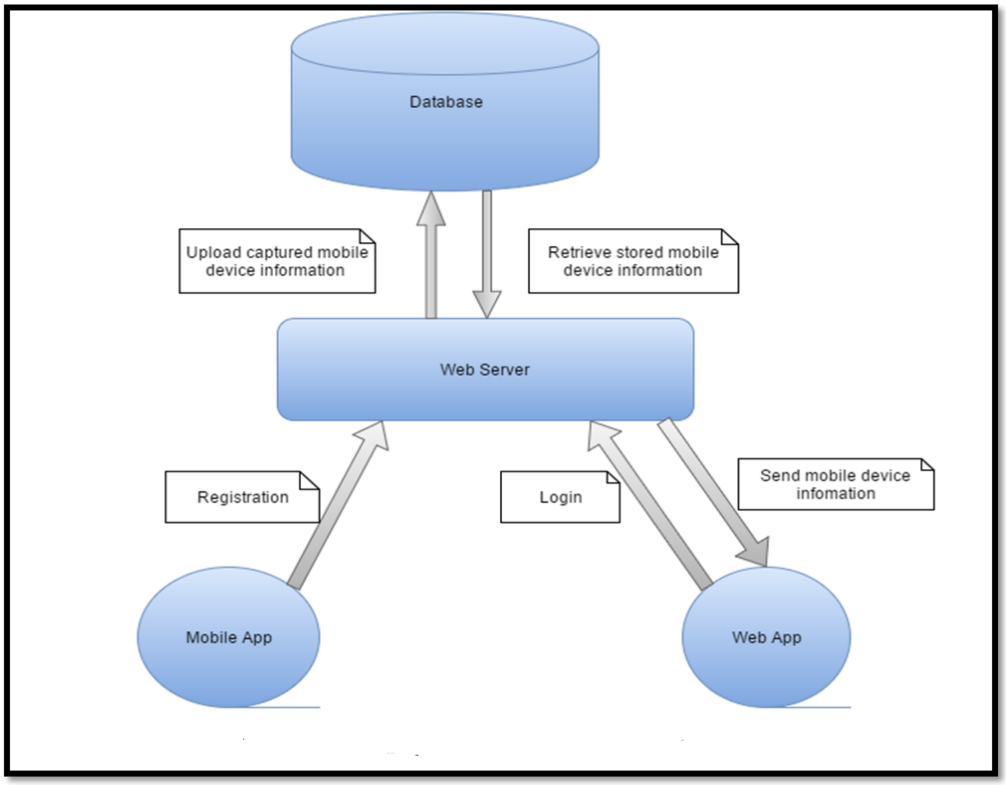

Figure 2. Componet Diagram for Phone Usage and System Activity Monitoring.

Figure 2 shows the main components of the phone usage and system activity monitoring system. The architecture separates the conceptual designs into different tiers. The Client tier constitutes of the user interfaces that interacting with the user. The server tier is responsible for generating and rendering components that are viewed by the user in the client tier.

Results

The results documented in this section were obtained during the final stages of the testing process. The system was tested on Android based phones of volunteers. During the testing, errors and omissions in the system development were revealed and addressed accordingly. The system was also subject to public tests during the Computer Science Open Day (May 2016) and Zimbabwe International Trade Fair (ZITF, April 2016) when it was selected to be part of the exhibit from the National University of Science and Technology, Zimbabwe. Figure 3 shows part of the call history captured by the application.

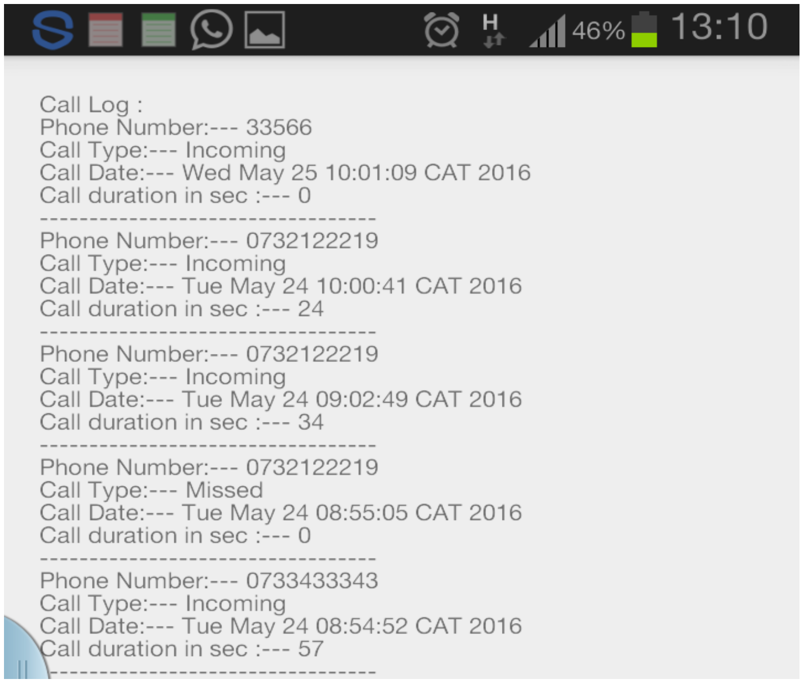

Figure 3. Call Histories from the Phone Usage and System Activity Monitoring System.

The system testing aimed at verifying that the program code had no runtime and logic errors, and at the same time validating that the functional requirements were met. Based on the results of the testing, module concepts and relations were refined to ensure that the application captures and records call summaries, system activities and current mobile device location in a way that ensures non-repudiation by phone users. The final system records mobile device activities as they occur, these include system usage logs, text messages and call logs whose reports are displayed on the web visualisation application shown in Figure 4.

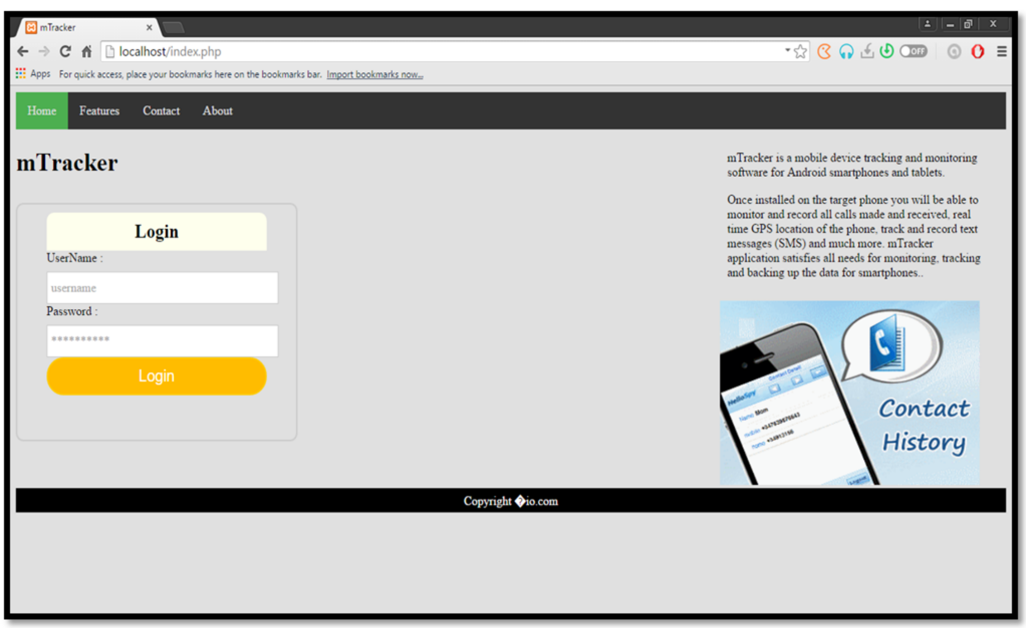

Figure 4. Web Portal for the Phone Usage and System Activity Monitoring System.

The reports that are produced on the web portal include summaries that can be drilled down for system usage logs, text messages, call logs, captured messages, the time and sender identities. The recorded data is mapped on the user account for the mobile devices that were registered for monitoring purposes. The web visualisation application is the major user interface of the web portal that provides access to the application server on the backend. The limitation of the phone usage and system activity monitor is that it was developed for devices that run on Android. In future, the system should be upgraded to support all mobile operating systems such as Windows, BlackBerry, Symbian and Apple's IOS.

Conclusion

The solution described in this paper detailed how to automate the usage logs and system activity for the purposes of monitoring and generating audit trails. Furthermore this solution assists in tracking the mobile devices in the event that they are misplaced or stolen. This system is targeted at organizations that desire to monitor eemployees' smart phones to mitigate phone misuse which may result into an expense for the organisation. The rapid application development process model was used guide using a four phase approach consisting of requirements planning phase, Functional design phase, Construction phase and transition phase. The research project culminated into a software artefact for phone usage and system activity monitoring which is alternative to current systems from specific telecommunication companies. These current systems had limitations in that they facilitate tracking of a mobile device that uses the said mobile services operators. This new system circumvents the problem of tracking a mobile device whose mobile operator has been changed or switched through changing the SIM card. Future research is required to address the privacy and security issues that result from usage of this system and further work is need on robust techniques for gathering evidence of misuse. The resultant phone usage and system activity monitoring application consists of three components, namely the mobile application, the application server and the web visualisation application. The mobile application component is the client side responsible for capturing phone usage and system activities. The application server is responsible for handling the logic database queries. The web visualisation application forms a web portal where users view mobile device usage and system activity reports.

