ICT4DEV FOR THE SOCIAL AND ECONOMIC DEVELOPMENT OF MOZAMBIQUE

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Abstract

This paper introduces ICT4Dev (Information and Communication Technologies for Development), a joint project between Politecnico di Milano and Universidade Eduardo Mondlane in Maputo (Mozambique), funded by the Italian Agency for Development Cooperation. The project aims to: (i) improve the ICT-related skills of students and faculty members at the Universidade Eduardo Mondlane, (ii) strengthen the development of innovative IT applications in the context of development initiatives, (iii) support the birth and development of new entrepreneurship, and (iv) help develop a knowledge network among research centers. ICT4Dev also wants to contribute to the reduction of the gender gap in Mozambique.

Questo articolo presenta ICT4Dev (Techologie dell'Informazione e Comunicazione per lo Sviluppo), un progetto congiunto tra il Politecnico di Milano e l'Università Eduardo Mondlane di Maputo (Mozambico), finanziato dall'Agenzia Italiana per la Cooperazione allo Sviluppo. Il progetto mira a: (i) migliorare le competenze relative alle TIC di studenti e docenti dell'Universitá Eduardo Mondlane, (ii) rafforzare lo sviluppo di applicazioni informatiche innovative nel contesto di iniziative di sviluppo, (iii) sostenere la nascita e lo sviluppo di nuova imprenditorialità e (iv) aiutare a sviluppare una rete di conoscenze tra i centri di ricerca. ICT4Dev vuole anche contribuire alla riduzione del divario di genere in Mozambico.

Keywords

ICT, Higher education, Development, Mozambique.

Introduction

Information and Communication Technologies are often considered key enablers for the achievement of the United Nations' Sustainable Development Goals [1], but they can also help us live better lives. Ponelis and Holmner state that Africa must improve and extend the use of ICTs for capacity-building, empowerment, governance, and social participation, but these technologies are also useful for strengthening scientific research, sharing information, and for creating culture (Ponelis and Holmner 2015). Digital technologies can play a prominent role in economic and social transformation in Mozambique and ICT4Dev (Information and Communication Technologies for Development), aims to play a role in it.

This project funded by AICS (Italian Agency for Development Cooperation) and implemented by Politecnico di Milano (PoliMi) and Universidade Eduardo Mondlane (UEM) in Maputo (Mozambique) addresses some of the issues related to the development of ICT in Mozambique. It responds to the needs for training and skills building in a rapidly evolving sector, to support the development of ICT applications that can foster, govern, and boost the social and economic development of the country. More specifically, ICT4Dev covers a wide spectrum of activities aimed to train students and faculty members and encourage entrepreneurial initiatives. The final goal is to contribute to the development of a new culture of novel, cutting-edge information and communication technologies.

The project was conceived by the Dipartimento di Elettronica, Informazione e Bioingegneria (DEIB) of the Politecnico di Milano in collaboration with the Universidade Eduardo Mondlane. The project then involves DEIB, as for PoliMi, and the Informatics Center (CIUEM), with the Innovation Space, and the Faculties of Science and Engineering, as for UEM. The activities are coordinated with AICS in Maputo for technical assistance, monitoring, and assessment. AICS Maputo is directly responsible for the activities related to entrepreneurship support, together with the Innovation Space.

The project started on June 1st, 2021, and it is being managed and administered in Maputo and in Milan in close cooperation between the parties and according to the administrative and financial rules dictated by AICS. The bilateral agreement signed between PoliMi and UEM in January 2022

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[1] "ICTs as a catalyst for sustainable development", https://sdgs.un.org/events/icts-catalyst-sustainable-development-28937.

was the last step to enact planned activities. The limitations imposed by the pandemic and other constraints significantly hurdled the first months of ICT4Dev, but during the rest of the first year which is the time frame covered by this paper, partners did everything possible to carry out the activities initially planned in the description of work.

The pandemic has severely impacted the different activities since the outset, from the delayed signing of the agreement to international mobility on both sides: from Maputo to Milan for UEM faculty members to attend master courses and start PhD programs, and from Milan to Maputo to offer planned training activities at UEM. We were forced to adopt a flexible hybrid model to start implementing educational and research activities, shifting smoothly from remote to in-person activities as needed and imposed by external events.

