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Community-centered, Project-based ICT4D Education in the Field

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Abstract. The growing demand for user-centered, sustainable, collaborative and ecosystem-aware ICT4D programs and projects brings requirements for education of a new generation ICT4D professionals. This paper presents a post-graduate field-based course in ICT4D that teaches how to co-create and deploy community-centered ICT services. The course has been jointly organized and deployed by VU Amsterdam and UNIMAS in Sarawak, Malaysia for a mixed group of computer science, information science and artificial intelligence students from VU and UNIMAS. The course design, experiences and outcomes are presented in this paper.

Keywords: ICT4D education · Community Service Education · Information system development life cycle · Context · User-centered approach · Ecosystem awareness · Sustainability.

1 The need for skilled, hands-on ICT4D professionals

”Design with the User”, ”Collaborate”, ”Understand the Existing Eco-system”, and ”Build for Sustainability” are the new imperatives, set by the international donor community for the ICT4D practitioners community [15]. Formulated as the new ”Principles for Digital Development[6]” these requirements mark a trend towards more agile, user-centered, and innovation-oriented approaches in ICT4D projects and practice (e.g. [14, 4, 9]). The trend results from the concerns about high failure rates in donor-funded ICT4D projects, especially where projects target the poorest populations and regions [10].

However, bringing agile, collaborative, user-centered approaches into practice in poor low-resource development environments is a challenging endeavour. Low resource, development regions may have lack of (physical, digital, energy) infrastructures, there may be high illiteracy rates, low purchasing power, or a variety of other complex social, economic, cultural or environmental factors [11, 1]. In recent years, new, user-centered approaches to ICT4D and Digital Development have emerged that use state-of-the-art

[6] See: https://digitalprinciples.org/

concepts, theories and methods from e.g. agile Information Systems (IS) engineering e.g. [5, 7, 12, 2]. These approaches can guide operational, socio-technical ICT4D developments in challenging and demanding development contexts. However, bringing with these frameworks into practice requires field experience and social, technical and organizational skills. Where do ICT4D professionals obtain these skills and knowledge?

Currently, ICT4D education at graduate or post-graduate levels is oriented at social, economic, development or policy studies[7]. These ICT4D curricula do not train ICT4D professionals for field-based information systems/requirements engineering under complex,real world conditions. Technical studies such as computer science, artificial intelligence and information science have traditionally focused on technology development for the "wealthy", connected world, and have not yet included ICT4D in their curricula. However, new trends in ICT4D policy and technological innovation are demanding a new type of ICT4D education, that caters for social, technical, practical and organizational skills and delivers professionals with hands-on and reflective attitude.

In this paper we present the design and implementation of a new type of community-centered, project- and field-based ICT4D education. The paper is structured as follows: in section 2 we discuss the theoretical framework to be used for course design. In section 3 we outline the course objectives, structure and assessment criteria; in section 4 we illustrate this with a case of a field-based post-graduate ICT4D course which was deployed in June 2018 at the University Malaysia Sarawak; in section 5 we discuss the evaluation and the outcomes and give recommendations and perspectives for further adjustments and deployments.

2 Theoretical frameworks for practical and societal ICT4D education

In terms of course design, an appropriate theoretical framework for designing and rolling out community-oriented, field-based ICT4D education is (Community) Service Learning (CSL) [3]. CSL is specifically designed to connect theory and practice and meet challenging social problems while educating students for a life as responsible citizens [3, 6]. CSL uses an experimental learning methodology, that integrates meaningful community service with instruction and reflection to enrich the learning experience, learn civic responsibility, encourage civic engagement and strengthen communities for the common good [13]. Moreover, CSL is useful for field-based operational ICT4D, as it combines two different (but related) goals: (i) an educational goal based on learning-by-doing and reflection (ii) a societal goal to serve the community, by co-creating meaningful solution.

