Abstract: - The term ICT4D refers to the opportunities of Information and Communication Technology (ICT) as an agent of development. Much of the research in the field is based on evaluating the feasibility of existing technologies, mostly of Western or Asian origin, in the context of developing countries. In a certain way, this agenda can be understood as a top-down approach which transfers technology in a hierarchical way to actual users. Complementary to the traditional approach, a bottom-up approach starts by identifying communities that are ready to participate in a process to use technology to transform their own strengths to new levels by designing appropriate technologies with experts of technology and design. The bottom-up approach requires a new kind of ICT education at the undergraduate level. An example of the development of a contextualized IT degree program at Tumaini University in Tanzania shows that the training requires a close collaboration with local stakeholders and a creative problem solving approach throughout the studies.

Key-Words: ICT4D, education, contextualized IT, Africa, playware

1 Introduction

Information technology (IT) should be an agent of change in the context of any developing country. To achieve that, IT education should be based on a bottom-up approach, which allows the education to serve better the needs of the society. However, such a bottom-up approach is by no means easy to implement, since it demands a change of attitude in curriculum development, where several components are left free to become defined during the educational program dependent on the challenges encountered through contextualized, hands-on experiences in IT design, engineering and problem solving. This puts a different kind of pressure on accreditation organizations, educational institute administration and teachers to become flexible and able to act to changes in demand from the bottom-up approach. Despite of the challenges that this may entail, it is important to notice that this essentially reflects the same challenges that are met every day in any knowledge based enterprise, where similarly knowledge-based workers are the assets of the enterprise by being the source of innovation, and therefore the enterprise must govern in a bottom-up way trusting the capabilities and innovations of the workers. Despite this perceived ‘freedom’, there are of course strategic guidelines and control functions in knowledge-based enterprises the same way as there should be guidelines and control functions in a bottom-up approach to contextualized IT education.

The bottom-up approach in IT education is based on an ICT4D paradigm that is complementary to the traditional ICT4D approach. In a typical case, the traditional ICT4D agenda starts from a readily available technology, such as mobile phones and SMS, the feasibility of which is evaluated in a context of a developing country. This approach has consequences to the competences that are required from an ICT4D professional. Because of the emphasis on evaluation, the traditional ICT4D agenda calls for people with an interest in the user aspects of technology, like sociologists or information systems professionals. Therefore, also the educational challenges of an ICT4D professional are in social rather than technical disciplines.

1 Although ICT4D, short for Information and Communication Technology for Development, is a generally accepted term for designing, using and evaluating modern digital technologies for development, we will use mainly the term IT (Information Technology) instead of ICT in our article. This is because IT covers all information processing technologies, including those required for communication.
2 How to Learn the Bottom-Up Approach for Designing Meaningful ICT4D

The key to implementing a true bottom-up approach for ICT4D is the integration of three components:

1. Contextualisation: providing identified, concrete contexts where IT can make a difference to people’s lives;

2. Problem oriented approach: shaping the undergraduate IT education in higher education institutions (HEIs) into a problem oriented approach;

3. Commercialisation: transforming inventions into commercial applications.

This means that an undergraduate IT education starts from teaching the student to identify and elaborate real needs in a particular context (e.g. like a rural hospital or a local business), work on this problem, together with a group of other students throughout his/her studies – linking courses to this problem – and finally uses the incubation facilities to launch business initiatives based on the learned. Thus, the ultimate goal of the bottom-up approach for ICT4D is to make all the stakeholders – the student and the problem owners – creators of IT, not just its users. In our point of view, this is the most important issue in development work, namely to provide training for people to become developers and creators rather than becoming receivers and users. This holds for most subject areas within development work, including more traditional subjects such as agriculture, where it has generally become accepted that the best aid is to provide agricultural training to allow people to cultivate the land themselves to become self-sufficient and self-sustaining. It is a peculiar case that IT training, with the traditional approach, has not adopted this agenda of self-sufficiency and self-sustainability. Hence, the bottom-up approach is focusing on making people able to develop their own hardware and software IT systems that fits the local needs, and which may provide a local and potentially a global market for these developers.

In order to allow for such development of creators of IT, the bottom-up approach demands a focus on the individual competencies. Emphasis is put on building up the individual competencies through a problem based approach, where the individual solves identified problems and challenges by gaining competencies when needed to solve the problems at hand. This demands access to resources, but not ‘passive resources’ as in the case of a more traditional curriculum for IT training, but to ‘active resources’ that are being used to create solutions for the identified problems. Hence, the resources come to active use in forming the creators of IT while at the same time it comes to direct use for the society in the solutions created with those resources. Here, resources can essentially be anything that may be utilized to create novel technological products, from local fabric and art to electronics, computer equipment and software.