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A Methodology to Improve Sheet Metal Bending CAPP for Reconfigurable Bending Press Machines Using Web Based System

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Abstract

Competition is now stiff in the sheet metal production sector, in order to lower the production cost and shorten the delivery times whilst retaining a large market share, companies need to change their production planning systems. In this paper, a method for developing of the CAPP (Computer Aided Process Planning) system in the form of a software is described. It explains how the design of user interfaces and databases, capturing of user data, translation of each functional module into a computer readable format as well as integration of the modules can be achieved. This paper explains how the system was developed to come up with a detailed process plan. The user interfaces include data capturing interfaces and feedback interfaces. The purpose of a user interface is to provide the user a means of communication with the system. The design of databases was done using phpMyAdmin. The user interface was designed using Dreamweaver CS6, 456 software dedicated to the design of web pages. Development of the three main modules of the system, which are feature recognition, central planning and remote planning were also explained. The content included some illustrations of the display output as well as code snippets for important modules. The purpose of a user interface is to provide the user a means of communication with the system. This paper is a roadmap for the design of "web-based" process planning systems and a cloud based manufacturing system for the Reconfigurable Bending Press Machine. The methodology will help to come up with different concepts for designing the "web-based" system.

Keywords: sheet metal, bending, web based, reconfigurable, improvement

Introduction

The sheet metal industry has made a few attempts to automate the bending operations. The increased demand for sheet metal parts and the need for shorter throughput times have placed new requirements on the corresponding process planning systems. The use of web based systems in industry has made it easier to customize applications and to update them. Web based systems are accessible anytime anywhere there is internet connection. They make it possible to rapidly integrate enterprise systems, improving work-flow and other business processes. Tsai, Sun. and Huang, 2006 proposed a web-based information sharing system that uses XML (eXtensible Markup Language), ontology, and access control technologies to deal with product design collaboration problems. This system was implemented in a new product development project to allow designers to be more productive and innovative through seamless information sharing, exchanging, and searching.

Ong, Lin and Nee, 2006 designed and implemented a decision-support software system based on web services, capable of modelling the supply chain and querying the supply-chain partners to provide information, regarding the availability of parts. The system simulates customer's orders impact on the supply-chain operation, while it utilises the Web services technology for facilitating the supply-chain control logic. Thakur and Pande (2006), designed and implemented an internet based system for feature modelling and process planning of sheet metal components commonly manufactured by blanking, shearing and bending processes. The latest ICT technologies including the Internet, Web, Java, XML, etc. are popularly used for collaborative process planning to support a networked, manufacturing environment. Java language was adopted to transfer a CAPP system to Web based environment so that its functions and operations can be distributed to various computer systems to reduce the computational load on a single computer (Thakur and Pande, 2006).

Kim et. al. (2015) introduced a web operation planning which consists of the manual and the semi-automated generation of an operation plan. The system web interface makes it possible for the manufacturers to keep a record of their machining practice in the database. The machining operation planning system is for practical use in small and medium sized manufacturers. Huang and Ameta (2016) developed software tools for estimating manufacturing energy consumption in machining operations based on manufacturing process plans. They introduced a XML validation and parsing which was demonstrated via case studies for machining energy estimation in machining operations. The method assisted users who have little knowledge about energy computations to estimate energy consumption during the manufacturing phase. Such energy estimation can be used to redesign the part and assemblies, leading to products with reduced machining energy. Targeting the Cloud manufacturing, an Internet- and Web-based service-oriented system for machine availability monitoring and process planning was designed. A tiered system architecture was proposed and IEC 61499 function blocks for prototype implementation were introduced by Wang (2013). This system enabled real-time machine availability and execution status monitoring during metal-cutting operations, both locally or remotely. The closed-loop information flow makes process planning and monitoring feasible services for Cloud manufacturing. Cai, M., et al. (2010) presented a prototype intelligent system SWMRD (Semantic Web-based manufacturing resource discovery) for distributed manufacturing collaboration across ubiquitous virtual enterprises. This was proposed on the semantic web to convert resources into machine understandable knowledge, which is a prelude to the meaningful resource discovery for cross-enterprise multidisciplinary collaboration.

A recent research on developing Web-based manufacturing systems has been reviewed by Yang, and Xue (2003). They show how these approaches can improve the efficiency and quality in product design, production, life-cycle integration, enterprise management and customer service. Problems of the currently developed Web-based manufacturing systems and future work for developing the next-generation Web-based manufacturing systems are subsequently discussed. Li, W.D., Ong, S.K. and Nee, A.Y., 2005 designed a Web-based system and it was integrated with a distributed feature-based design system, and can generate design models and re-represent them in an XML representation based on VRML and attributes of features to provide the input of the former. A process planning module, can optimize the selection of machining resources, determination of set-up plans and sequencing of machining operations to achieve optimized process plans, has been wrapped as services and deployed in the Internet to support distributed design and manufacturing analysis. Tarantilis, Kiranoudis and Theodorakopoulos 2008 designed a Web-based ERP system for solving business problems and managing real-world business processes ranging from simple office automation procedures to complicated supply chain planning. It was developed for the specific needs of Greek Construction Manufacturing Enterprises. The system involved a powerful workflow engine that manages the entire process event flow within the enterprise increasing efficiency and control at the same time. The problem was formulated to assign project tasks in form of lots to enterprise resources to minimize resources idle time and delays in project preparation time. A simple and effective heuristic algorithm was used to solve the problem.

Design of User Interface

The purpose of a user interface is to allow the user to interact with the "engine" of the software User Interface (UI) Design focuses on anticipating what users might need to do and ensuring that the interface has elements that are easy to access, understand, and use to facilitate those actions. UI brings together concepts from interaction design, visual design, and information architecture. The user interface is one of the most important parts of any program because to provide the user a means of communication with the system. The user interface was designed using Dreamweaver CS6, 456 software dedicated to the design of web pages. The software provides two design environments: the code environment and the design environment. In the code environment, web objects are defined using lines of HTML and PHP code encapsulated in tags. The designer can add and edit code which will execute at runtime. In the design environment, the objects are visually displayed and look more like they will be at run time. Here development is through inserting and editing objects such as text fields, tabs etc. using a graphical user interface. The corresponding code is automatically updated as the user visually edits objects. The split view provides both code and design views side by side.

Interfaces designed in Dreamweaver

Home Page

This is the first page accessed by a user. It provides options to log into the system or to create a new account. Named as index.php, the home page is shown in the development environment.

Main Page

The main page is specific to the user. After the user logs in to the system, the main page will display all the user's transactions in a list. Extra information on any transaction can be displayed when the transaction is clicked. The main page provides links to managing jobs that are already available and that need to be created.

Forms

Forms are user interfaces used for uploading data to the system. The system has two main forms: registration form and new order form. The registration form provides an interface for creating a new user account. The new order form provides an interface for placing a new order.

Database Design

A MySQL database was created using the phpMyAdmin tool, which comes with the XAMPP package. This tool provides an interactive graphical user interface for creating, managing MySQL databases. PhpMyAdmin interface runs on a web browser. Three databases were created for the distributed CAPP system. The first is the customer orders which manages information pertaining to customers and their respective orders. The second is the tools database which manages information on the whole range of tools available. The last is the machine database which manages information on machines. Figure 1 shows an interface for creating a new database, and existing databases in a list, including the three CAPP system databases.

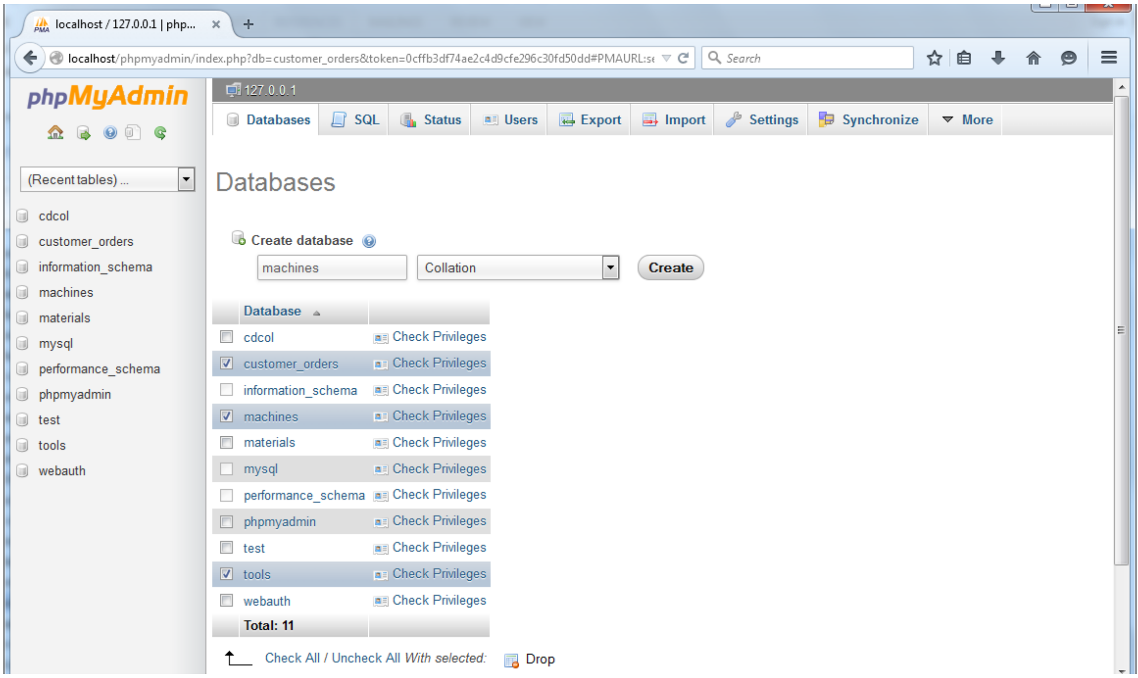


Figure 1. phpMyAdmin page which provides the user an interface to create or delete (drop) a database.