In terms of ICT4D content, a theoretical framework and user-centered and context-aware approach that covers the full information system (IS) engineering life-cycle is "ICT4D 3.0" [2], see Figure 1. This approach is substantiated by extensive field research and collaboration with local communities in rural regions of West Africa and can guide practical, field-based and hands-on sociotechnical ICT4D. It includes meth-

[7] See educational programs in ICT4D: e.g. https://www.manchester.ac.uk/study/masters/courses/list/06237/msc-icts-for-development/ or https://www.oii.ox.ac.uk/blog/tag/ict4d/

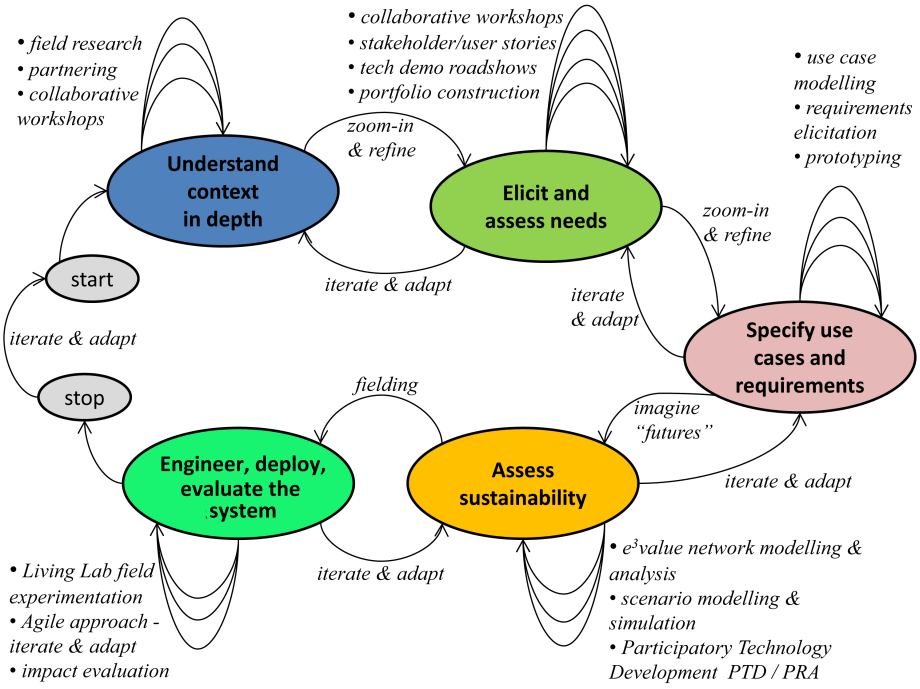

Fig. 1. ICT4D 3.0 Framework [2] how to build ICT services in low resource environments using a collaborative, adaptive, iterative approach, from Bon et al. 2016.

ods for field-based context analysis, use case and requirements analysis, design, modeling, iterative building and testing, and sustainability assessment. ICT4D 3.0 can be used as a learning-by-doing approach.

3 Designing a post-graduate course: ICT4D in the Field

Based on the theoretical frameworks CSL for education and ICT4D 3.0 for content we designed a post-graduate ICT4D course. This consisted of setting course objectives, defining content, methodology, admission criteria and assessment method. The course design is evaluated by its implementation.

3.1 Course objectives

Based on the above considerations of section 1, we formulated the course objectives as:

- to make the next generation of information and computing scientists aware of the potential role of ICTs for the developing and emerging world, with a strong appreciation for the highly diverse and complex contexts (in contrast to a one-size-fits-all-approach), social-cultural factors and human needs that must be addressed;
- to equip students with relevant field research and development methods and skills to develop technologies in a (poor) rural/suburban community/developing region;
- to acquire and reflect on the experience of carrying out a full life-cycle of a real-world software development project in the field, learning to be able to deal with unfamiliar and complex contexts, and engage with communities with their specific contextual constraints, needs and goals.

3.2 Course structure

Based on the time available (a 6 ECTS course equals one month of full time education), the course takes 4 weeks for field research and designing, modeling, engineering, testing and deploying an information system, that must serve a local community's need.

The course comprises lectures, field visits to (rural or sub-urban) communities where the envisaged users live and work. Interviews and focus group discussions, user test and feedback sessions are part of the course assignment(s). The course starts with lectures in which important topics are reviewed: (i) use case, context and requirements elicitation and analysis; (ii) conceptual modelling of information systems; (iii) selected technical aspects of ICT4D projects; (iv) value modelling and economic sustainability analysis; (v) guidelines and protocols for interviewing and focus group discussions with local communities. Based on meetings with user groups and context analysis in the field, students form teams (of 4-6 persons). Each team selects a relevant use case to elaborate, build a prototype, test with the users, evaluate, improve and deploy. Sustainability analysis and value modeling are part of the assignment. Students work in self-organizing teams, dividing tasks and working closely together. Users must be involved to make sure their needs and (business) requirements are met. The course involves reflection and open dialogue. The constraints and opportunities of the real world context are taken into

consideration. The students interact and receive daily feedback from the lecturers. At the end of the course the results of the project are presented by the student teams to the users, local experts and other stakeholders, during an official symposium.

