*International Journal of Education and Development using Information and Communication Technology (IJEDICT),* 2015, Vol. 11, Issue 1, pp. 55-79

# Community outreach projects as a sustainable way of introducing information technology in developing countries

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## ABSTRACT

The paper describes an approach to the sustainable introduction of IT in developing countries based on international collaboration between students taking the form of a knowledge bridge. The authors consider the challenges for introducing information technologies in developing countries; one of these is lack of reading materials ultimately leading to lack of reading skills in pupils and poor overall performance. A theoretical framework for the sustainable introduction of IT is proposed. It comprises the following components: (1) the model of a knowledge bridge, (2) the managerial model of the interactions between key stakeholders, and (3) the model of impact of a Community Outreach Project (COP) on target schools. The proposed models have been mapped to the widely adopted DPSIR framework used in sustainable development studies. As a case study, the authors discuss the E-readers Project run in two primary schools in Northern Tanzania. The paper also demonstrates how interaction and collaboration between Tanzanian and Dutch students was organized during preparatory stage and project implementation. The paper concludes with general recommendations on how to run a sustainable IT-based COP. These recommendations have been drawn from the analysis of the COP experience in the developing country, namely Tanzania.

***Keywords:*** *Community Outreach Project; knowledge bridge; e-readers; sustainability; information technology; developing country*

## INTRODUCTION

Outreach is an effort by individuals in an organization or group to connect their ideas or practices for the benefit of other organizations, groups, specific audiences or the general public, while a community consists of people with a common interest, usually living in a particular area. A Community Outreach Project (COP) is a project carried out by organizations or groups in order to transfer their knowledge and skills for the benefit of a deprived community (Weide & Zlotnikova, 2013). There are many examples of COPs run all over the world, a classification is provided by Weide and Zlotnikova (2013). In this paper, the focus is on COPs which involve the introduction of Information Technology (IT) in developing countries. Our particular interest is in COPs that are based on cooperation between students from universities in developed and developing countries. We refer to this cooperation as a knowledge bridge. The concept of a knowledge bridge is explained later in this paper.

According to IFAD (2009), sustainability means ensuring that the institutions supported through projects, as well as the benefits realized, are maintained and continued after the end of the project. Carroll and Rosson (2006) define sustainability as a dynamic process in which IT professionals, designers, and researchers work with community groups in ways that give them greater control over technology in their organization. Sustainable IT projects are those that can

pay their own way, generally without reliance on government funding (Hearn et al., 2005; Lennie et al., 2005).

Researchers identify several kinds of project sustainability:

1. Technical sustainability (Etta & Wamahiu, 2003; Young et al., 2001);
2. Financial/commercial/economical sustainability (Etta & Wamahiu, 2003; Ripamonti et al., 2005; Young et al., 2001): breaking even, profit-making, etc.;
3. Social sustainability (Hearn et al., 2005; Lennie et al., 2005; Mayanja, 2006; Simpson, 2005);
4. Organizational/institutional sustainability (Mayanja, 2006; Ripamonti et al., 2005): matters related to the running and management of the project, including capacity building, infrastructure maintenance, etc.;
5. Managerial sustainability (Etta & Wamahiu, 2003; Young et al., 2001);
6. Policy-related sustainability (Mayanja, 2006): a conducive policy environment, related to connectivity, IT infrastructure, etc.

In this paper, we restrict ourselves to technical and organizational sustainability of the IT introduction in a low infrastructure situation. The general objective of this study is to develop an approach to the sustainable introduction of IT in developing countries through COPs. This general objective is broken down into specific objectives as follows.

1. Objectives related to the Introduction of IT:
    a. To propose a framework for the sustainable introduction of IT in educational organizations in developing countries.
    b. To develop a mechanism for ensuring technical and organizational sustainability of the IT introduction.
2. Objectives related to the Community Outreach Project:
    a. To identify the content of the COP course to be delivered to young professionals as part of their training.
    b. To develop mechanisms and tools of coordinating activities between young professionals from developing countries and their counterparts in developed countries.
3. Objectives related to linking the sustainable introduction of IT and Community Outreach Projects:
    a. To propose a model of a knowledge bridge between developing and developed countries.

In achieving the stated specific objectives 1a, 1b and 3a, the dominant method used is extensive literature review and analysis. The literature sources included both published papers and unpublished documentation on the E-readers Project. To achieve specific objectives 2a and 2b, the following methods have been employed: questionnaires; face-to-face interviews; direct observation; group discussions; experimental teaching.

We also have considered a case study of a COP aiming at supporting the introduction of e-readers in Tanzania — a cooperation between the Nelson Mandela African Institution of Science and Technology (NM-AIST), Tanzania, and the Radboud University Nijmegen (RUN), the Netherlands — by organizing a joint course in their curricula. This COP was built upon the E-readers Project.

The structure of this paper is as follows. First we explain the approach to choosing appropriate technology, based on comparison of different sustainable IT devices. Secondly we describe the theoretical framework for the sustainable introduction of IT in developing countries, and the concept of a knowledge bridge. Then we present the case study of a COP aiming at supporting the introduction of e-readers in Tanzania. Finally we give recommendations and draw conclusions.

## CHOOSING APPROPRIATE SUSTAINABLE TECHNOLOGY

Community Outreach Projects, as the name suggests, are intended to serve communities. The content and structure of the projects, as well as chosen technology, should address community needs (as identified through questionnaires, interviews, surveys, observations, discussions with community leaders, etc.). The E-Readers Project, used as a case study in this paper, was launched after a thorough community needs assessment (Arusha EcoLab, 2013b; Mwanga et al., 2013). Communities, however, are not always able to make a right choice of sustainable IT devices (due to lack of information) and purchase these devices (due to financial constraints), so they need help from governmental, non-governmental, or international organizations or as in the case under consideration, from institutions of higher education.

Project sustainability is one of the general challenges facing communities (as noted, for example, by Pouezevara, Mekhael and Darcy (2014)). There is a direct link between sustainability of the introduced IT itself and technical sustainability of the project introducing this technology. Technical sustainability of a project means that technical problems, even severe ones, do not lead to the termination of the project. Ideally, sustainable IT devices should not require any repair or replacement during the project lifetime and afterwards. Maintenance should be very easy and not require special skills. However, this ideal device does not exist yet. So technical sustainability does not necessarily mean that the project does not experience any technical problems at all, but those problems can be quickly and easily solved. This can be achieved through technical staff capacity building and selection of sustainable IT devices.

Sustainable IT is a technology that can work throughout the years without the need for repair or replacement. Sustainable IT currently mostly is understood as green IT. Murugesan (2008) states that green IT benefits the environment by improving energy efficiency, lowering greenhouse gas emissions, using less harmful materials, and encouraging reuse and recycling. Green IT refers to environmentally sound IT. Green IT also strives to achieve economic viability and improved system performance and use, while abiding by our social and ethical responsibilities. Thus, green IT includes the dimensions of environmental sustainability, the economics of energy efficiency, and the total cost of ownership, which includes the cost of disposal and recycling.

Computers, laptops and mobile devices with lower energy consumption and a longer life cycle would, a fortiori, be a right choice for projects run in the communities where resources (money, energy, learning/reading materials, etc.) are scarce. These are challenges other than project sustainability facing Tanzanian public schools, being part of a community, as identified by Nyirenda (2012): inadequate resources, lack of teaching and learning facilities, and inadequate infrastructure. The list of challenges facing schools was extended by members of Arusha EcoLab (an initiative group within Nelson Mandela African Institution of Science and Technology) at the preparatory stage of the project. Later on, this list was refined by the NM-AIST students as part of their exercise in needs assessment. The list of identified challenges faced by two primary schools — Nambala and Nganana — and proposed solutions, is shown in Table 1. Although the identified challenges (as shown in Table 1) are well-known to anyone who ever ran educational projects in Tanzania or came into contact with public schools, the requirements to IT devices to be introduced in two public schools were refined after discussions with some of the stakeholders.