Data Capturing

The information in the system can be categorized into two: user information and system information. User information is related to the user and the data is captured at runtime. User data is manipulated by the system to produce process plans. Typical user data is the CAD model data and user credentials. System data, on the other hand, is captured at design time or during a system update. This provides information essential to the running of the system. System data does not change during run time, but effects change on user data. Typical system data is tooling data, machines data and time standards.

User Information

Model data from the user are captured by the new order script. This is a PHP script which validates the data from the new order form before posting it to the orders table in the customer orders database. Data is passed between the script and the form in an array named $_POST. Validation rules are as follows:

- Check for empty fields in the new order form. All fields require filling,
- Check if the order quantity is numeric. The system will accept numeric values only,
- Check if the user has uploaded a file and if the file type is supported by the system,
- Check if tolerance is less than 0.1, the system accepts tolerance values less than 0.1 only.

User credentials are captured in the same way. The registration script captures user data from the registration form. Validation for user credentials is on:

- Empty fields, All fields require filling,
- Phone number should be all numeric,
- The email address must have a '@' and a '.' Somewhere in between,
- The two passwords are to be identical to each other,
- The user name must be unique to those already in the database.

System Information

System information is captured using phpMyAdmin interface. This cannot be done during run time but only during system development or system upgrade.

Queries

After capturing data, it is stored in the MySQL database. Accessing the database during runtime to add, edit or retrieve information is done through queries. First, a connection to the MySQL server has to be established. This is done through a mysqli_connect statement in PHP. When the connection is successfully established, the program performs a data query which either adds, retrieves edits or deletes data from the specified database. The system uses the following queries:

SELECT – this query retrieves specified records from the database.

INSERT – this query creates a new row in a specified table and adds the specified data in the specified columns.

DELETE – this query a certain record in a specified table.

UPDATE – this query changes information in a specified existing row in a specified table.

Feature Recognition

Feature recognition modules are built in the Autodesk inventor Application Programming Interface. The inventor software was chosen for the following reasons:

It is versatile – inventor can decode files created by other CAD software. The scope of Inventor encompasses all file formats Boundary Representation objects can be conveniently accessed through Visual Basic for Application (VBA) Application Programming Interface (API) from the decoded objects. Vast programming help is embedded with the application, making the task of writing programs quicker and easier. Tools such as the Object model, add-ins, Software Development Kit (SDK) Common API reference, and object browser make the inventor API much more user friendly. The Inventor programming interface environment is shown in Figure 2.

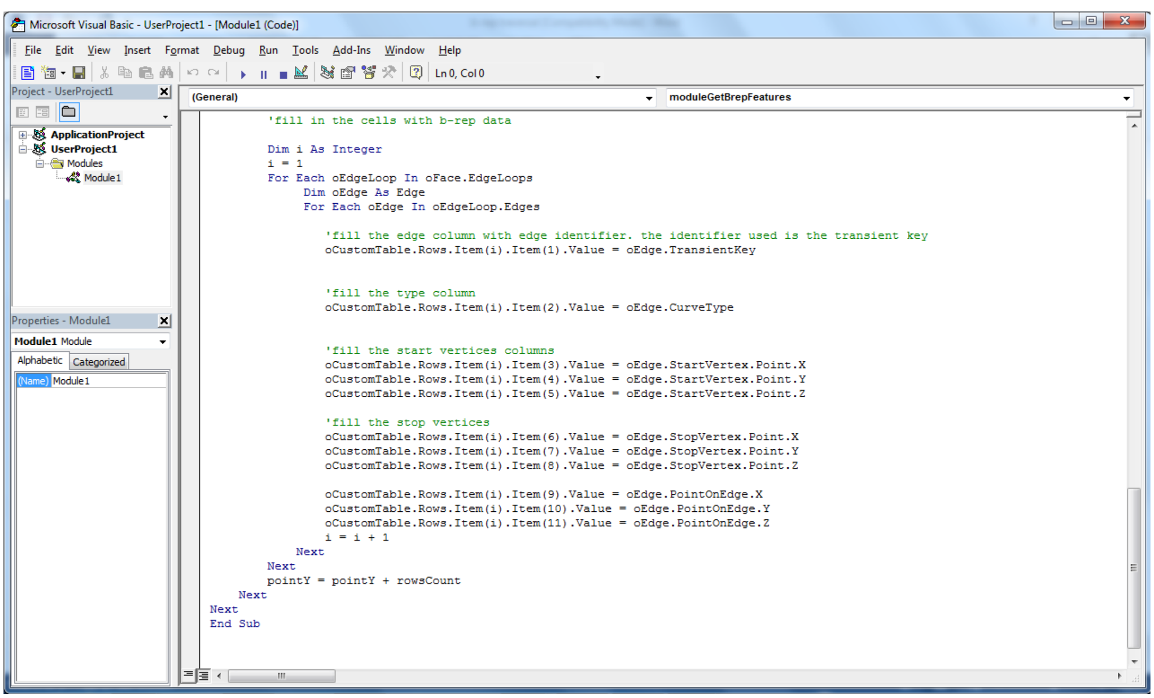


Figure 2. Inventor Application Programming interface, showing B-rep extraction code.

During feature recognition, the model is opened by the inventor software and the features are extracted as the model is open. The translation module first determines the part type by checking its extension. An appropriate translator add-in is then selected to open the file using a select case statement. When the translator add-in opens the model, B-rep features are then extracted and saved in a table. The b-rep results are then filtered by eliminating edges of the least length. After filtering features can be directly extracted by identifying curved edges, which mark the bends. For each curved surface there are two edges. One edge represents the bend length and connects at right-angles to the curved surface. The other edge represents the distance between bends and hence the length of a face.

Central Planning

Central planning modules were built in the MATLAB R2009 environment. MATLAB is a modelling software which can be used to perform mathematical functions automatically. This software was chosen, among other softwares, for the following reasons:

High execution speed, which makes it suitable for programs that process large volumes of data. It has a vast library for mathematical functions. One mathematical function of interest is the 'perms ()' function, which finds all permutations of a given number. It has a strong notation of manipulating matrices, which makes it suitable for working with 3-dimensional point coordinate data. MATLAB can show the output of a program in a convenient way through the command window as well as the value of variables through the workspace window, which makes debugging a lot easier. Programming in MATLAB is done through scripts. The scripts are listed to the right side of the MATLAB window and can be edited using a text editor. MATLAB comes with an embedded text editor which can be used for construction of scripts. Several modules were constructed in MATLAB; all modules from tool selection to producing the bend.

Tool Selection

Tool selection was done using a query in PHP, which selects that match the given criteria.

Determining Feasible Sequences

The most significant modules are the ones which simulate the bending process and the ones which test for collision. These two functions work as follows: the CAPP_input module scans part and tool data from a temporary file. Permutations are generated by the bend_trial module, which is the central module. This is done by employing the 'perms ()' function on the number of bends. The central module will then call for transformation module which positions the part at the required z-axis for bending. The bend module will then rotate the coordinates of the part.

The tpCollision module tests for any collision between part and tool. Collision is tested by comparing each point coordinate value to a set of conditions. If the value matches the conditions then the tool and part can collide, and a variable called collision is set to 1. When collision=1 the simulation procedure for that bend sequence terminates and a new sequence is simulated, until all sequences have been tested.

The part is tested for machine-part collision as well, by comparing the required tool height, width and bottom clearance to the machine height, width and bottom clearance respectively. The tmCollision script does the testing for each sequence, after it is completed. The process is repeated for each bend in a sequence and for each possible sequence. A report on all the possible sequence is generated, showing the sequence number, linear distance (dLinear), angular rotation(dAngular), number of flips (nFlips), overall bending time (bend_time), minimum required machine width (minWidth), minimum required machine height (minHeight) and minimum required machine bottom clearance (bottomclearance).

Heuristic Search

An algorithm for selecting the optimum sequences was also done in MATLAB. Ascript called optimum sequences calculates the bending threshold, which is: maximum setup time + minimum bending time. The maximum setup time is determined by the bend structure: i.e. number of bends gives maximum number of tools and the total length of all bends determines the maximum number of modules required. All values above threshold are eliminated and a matrix variable named optimum Sequences, containing all qualifying sequences, is created.

Machine Selection

The machine selection module selects the most optimum machine-sequence combination. This involves calculation of the objective function by a script named machine selection. After this calculation the minimum throughput serves as a threshold for selecting optimum plans.

Remote Planning

Remote planning produces the final plan which summarizes all the results for use by the user. The remote planning module compiles, for each job, the machine involved, configuration for the selected sequence, bend order, associated tools, total time and cost. These values are stored in a file which can be used for shop floor processing. The output for remote planning is shown in **Error! Reference source not found.**.

Table 1. A detailed process plan.

<table>
<tr><td colspan="6">PROCESS PLAN SHEET: DISCAPP CORPORATION</td></tr>
<tr><td>PART #
A01</td><td>PART NAME:
ELECTRIC MOTOR SHEET COVER</td><td>PLANNER:
J. MANJORO</td><td>CHECKED BY:</td><td>DATE:
21/03/2015</td><td>PAGE:
1/1</td></tr>
<tr><td>MATERIAL:
MILD STEEL</td><td>STOCK SIZE:
500mm x 500mm x 3mm</td><td>MACHINE PARAMETERS
ID: R331NX
FORCE :5kN
TOOLS 3</td><td colspan="3">MODULES:
Height=2 X 500mm
Length=1 X 1000mm</td></tr>
<tr><td colspan="2">OPERATION NUMBER</td><td>BEND SEQUENCE</td><td colspan="3">TOOLS</td></tr>
<tr><td colspan="2">1</td><td>4</td><td colspan="3">X55</td></tr>
<tr><td colspan="2">2</td><td>3</td><td colspan="3">X55</td></tr>
<tr><td colspan="2">3</td><td>1</td><td colspan="3">X55</td></tr>
<tr><td colspan="2">4</td><td>6</td><td colspan="3">X36</td></tr>
<tr><td colspan="2">5</td><td>2</td><td colspan="3">X36</td></tr>
<tr><td colspan="2">6</td><td>9</td><td colspan="3">X36</td></tr>
<tr><td colspan="2">7</td><td>7</td><td colspan="3">X29</td></tr>
<tr><td colspan="2">8</td><td>8</td><td colspan="3">X29</td></tr>
</table>

Verification

Verification procedures were mostly carried out during the system development process. Parts of the system were verified as follows:

Cross Checks

Cross checking was mainly done to verify the data capturing function and all other communication functions. This involved executing the interface scripts using Mozilla Firefox web browser and cross checking whether the intended function. For instance, cross-checking whether user information was submitted correctly was done by first submitting the information on the form. The information is then cross-checked in the MySQL database. The information will appear as shown in the database as shown in Figure 3.

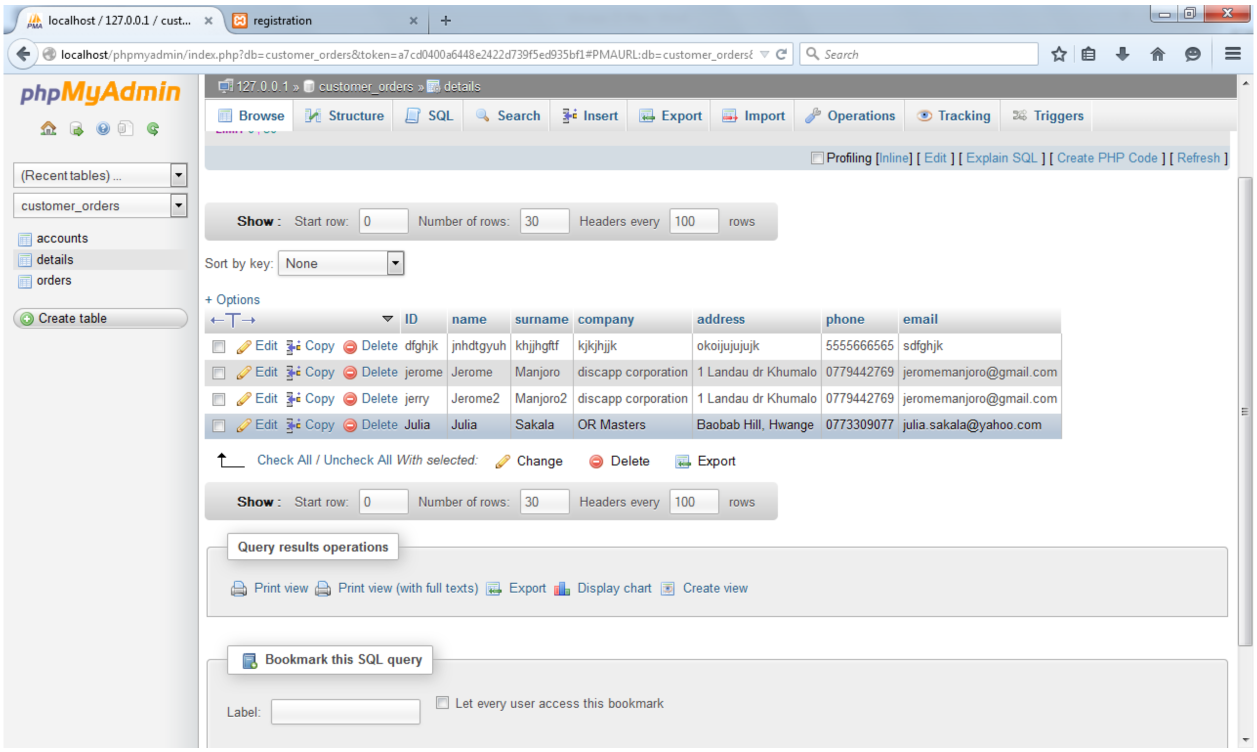


Figure 3. Verification of the user information submitted by the form. The user is highlighted in blue.

Expected Output

Another common method used for verification was to use inputs with known outputs. This was done on most modules during the development phase. Data input used for this purpose were the three input scripts which are input one, input two and input three. All the bending procedures were tested using these three scripts as inputs. Each module was run on these three inputs and the outcome compared to the expectations.

Of importance is the collision detection module tpCollision, which was tested using this approach. The tool profiles were imitated by drawing a tool profile in AutoCAD. A point inside the tool profile, which clearly indicates a collision, was then used as input, alongside the associated tool. The collision detection module was run to view to check whether it can detect the collision. Figure 4 shows an AutoCAD screen showing an acute tool profile and a part which collides with the tool. The collision coordinates are shown at the bottom left corner as the cursor is positioned on the colliding point.

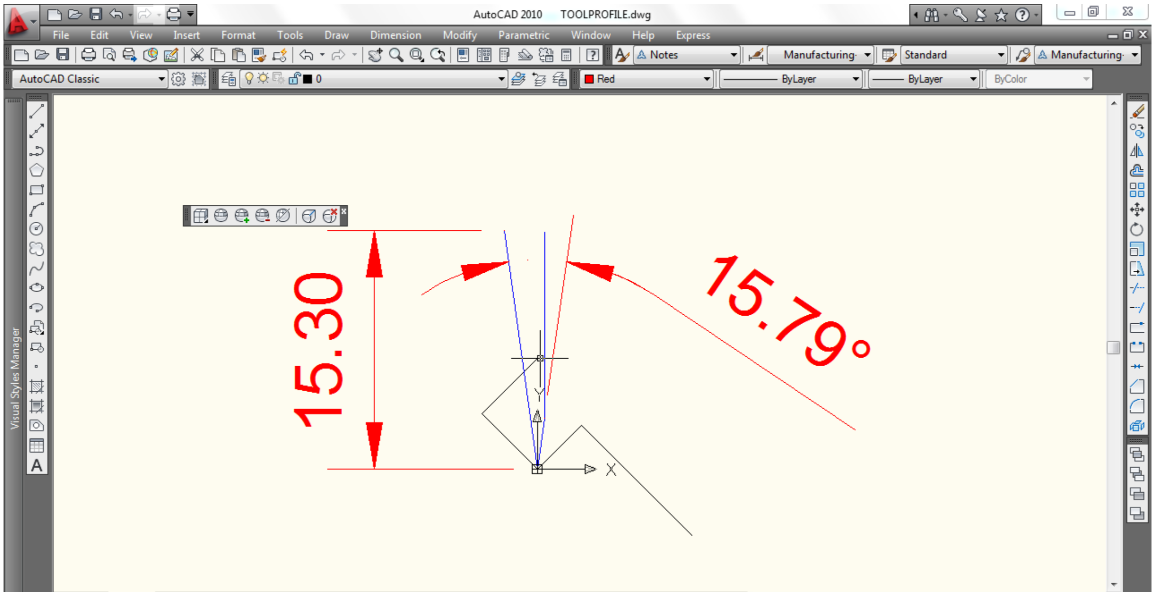
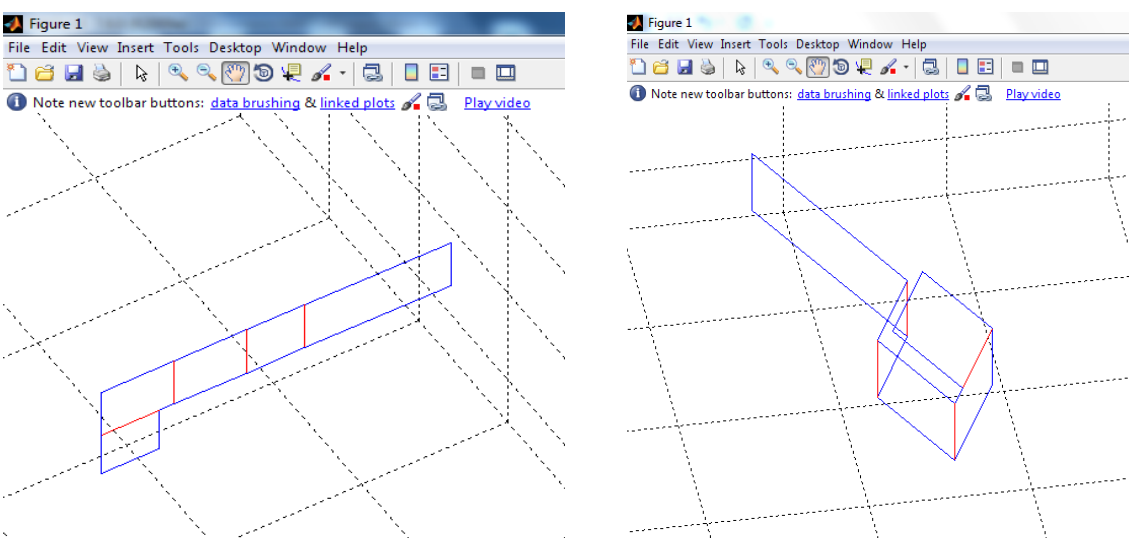


Figure 4. Tool and part coordinates dimensions for collision detection test in the AutoCAD window.

Plotter

Visual verification was also employed especially during constructing the bending simulation modules. The output was visually displayed by a testing script called plotter, which plots coordinates of a part at any time. The plotter script represents boundary edges in blue and bend ledges in red. For instance, the output of input three, which has four bends, before and after applying the bend sequence seq(1 4 3 2) is shown in Figure 5.



(a) *(b)*

Figure 5. Visual display of input three using plotter (a) before bending and (b) after bending

Validation

The validation is to test whether the system correctly represents the real process. Validation was performed by performing a manual process plan on input three and running the model for verification. Using hand simulation, the following tools were tested on sequences seq(1 4 3 2), seq(4 2 1 3) and seq (4 1 3 2). The first sequence, as expected, was successful. The second had a tool-part collision and the third had a machine-part collision.

Production Runs

Production runs were carried out using the following inputs:

Tools used are shown in **Error! Reference source not found.**2, and ***Machines*** used are shown in **Error! Reference source not found.**3.

Table 2. Tools used for the production runs.

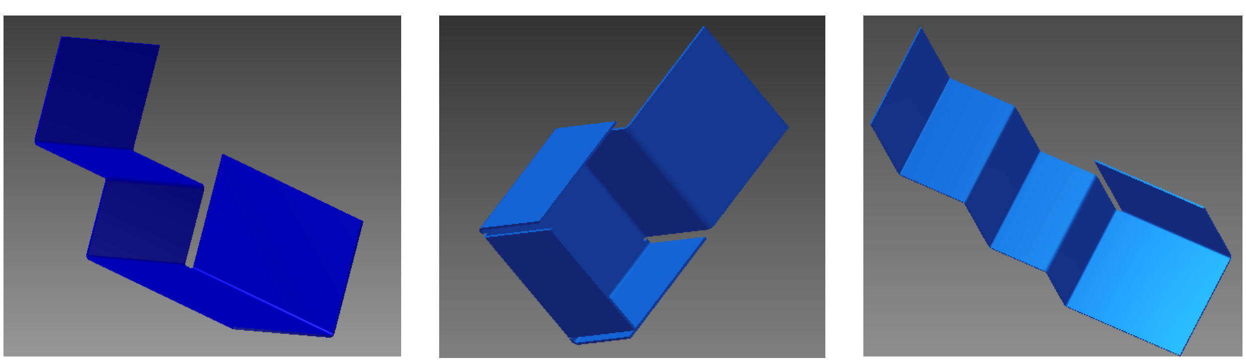
Type	Length	Width	Height	Angle θ	tool ID	Bend number
goose neck	1146	573	500	72	55	1
goose neck	1146	573	500	72	55	2
standard	500	100	60	60	56	2
standard	500	100	60	60	56	3
standard	500	50	60	30	57	4
goose neck	800	573	500	72	58	4

Table 3. Machines used for production runs.

machine ID	Time remaining	installed length	installed height	initial length	initial height	maximum length	maximum height	maximum length configuration	maximum height configuration	machine width	bottom clearance	installed tools
1	5	1	0	4500	1000	9000	3000	3	3	1200	500	5
2	4	1	2	4500	1000	9000	3000	3	3	1400	500	2
3	1	3	3	2000	1000	6000	1250	3	3	500	300	5

Input parts

Three part types were tested for a mock production run. The run was for 10 parts of each type. The part inputs A, B and C are shown in Figure 6.



(a) 4 bends *(b) 5 bends* *(c) 6 bends*

Figure 6. Parts input for production run.

Results

Part A produced 1 feasible sequence out of 24, and automatically the feasible sequence qualified as the optimum sequence. Part B produced 50 feasible sequences out of 120. Two optimum sequences were found on machine 3. Optimum plan results are shown in Table4.

Table 4. Final results for machine and sequence selection.

Part	machine number	sequence number	total bend time	Machine Remain time	setup change time	module configuration time	throughput
A	3	6	0.5902	1	0.16	0.5	2.2502
B	3	8	0.13	1	0.16	0.5	1.79
B	3	56	0.13	1	0.16	0.5	1.79
C	3	346	0.33	1	0.16	0.5	1.99

Comment on Results

Bend times for single parts appear in localized areas in the feasible sequences list. The major contributing factor to bend times is the linear displacement. For instance, in part sequence 75 and 76 have less linear movements and hence low displacement times. A snippet of bend times is shown in Table 5.

Table 5. A sample of Part A bend times.

Bend Sequence	**linear displacement**	**Angular displacement**	**number of flips**	**bend time**
74	36.7967	0	1	0.0478
75	15.1327	1.5708	0	0.0283
76	15.1327	1.5708	0	0.0283
77	38.4057	0.7854	0	0.05
78	38.4057	0.7854	1	0.051
79	36.7967	0	1	0.0478
80	36.7967	0	1	0.0478
81	29	0.7854	1	0.0416
82	29	0.7854	1	0.0416
83	25.0799	0	1	0.0361
84	25.0799	0	1	0.0361
85	29	0.7854	1	0.0416
86	29	0.7854	1	0.0416
87	15.1327	0	1	0.0261
88	15.1327	1.5708	0	0.0283

Looking at the sequences with allocated tools, it shows that the major contributor to the selected machine is the remaining hours. Even in situations where a part takes longer bend time on a specific machine, the remaining time will vastly affects the results. The effect of remaining time is shown in Table 6, where the three least throughput processes on each machine are selected. Large batch quantities can shift the plan to a more optimum position by making remain time less significant.

Table 6. Analysis of least throughput times on three machines.

machine number	sequence number	total bend time	Machine Remain time	setup change time	length modules	module configuration time	throughput
1	6	0.3801	5	0.16	0	0.1	5.6401
2	346	0.33	4	0.1	0	0.3	4.73
3	346	0.33	1	0.16	1	0.5	1.99

Conclusion

The presented methodology acts as a road map in the development of different concepts to be used to design a cloud Manufacturing and web based system for the Reconfigurable Bending Press Machine. In conclusion, this paper focused on the development of the system, validation, testing, and production runs. The user interfaces included data capturing interfaces as well as feedback interfaces. The implementation of databases was done using phpMyAdmin. Development of the three main modules of the system, which are feature recognition, central planning and remote planning were also explained. The first section explained on testing the testing methods employed, which are mainly cross-checks and expected output verification. The second section explained validation used on the simulation model. The third section described the production runs performed while the last section gave a brief analysis of summarized results.

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The Appropriate Technology Movement: Tinkerers or Futurists

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Abstract

The appropriate technology movement is considered one of the most promising sources of hope to overcome global problems and bring about sustainable development. It is also, sometimes dismissed as a failure when it comes to assessing its impact on technological education, policy and practice. This paper uses observations and lived-experiences, having been part of a "failed" appropriate technology project and a member of an international appropriate technology network (INAT) for a decade, to discuss some of the main criticisms of AT and challenge the notion of its "failure". In joining the conversation about the relevance and future of AT, this paper explores scholarly literature by a portion of the AT movement at the series of International Conferences on Appropriate Technology (ICAT).

Keywords
Technological development and assessment, appropriate technology projects, movement knowledge

Introduction

Suppose a group of non-literate women from a remote village in Africa learned about solar technology and managed to go on a training course that taught them how to solar electrify their village. Should success be limited to the benefits electricity will bring to that community, e.g., income generation, or also extend to changes in community perceptions and relationships? How important are these "unplanned" outcomes when a project "fails" to accomplish its set goal? This scenario happened in a rural development project targeting two villages in the Nuba Mountains, Sudan, and involved the training of four non-literate grandmothers as community solar engineers at the Barefoot College (India). Upon their return, they solar electrified the first village before conflict broke out in the region and displaced the two communities. Although the project "failed," its experience was expressed by one of the women as having changed her from "a woman to an engineer." The women set up the Barefoot Cooperative: two of the women are providing solar repair services to those who saved their solar equipment when they ran for their lives, and one set up a small phone-charging business (Kadoda 2014). These unintended consequences of the project on the women and their communities kept the hope of reconstruction alive. Illich (1973) would perhaps challenge this understanding of "failure" and see instead the autonomy and creativity of these women, as well as the conviviality of solar technology. Was this project a mere tinkering or more than that?

Paul Polak (2010), a prominent technology innovator and social entrepreneur, in his article "The Death of Appropriate Technology", argued that the main reason of the movement's demise is because it is "led by well-intentioned tinkerers instead of hard-nosed entrepreneurs designing for the market" and that the only salvation is by developing market-oriented approaches. From inception during Gandhi time, and his self-sufficiency and self-reliance philosophy and work, and later by Schumacher and his ideas on intermediate technology, there has been several enduring criticisms of what became known as the appropriate technology movement in the early 1970s. For example, the "failure" of the movement, in subverting mainstream technology policy and practice or having a visible impact on the growing global problems such as poverty or environmental degradation. Against this backdrop, this paper uses observations and lived-experiences, having been part of a "failed" appropriate technology project and a member of an international appropriate technology network (INAT) for a decade, to discuss some of the main criticisms of AT and challenge the notion of its "failure". In joining the conversation about the relevance and future of AT, the paper explores scholarly literature by a portion of the AT movement at the series of International Conferences on Appropriate Technology (ICAT).

Main Criticisms of the AT Movement: A Brief Overview

Now in its fifth decade, since Schumacher seminal work "Small is Beautiful", the Appropriate Technology movement had been promoting the use of small-scale technology, focusing on the wellbeing of humans and the environment, and becoming increasingly popular in international development. It is well established with an identifiable body of literature, an extensive network of organizations, and vast numbers of projects and field experiments. It has also achieved a modestly impressive track-record of successful projects which lend weight to the movement's claims. Despite these opportunities, however, together with the appeal and common sense nature of the movement's core ideas, the movement has largely failed to evoke the transformation of industrial and technological practice in most countries in accordance with the principles of Appropriate Technology. In other words, while becoming a significant international movement Appropriate Technology is still a minority theme within technology policy, education, and practice. Take Sudan as an example, appropriate technology is not taught at engineering schools and there is no "technology choice" national policy. Appropriate technology is still a topic mostly for activist engineers and international development agencies. Shall we blame the "system" that produces the mind-set that see appropriate technology as inferior to teach or utilise its philosophy? Or shall we rejoice for the growing number of students and young professionals, and civil society organisations who join the movement, in scholarship and/or practice?

Common among the criticisms is the claim that appropriate technology is inefficient, a technology that is not congenial to growth and improving the standard of living. Often the cost of pilots and failed projects based on appropriate technology are cited as evidence in support of this criticism (Akubue 2000). Success and failure of appropriate technology projects, achievements or lack of, is a continued conversation. Eckaus (1987) argued that the movement "has only a few cloths on" in terms of achievements, to which Steward (1987) responded with making the case for AT and arguing against Eckaus's claims that AT subscribes too much to technological determinism and produced little scholarly literature. For Steward, AT as a concept is about indicating a direction of change not providing a one-size-fits-all solution, and argue instead that the lack of work on AT policies is in fact, the problem. Critical views along Eckaus's, deem "appropriateness" as too vague, context-specific and time-dependent a term, for theory development or for impact assessments to have the rigor of the scientific method, arguing that this vagueness limited the development of systematic AT policy, and therefore the influence of the movement. Brooks furthers this critique claiming that the confusion has also led to polarised viewpoints about appropriate technology (Brooks, 1981). At one end, he identified those who believe in a new revolutionary path to technological development and at the other side those who argue that it is anti-development.

The assumptions about the "free market" and "modernisation" seem to be at work in some of these critiques. Willoughby (1990:234), in his analysis of the different criticisms (technical, economic, social), argues that in fact many are "based upon either ignorance of available empirical evidence, distortion of the claims of leading protagonists, or reliance upon examples from the literature which differ from the consensus of the movement but which suit the biases of the critic." Nonetheless, criticisms also advance the conversation about AT as a movement and the opportunities (and detractions) it can present to associated concepts like sustainable development (Zalenka & Pearce 2011). They also encourage historical reviews such as that by Lissenden and colleagues (2015), who responded to Polak's claim of the movement's demise by exploring scholarly literature on AT over a 35 years period. What they concluded highlighted achievements and evolving thought but also supported critiques of AT theory describing its literature as "vague and disjointed", and that the movement's diverse goals made it difficult to develop a "unified paradigm" seen by the authors as important for the future of AT (2015: 31-32). The movement is perhaps best described by Willoughby (1990:12), "an enigma", being "one of the most promising sources of hope that the constellation of contemporary global problems may be overcome" but that its failure "to become the dominant mode of technological practice raises a shadow of pessimism over this hope." At a recent symposium in Khartoum on the concept of "Hope", in discussing new social movements, Hale (2016) argued that "any slight movement of the people is worthwhile". The slight movement of the women solar engineers from the Nuba Mountains of Sudan, did not follow the planned path but an agile one that responded to their changing priorities. Seeing the project as a failure would have to ignore the changes they brought about in the community and in themselves.

Knowledge in ICAT Proceedings

The claim that appropriate technology movement had low impact, points at gaps between its theoretical ambition and practical realisation, but also at what is seen as vagueness of definitions and fragmented scholarly work. Polak sees the solution in developing "market-driven methods" for the movement to reach the bottom of the pyramid who are not a priority for current international businesses. Responding to Polak, in part, Lissenden et. al. (2015) conducted a systematic literature review of publications from 1978 to 2013 to explore how the definitions and tenets of appropriate technology evolved over time and with developments in globalisation, shifting macroeconomic and political environments, and changing user preferences. In a similar manner, this paper reports a preliminary exploration of the output of INAT, its evolving themes and the types of knowledge the network produced over the past decade. While INAT started forming a few years before the conference series started and that the network activities are not confined to organising the biennial International Conference on Appropriate Technology (ICAT), the conference proceedings represent the best-documented and most consistent activity. The analysis uses presentations in the paper category from the second to the sixth ICAT (2006 – 2014).

Figure (1) shows the number of papers presented in the past five conferences. The fluctuations in the number of papers from conference to conference raises an initial question about what makes one conference receive more submissions than another. Reasons can be about problems in planning, funding, theme, etc. For example, while the low number of papers in the second ICAT can be attributed to early years in network's formation, the reasons behind the low numbers of papers in the fourth ICAT is more open to speculation. One explanation that the author suggests is that the engagement of the local technology community is important in increasing the overall number of papers and local participation. The fourth ICAT, held in Ghana, had low number of papers (only three of which were presented by local participants). How does the selection of location and/or schedule of the conference influence local participation?

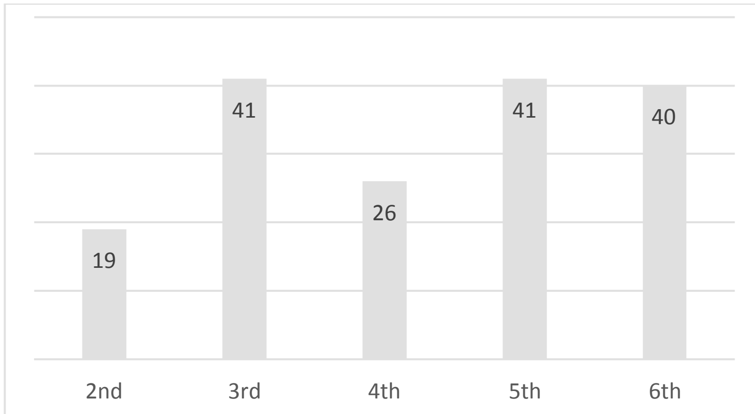

Figure 1. Papers Published in ICAT Proceedings (2nd to 6th ICAT)

In describing the process of conference planning in his comments on an earlier version of this version, John Trimble, relates the change of conference timing to November since the third ICAT because many schools have a break time during this time of the year. There are also several factors that are considered in selecting conference locations. Primarily, an expressed interest of an African science and technology university is required. Other factors, in addition to ensuring the existence of a conference community, include the sponsorship, local support and partnerships, the bidding university is presenting. On the ground, these factors further subdivide, and are influenced, by the dynamics and actual setup. For example, the relationship between the university's management and the local organizing committee largely affects the planning process and determines the actual support the conference gets.

The geography of the place also matters. One of the possible reasons for the high turnout at the third ICAT could be the fact that Kigali Institute of Science and Technology (KIST) (the hosting institution, now College of Science and Technology at the University of Rwanda), that the conference venue was located in close proximity to other educational and technical colleges. This advantage was not present for the fourth ICAT in Ghana sponsored by Kwame Nkrumah University of Science and Technology (KNUST). In this case, the fact that the conference was held in Accra while KNUST is based in Kumasi might have influenced the turnout at the conference. It is worth noting that numbers of participants levelled back in the fifth ICAT with that the third ICAT's (and maintained in the sixth) where the conference was sponsored by the University of Pretoria and held in the same city.

Changing Terminology

Before exploring the topics of the papers in terms of numbers and the types of knowledge they produced, figure (2) traces keywords used in composing paper topics and their lifetime, to explore the changes in terminology, the topics that disappear and those that come on board, but also to illustrate how the network is evolving and expanding its knowledge boundaries.

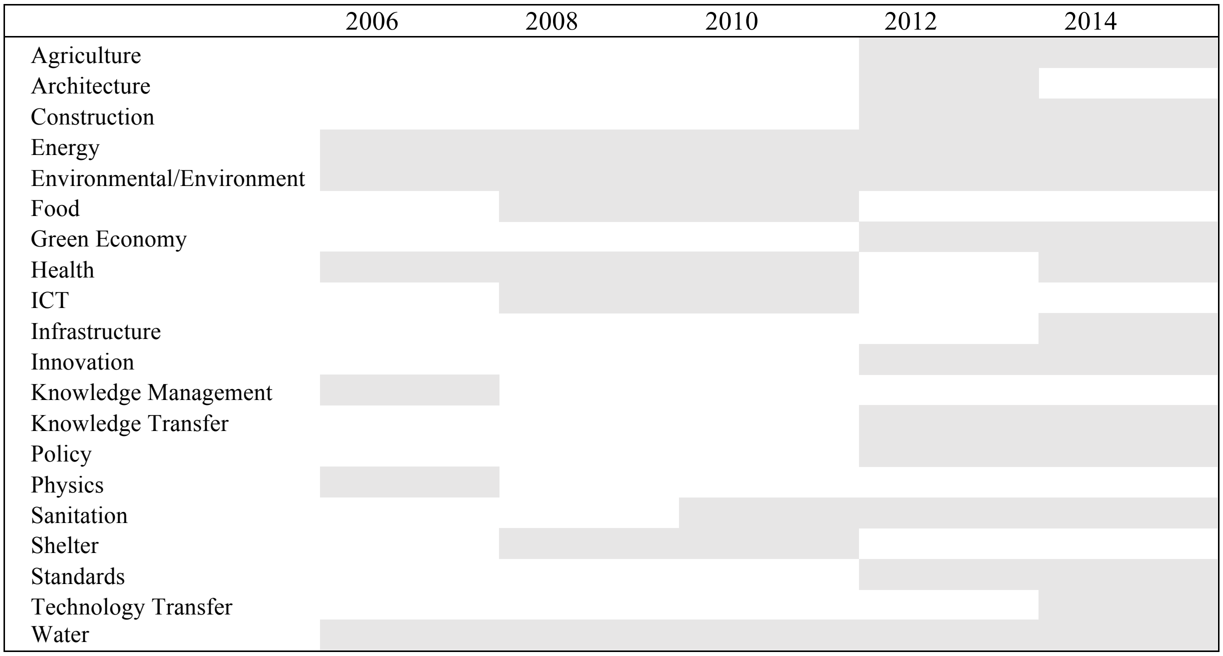

Figure 2. ICAT Topics Lifetime (2006 – 2014)

Apart from energy, environment and water that have maintained their presence over the years, followed closely by health that returned after a brief disappearance in 2012 (5th ICAT), the figure shows considerable change of terminology used to describe a topic, and that topics are increasing every conference. In comparison to earlier conferences, a greater number of new topics (8) were added in the 5th ICAT that have carried on to the following conference (making these two last conferences the most similar compared to earlier consecutive conferences). This can both indicate that the network arrived at a set of established topics as well as still renews itself.

The changes in terminology, as well as new topics, show several trends. First, a trend of market-orientation, e.g. food turning to agriculture, shelter to construction, as well as the addition of green economy and innovation category in the fifth ICAT that remained intact in the following conference. Another trend is bringing in international development terms, seen in additions (e.g. sanitation) and modifications (knowledge management to ICT). Only two topics disappeared completely. It is interesting how a basic science topic (physics) was automatically incorporated into newer generic term (energy), while knowledge management (already new), which also disappeared after the second ICAT kept changing first into ICT (3rd and 4th), to knowledge transfer (5th), and ending in the 6th ICAT as a combined category of knowledge and technology transfer. The introduction of policy and standards from the fifth ICAT further highlights a shift of focus to practice and national policies, as also demonstrated in recent conference themes (including this year's).

Topics and Conference Themes

While the link between research, theory and practice have been the underlying and fixed theme of ICAT (Trimble 2008), there is still a difference between the first three (2nd – 4th) that focused on specific solutions in health, energy, and water, respectively, and the broader theme of AT in the 21st century (5th – 7th). One of the difference is the emphasis on AT relevance to the future, a question that motivated Lissenden's literature review, and interestingly also been explored in the two conferences preceding the shift (Tharakan 2008; 2010). A manifestation of this shift are new topics in the proceedings on AT assessment and ethics, adding economists and philosophers to the INAT community (initially more composed of basic sciences and engineering academics and practitioners). Figure (3) illustrates the percentages of papers presented in each of the eight topics (along the categories in the 5th and 6th ICAT) in relation to the total number of papers in each conference.

Apart from completely new categories (e.g. green economy) which required closer examination of the papers, the reallocation of papers from previous conferences to the updated set of categories was straightforward in most cases. The top part of the figure shows the conference theme along two descriptors. The first denotes a “value” or “approach” that INAT is highlighting that year (like “empowerment of the people”, “linking research to practice”), or global problems at the core of the AT mission such as climate change. The second descriptor denotes the specific focus of the year’s conference, which can lean towards an application area, and more recently, vision. This change in theme construction can be observed in the shift of emphasis on application areas (e.g. land, health) in earlier conferences to the future of AT and sustainable development.

The identification of “shared values” that represent the appropriate technology movement (specifically INAT) have started in earnest in 2010 at one of the Spring Symposiums at Howard University, where participants signed the “Declaration on Appropriate Technology”. This conversation continued later that year in Ghana aiming for the development of “Appropriate Technology Manifesto”. (Trimble 2010) The manifesto (under development) calls for a paradigm shift in technology development to empower people and protect the environment. This set of values that embody the paradigm shift, the thrust of the movement, can guide this kind of exploration of achievements for instance in terms of reach (number of organisations signing up), and depth (impact on communities or environment). Finalising the manifesto is required before dedicating effort to define metrics and qualitative criteria to measure or read the trends of growth and influence of INAT.

The figure below is not concerned with the change in categories or values (discussed above). nor does it give an accurate account of change. For instance, the “Policy and Standards” category was added in the 4th ICAT, however, in the 3rd ICAT an unclassified paper, (Verharen 2008), is a policy and standards paper that influenced the introduction of this category in the following conference. The figure, therefore, is not intended for discussing change (since categories were standardised and papers from earlier conferences reallocated), but the distribution of papers among the categories.

The distribution of papers along the categories would firstly depend on the conference theme and the application focus (as seen in more health papers in the 2nd, more energy in the 3rd, and so forth). The distribution along application areas is expected to be more uniform in the 5th and 6th ICAT because the theme shifted to broader categories (e.g. innovation, empowerment). What other factors are influential in the distribution of the papers along categories? How much the location, schedule, or local participation play a role in determining which categories become dominant and which has a dwindling number of papers?

INAT Value	Knowledge sharing, research and practice	Climate change, research and practice	Thirst planet, solutions	Education, research, practice, policy	Technological innovation, empowerment
Focus	Health	Energy	Water & Sanitation	AT in 21st century	AT in 21st century

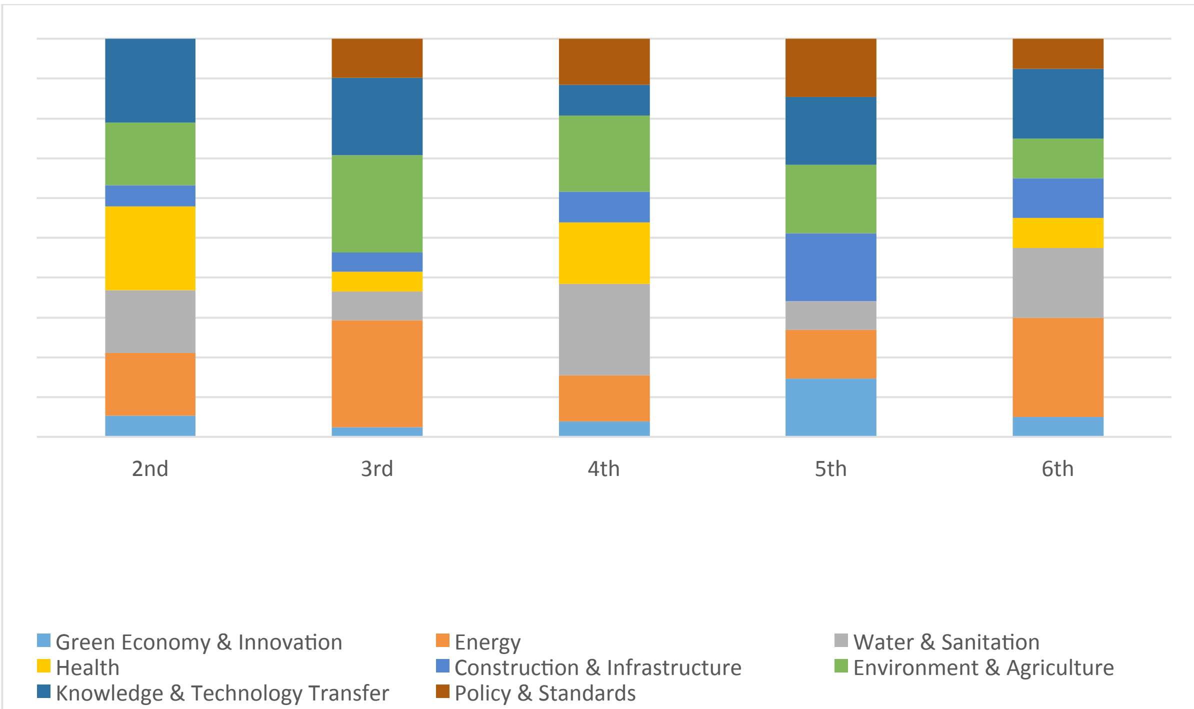

Figure 3. ICAT Themes and Topic Categories

The relationship of the number of papers in a category with the conference theme is clearer in the first three columns, but less clear when conference themes became broader (where a more even distribution of papers along categories can be observed). Other influences on the submission rate for paper categories can include the area of expertise of the dominant group in the local organising team and/or the host department (noting possible impact on 5th and 6th submissions). It can also be the result of retaining or attracting a group of homogenous set of participants (e.g. from the previous conference or through connecting with another body like in the case of the Sudanese Knowledge Society whose members fed into the knowledge/technology transfer category in 2012 and 2014). While these are observations drawn from the (single) perspective of the author, they are useful in continuing discussions about INAT's community building dynamics as well as challenges and opportunities for growth and influence.

Types of Knowledge Produced

For generating the data for this analysis, papers were scanned and allocated to a set of categories that is based on the "type" of knowledge the paper produced. The type of knowledge used two criteria or features of knowledge (adapted from knowledge management) to differentiate between the papers, "knowledge as a process" (how it is produced) using the strategy of research utilised in the study; and "knowledge as a product" (what it contains) identifying what is represented/codified by the study. Sorting the papers went through several rounds to finalise the data table where papers are categorised according to their dominant feature: (1) papers employing quantitative approaches (experiments and surveys); (2) papers reporting case studies and projects; (3) papers involving critiques and conceptual analyses; (4) papers producing models or frameworks; and (5) papers focused on indigenous knowledge. Figure (4) shows the percentages of papers by dominant feature from the total number of papers in each conference. The last category had very few papers and could have been distributed along its strategy feature for example, or by identifying whether it is an analytic or descriptive piece. Being so few, keeping them separate seemed more useful to highlight the gap and question our intellectual leaning. These features turned paper categories, which are by no means complete or perfect, provided an alternative lens to explore the INAT community in terms of the knowledge it produces and the prevalent worldviews held by network members. Are we inclined toward determinism, constructivism? Are we developing or applying theory? What are our dominant modes of knowledge production? Are we engaging the people and what they know? In short, do we have the right mind-set to empower the people?

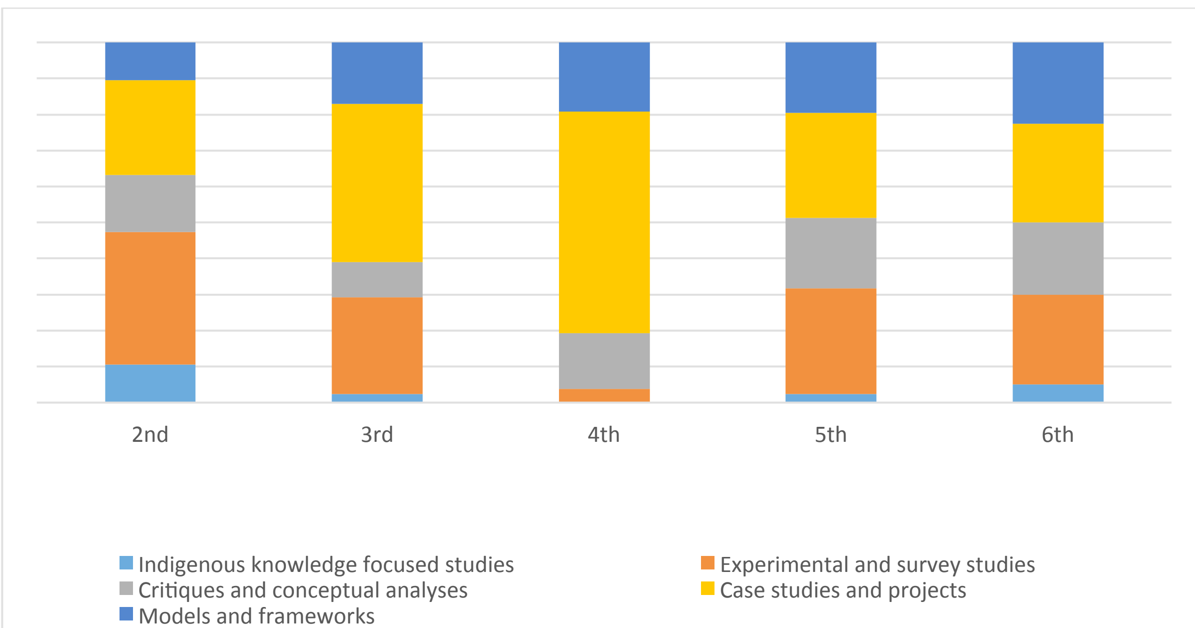

Figure 4. Types of Knowledge Produced

With the exception of the first conference in the set, site-specific knowledge (from case studies and projects), form the bulk of papers followed by experimental and survey research. This can indicate that ICAT is engaging researchers holding distinct philosophical worldviews, a feature of a diverse scientific community. The steady increase in studies proposing models and frameworks, in addition to the continued presence of critiques and conceptual analysis, can be regarded as the attempts of the community to add to AT thought, through replication, standardisation, and theoretical inquiry.

Concluding Remarks: The Future of AT

This preliminary exploration of ICAT proceedings may have shown that the network is evolving its ideas and membership, as well as producing "knowledge". The "Declaration on

Appropriate Technology" and "Appropriate Technology Manifesto", developed by INAT, can be used to discuss and evaluate achievements, as well as bolster relationships that come with each new conference. The need to sift through the papers and develop mechanisms to map and connect the growing literature, was a recommendation from the 6th ICAT that has been reinforced by this exploration but also by findings of relevant studies and critiques of AT. According to Lissenden's (2015) literature review, AT philosophy is lacking in three areas. The first gap is in the lack of "bilateral knowledge exchange" in AT ventures for understanding social norms and values, and utilising local knowledge; the second in the lack of "emphasis on venture scalability"; and the third in the lack of "integration of implementation strategy through the project lifecycle". The authors argue "that rethinking and repositioning AT with a human-centric narrative emphasising sustainability and scalability is imperative in order to revitalise and accelerate the AT movement and to achieve the large-scale impact it was expected to deliver." (2015:33) ICAT is lacking in indigenous knowledge ventures and scalability emphasis, though to explore the lifecycle of projects presented, would require a concerted effort by the network to trace pilots, project ideas, case studies, etc., to understand success and failure of AT ventures. Unless this understanding of uptake or rejection of AT is achieved, Nanheimer (1992) concludes, "the potential of AT will never be realised", arguing that AT movement should share the concern amongst development agencies of how to scale up and multiply successful ventures. These "single, isolated achievements" are meaningless according to his analysis (similar to Polak and others who promote a market-oriented approach to AT), if they do not repay their investment.

It must be noted that even the harshest of criticisms, e.g. declaring the movement dead or having little impact, still the good intentions of its followers are recognised. The assumptions about intentions in a way is similar to those about the free market. In the face of growing poverty and disparity (within and across regions and countries), good or bad dichotomies about people or technology should not be assumed or be the focus of the debate, but approached through ethical and participatory inquiries. AT, a social movement at base, is about social change and social justice, a process and goal to subvert a dominant social order. In the specific case of INAT, that change is seen as empowered people who define their own path of technological development, be it to combat poverty, to save the environment, or in today's notion of think different and innovate. AT was new thinking and a breakthrough in the early 1970s in development economics, almost a futurist, leading the way to new economic thinking of technology choice, and various models to integrate new and local technologies such as technology blending. The more recent, and prevalent, technology-for-development or technology justice mode of programming in international development, can be seen as advancing the concept of AT. The movement has allies in various fields, e.g. Science, Technology and Society (STS) studies, Actor-Network Theory (ANT) on technology inscription and translation, Illich's theory of "conviviality of tools", technology for social change research, and cultural analyses of innovation, all can offer ways to explore technological development in a given context. For instance, these forms of analysis can further our insight into the ways that people appropriate a technology for their own needs. Asking questions about how technologies were transformed by users, whether the technology is "convivial", or is it because "use instructions" are "weakly" or "strongly" inscribed, can inform us about technology features that offer more possibilities to be adapted by users, and through the adaption process, empower them.

Different perceptions of appropriate technology, among researchers and communities, require analysis of beliefs and values, local knowledge and the cultural consequences for assessing impact. Social movement theory and historical analyses, literature on new social movements, and movements that "mobilise science", can offer insights into the current state of the AT movement and readings about its future. The future of AT should involve researchers from social sciences and ethnographic studies, explore appropriate approaches to market like cooperatives and collectives, and master advocacy skills. More crucially, gesturing towards social change theory, can bring liberatory pedagogies and resistance tools, to help with the revolutionary thought of the AT movement and help local actors in raising the questions and pushing the policies required for walking their appropriate technological development paths.

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