3.3 Assessment

Assessment of the student work is based on four types of deliverables:

(i) a personal (individual) reflection about the course and the student's role in the process, and what he/she learned from it. Deliverables for each team consist of: (ii) a working information system/app, tested and validated by key users, documented and available as Open Source (group work); (iii) a group presentation/pitch during the end conference. (iv) a technical report containing the following items:

- Context description;
- High level system design and user scenario;
- A justification of the project (short);
- Interviews typed out (not necessarily literal), containing relevant info (e.g. all user and business requirements, key points, important details etc.);
- A use case and analysis report according to the structured narrative format including a stakeholder analysis, a system architecture, information concepts (activity diagram, class diagram, user interaction diagram, deployment diagram), summary of requirements in MuSCoW terms; fidelity.
- A sustainable value model/multiple scenarios using e3 value (quantitative assessment of sustainability);
- Report of user tests (preferably two cycles);
- A reflection of the (iterative) process, and user interactions with the group (how were the interviews);
- A discussion section on the outcomes and what aspects of the project need further research.

3.4 Soft and hard selection criteria for admission

To be admitted to the ICT4D in the Field course students must dispose of technical (programming, modeling, requirements engineering) skills and social/communication skills. Moreover, a specific attitude is expected as well: openness to other cultures, willingness to collaborate in an interdisciplinary team, a hands-on mentality, a social orientation and a reflective nature.

4 The case of "ICT4D in the Field" in Sarawak, Malaysia

To improve/adjust the course design, the course is implemented and evaluated. This was done in June-July 2018, at UNIMAS, in Sarawak, Malaysia. The initiative to set up a joint "ICT4D in the Field" post-graduate course started in 2015, during talks between VU Amsterdam and UNIMAS. At VU an interdisciplinary ICT4D research program had been running since 2009[8]. VU was offering since 2013 an elective (6 ECTS)

[8] The Web alliance for Regreening in Africa, http://w4ra.org

classroom-based ICT4D course in the master tracks of computer science, information science and artificial intelligence, in which the field component was clearly lacking. In 2015 VU had set up a working group to promote and roll out Community Service Learning, with the ambition to include it in every educational curricula of VU.

UNIMAS had been engaged in ICT4D research since 1999 through the eBario and Long Lamai projects that aim to connect remote communities in Sarawak. Community service learning was also part of UNIMAS' educational curricula. To share experiences and learn from each others strengths, a joint ICT4D course was set up, by collaborating researchers from both universities.

In June 2018 eleven master students computer science, information science and artificial intelligence from VU joined a group of ten computer science students from UNIMAS in Sarawak, Malaysia for a one month ICT4D project-based field course, by a joint VU/UNIMAS lecturers team. The course was hosted at the UNIMAS campus. Here the students followed classes and did their group assignments on a daily basis. Various field work and community visits took place in the environment.

4.1 Context analysis

To learn about the local context, the students and lecturers visited a banana plantation and a small banana factory, talked to inhabitants of sub-urban community (kampung) PJ and visited a community primary school. Focus groups discussions and various interviews with users led to a list of project ideas. Three mini-ICT4D student projects were selected, that were both relevant for the community and technically feasible as an ICT4D student project. They were dubbed (i) BannaTree, (ii) Appong and (iii) EDUCOMX. The projects are briefly described in the following paragraphs. The full student reports are available at https://w4ra.org/student-papers/.

4.2 BannaTree student project

During the context analysis field visits the students learned that the government of Sarawak wants to increase income and standards of living of banana contract farmers. This is done by providing support to banana chips factory and improving the work conditions of contract farmers. The contract farmers plant and harvest bananas called pisang sekaki. These are sold to small local banana chips factories, where they are processed and packed for (international) export.

Analyzing use case and user/business requirements: According to the interviews with farmers and other experts, banana crop yields are poorly planned at the moment. Lack of information on timing and amount of expected crop yields leads to planning problems for the factory, waste of bananas for the farmers and supply inconsistencies for the banana chips export. To improve coordination and logistics between farmers and chips factory, the students proposed an information system with a mobile users interface: the BannaTree application. The information system and information processes were modeled by the students according to the users and business requirements they collected.

Much attention was given by the students to stakeholder analysis, and to understanding their operational goals. To understand the complete use case and elicit the

exact requirements for the system. They modeled the complete work process and information flows. Many discussions were held with key experts and users.

Iterative building of the app: The prototype system was discussed with the banana farmers, representatives of the banana factory, fertilizer experts, the agricultural department and a key expert from UNIMAS. The discussions led various times to changing requirements and two major redesigns of the system in a week time. The first working prototype of the BannaTree application was delivered in the third week of the course to two local experts.

Reflection: The students became aware of the complexity of (sometimes opposite) interests from various stakeholders on this use case. The requirements changed several times, making the time to really finalize and finetune the application a stressfull activity for the last few days before the deadline. The team learned much from the complexity of the use case and discussed together their roles as reflective practitioners. The project was ready in time but the final delivery test to the banana farmers was unfortunately cancelled due to external reasons.

Delivering the system: The full BannaTree project is documented and can be downloaded[9]. BannaTree was a joint project of VU and UNIMAS students[10].

4.3 The Appong student project

The second use case, dubbed Appong, consisted of a need of (independent smallholder) sugar palm farmers, to increase the sales of their product: Gula Apong.

Needs assessment: From interviews with the kampung inhabitants, in the first course week, the students learned about *Gula Apong*, a traditional Malaysian sweet/sugar, produced from the Nipa palm by family farms in the mangrove forests along the estuaries of the Sarawak river. The Nipa juice is collected manually, and produced (boiled) locally, in the forest. The work here is challenging: there are ants and snakes in the forest. When the tide is high, the mangroves are a dangerous place for the farmers, risking crocodile attacks. The government wants to support these small producers, because Gula Apong producers protects the mangrove forests, which are environmentally protected areas of important biodiversity. Moreover, there is a growing consumer market for Gula Apong which needs further exploration.

Analysing the use case: A mobile app might help to increase sales of Gula Apong, while stimulating cooperation between the producers in this region. The app must allow producers to enter information about current Gula Apong offerings and sales locations. This will facilitate and improve marketing and sales of Gula Apong. Meanwhile,

[9] See for source code and documentation https://github.com/aoelen/banna/blob/master/README.md, accessed 10 October 2018

[10] BannaTree is developed by: Allard Oelen, Aron van Groningen, Amir AziziMusa, Deva Ramakrishnan, Hameedat Omoine, Linh Tran.

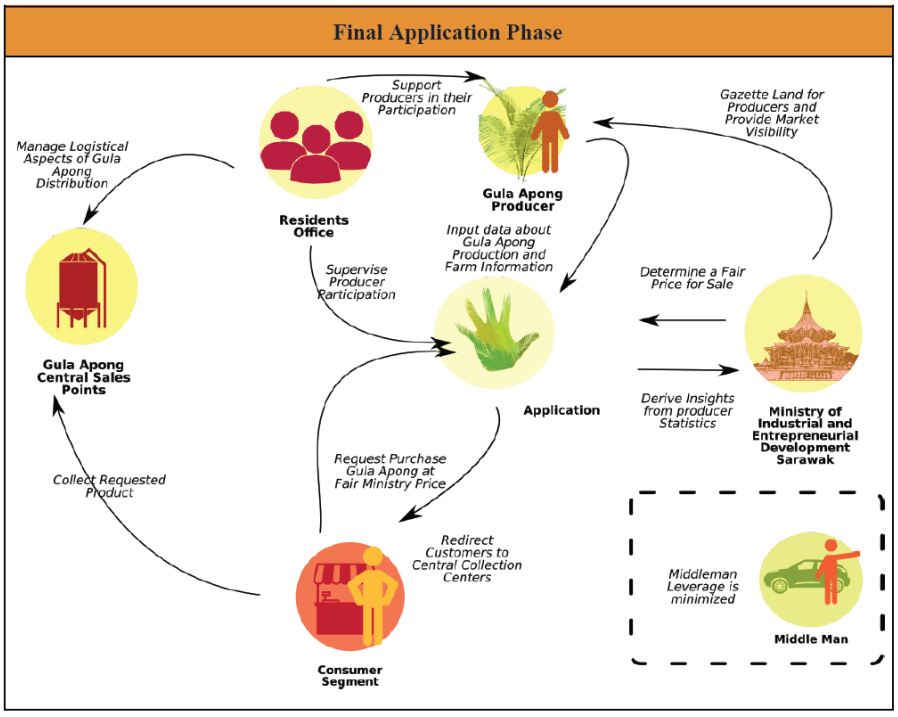

Fig. 2. Use case analysis modeled for the Appong project, by student group 1

the government wants to monitor the sales of Gula Apong to support the farmers by providing them rights to harvest in the public mangrove forests, in return for their production data.

Context analysis: The Appong use case and project was tackled by a mixed group of students from VU and UNIMAS[11]. The group held interviews at the Ministry of Industrial & Entrepreneur Development (MIED) in sarawak, and visited Gula Apong farmers in the mangrove forest. They saw how the farmers collected Nipa juice and observed the production and packaging of Gula Apong at home. They visited the farmers' homes, to get to know the local livelihoods.

Sustainability analysis: The economic feasibility of the Appong application is assessed using the e3value methodology [8]. One of the possible business models is given in Figure 3. The e3value method maps the actors (or market segments) in a value network, the value they exchange with each other, and calculates for each actor the income this generates. This model can evaluate quantitatively the feasibility of a complete value network.

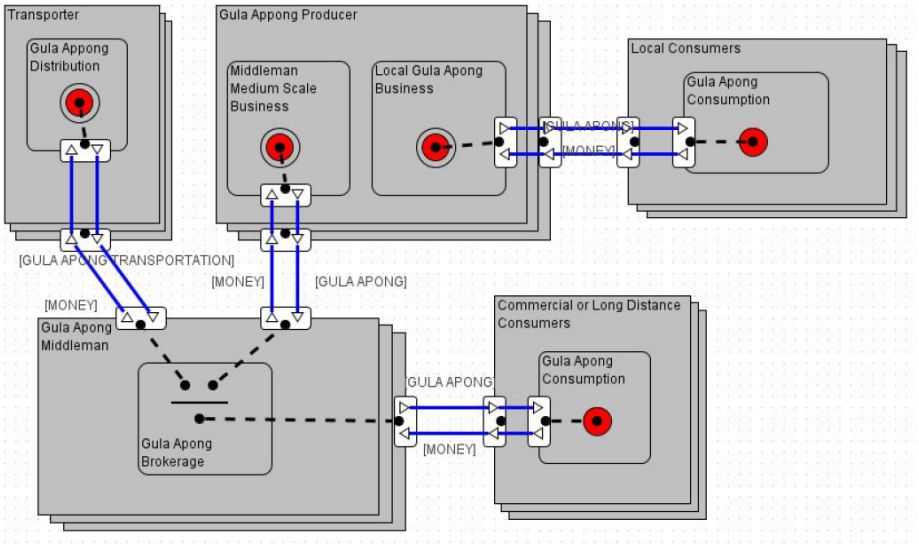

Fig. 3. The current value model for the Gula Apong business, by student group 1

4.4 The EDUCOMX student project

During interviews with parents, school teachers and children in Kampung PJ, the ICT4D students learned that, although English is widely spoken in urban areas of Malaysia, in

[11] The Appong project was developed by Kuan Huiggy, Giorgi Kikolashvili, Judith Schermer, Chris Valladares.

poor rural areas English education at primary schools lags behind the urban (private) schools. Since school subjects such as science and math are taught in English, poor knowledge of English limits the education of rural children even more.

Needs assessment: Learning English is considered of key importance according to the parents and school teachers, who were interviewed by the students. Since educational resources at public schools are not sufficient, alternative learning methods are sought. The students propose a mobile Smartphone app, (as most of the families here in the kampung own a SmartPhone, despite a lack of Internet connectivity). The app, built by a mixed group of VU and UNIMAS students is dubbed EDUCOMX[12]. The app can be run on SmartPhone or on OLPC's XO laptop, as UNIMAS has deployed a number of XO's for user tests.

Design decisions based on contextual issues: There are two main contextual issues that influence design decisions: (i) connectivity and (ii) specificity. First, in rural areas there is no (consistent) internet access, making online content not a design option. Second, the now existing digital learning platforms are not tailored to the local culture or specific wishes of the end users (the children).

Iterative building the app: The students decide to build EDUCOMX as a pilot mobile app to teach children English. They try to make the app engaging, while staying in the scope of the English learning methods used at school. For the use case and requirements analysis, the students meet a group of children in the kampung, and ask them to draw their favorite superheroes and write down their hobbies and aspirations, as inspiration for the artwork that will be used for the reading material of the app. This process has great significance in context analysis – as taught by the ICT4D 3.0 framework – user interviews and stories are often deciding factors in the success of an application deployed in the field.

For EDUCOMX, gamification methods are used, as a game will unconsciously help you to improve your level of English. First of all, the design looks playful and includes animations, sounds, fun colors and images. A scoring system is also implemented. Users (children) can continue through chapters that look and feel like game levels, which they have to complete successfully in order continue to the next one. There are status bars that show progress and scores of the user.

Testing the app with children: After one week of building and lab testing, the first user tests for the prototype were carried out in Kampung PJ with a group of 21 children in the style of a living lab. The children were able to freely play with the application, see Figure 4. Their age range was 10 – 12. The children liked the concept of the comic books and started to read the sentences aloud so it was good to hear their reading skills. The questions at the end were a bit difficult for them. We noticed that there were too many pages before the quiz started so after some pages they were having a hard time concentrating on reading. The children seemed to enjoy unlocking new chapters and

[12] EDUCOMX is developed by Guusje Boomgaard, Anastasios Sidiropoulos, Ludwig Hoon and Nip van Wees.

Fig. 4. Testing the EDUCOMX app with children in the kampung. EDUCOMX is platform independent. Here it has been deployed on OLPC's XO.

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were really motivated to get all questions correct. They started to share answers with other children to help them unlock new chapters as well. They liked the sound effects of answering the questions correctly. Another thing we noticed was that when they wanted to return to the homepage, the logout button was at a wrong place on the screen and should be moved. A demo of the EDUCOMX project can be assessed[13].

4.5 Project results

The three student groups delivered their project reports and full deliverables in time and presented their projects (i) at a community ceremony at kampung PJ and (ii) at a final ICT4D conference at UNIMAS. Personal reflection reports were also submitted. All students passed the assessment[14]. A short videoclip on the making-of the student projects can be seen at https://w4ra.org/2018/06/28/a-living-lab-in-kampung-pinggan-jaya-sarawak-short-clip/.

5 Evaluation and conclusion

In line with CSL principles, evaluation of the ICT4D course is done along two axes: (i) is the course successful in achieving its educational course objectives? (ii) are the ICT4D projects carried out in a community-centered way and do the results meet the needs of the local communities?

To evaluate if (i) the educational goals were met, we want to evaluate if this course makes the next generation of information and computing scientists aware of the potential role of ICTs for the developing and emerging world, with a strong appreciation for the highly diverse and complex contexts, social-cultural factors and human needs that must be addressed. Based on the student assessments, the reflection reports and the group deliverables, the course " ICT4D in the Field" has achieved its societal goals. Based on the outcomes of the three ICT4D projects, it can be said that they have collaborated sufficiently with the users, learned from the context, and worked iteratively, while testing and improving the technological solution according to the users needs.

To evaluate if (ii) the project meets the requirements of community-orientation and context-sensitivity, it is difficult to compare outcomes of the three projects which are not comparable due to differences in stakeholders and their operational goals.

Concerning lessons learned and future work about what was effective, and what can be improved, it is clear, in terms of serving the community, with a proper ICT4D project, that one month is far too short to do a full context analysis, engage with the users, build a long term relationship and really deploy a working information system. We can consider this course, in terms of ICT4D 3.0, a first cycle deployment with a number of sub-iterations. It is important to foster the long-term partnerships and work with local partners. The long relationship between UNIMAS and the local communities is key in the successful collaboration. The collaboration between the two universities (VU and UNIMAS) was very fruitful due to high commitment at both sides.

[13] See at https://tinyurl.com/yddldu8p, accessed 10-1-2018.

[14] The three project reports can be assessed at https://w4ra.org/student-papers/

A great challenge for the long term sustainability of the course is to find funding mechanisms. Another point is planning the right time for the course. Organization of a course between two continents is an interesting experience, but also takes a lot of effort and time. For the lecturers the lecturing effort is heavier than in regular courses. In terms of community service orientation, the project is only a first step towards sustainable ICT4D solutions. Continuation of the project is needed and more time to build up long lasting partner relationships with the communities and achieve long term sustainability of the deployed solutions. The majority of student reflection reports all show that the whole experience of designing, building, deploying community-oriented ICTs in a poor rural community has been life-changing.

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