Over the last decade, we had a long and intense work in southern Tanzania (e.g. [1]), which has resulted in launching a contextualized IT B.Sc. program at Tumaini University, the extensive use of high tech hands-on tools for the development of novel contextualised products, and the establishment of the first East African Science Park at the Tumaini University’s Iringa campus. The Science Park was inaugurated by the Minister of Higher Education, Science and Technology on 10th July 2006.

The approach is summarised in figure 1 that shows the interplay between the development of a contextualized IT program, the identification of the local context, and the business incubation.

An important component of the approach is the resources for contextualised IT creation in education and business in the local context. Resources include both technological resources and human resources. Human resources will become available locally by the contextualised IT degree program, and the utilisation of the IMPDET online PhD program (www.impdet.org) which allows PhD students to work on their R&D projects in the home country. Thus, the development activities of the current program are linked to...
blocks such as the I-BLOCKS [2, 3], which are used as manipulative technology that allows any learner or business developer in the local context to become creative with high tech product development after only few sessions of hands-on experiments [4, 5]. The simple manipulative technology is essential for releasing the creativity of high tech products in the local context, e.g. in rural areas, and has shown itself as a motor for confidence and creativity building amongst learners and business developers in Tanzania. As an example, other technological building blocks such as the modular interactive tiles have been used from the Science and Business Park in Iringa, Tanzania, to make projects in the local context for physiotherapy of handicapped children at the Neema Craft rehabilitation unit, where the technology is developed locally to adapt to the local practice for engaging the children in playful physical rehabilitation.

Several IT programmes in African universities have been directly adopted from other continents (specifically Europe and America) and implemented into African universities without taking care that the content of the curriculum fits to the local needs. This may pose threats that the knowledge and skills learned by students are obsolete due to the technological and cultural background of the country.

A dual focus on the social context and technical opportunities is important in the IT education field. New students are the ones who will be designing meaningful applications to these contexts, by using modern technology. Computer science education is often theory driven and this kind of approach does not meet the constructivist learning principle. The situated learning approach is a way to acquire applicable knowledge within a context.

A contextual design approach to computer science has rarely been used in the African context. In the bottom-up, contextualised IT curriculum, we focus on a new approach that is contextualized to the local needs of an African society. Designing a meaningful curriculum for information technology (IT) studies requires deep awareness of the needs of the surrounding society. In the context of a developing country, this challenge goes hand in hand with the incoming IT students’ limited experience of technology.

A contextualized IT degree programme is based on the CATI (Contextualize-Apply-Transfer-Import) model which emphasizes students’ early identification of societal expectations from technology. The degree programme follows six principles: contextualization, local problems as starting points for projects, practical and interdisciplinary orientation, international recognition, and continuous research for the programme’s formative development. As of the resources, the curriculum makes also use of international academic visitors, not primarily as lecturers, but experts helping the students to specify solutions to their identified problems and elaborate them forward towards working solutions, for the benefit of local end users.

Further, it is essential that students are given the possibility to create IT solutions in a simple manner. For instance, intelligent building blocks are developed and used for this purpose. Miniaturization of computing makes it possible to employ new educational practices and revolutionize our idea about programming through the use of technological components. With the development of intelligent building blocks it becomes possible to ‘program by building’, which allow easy development and use in any context. The construction with intelligent building blocks results not only in the development of a physical structure, but also in the development of a functionality of the physical structure. So construction of functionality can happen with physical building blocks that each contains computational processing and communication, and will result in easy ways to develop prototype high technology products. Such opportunities will be exploited for both local educational purposes and business purposes, allowing local development of new businesses for both the local and global market through business incubation.

The business incubation should happen in a tight collaboration between academia and business, and therefore demands the development of a science park which can host academic staff, start-up companies and external companies within the field of IT, in order to ensure tight collaboration between these parties and to ensure the transfer of knowledge from academia to business. The knowledge may come directly from the contextualized IT creating unique solutions based upon the local needs. However, due to uniqueness of such contextualized IT solutions, a number of such solutions may create opportunities on the global market due to their unique nature. The local innovation potential will be utilized to create both local and global business opportunities.

It is noteworthy to observe that contextualization is far from a patronizing agenda which can occasionally stay behind even various localization efforts. Instead of starting from a simplistic search for needs, contextualization is a process that strives to understand the situation of a certain context as a whole. Instead of needs, the emphasis should be on talents, i.e. resources that the context feels responsible for. For example, a contextual analysis of a rural hospital should start from, say, its staff’s training – something that exists and they should use for saving human lives – rather than complaining about apparent needs, like lack of funds to buy new beds. Table 1 compares needs-based approach with a talent-based approach.
Table 1 Comparing needs-based approach and talent-based approach in using and developing ICTs.