The rest of the paper is organized as follows. Section 2 contextualizes the project and tries to link it with the Sustainable Development Goals set by the UN. Section 3 sketches the main goals of the project and the corresponding concrete actions. Section 4 discusses the foreseen outcomes, while Section 5 discusses how results are being evaluated and communicated. Section 6 summarizes the key results achieved so far, and Section 7 concludes the paper by identifying the next steps.

Context

With widespread poverty and vulnerability, Mozambique ranks 181 out of 190 countries as for the Human Development Index. After an impressive decade of economic growth, from 2016 the country entered an economic crisis recently exacerbated by the COVID-19 pandemic. The crisis has provoked severe job and income losses both in the formal and informal economy. Half a million new job seekers have been entering the labor market every year (Lachler and Walker 2018), and evidence shows that there is a mismatch between the skills supplied by Mozambique's formal education and vocational training systems, the skills youth and women need for (self) employment and those required by companies in fast-growing sectors. This mismatch between supplied and required skills, along with the reduced competitiveness of Mozambique, can result in the country forgoing the significant, upcoming employment opportunities: if well managed, they can produce, directly or indirectly, 1.5 million jobs in the next 15 years (World Bank 2021).

Mozambique has the lowest mobile Internet cost in sub-Saharan Africa (1.97USD per gigabyte) with a 50.4% mobile phone penetration rate (Gilbert 2019). Regulatory reforms have fueled competition in the telecommunication market, and mobile broadband penetration has been growing rapidly in recent years, with some 16 million Mozambicans who have access to mobile broadband (Digital 2021). It is estimated that the associated economic benefits of ICTs have reached up to 370

million USD, 2.7% of the total GDP created in Mozambique during the period 2012-2019 [7]. In addition, 40.3% of companies registered in Mozambique operate with their own website, close to 10 points above the average of sub-Saharan African countries (World Bank 2019). Improved digital connectivity is one side of the coin. On the other side, the desired transformational impact on social development and inclusive growth can only be achieved if it is combined with improvements in digital literacy and skills, support to start-ups and existing businesses, and access to other digital services (e.g., payment and financial services). According to the World Bank: "With such capabilities, the Mozambican economy can harness digital data and new technologies, generate new content, link individuals with markets and with government services, and roll out new and sustainable business models" (World Bank 2019). Economic opportunity and inclusive growth must also work on creating a "safety net" that safeguards the inclusive growth from being overshadowed by the economic opportunity.

In this context, ICT4Dev aims to address some of the key issues related to the development of ICT in Mozambique, with particular emphasis on training and skills building. By developing relevant skills capable of realizing the potential of the ICT sector in Mozambique, the project is expected to contribute to the economic development of the country, create new jobs, reduce inequalities, and make progress on diverse UN's Sustainable Development Goals (SDGs). ICT is intended as enabler for the achievement of all SDGs, but ICT4Dev aims to contribute specifically to:

- Ensure by 2030 equal access for all women and men to affordable and quality technical, vocational, and tertiary education, including university (SDG 4.3)
- Increase substantially by 2030 the number of youths and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs, and entrepreneurship (SDG 4.4)
- Enhance scientific research, upgrading the technological capabilities, and expanding higher education scholarships in ICT and engineering offered to students and researchers (SDG 4.8)
- Develop the industrial sector in Mozambique, encouraging innovation, and increasing the number of research and development workers (SDG 9.5)
- Share knowledge and cooperation for access to science, technology, and innovation (SDG 17.6)
- Strengthen the science, technology, and innovation capacity (SDG 17.8).

In the context of the SDG Voluntary National Review processes in 2020, Mozambique has defined a National Framework of SDG indicators, with specific targets to 2024 and 2030 for several SDGs (Republic of Mozambique 2020). Drawing from these National Indicators, we have chosen a few relevant impact-level SDGs indicators of interest for the project: Number of students in tertiary

education per thousand inhabitants (M/F) (4.3.1), Proportion of adults and youth with ICT skills, by type of skill (M/F; Age) (4.4.1), Research and development expenditure as proportion of GDP (9.5.1), Researchers per million inhabitants (M/F) (9.5.2).

ICT4Dev in a Nutshell

ICT4Dev aims to train students and faculty members and support the creation of a cultural environment that enhances the use of ICT for the economic and social development of Mozambique. More specifically, the project intends to:

- Improve the knowledge, skills and abilities of students and faculty members in the broad area of ICTs at UEM, through theoretical and practical training initiatives, scientific and technical innovation, and entrepreneurship support. The involvement of female candidates is key to contribute to the reduction of the gender gap in Mozambique.

- Strengthen the capacity of developing IT applications to support and promote the development of projects in fields like e-Government, e-Health, e-Commerce, e-Agriculture, and e-Learning.

- Support the birth and development of new entrepreneurship initiatives and culture in the ICT sector to meet the needs of the country, with attention to overcoming the existing gender gap in the access, use, and knowledge of ICT.

- To help develop a scientific and technological knowledge sharing network with Italian, African, and other ICT research centers to create useful synergies and stable collaborations.

To pursue these high-level objectives, ICT4Dev is organized around three main threads, each with its dedicated activities and outcomes.

ICT4Dev wants to train students, professors, and researchers on new ICT technologies for the development of innovative solutions to problems in different sectors of society. The training plan includes short-term summer courses for students in Mozambique, participation of Mozambican professors in six-month (13/14 weeks) master's degree courses at PoliMi, and the training of PhD candidates at PoliMi. The research and specialization areas will be chosen so that they can be applied to the Mozambican context and reused within master's courses at UEM. The project is also supposed to investigate possible improvements to the curricula currently taught at UEM. This activity is further articulated through the following actions:

- Realization of short intensive courses (Summer School),
- Participation of UEM professors and researchers in master's degree courses at PoliMi,

- Attendance of PhD program in information engineering at PoliMi,
- Support for the realization and supervision of degree theses at the Innovation Space,
- Realization of IT applications using the results of the research carried out,
- Calls for ideas to promote the creation of ICT4Dev-related start-ups by students and researchers to foster self-employment.

ICT4Dev plans to equip the business incubator with furniture and instruments to allow start-ups to carry out their activities by using the services they need for a period of one year. UEM and AICS have plans to launch a business incubator at the Innovation Space, to allow for the application of innovative solutions to concrete societal problems. The business incubator will offer the possibility of creating start-ups to students and researchers who present appropriate initiatives. This activity is further articulated through the following actions:

- Acquisition of supplies and IT equipment to allow the innovation space to incubate start-ups,
- Communication campaign and selection of business ideas,
- Participation of the Innovation Space in national and international competitions.

ICT4Dev aims to position the Innovation Space within a national and international collaborative network of research centers in innovation and communication technologies (for development). The Innovation Space promotes (virtual) seminars on ICT, called ICT4Dev talks, and invite people from the UEM's ecosystem to attend them. ICT4Dev organizes specific events, called Marketplaces of Needs and Ideas, where university, companies, and other institutions can meet identify and discuss novel solutions for social development. Project members will participate in international seminars to be exposed to and become part of a wider community, and to gather similar experiences in other contexts. The final goal is to become part of a network of national/international research centers to widen its capabilities, exchange know-how, and share experiences. This activity is further articulated through the following actions:

- Creation of the "Marketplace of Needs and Ideas",
- Stipulation of research and innovation agreements with international research and development centers,
- Participation in international seminars.

Outcomes

This section identifies the main outcomes foreseen by the project in terms of both training activities and support to and development of the Innovation Space. As for the first part, we start by sketching the methodology identified to carry out related activities. The second part focuses on the main actions foreseen to give more visibility, opportunities, and energy to the lab.

Training methodology

The training methodology adopted by the project is based on active and participatory teaching methods applied through advanced collaborative classroom techniques, that is, based on active groups assisted by experts. The didactic objective is to transfer the main ICT-related theoretical and practical knowledge. The different types of training activities are also supposed to insist on the ability to work in groups to address problems, design solutions, and produce results.

Furthermore, teaching activities are aimed to emphasize the importance of innovative research. They have been designed to form students to acquire new knowledge by means of basic and applied research, mainly in the form of homework and individual/group projects, to be able to manage self-learning practices in the future. The culture of research and its ability to always update and enrich the training activities is a distinct feature of the proposed methodology.

Finally, the methodology also tries to emphasize soft skills: besides focusing on computer science, ICT4Dev wants to expose students to the social, economic, and cultural issues that need to be known to address the economic and social problems of their country by means of ICT.

The training methodology is therefore closely integrated with the set of activities that will be undertaken by the project as for research, practical development of projects, collaborative relationships with national/international research centers, marketplaces of needs and ideas, and participation in international conferences. Teaching and academic activities are held in English, while dissemination actions are both in English and Portuguese, to ease the participation of the local stakeholders. The evaluation is of a continuous type (formative evaluation) and of a final type (summative). The first has the goal of constantly adapting the teaching methods to the characteristics of the students, the second takes place by examination or by final evaluation.

The proposed training offer is divided into four levels, each aimed at specific groups of beneficiaries: undergraduates, graduates, PhD students, and professors and researchers serving at UEM.

Summer schools, PhD program, and training activities

The summer schools in Maputo are aimed at university students in the last years of degree courses in Computer Science, selected through a public competition. They comprise two/three intensive courses for classes of 25 students each. These courses are divided in 20 hours of classes, along with 40 additional hours of individual exercises and project development. After the classes, students develop specific projects to apply what learned over the course.

Two/three summer school courses are planned to be held annually for the development of innovative software solutions (for example, mobile technologies, Web-based systems, data management and mining, and machine learning techniques). The actual content of the courses will be decided year by year, based on the needs of UEM and the availability of instructors.

The selected teaching methodology follows the practical approach of learn-by-doing. The teachers are supposed to assist and guide the students' work at both individual and group level. Each edition of the summer school will focus on the development of specific software projects. Greater participation of women in courses is promoted, giving priority to female enrollments with equal merit, to possibly reach a higher percentage than that of the university courses of origin.

The training of PhD candidates at PoliMi is aimed to: (i) acquire the skills necessary to carry out highly qualified activities at universities, public bodies, or private subjects, (ii) develop scientific and technological progress, and (iii) shape people with a high-level professional culture and a corresponding international openness. In particular, the course proposes a suitable path for the training of professionals capable of developing high quality and innovative research-oriented solutions to development problems. This also moves in the direction of helping UEM to become a research-lead university and an international hub for the country and for the geographical area in general.

Because of the initial delays, the project can only support one PhD candidate. The scholarship, which is part of the structural agreement between UEM and PoliMi, allows the student to spend most of the PhD program in Milan and become part of one of the research groups at DEIB, where he is required to carry out study and research activities on topics of interest for the project.

The candidate was identified through a public selection process coordinated by AICS. The winner has been enrolled as PhD student at DEIB, where he was presented some alternative research projects for his PhD studies. The program requires the compulsory attendance of doctoral courses at the Politecnico in collaboration with world-renowned researchers. The courses range from research methodologies to specific elements related to current scientific topics.

The professional training and development for UEM professors and researchers on teaching and research topics is based on their active involvement in the initiatives carried out by the project and

on the collaboration between Mozambican and Italian professors and researchers. ICT4Dev plans to support these activities by research periods of UEM faculty members at PoliMi (some six months per visit) and by PoliMi professors at UEM for short periods and for focused courses.

The goal is to establish a Mozambican-Italian research group, with interests in the different areas of ICT for development, and that can last after the end of the project and can become the spark for many other initiatives. The cooperation between specialists who work in different fields and with different backgrounds, and who can see the same problems from different angles, is fundamental to obtain proper results with social and economic impact.

Curricular revision at UEM

Given the project has no resources to incubate and start a new master's program, ICT4Dev aims to support UEM to review and ameliorate their bachelor's and master's programs with the goals of (i) helping them provide their students with a better offer, (ii) fostering a multi-faceted approach towards the adoption of modern and sustainable ICT solutions for development, and (iii) providing the seeds for additional courses and degrees (outside the scope of the project).

The bachelor's degree at UEM lasts four years and provides a wide and well-articulated coverage of the main ICT topics and technologies, with more emphasis on the theoretical basis, instead of insisting on particular technologies, which can always be learnt afterwards. There is not much the project can contribute here: maybe more attention to soft skills and a wider variety of project proposals directly related to sustainability and development could help the students get better opportunities to complete their studies. Instead, the master's program has room for improvement, even if the project has no dedicated budget to support any concrete action. Similarly to what is offered in Italy, the current master's program lasts two years and is divided into two phases: the first year is dedicated to more theoretical courses, while the second year is spent on applied research and preparation of the final thesis. The total number of credits is 120, and there are two specializations: information systems and software engineering, which sound a bit dated today.

The actions proposed by ICT4Dev are moving into three parallel threads. First, we propose the addition of further courses and threads related to data science, computer and cybersecurity, and machine learning and AI in general. The second thread refers to the addition of soft skills needed to address social innovation and development not only from a technical perspective, but towards a more inclusive and complete approach. The master's program could provide students with a combination of skills, both technical and contextual, in the field of ICT for development,

sustainability, and social innovation. These courses should include both theoretical and practical aspects: the goal is to both provide the basis and ask the students to apply them on the development of projects aimed to the creation of innovative software solutions related to e-Government Systems, e-Health, e-Business, smart agriculture, and social inclusion. The soft skills could add capabilities towards project and business management, oral and written presentations, innovation management and entrepreneurship, and socio-economic development. While rooted in computer science, the newly shaped master would be in line with the most advanced training courses on ICT for development and would follow a training approach that values the promotion of human rights, gender equality, environmental protection, social inclusion, and sustainable development.

The final dissertation, pre-condition for earning the degree, could be based on the development of a significant project, carried out in strict cooperation with important stakeholders in the country. This could be a win-win solution, where stakeholders propose projects and ideas, and students develop them by adopting modern technologies and use their enthusiasm to carry out new and appropriate solutions. Being developed by students, the costs of these proof of concepts would be limited and the stakeholders would have a proper means to carry out experiments with novel ideas and trends.

The last hypothesis refers to the opportunity of exploiting existing teaching material to complement some of the deficiencies of the current system. Nowadays, many universities offer online courses (and PoliMi is one of them): if ICT4Dev were able to solve both the linguistic barrier (most of these courses are taught in English) and the problems related to the fees behind these courses, this could become a feasible and quick solution to diversify the current offer.

An additional aspect ICT4Dev might try to address is the scarce appeal the current master's program has for potential students. We must consider the context and the fact that students have already spent four years to get the bachelor's degree. We must also consider that local companies tend to hire young professionals as soon as they are available, and a master's degree could then become an unneeded delay. The hope is that a more diversified offer, aligned with some of the current trending topics, more emphasis on soft skills, and a more application-oriented approach could help change the perception and could attract more students.

Strengthening of the Innovation Space

The Innovation Space is an important hub for training and research initiatives and activities. It is the place where selected stakeholders will be able, through dedicated meetings (Market Place of Needs and Ideas), to identify the actual needs and put forward ideas and proposals for their

implementation. The Innovation Space, through the involvement of students, researchers, professionals, and entrepreneurs, is a center dedicated to developing innovative solutions for these needs and will be paired with a business incubator (outside the scope of this project) to offer those who propose innovative solutions the tools required to develop their business ideas.

The Innovation Space wants to ease the access to a wide audience of students and faculty members from different areas and economic and social categories, as well as of potential entrepreneurs. A key additional goal is also to become a viable means for bringing women closer to ICT-related opportunities.

ICT4Dev is supposed to help the Innovation Space establish collaborations with other similar hubs and research centers in Africa and Europe, with the aim of sharing mutual experiences. UEM students are being able to use the premises of the Innovation Space to prepare their final dissertations, with the support of Italian and Mozambican professors and researchers involved in the activities of the project.

Evaluation and communication of obtained results

All activities are governed by the technical and administrative project managers and by more focused and dedicated project groups. In addition, obtained results are monitored constantly to understand how the project is developing and progressing, possible problems and bottlenecks, and significant deviations. This is achieved through systematic data collection and their analysis, periodic meetings with all involved parties, and online collaboration tools to allow for an always-updated view of the project's activities.

As for communication (of obtained results), UEM is giving wide visibility of the initiative through press release, institutional web sites and social networks, seminars, workshops, and public competitions for the selection of involved students, personnel, and professors. The Innovation Space is promoting the initiative in the ICT business sector to organize the Marketplace of Needs and Ideas, where businesses and civil society meet to identify and propose innovative solutions for social development by means of ICT.

In terms of external communication, ICT4Dev is following the orientation of the AICS Communication Guidelines to convey the progress of the initiative and the achievement of results and objectives through web channels (UEM, PoliMi, and AICS) and media (Mozambicans and Italians). The project is also contributing to the achievement of the strategic objectives of the Italian

Cooperation with the involvement of the relevant stakeholders to demonstrate the effectiveness and relevance of the intervention.

First Results

Even if all first-year activities were delayed because of the pandemic, the project managed to devise alternative plans, when needed, to carry out what foreseen over the first year. Some of the activities had to be postponed, and we are pretty sure we can catch up if no new unforeseen huge events happen. The main activities planned and carried out so far are:

- We have been working from the very beginning on creating a comprehensive, synergetic, and well-balanced project group. This also meant identifying all key figures and setting up all modern tools needed to work cooperatively in a very distributed context and be able to share documents and artifacts properly. For example, we have an initial web site (ict4dev.uem.mz) to both communicate results and advertise open positions.

- We organized different online events ---through Zoom--- to let people become aware of the project, and to start the promised dissemination activities. We then organized special-purpose events to present the PdD program in computer science and the master's courses taught at Politecnico in the context of the master's degree in computer science and engineering. We also organized four ICT4Dev talks to start presenting some of the research activities carried out at DEIB.

- We organized the first summer school in Maputo in July/August 2022, even if it was planned for January/February. We taught: Web development with Python and Django (20 students, 31.6% female), Mobile applications with Flutter (22 students, 19% female), and Data Mining (24 students, 17.4% female). We had a total participation of 66 students to the three courses, an average participation of 25% female students, with roughly 45% of students who successfully submitted their final projects on time and completed the courses.

- After selecting a first PhD candidate, he started the PhD program in May, and has also started attending classes and joined the DEpendable Evolvable Pervasive Software Engineering (DEEP-SE) group at PoliMi.

- We launched a first call for ideas in June, and we collected some seventeen expressions of interest.

- After distributing the list of master's courses taught at PoliMi, UEM faculty members expressed interest in attending some of them. The colleagues attended different courses online during the first semester of the academic year 2022-23. The plan is to be able to host them in Milan for

the second semester to foster in-person attendance. The total number of attended courses by UEM staff foreseen for the first semester is 18 and 14 for the second semester.

- Finally, we also started preliminary analysis of existing curricula in computer science at UEM, and some of the initial outcomes and proposals have already been reported in this paper.

Next Steps and Conclusions

This paper presents ICT4Dev, the context in which it is operating, its envisioned organization, and the main expected outcomes. After a bit more than one year, out of a project's duration of three years, we have also identified the activities we carried out, even if most of the project was severely delayed because of some internal problems and because of the COVID 19 pandemic.

The first year has also been useful to know and understand each other. While the project proposal was written long ago and with just on physical meeting, the first activities gave us the opportunity to become aware of the different contexts, needs, and habits. We wanted to work together, but we had to understand how, we had to create a team of motivated people and to learn to behave as a cohesive team. We had long-lasting meetings to always decide and act when the deadlines were almost over.

The group is now settled, and the project is on the right track. We must still coordinate better and learn that we can work asynchronously through mails and shared documents, but things are improving. If we can get back to a "new" normality, we are confident we can continue implementing the project as originally planned, catch up with the delay, and pave the ground to a very fruitful cooperation and develop additional, unforeseen results within the context of the project and beyond.

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