***Table 1:*** *Identified challenges and proposed solutions for two primary schools in Tanzania*

| S/N | Challenge | Solution | Proposed IT device |
|---|---|---|---|
| 1. | Limited access to reading materials for both teachers and students | To provide reading materials as soft copies in an unlimited number of copies | IT device which allows to download and read texts, preferably also supporting graphics, audio and interactivity |
| 2. | Numerous power cut-offs or lack of power supply | To use IT devices which do not require stable and permanent power supply | "Green" IT device |
| 3. | The work environment is not conducive for both teaching staff and pupils | This problem cannot be solved only by introducing IT devices, however, using IT devices may increase motivation of teachers and pupils | IT device with a user-friendly interface which is easy to use |
| 4. | The number of teachers is not enough | Open, Distance and E-learning | IT device which allows interactivity and Internet access |
| 5. | Teachers are challenged with professional development | Open, Distance and E-learning, self-study using downloaded materials | Ideally it has to be an IT device which allows interactivity and Internet access. However, if such a device is not available/affordable, it could be any IT device allowing to download materials |

However, even modern, energy-saving, laptops need to be charged every several hours, which is not always possible given the conditions in developing countries. Thus there is a need for alternative devices that can be operational for several weeks without charging.

**Candidate Devices**

In this section, we provide a description and comparison of the most popular IT devices to support the educational process of schools in rural communities and evaluate them in terms of sustainability. Comparison of IT devices with traditional print books is left out of consideration, since each of the IT devices described in this section can carry thousands of books, as well as other educational materials, and, once purchased, can work for several generations of pupils. In the long run, IT devices will appear more cost-effective than traditional print books (WorldReader, 2012).

***Laptops***

The first known attempt to create a sustainable IT device specifically for developing countries has been undertaken in the One Laptop Per Child project (OLPC, 2014). The OLPC aims at providing children in developing countries with "a rugged, low-cost, low-power, connected laptop" (OLPC, 2014), giving them access to modern education. Laptops are sold to governments who then deliver them to schools. This computer is referred to as the XO computer.

The project is mostly run in Latin America (roughly two million children and teachers involved), with another 500,000 in Africa and the rest of the world. Although there are several African countries involved, this project is not supported by the Tanzanian government.

***Internet kiosks***

Internet kiosks is a widely applied model for the delivery of IT services to rural and poor populations, initially introduced in India and then extended to other developing countries. The important feature is ruggedness of these kiosks which helps to avoid destroying them by vandals. This feature also allows for minimum intervention to maintain kiosks. Services provided by these kiosks are delivered at a cost.

Internet kiosks are also found in countries of sub-Saharan Africa. The Rural Internet Kiosk (RIK) is an independent, self-contained, 100%-solar-powered kiosk, featuring three industrial-design computer terminals, an administrator terminal, and broadband wireless Internet connectivity (Kigoni & Ervin, 2010). The RIKs can provide the following development solutions to communities: eAgriculture, eCommerce, eHealth, eGovernment, eBanking, eLearning, relief services, local content creation, skills training, employment opportunities, independent local media, and knowledge exchange between developed and developing countries.

***Mobile phones***

The rapid growth of mobile communications and high penetration rates in Africa inevitably has led to the idea of using mobile phones in schools as a cheap and sustainable alternative to computers.

As it is indicated in the UNESCO guidelines (2013), given the ubiquity and rapidly expanding functionality of mobile technologies, they have a potential to improve and facilitate learning, particularly in communities where educational opportunities are scarce. Initiatives on mobile learning in African countries are numerous (see, for example, Brown, 2005; Kasumuni, 2011; Mafenya, 2011; Otto, 2011).

***Tablet computers***

Tablet computers are thought by many as perfect IT devices for schools. While schools in developed countries choose to buy iPads, schools in countries of sub-Saharan Africa are in obvious need for cheaper options. There was also an attempt to develop a tablet computer specifically for Africa (OLPC, 2014), the cost of which is still around 200 Euros. OLPC also recently introduced tablet computers as an alternative to their XO computers.

Main advantages of tablet computers, as compared to notebooks and netbooks, are a relatively long battery life (eight to 10 hours) and lightweight, while its screen size allows for easier input and reading than smart phones. However, the main issue here is that tablet computers still require to be charged every few hours, they are costly and not robust (can be easily destroyed).

***E-readers***

E-readers are electronic devices displaying digital texts such as books, pdf files, word processing documents, and a variety of other text formats (Barron, 2011). E-readers use e-Ink technology which, in contrast to a backlit screen, emits no radiation and achieves a level of text clarity and readability comparable with printed books. They can be used as an alternative to both traditional books and fully-functional computers in schools in developing countries if the main goal is to develop reading skills in pupils.

### Comparing the various devices

Table 2 presents a weighted comparison of the IT devices considered in the previous subsection, based on the following sustainability parameters: (1) energy consumption, (2) robustness, (3) weight, (4) functionality, (5) ease of use, and (6) cost. Each parameter was weighted on a 5-point scale, with 0 being worst and 4 being best.

***Table 2:*** *Comparison of sustainability parameters for different IT devices*

| S/N | Device | Energy Consumption | Robustness | Weight | Functionality | Ease of Use | Cost | Total |
|---|---|---|---|---|---|---|---|---|
| 1. | XO computers | 4 | 3 | 4 | 2 | 3 | 2 | 18 |
| 2. | Internet kiosks | 4 | 4 | 0 | 2 | 3 | 0 | 13 |
| 3. | Mobile phones | 3 | 0 | 4 | 2 | 3 | 3 | 15 |
| 4. | Tablets | 1 | 0 | 4 | 4 | 2 | 1 | 12 |
| 5. | E-readers | 4 | 3 | 4 | 1 | 4 | 3 | 19 |

From this table we conclude that e-readers exhibit the best value for technical sustainability and cost. XO computers are slightly more expensive, but possess better functionality. However, in case of Tanzania, the OLPC project supplying XO computers to schools has not been supported by the government. Thus, the most technically sustainable and cost-effective supporting technology for schools in Tanzania was e-readers. Additional advantage of e-readers is the ease of their use. They require less adaption from teachers and pupils than tablets, smart phones, laptops or even XO computers. Everybody, who could handle a simple mobile phone, could operate an e-reader.

Parameters given in the last column of Table 2 are only indicative. The exact choice of IT devices depends on the clearly identified community needs and might change from one community to another. In the case of two primary schools in Tanzania (considered in detail in the described case study), e-readers appeared to be the best choice.

## FRAMEWORK FOR THE SUSTAINABLE INTRODUCTION OF IT

In this section, we provide a framework for the sustainable introduction of IT. A theoretical framework (Merriam-Webster, 2014) is a set of ideas or facts that provide support for something (in our case, the sustainable introduction of IT). The general purpose of using frameworks is that these may be effectively used to represent conceptual procedures for understanding, modeling and managing decisional issues (Paoletti, 2014). Since the main focus of this paper is on sustainability of the IT introduction, the aim of this section is not only to propose models of the sustainable introduction of IT, but also to investigate how these models fit into one of the broader frameworks dealing with sustainability — the Driving forces-Pressures-State-Impact-Responses (DPSIR) framework (EEA, 2007).

The DPSIR causal framework adopted by the European Environment Agency (EEA) is used for describing the interactions between society and the environment. The DPSIR represents a systems analysis view: social and economic developments exert pressure on the environment and, as a consequence, the state of the environment changes. This leads to impacts on, for example, human health, ecosystems and materials that may elicit a societal response that feeds

back on the driving forces, on the pressures or on the state or impacts directly, through adaptation or curative action (EEA, 2007). The original DPSIR model is shown in Figure 1.

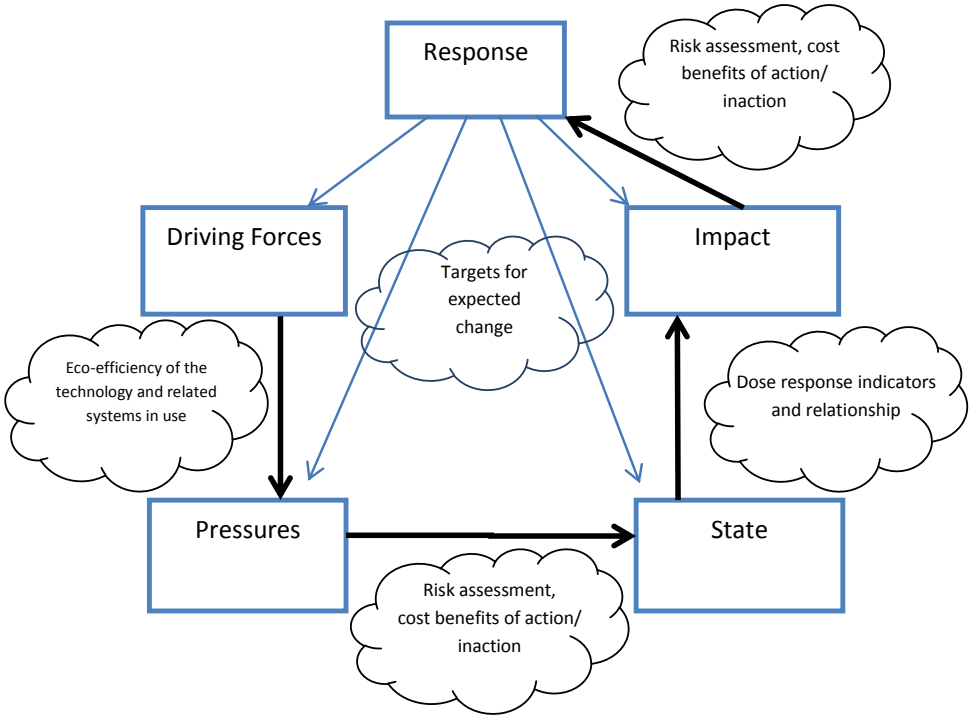


***Figure 1**. Original DPSIR framework (EEA, 2007).*

Components of the DPSIR framework were described by Paoletti (2014); we added the context of our study to this description, as follows.

1. Driving forces (D) are the major social, demographic and economic developments in society and the corresponding changes in lifestyle. In the context of our study, the driving force is the sustainable IT technology being introduced.
2. Pressures (P) are the effects of the driving forces, affecting the resources. In our context, the sustainable IT has to be introduced fast to achieve the best results in a short time. However, there are factors preventing the fast introduction, such as poor IT infrastructure, lack of technology knowledge, insufficient resources, lack of competent staff, organizational resistance to change, etc. Thus, the introduction of IT might put pressure on the project coordinators as well as on the benefitting partners.
3. State (S) is the state of the resources. The core input indicators for evaluation of the initial state of resources in ICT in Education projects are proposed by Wagner et al. (2007).
4. Impact (I) is evaluation of the state changes; in our case, evaluation of state changes is being done using core outcome indicators proposed by Wagner et al. (2007).
5. Response (R) is preventing, compensating or mitigating the negative outcomes of state changes. In our case, the response to the possible negative outcomes of the sustainable introduction of IT is a Community Outreach Project using the expertise from inside and outside the country. It takes the form of a knowledge bridge, as described in detail in the next subsection.

In the following three subsections, we describe the following models: (1) the model of a knowledge bridge, (2) the managerial model of the interactions between key stakeholders in a country where IT is being introduced, both inside and outside the beneficiary partnering organization, and (3) the model of impact of COP on target schools. The latter is a combination of the model of a knowledge bridge and the managerial model of the stakeholder interactions.

### The model of a knowledge bridge

The main assumption made in this research is that we consider a COP as a knowledge bridge between two (or more) partners in developed and developing countries. The concept of a knowledge bridge is introduced by Pscheidt and Weide (2010). We also assume that the transfer of knowledge happens mostly in one direction — from the more experienced partner to the less experienced partner. This does not necessarily mean that the knowledge is transferred from a partner in a developed country to a partner in a developing country; however, it holds in many cases, including the case of the E-readers Project which is described in our case study. Our last assumption is that successful establishment of a knowledge bridge contributes to sustainability of IT introduction.

We further assume that, at the initial stage of the IT introduction, the partner on the receiving end may demonstrate a lack of knowledge of the technology to be introduced (its maintenance, effective usage, impact, etc.), especially if the technology is introduced by leapfrogging. Thus, there is a need for skills and knowledge being effectively transferred from the more experienced partner (which we call "a knowledge partner") to the less experienced partner ("an intermediary partner"). The intermediary partner then further transfers knowledge to target schools (serving as an intermediary). We refer to this transfer mechanism as a knowledge bridge (Pscheidt & Weide, 2010). The model of the knowledge bridge is shown in Figure 2.

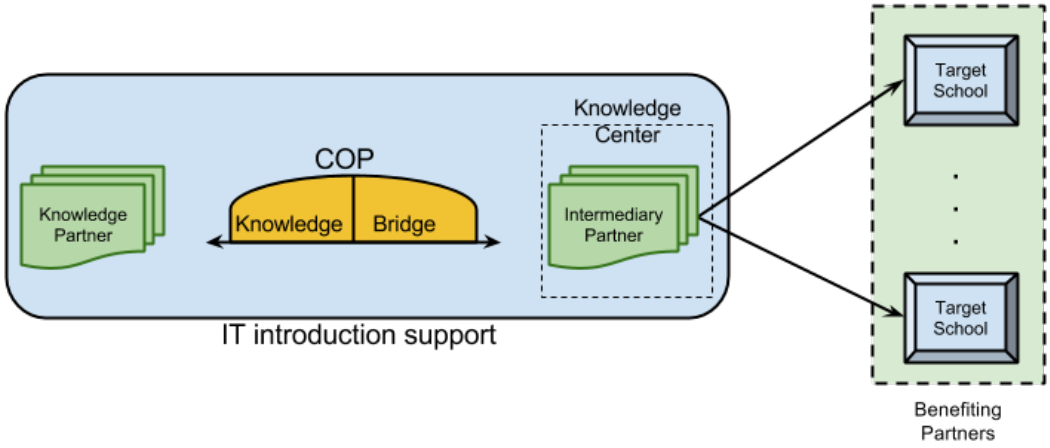


***Figure 2.*** *The model of a knowledge bridge.*

The knowledge bridge is intended for situations where, besides the actual introduction of IT (for example, at schools), there is also an overarching infrastructure to be build. The knowledge bridge connects two partnering organizations which may stand at totally different levels of development. Although knowledge is mainly transferred in one direction — from the knowledge partner to the intermediary partner — there is also feedback coming from the intermediary partner,

as well as country/ organization-specific information which cannot be obtained from outside the country. Many people in both countries are involved; we identified them as stakeholders.

The link between the model of a knowledge bridge and the DPSIR framework is identified in the later subsection “Mapping of the proposed models to DPSIR.”

**The stakeholder interaction model**

Identification of key stakeholders and their full awareness and involvement contributes to project sustainability. Knowing key stakeholders' interests, interdependencies, influence and potential impact helps to understand better how each of them can ensure that the project will continue after the financing stops.

For the introduction of IT in an educational environment, the following groups of key stakeholders have been identified: (1) the educational staff, (2) the learners, (3) the technical staff, (4) the product developers, (5) the donors, (6) the school management and (7) the government.

Our proposed model of stakeholder interaction describes an ideal situation where interactions between stakeholders are smooth, and stakeholders never fail to perform their tasks. This is not normally the case in real-life situations, but we assume it for the sake of modeling. In this ideal situation, the educational staff contributes to sustainability of the project by continuous professional development, increasing their ability to use IT in teaching, subject expertise and motivation. The learners contribute to sustainability by developing positive attitudes to learning, specifically, learning with the use of IT. The technical staff's capacity to maintain and repair the IT equipment ensures technical sustainability. The product developers contribute to project sustainability by providing relevant educational content and applications. They might also wish to provide their content and applications at a discounted cost or at no cost at all, thus contributing to financial sustainability. The donors might continue supporting the project in different ways (not limited to financial support) after the financing stops. The school management is to provide a systemic approach to ensuring project sustainability through capacity building, continuous training and professional development of teachers, providing incentives, encouraging and motivating teachers and learners to continue using IT, and taking care of school IT infrastructure. The function of the government (if it is not directly involved in the IT introduction) is to provide general support, to monitor content development (to be relevant to curricula) and to develop an IT educational framework.

The interactions between various stakeholders are depicted in Figure 3. Here the arrows indicate the causal influence relations. The figure shows that school management is influenced by the government, while the school management influences the educational staff, the IT department and the technical staff.

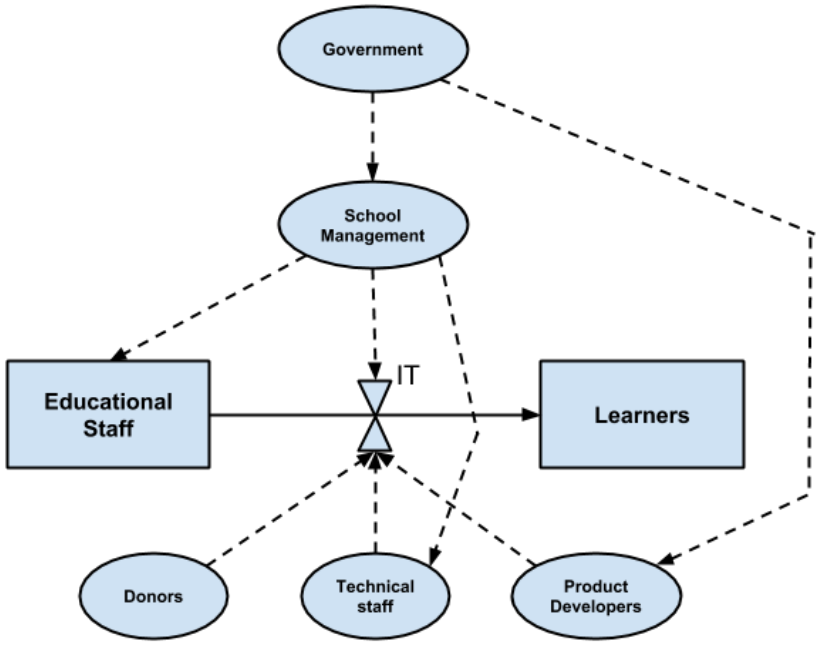


***Figure 3.*** *The managerial model of the interaction between stakeholders.*

IT support is modeled as a valve that monitors the transfer rate of knowledge and skills from the teaching staff to the learners. Via this valve, school management monitors the quality of the educational staff, support of the IT introduction and the supporting technical staff. School management is influenced by the governmental rules and policies. Support of the IT introduction is further influenced by the technical staff and the developed product/content. Product/content development, as it was mentioned before, is monitored by the government.

The donors play an important role in introducing ICT, running COP and providing sustainability. This role is not limited to financial support. In this paper, we concentrate on young professionals — namely students — who would donate their labor rather than their money. Support of the IT introduction by young professionals takes the form of a knowledge bridge. These young professionals can work on different levels as shown in Figure 4. This figure describes the standard abstraction levels of administration (Juran, & Godfrey, 2000).


***Figure 4.*** *The various levels of administration.*

During and after the project, at the strategic level the young professionals influence the school management by providing their recommendations on how to introduce and maintain IT, which leads to long term sustainability of the process as a whole. At the execution level the young professionals are involved in teaching classes and workshops. Later the young professionals will also grow into the managerial level and into the strategic level.

The link between the stakeholder interaction model and the DPSIR framework is identified in the later subsection “Mapping of the proposed models to DPSIR.”

### The COP impact model

In Figure 5, we show how a COP impacts the target schools.

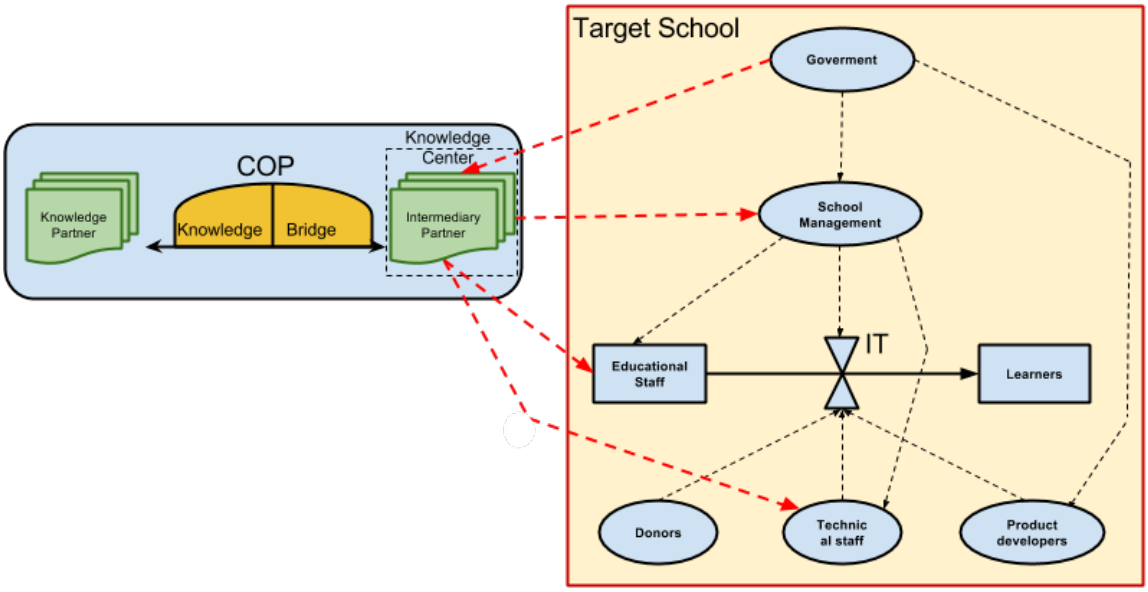


***Figure 5**. Model of the impact of the COP on target schools.*

The source of the impact is the intermediary partner, which then transfers knowledge to target schools. The government (if involved in the project) not only provides the context and budget for the project, but also the overall legislation, specifically educational policies. The intermediary partner directly influences school management, educational and technical staff. This allows the intermediary partner to have an impact at the strategic level (see Figure 4) via the school management, at the managerial level via the educational staff and at the execution level via the technical staff.

The link between the COP impact model and the DPSIR framework is identified in the next subsection “Mapping of the proposed models to DPSIR.”

**Mapping of the proposed models to DPSIR**

Table 3 shows mapping of the context of our study which is the sustainable introduction of IT to the DPSIR framework. It summarizes what was discussed in the section "Framework for the sustainable introduction of IT."

***Table 3:*** *Mapping the Sustainable Introduction of IT to the DPSIR framework*

| DSPIR | Sustainable Introduction of IT |
|---|---|
| Driving forces (D) | Sustainable IT |
| Pressures (P) | Pressures experienced by project partners and beneficiaries, when IT are introduced too fast and with insufficient resources |
| State (S) | The initial state is evaluated through core input indicators (Wagner *et al.*, 2007) |
| Impact (I) | The impact (state changes) is evaluated through core output indicators (Wagner *et al.,* 2007) |
| Response (R) | Community Outreach Projects taking a form of the knowledge bridge |

Driving force (D) is the sustainable IT introduction of which leads to the major social, demographic and economic developments in society and the corresponding changes in lifestyle.

Pressures (P) are the effects of the introduction of the sustainable IT. It might put pressure on both the project coordinators and the benefitting partners, especially if the sustainable IT has to be introduced quickly. There are also some other factors which might add to the experienced pressure, such as poor IT infrastructure, lack of knowledge of technology, insufficient resources, lack of competent staff, organizational resistance to change, etc.

State (S) is the initial state of the resources before the sustainable introduction of IT. It could be, for example, evaluated using the core input indicators for ICT in Education projects as proposed by Wagner et al. (2007).

Impact (I) is evaluation of state changes as a result of the sustainable introduction of IT. It could be done, for example, using core outcome indicators proposed by Wagner et al. (2007).

Response (R) is preventing, compensating or mitigating the possible negative outcomes of the introduction of the sustainable IT. One of the responses is a Community Outreach Project using the expertise from inside and outside the country. It takes the form of a knowledge bridge.

Table 4 shows the links between components of the models proposed in three previous subsections. The COP impact model is not included into the table since it combines components of other two models. The identified link is denoted as "X". If the link is not identified, the cell is left blank. Detailed descriptions of the identified links are given below.

The knowledge partner supports the sustainable introduction of IT through the knowledge transfer, but in some cases also financially (then they are also called *donors*). The knowledge partner experiences pressure due to lack of resources and expertise in the country where IT have to be introduced, especially if the introduction has to be quick. Normally, the initial state of the knowledge partner is not evaluated. It is assumed that the knowledge partner is able to introduce IT. The impact on the knowledge partner is not evaluated. In some cases it is the responsibility of the knowledge partner to evaluate the initial state of the beneficiary organization and the impact

of the sustainable introduction of IT on it. The response of the knowledge partner is to transfer the knowledge to the intermediary partner as part of the COP. The COP takes a form of the knowledge bridge.

***Table 4:*** *Identification of links between components of proposed models and DPSIR framework*

| S/N | Components of the proposed models | DPSIR Framework | | | | |
|---|---|---|---|---|---|---|
| | | D | P | S | I | R |
| The Model of a Knowledge Bridge | | | | | | |
| 1.1 | Knowledge Partner | X | X | | | X |
| 1.2 | Intermediary Partner | X | X | X | | X |
| 1.3 | Target Schools | X | X | X | X | X |
| The Stakeholder Interaction Model | | | | | | |
| 2.1 | IT | X | | X | X | |
| 2.2 | Government | X | X | X | X | |
| 2.3 | School Management | X | X | X | X | X |
| 2.4 | Educational Staff | X | X | X | X | X |
| 2.5 | Learners | X | X | X | X | X |
| 2.6 | Donors | X | X | | | |
| 2.7 | Technical Staff | X | X | X | X | X |
| 2.8 | Product Developers | X | X | | | |

The intermediary partner helps to introduce sustainable IT in target schools. The intermediary partner experiences pressure due to lack of resources and expertise. The initial state of the Intermediary partner might be evaluated in order to ensure that they are able to support the sustainable introduction of IT; however, the intermediary partner is not the main target of it. Thus, the impact is not evaluated. The response of the intermediary partner is to receive the knowledge from the knowledge partner and then pass it to the target schools.

The target schools benefit from the sustainable introduction of IT. At the same time they experience pressure due to lack of resources and expertise. The initial state of the beneficiary must be evaluated. The impact is evaluated as part of the monitoring and evaluation plan. The response of the target schools is to receive the knowledge and support from the intermediary partner within the country.

IT are the driving forces, and they are being introduced sustainably. The initial state of IT in the beneficiary partnering organization must be evaluated; however, in many cases, before the introduction, IT are not present at all. The impact must be evaluated as part of the monitoring and evaluation plan.

The government may do the following: (1) introduce sustainable IT, (2) sponsor the sustainable introduction of IT, (3) support the sustainable introduction of IT and (4) provide legal framework for introducing IT. It may experience pressures due to lack of resources and expertise. Intentions of the government may be misunderstood by beneficiaries and the general public, thus adding pressure on it. Some national educational and socio-economic indicators might be used to evaluate the initial state and impact, as suggested by Wagner et al. (2007). However, the government is not a part of a COP, thus there is no link with the response.

The school management helps to introduce sustainable IT and benefits from its introduction; however, they might resist change. They experience pressure due to lack of resources and expertise. The initial state of competences and the impact are evaluated as part of the monitoring and evaluation plan (Wagner et al, 2007). The school management receives knowledge and support from the intermediary partner.

The educational staff benefits from the sustainable introduction of IT; however, they might resist change. They experience pressures due to lack of resources and expertise. The initial state of competences and the impact are evaluated as part of the monitoring and evaluation plan (Wagner et al, 2007). The educational staff receives knowledge and support from the partner within the country.

The learners are the main beneficiaries of the sustainable introduction of IT. They experience pressures due to lack of resources and expertise, but to a lesser degree than other stakeholders (since they do not have to introduce IT or support this introduction). The initial state of competences and the impact are evaluated as part of the monitoring and evaluation plan (Wagner et al, 2007). The learners are on the receiving end of the knowledge bridge.

The donors support the sustainable introduction of IT by donating their money, equipment, expertise/knowledge or labour. They experience pressures due to lack of resources and expertise; sometimes their intentions are misunderstood by beneficiaries and the general public. Their initial state and impact are not evaluated. If only money or equipment is donated, donors are not considered as a part of the response. If donors provide their knowledge, they are considered as knowledge partners.

The technical staff supports the sustainable introduction of IT technically and also benefits from it. They experience pressure due to lack of resources and expertise. The initial state of technical competences and the impact are evaluated as part of the monitoring and evaluation plan (Wagner et al, 2007). The technical staff might receive knowledge and support from the intermediary partner.

The software developers support the sustainable introduction of IT by providing relevant software. They experience time pressures if software is to be developed fast. Their initial state and impact are not evaluated, and they are not a part of the Community Outreach Project.

The identified links between the widely adopted framework for sustainable development, such as DPSIR, and proposed models for the sustainable introduction of technology prove that those models “may be effectively used to represent conceptual procedures for understanding, modeling and managing decisional issues” (Paoletti, 2014).

## SUSTAINABLE INTRODUCTION OF TECHNOLOGY: CASE STUDY OF TANZANIA

There are several programs that offer schools in developing countries an opportunity to obtain a technology "push" from either inside or outside the country. Examples of such a push include mass establishment of computer labs undertaken by governmental or non-governmental organizations (Farrell & Isaacs, 2007) and the introduction of the 4G mobile technology (Deign, 2013). In this section, we discuss another example of a push, a substantial donation of e-readers in primary schools. As discussed before, e-readers are a reasonable choice for the introduction of IT in schools in developing countries. They require a rethinking of the teaching process but do not impose strong requirements on the infrastructure. Part of this introduction was done as a COP by Dutch and Tanzanian students.

As it was shown earlier, the introduction of technology will have a significant impact on education only if it is sustainable, meaning that organizations and individuals will continue with the projects on their own after financing stops. It requires a certain level of organizational maturity from the intermediary partner.

**Background of the E-Readers Project**

In order to address its motto "Academy for Society and Industry," the Nelson Mandela African Institution of Science and Technology (NM-AIST) located in Arusha, Tanzania, runs a number of projects, including the one which introduces e-readers in primary schools. The project was initiated by the members of Arusha EcoLab. The target schools in this project are two rural primary schools — Nambala and Nganana — located in the Arumeru district in close vicinity of NM-AIST.

***Project goals and measures***

The project activities included a community needs assessment, delivery of e-readers to two primary schools, uploading the relevant content, teacher training, and development and implementation of a sustainability plan. The implementation of a sustainability plan was done by the Dutch volunteers from Radboud University Nijmegen (RUN) who came after the project launch in August 2013. In future, those activities will be continued by further generations of Tanzanian and Dutch students.

***Table 5:*** *The project goals and measures to achieve them*

| S/N | Project Goal | Measures |
|---|---|---|
| 1. | To improve overall performance of teachers and pupils in subjects included into the primary school curriculum, leading to the better performance at Standard Seven, and, later, at Form Four and Form Six exams. | 1.1 To introduce the use of e-readers in primary schools as an alternative to traditional textbooks<br>1.2 To develop basic skills of using e-readers in primary school pupils<br>1.3 To provide relevant digital content in accordance with the curriculum |
| 2. | To increase teachers' capacity to teach and pupils' capacity to learn | 2.1 To give teachers the knowledge and skills to use e-readers in teaching the primary school curriculum<br>2.2 To develop basic skills of using e-readers in primary school pupils. |
| 3. | To achieve sustainability of the project | 3.1 To develop basic skills of safe using and maintenance of e-readers in primary school teachers and pupils<br>3.2 To involve parents and other members of the local community and create awareness on the use of e-readers among them |
| 4. | To overcome a negative impact of shortage of learning materials, lack of the Internet access and poor infrastructure in primary schools. | 4.1 To introduce the use of e-readers in primary schools as sustainable IT devices with reduced energy consumption<br>4.2 To identify and download relevant learning content (if necessary, to develop relevant content) and incorporate it into the primary school curriculum. |

The overall project goals and measures to achieve them as identified by the project coordinators are shown in Table 5.

These goals define phases and milestones in the E-readers Project long-term lifecycle.

***The initiation of the E-readers Project***

After assessing the needs of the two primary schools and choosing e-readers as most suitable and sustainable IT device, the members of the initiative group started the process of raising funds and purchasing e-readers (with the help of the non-profit international organization WorldReader). By joint efforts, the projects coordinators were able to purchase 300 e-readers. On April 23, 2013, the e-readers arrived at NM-AIST. Members of the initiative group, representatives of WorldReader, students and staff of NM-AIST started preparation for the project launch.

The project preparation stage included a detailed training needs assessment and training of the teachers and pupils. In the beginning of May 2013, questionnaires addressing the training needs were delivered to teachers in the two pilot primary schools. The total number of the respondents was 35, including 22 teachers in the Nambala primary school and 13 teachers in the Nganana primary school. Face-to-face interviews have been conducted with the school headmasters. This exercise was performed by NM-AIST students as part of their course on ICT and Development. The data collected from teachers and headmasters included their personal data (age, gender, qualifications, etc.), ICT literacy levels, subjects taught and training needs. Collecting and analyzing this data helped to tailor the training content to schools' needs.

The project preparatory stage culminated in the project inauguration on May 10, 2013. The two primary schools received 300 e-readers with 120 books each. The e-books were textbooks, story books, religious books and reference materials, some written in English and others in Swahili. The updates of the E-readers Project were disseminated via a weblog (Arusha EcoLab, 2013a).

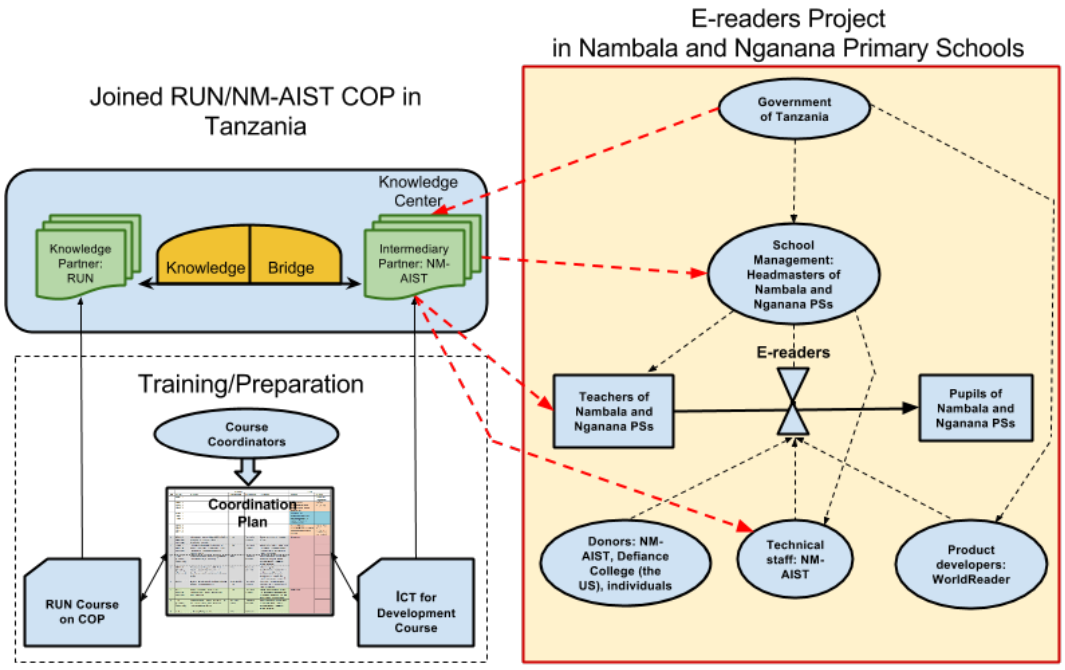


***Figure 6***. Application of the COP impact model to the case study of Tanzania.

In order to achieve better understanding of the interactions between stakeholders in the E-Readers Projects and joint RUN/NM-AIST COP, as well as links between these two projects, the general COP impact model (Figure 5) was applied to the case study of Tanzania. The result of this application is shown in Figure 6.

Figure 6, unlike the general model, includes preparatory courses which were important part of the RUN/NM-AIST. These courses are described in the next section, "Training for the sustainable introduction of IT."

**Training for the sustainable introduction of IT**

In the following three subsections, we describe the courses delivered at both universities at the preparatory stage of the COP. Not only were the time frames and planned activities different for students from the two countries; courses delivered in NM-AIST and RUN were different by their nature. While the ICT and Development course (NM-AIST) was mostly practice-oriented, the COP course in RUN combined theory and practice.

***The ICT and Development course (NM-AIST)***

While both universities are research-based, NM-AIST has only Masters' and PhD programs. The level of social conscience, motivation and ambitions of NM-AIST graduate and postgraduate students are very high as they prepare themselves to the role of champions of social change, technopreneurs and leaders. They are likely to question delivered learning materials as they always want to know how the delivered material will contribute to the development of their country as well as to their personal success. Thus, the students commonly demonstrate negative attitudes towards purely theoretical courses (especially those in humanities) which they consider useless. To keep students motivated, the course should be predominantly practical, touch upon sound social problems and include hands-on experience. Unfortunately, the majority of lecturers in NM-AIST has not yet grasped student-centered teaching approach and innovative teaching methods. They see their mission in delivering theoretical knowledge to be memorized by students. So the prevailing model of teaching and learning in NM-AIST is still lecturer-centered, in spite of the efforts to become a research-based university.

The ICT and Development course represents a different, student-centered, model. It involves problem- and project-based learning, active methods of teaching and learning, and learning-by-doing. It also requires a high degree of interaction between students and the lecturer, as well as between students and members of the communities.

The objectives of this course are as follows: (1) introduce the students to the idea of transforming people's lives through the usage of ICT; (2) introduce the students to the importance of the international cooperation; (3) identify the components of a successful ICT project; (4) identify factors influencing success and sustainability of ICT initiatives in developing countries; (5) introduce the students to the importance of monitoring and evaluation while running ICT projects, and (6) give the students practical skills for carrying out ICT4D projects, including monitoring and evaluation. All these objectives can be achieved through direct students' involvement in COP. Thus, the most important part of the course is practical — contributing to the E-readers Project.

The topics delivered in this course included: (1) the overview of existing Community Outreach Projects and their classification; (2) the role of ICT in transforming people's lives in developing countries; (3) the overview of recent ICT initiatives in developing countries; (4) the sustainability of ICT initiatives; (5) the critical success factors of ICT initiatives and components of a successful ICT project; (6) the importance of monitoring and evaluation of ICT projects and the practical

skills of monitoring and evaluation; (7) the emerging technologies in developing countries; and (8) ICT interdisciplinary projects.

The practical assignments given to NM-AIST students in 2013 and 2014 years were as follows: (1) situational analysis; (2) training and content needs assessment; (3) school teacher and pupil training; (4) uploading educational content to e-readers; (5) preparing the E-readers Project launch; (6) identifying factors contributing to project sustainability; and (7) monitoring and evaluation of the project.

***The RUN course on Community Outreach Projects***

The COP course at RUN focuses primarily on intercultural aspects of COP, with the Hofstede Cultural Model used as a main theoretical framework. The three week mini-internship in developing countries is considered mainly as a practicum for validating the Hofstede Cultural Model.

The first objective of this course is to make students aware of how they can add value to other people's lives and improve their situation by sharing and transferring knowledge and skills to those who are deprived of resources. The second objective is to teach students to appreciate a different culture by doing a project in another country, where circumstances are totally different, and values and traditions have another meaning than those values and traditions the students are familiar with. It gives them a deeper insight into their own values and stimulates reflection on their own position in society as future professionals.

The structure of the course is as follows (Zlotnikova & Weide, 2011). The theoretical part includes weekly lectures and workshops in which technological (IT), educational, entrepreneurial and cultural issues are discussed. Experienced speakers from the field (COP leaders) are invited as guest lecturers and trainers. This information helps students to formulate their own project plans. Then, during their summer vacations, students go to different locations for three weeks to implement their projects.

The RUN course consists of a number of blocks: (1) the cultural block, where the students learn to be able to interpret, understand and handle other cultures; (2) the educational block, in which the students learn to be able to define an educational program for another culture in a sustainable way; (3) the financial block, in which the students learn to be able to write a business plan for a small company; (4) the technical block, in which the students learn to understand IT maintenance policies and acquire some practical skills; and (5) the gender block, in which the students learn to understand different gender roles in the context of another culture.

At RUN, IT-based COPs not only are considered as a way of improving people's lives but also as an important tool for training students of different specialties — especially prospective computer engineers — to develop their professional soft skills. COPs have been run in RUN since 2006. Examples of the projects are (1) IT training and content development for secondary schools in the townships of Lusaka, Zambia, and (2) digitizing the archives of the City Hall in Gondar, Ethiopia. Some other countries where RUN students have participated in COPs are: South Africa, Uganda, Zimbabwe, India, Papua New Guinea, Nepal, Ghana and India.

***Coordination of the two courses***

Although coordination of the activities was rather complicated due to differences in course contents, delivery timeframes, connectivity problems (at the Tanzanian side), and even time difference between the two countries, these efforts paid back when the Dutch students came to Tanzania. They started working immediately after arrival, since they already were aware of the current situation in schools. Interaction with NM-AIST students added a practical facet to the

mostly theoretical course on COP run in RUN. Fragments of the activity coordination plan are given in Appendix A.

**Results and recommendations**

Based upon lessons drawn from the experience of running COPs in Tanzania, by joint efforts of NM-AIST and RUN students, we have formulated the following general recommendations on running a sustainable IT-based COP:

1. The contents of an IT-based COP must be socially sound and address the most pressing issues within local communities. These issues have to be identified long in advance before a visit of the international volunteers (needs assessment). This is one of the reasons why it is so important that the international participants have their local counterparts. Social soundness of a project is a guarantee that it will be continued by the members of local communities (social sustainability).
2. COPs, if possible, should be a part of a bigger project introducing IT. It could be not just one COP, but many of them run subsequently, by generations of students.
3. One of the factors contributing to sustainability of the COP is geographic location. The geographic location of a COP run jointly with a local university should be chosen, if possible, in a close vicinity of this university campus. First of all, running such a project will help create a positive image of the university among members of the local communities. Secondly, it will help with safe accommodation for international students (which is always the issue in developing countries). Lastly, if there is no need for travelling far from campus, the project sustainability will be ensured by continuous participation of generations of the university students.
4. The coordination of the project activities between local and international participants is a very important issue, especially if the time frames are different. Communication by e-mail and phone must be complemented by videoconferences. It helps to create the link between local and international participants. All project materials developed by one group of the participants must be made available to other group immediately. The easiest way to ensure the fast update of the materials is to upload them into a cloud.
5. Other recommendations for ensuring sustainability of a COP include increasing internal motivation of participants, distribution of functions between participants, peer-coaching teachers (or other categories of participants if a project is not educational) and getting parents — or other members of communities — involved.
6. To ensure the technical sustainability of an IT-based COP, it is necessary to come up with the sustainable technical solution. Our research shows that currently there is no IT device which is completely sustainable — that is, possesses all of the following properties: reduced energy consumption, longer life cycle, robustness, easy recycling, inexpensive, easy to carry and easy to take care of.

**The project's future**

The NM-AIST students and staff will continue working on the E-readers Project. If funding is available, the E-readers Project will be extended to other primary and secondary schools of the Arumeru district, and, later on, to other regions of Northern Tanzania. Monitoring and evaluation exercises will be continued on a regular basis. More students/volunteers from developed countries are expected to come this and following years.

The pilot project has shown that e-readers are not actually sustainable IT devices, since they can be easily broken. The other issue is the relatively high cost of the device. Thus there is a need for creating a truly sustainable device. This could be a research agenda for Tanzanian and Dutch students of computing specialties.

The limited functionality of e-readers is still an issue and may put up obstacles to their sustainable introduction in schools. Thus, there is a need for a both sustainable and fully-functional IT device which currently does not exist, but due to technological advances may appear any time soon.

## CONCLUSION

Based upon our experiences of running Community Outreach Projects, we have developed an approach to the sustainable introduction of IT in developing countries based on international collaboration between students taking the form of a knowledge bridge.

We have identified challenges for introducing information technologies in developing countries: the limited access to reading materials for both teachers and students, numerous power cut-offs or a lack of power supply; the work environment is not conducive for both teaching staff and pupils; the number of teachers is not enough, and teachers are challenged with professional development. Lack of reading materials ultimately leads to lack of reading skills in pupils and poor overall performance. We have presented a weighted comparison of the sustainable IT devices based on the following parameters: energy consumption, robustness, weight, functionality, ease of use and cost. The e-readers thus have been identified as the most sustainable option for schools in developing countries. However, as our research shows, up until now there has been no truly sustainable IT device; thus, there is a need for creating it.

We have proposed the theoretical framework for the sustainable introduction of IT comprising the following components: the model of a knowledge bridge, the managerial model of the interactions between key stakeholders, and the model of impact of COP on target schools. We also identified the links between the proposed framework and the widely adopted DPSIR.

As a case study, we have discussed the E-readers Project run in two primary schools in Northern Tanzania. In this project, e-readers have been used as a sustainable alternative to printed books and fully functional computers. The paper also has demonstrated how interaction and collaboration between Tanzanian and Dutch students was organized during the preparatory stage and project implementation. We have given our recommendations on how to run a sustainable IT-based Community Outreach Project. These recommendations have been drawn from the analysis of the COP experience in the developing country, namely Tanzania.

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## APPENDIX A. FRAGMENTS OF THE ACTIVITY COORDINATION PLAN

| | | NM-AIST | | | | RUN | |
|---|---|---|---|---|---|---|---|
| Wk | Date(s) | Activities | Responsible | Participants | Outcomes | Activity | Product |
| | 04.02.13 | | | | | | Admission Assignment |
| | 11.02.13<br>18.02.13<br>25.02.13 | | | | | Culture Block<br>*To be able to interpret, understand and handle other cultures* | Explorer Document |
| | 07.03.13<br>14.03.13<br>21.03.13 | | | | | Education Block<br>*To be able to define an education program in another culture in a sustainable way* | |
| | 28.03.13<br>18.04.13<br>25.04.13 | | | | | Financial Block<br>*To be able to help to write a business plan for a small company* | Project Plan Ch 1: Introduction and Context |
| 1 | 29.04.13 (Monday, morning) | Introductory lecture #1 on COP including examples of RUN COPs done in developing countries | Irina | Tanzanian students | Tanzanian students are aware of COP | No lecture | |
| 1 | 29.04.13 (Monday, morning) | Lecture and practical assignment on Needs Assessment (Assignment 1, Part I "Developing interview guides and questionnaires" | Irina | Tanzanian students | Tanzanian students know how to develop interview guides/ questionnaires and perform needs assessment | | |
| 1 | 30.04.13 (Tuesday, afternoon) | Presentation on E-readers Project from Dina Machuve (30 minutes) | Dina | Tanzanian students | The students are aware about E-readers project; ***Dina's presentation is sent to the Dutch students*** | | |
| 1 | 30.04.13 (Tuesday, afternoon) | Finalization of Assignment 1, Part I on Needs Assessment, discussion of developed questionnaires and interview guides | Irina | Tanzanian students | Interview guides and questionnaires are developed and discussed; Tanzanian students are ready to do needs assessment in schools | | |
| 1 | 2.05.13 | Visits to Nganana and Nambala primary schools, needs assessment | Dina, Patrick, Irina | Tanzanian students | Interviews are carried out, questionnaires are delivered, data is collected | | |
| 2 | 6.05.13 (Monday, morning) | Needs assessment analysis and presentation of results (Assignment 1, Parts II and III) | Irina | Tanzanian students | ***Needs assessment is carried out, results are analyzed and presented; presentations are sent to the Dutch students*** | No lecture | |
| 2. | 7.05.13 (Tuesday, afternoon) | Presentation of COP run in NM-AIST by Ms. Liliane Pasape, HoD, Business Studies and Humanities | Ms Liliane Pasape | Tanzanian students | The students are aware about COP in NM-AIST; ***Liliane's presentation is sent to the Dutch students*** | | |
| 2 | 7.05.13 | Lecture 2; Assignment 2 | Irina | Tanzanian | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (Tuesday, afternoon) | | | students | | | |
| 2 | 8.05.13 (Wed, morning) | Assignment 3 | Irina | Tanzanian students | | | |
| 2 | 9.05.13 (Thursday, afternoon) | ***Videoconference with Dutch students. Introductions. Q &A session. Discussion of the results of needs assessment.*** | Irina, Theo, Augustino | Students (all) | ***The Dutch and Tanzanian students introduced themselves. The Dutch students aware of the current situation in schools*** | | |
| 2 | 10.05.13 (Friday) | Launch of the E-reading project in Nganana and Nambala Schools | NM-AIST | Tanzanian students | ***The report on the launch to be sent to the Dutch students*** | | |
| 3. | 13.05.13 (Monday, morning) | Lecture 4. Sustainability of ICT Projects. Assignment 4. ***Project descriptions for COPs to be run in Nganana and Nambala primary schools*** | Irina | Tanzanian students | ***Project descriptions to be sent to Dutch students*** | | |
| 3. | 14.05.13 (Tuesday, afternoon) | Assignments 4 (cont'd) and 5 (Presentation of Project Descriptions) | Irina | Tanzanian students | ***Project description presentations are sent to the Dutch students*** | | |
| 3. | 15.05.13 (Wednesday , morning) | Lecture 5, Assignment 6 | Irina | Tanzanian students* | | | |
| 3 | 16.05.13 (afternoon) | ***Videoconference between Dutch and Tanzanian students. Discussion of presentations. Dutch students ask questions about schools, prospective projects, NM-AIST, Arusha and Tanzania in general.*** | Irina, Theo, Simone, Augustino (ICT) | Students (all) | ***Dutch students have received answers to their questions. Current situation in schools is discussed. The project topics and content are outlined.*** | | |
| 4 | 20.05.13 (Monday, morning) | Lecture 6, Assignment 7 | Irina | Tanzanian students | | | |
| 4 | 21.05.13 (Tuesday, afternoon) | Assignment 8 | Irina | Tanzanian students | | | |
| 5. | 22.05.13 (Wed, morning) | Lecture 7, Assignment 9 | Irina | Tanzanian students | | | |
| 4 | 23.05.13 (Thursday, afternoon) | ***Videoconference. Inputs from Dutch students on how to improve project descriptions. Outlining further actions*** | Irina, Theo, Augustino (ICT) | Students (all) | ***Dutch and Tanzanian students improved project descriptions based upon inputs for Dutch students*** | | |
| 5 | 27.05.13 (Monday, morning) | Assignment 10 | Irina | Tanzanian students | | HIV/AIDS lecture *To be able to understand the HIV/AIDS problematics,* | |