<table>
<thead>
<tr>
<th>MOTIVATION</th>
<th>NEEDS-BASED</th>
<th>TALENT-BASED</th>
</tr>
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<tbody>
<tr>
<td>USE</td>
<td>Import and transfer of ICT4D; dumping solutions</td>
<td>Constructive and innovative evaluation of existing technology</td>
</tr>
<tr>
<td>Example: introduction of Facebook</td>
<td>Spin-offs/ unexpected uses of existing technology</td>
<td></td>
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<tr>
<td>DEVELOPMENT</td>
<td>Localization of solutions according to the needs of the people</td>
<td>Innovative solutions</td>
</tr>
<tr>
<td>Innovations are rare</td>
<td>Real inclusion of local people to the development process</td>
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<tr>
<td>Example: Localization of Facebook to meet the needs of a community.</td>
<td>Example: A novel tool (e.g. Voicebook) for the benefit of the community.</td>
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3   Example: ICT4D Education Initiative in Tanzania

This approach is exemplified here with the Tanzanian case. The contextualised IT business and development program is implemented as follows:

1. Research and Learning
   a. Renewed IT Degree Program
   b. Postgraduate Program
   c. International expert consultancy and supervision program
2. IT Business Incubation
   a. Science Park
3. Contextualised IT
   a. Identification of representative challenges and expectations
   b. Intelligent Building Block development

1. The new IT degree program is based upon the contextualised IT ideas, focusing on a problem based approach which identifies local needs and develop skills to make solutions to help solving such needs. One outcome of this is also a “contextualised IT education handbook”, which describes the preferred implementation of such a novel IT degree program. The program has started at Tumaini University, Iringa, Tanzania September 2007. Local designers of the program will work for their Master or PhD studies on various aspects of the building process of the program, e.g. as students of the online IMPDET PhD program. On a regular basis, a roundtable of major national decision makers and stakeholders meet with international scientific experts to decide upon any further measures needed to be taken. The role of international experts is also to network the initiative with other, similar initiatives in other parts of the world. In particular, the Tanzanian experience in both the needs and opportunities will be taken to international forums.

2. It is important to develop local business opportunities in the field. The Science Park in Iringa should grow in number of high technology companies emerging from the Science Park and being hosted in the Science Park. Hence, a program for a) promoting the Science Park locally (and globally), b) attracting companies to the Science Park and c) helping local start-up companies to emerge will be implemented. For instance, the program should include venture capital for local start-up companies. The venture capital may be distributed based upon evaluation of business plan proposals from the local start-up companies. Further, the Science Park will host business mentors to assist the local startup companies.

3. In order to create relevant technology for local needs, a few R&D hot spots have been / will be identified, some in rural, some in urban areas. The local people are invited to work with IT students. Specific tools are to be developed to allow any person locally to develop prototypes of high technology artefacts to meet local needs. This will be achieved by making Intelligent Building Blocks (e.g. IBLOCKS) that contain computing power and which become technological prototype artefacts when putting such blocks together.

4 Conclusion

The first undergraduates from the Tumaini IT program will complete their studies here in 2010. The experiences from the first three years of the program indicate that

- a novel IT curriculum can be launched – proudly – at a young but determined university in a developing country;
- a home-made IT program promotes ownership, commitment and professional pride among the students, and thus positive attitudes; and
- a contextual sensitivity to the surroundings inspires to new initiatives, like indigenous mobile services and green computing.

A bottom-up approach to IT education, although here presented from the point of view of ICT4D, can contribute to Computing Education Research in general. It is important that IT education becomes more flexible than it is
nowadays. It needs to take distance from the current linear approach where the courses follow each other in a very fixed order. Instead of the linear structure, the IT education needs to be based on a creative tension between a set of aspects that have been traditionally been understood opposite, even alternative, like human – technology, theory – practice, poor science – business, universal – contextual. The presented approach can probably have a positive impact on the decreased interest in Computer Science studies among high school students. A bottom-up curriculum can be linked in a straightforward way to various community projects that high school students can participate in, in close collaboration with CS students from a university. While the curriculum is flexible and promotes business opportunities, it is also closer to potential employers. This means that graduates will find jobs faster. With a wider skill profile, so they can find work also outside traditional CS jobs. A better position of CS graduates will be another attractive factor to choose CS studies after completing high school.

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References: