Dual Engineering Study Program with Focus on Sustainability in Cote d’Ivoire

Charlotte Newiadomsky, Lukas Saars, Arne Graßmann
Hochschule Niederrhein, University of Applied Sciences
Germany
email: charlotte.newiadomsky@hs-niederrhein.de

Ahoutou Paul KOUAKOU
University NANGUI
ABROGOUA, Côte d'Ivoire
email: kouakoupaul.sfa@univ-na.ci

Abstract

The access to electricity and water in rural areas in Côte d’Ivoire as well as in large parts of Africa is limited. According to Ivorian government sources, the national coverage rate of drinkable water and electricity was about 80% in 2020, whereas there are differences between rural and urban regions. The coverages are lower in rural areas that are situated far from the governmental infrastructures.

The poor supply of electricity also hinders education, since petroleum lamps are often the only source of light for learning after sunset. Besides, increasing demand for electricity is predicted in Côte d’Ivoire due to economic growth. The economic power is also affected by the poor supply of electricity, so only a limited production of goods is possible.

A further big concern in Côte d’Ivoire is the employability of graduate students, as the educational system has a strong theoretic character, not yet taking enough into account practice orientation. Scientific public universities in Côte d'Ivoire often offer only subjects such as mathematics, physics, or chemistry but hardly any engineering.

Although the unemployment rate of the total labor force with advanced education was only about 12% in 2017, the labor market cannot provide enough skilled jobs in several economic sectors (e.g., renewable energies) (World

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Bank Group 2017). As a result, graduates often start to work in sectors that do not require the special knowledge of their former studies.

This paper presents some solutions to tackle these problematics in Côte d'Ivoire by implementing a dual study program that combines practical and theoretical teaching modules with a focus on renewable energies and water supply. It can make an important contribution to combating the high unemployment rate among graduates and at the same time can accelerate the expansion of renewable energies and water supply infrastructure and increase the security of supply in Côte d'Ivoire.

Introduction

Africa is a priority region in the World Energy Outlook 2019 to provide a robust, evidence-based platform for energy decision-makers (International Energy Agency 2019). The "Sustainable Africa Scenario" of the African Energy Outlook 2022 wants to achieve universal access to affordable electricity by 2030, although 43% of the total population lacks access to electricity at present (International Energy Agency 2022).

Many studies have already concluded that access to electricity and water in rural areas in Côte d'Ivoire as well as in large parts of Africa is limited. As an example, in 2020 around 70% of the total population in Côte d'Ivoire had access to electricity, whereas it was nearly 95% of the urban and only 43% of the rural population (The World Bank 2022).

In 2020, around 71 % of the total population was using at least basic drinking water services, of which 85% of the urban and 56% of the rural population. In contrast, only 35% of the total population (55% urban and 15% rural) could use safely managed drinking water services (The World Bank 2022). One of the main causes of this disparity is the lack of infrastructure in rural areas.

The supply of electricity and clean water are closely intertwined and leads to direct interdependencies and impacts (Newiadomsky and Tietze 2017). This conflict can be complemented by other areas, such as education.

The sometimes long and time-consuming supply chain for potable water, which is largely handled by adolescents, especially girls, severely limits the educational and training opportunities of those affected (Noubactep 2016; Mitsubishi UFJ Research and Consulting Co., Ltd. 2013). The poor supply of electricity also hinders education, since petroleum lamps are often the only source of light for learning after sunset.

The economic power is also affected by the poor supply of electricity, so that only a limited production of goods (e.g., with the help of electrical tools) is possible. Besides, increasing demand for electricity is predicted in Côte d'Ivoire due to economic growth (International Energy Agency 2019).

In most of the public universities in Côte d'Ivoire, learning is more theoretical than practical. The courses given are certainly very complete but the laboratories for practicing physics or other scientific subjects are not equipped. The collaboration between universities and companies is almost inexistant. This makes it difficult to find a job after studying.

According to Yapo (2018), the integration rate of graduates in Côte d'Ivoire was only 14.43% in 2016, which means that almost 86% of these graduates were unemployed. Interestingly, the average overqualification rate in Côte d'Ivoire is 29.69%, whereas workers with secondary and higher general education are more affected by overqualification (38.15% and 30.68%) and especially women are more exposed than men (30.97% versus 29.25%).

As it is shown, many graduates in Côte d'Ivoire are not able to work in their original profession. One main problem is, that the labor market cannot provide enough skilled jobs in several economic sectors (e.g. renewable energies). As a result, graduates often start to work in sectors that do not require the special knowledge and skills of their former studies, so a quick adaption to the field of work is necessary.

Human resources managers at Ivorian companies are often convinced that the knowledge of university graduates is based on a purely theoretical foundation. Therefore, it is believed in industrial human resources management that graduates are not ready to enter the industry because their practical experience is still lacking. In general, graduates start to work as a trainee in industrial companies for around two years after graduation, in order to be considered full employees. As a result, universities and companies in Côte d'Ivoire very rarely work together or enter into long-term collaborations.

The practical relevance is the biggest advantage of dual study programs. The main goal is to enable students to simultaneously gain theoretical knowledge and learn from practical work in a local company in the field of e.g. energy or water supply. Students who study in dual programs already gain a lot of work experience during their studies and are prepared for professional life in terms of working experience. Currently, there are no dual study programs in Côte d'Ivoire, although they have great potential to strengthen cooperation between universities and companies and

reduce unemployment rates among graduates. This and the fact that the Ivorian government has issued optimistic targets for the expansion of renewable energies were decisive for the development of the project idea and concept.

2. Project Concept

The main goal of the project is to set up a dual master's study program with a jointly developed curriculum between the University NANGUI ABROGOUA (Côte d'Ivoire), the Hochschule Niederrhein (Germany) and companies, which enables its graduates to build, modify, install and operate systems in the fields of "renewable energies" and "water supply". The first generation of students is expected to develop, build and commission a prototype for an electricity and water supply system as part of practical teaching modules in the study program. Together, teaching modules (involving external expertise, partner universities and business partners) are to be developed on the basis of a set of specifications in which the following questions, among others, are to be answered:

- What general knowledge is required for planning and implementing a power and water supply station?
- What knowledge is typically available on completion of a study course at the University NANGUI ABROGOUA?
- What relevant knowledge is present from the lecturers?
- What are the lecturers' didactic strengths? In which areas might they need further support? Which knowledge gaps need to be managed and is it possible to get help from the Hochschule Niederrhein or from company representatives?
- Which competencies must be available to the students after completion of the study course?

In order to overcome lacking knowledge in terms of didactical knowledge, each workshop meeting reserves time to focus on changing didactic topics. Several milestones have been formulated and linked to either workshops or project modules/works during the study course:

1. Curriculum approved by the partner universities.
2. Suitable group of students selected with a desired equal composition of both genders.
3. Detailed planning of prototype 1 for a plant for electricity and water supply completed
4. Prototype 1 for a plant for electricity and water supply put into operation
5. Detailed design of prototype 2 completed.
6. Prototype 2 put into operation at university for testing purposes.
7. Prototype 2 sent and put into operation in the model village.

8. Partners for new projects and a new group of students won

A four-semester continuing education course, based on a Master's programme will take place at the University NANGUI ABROGOUA in Côte d'Ivoire. A semester abroad at the Hochschule Niederrhein is firmly anchored in the curriculum (third semester of the study course). The study in Germany is to be structured with a duration of one semester including the practical part (50%). For this purpose, teaching and learning materials and workplaces are to be prepared for the practical part of the study.

The first two practice-oriented project modules of the study course are intended for concept development and detailed planning of a prototype by the Ivorian students. During the third semester, the students travel to the Hochschule Niederrhein to build-up and operate prototype 1. After completion of the semester abroad, the training material and facilities are to be transferred to the University NANGUI ABROGOUA in Côte d'Ivoire. Subsequently, students from the Hochschule Niederrhein (of existing study courses, which fit thematically into the topic of the study course in Côte d'Ivoire) visit the University NANGUI ABROGOUA, to work together with the Ivorian students on prototype 2.

The mixed student group has to consider their experiences during the build-up of prototype 1, as well as local sourcing for components and necessary works to be done, i.e. hole drilling. Furthermore, possible additional project partners from industry will be addressed, a model village to set up prototype 2 is selected and business models for a small series of the system will be developed. The best business model will be selected in the course of a competition, involving local financiers and industry partners. Afterwards, the German students travel back to Germany. Simultaneously, the procurement for prototype 2 starts and the workplace for it is prepared, while prototype 1 is set up at the campus in Abidjan and put into operation.

Further German students (not necessarily from the mentioned group before) travel to Côte d'Ivoire during the fourth project year and write their thesis about the project from technical and economical perspectives. At the same time, the Ivorian students build prototype 2 on-campus and put it into operation. After the successful installation and operation of prototype 2 at the University NANGUI ABROGOUA, prototype 2 is brought to the selected model village and put into operation. The last practice-oriented task during the study course is the evaluation of the operation experience and an improvement of the planning steps, in order to enhance the existing plans from prototypes 1 and 2 as a basis for a small series.

3. Methodology

One of the most important components of the project is the curriculum for the dual engineering program with focus on energy and water. For the development of the study program, the European understanding of a dual study programs has to be transferred to the Ivorian academy. The first step is the creation of a rough draft of the curriculum by the Hochschule Niederrhein in Germany. It lists all the possible teaching modules required for the development of a prototype for an electricity and water supply system in remote areas. The next step is matching the rough draft with the academic framework at the University NANGUI ABROGOUA. Since this is a dual master's program, it is particularly important that the level of knowledge of an Ivorian bachelor's graduate is defined in advance, so that missing competencies can be identified. For this, a workshop is prepared in advance of the first face-to-face meeting in Côte d'Ivoire by project members, which can be divided into four main work packages (see Figure 1).

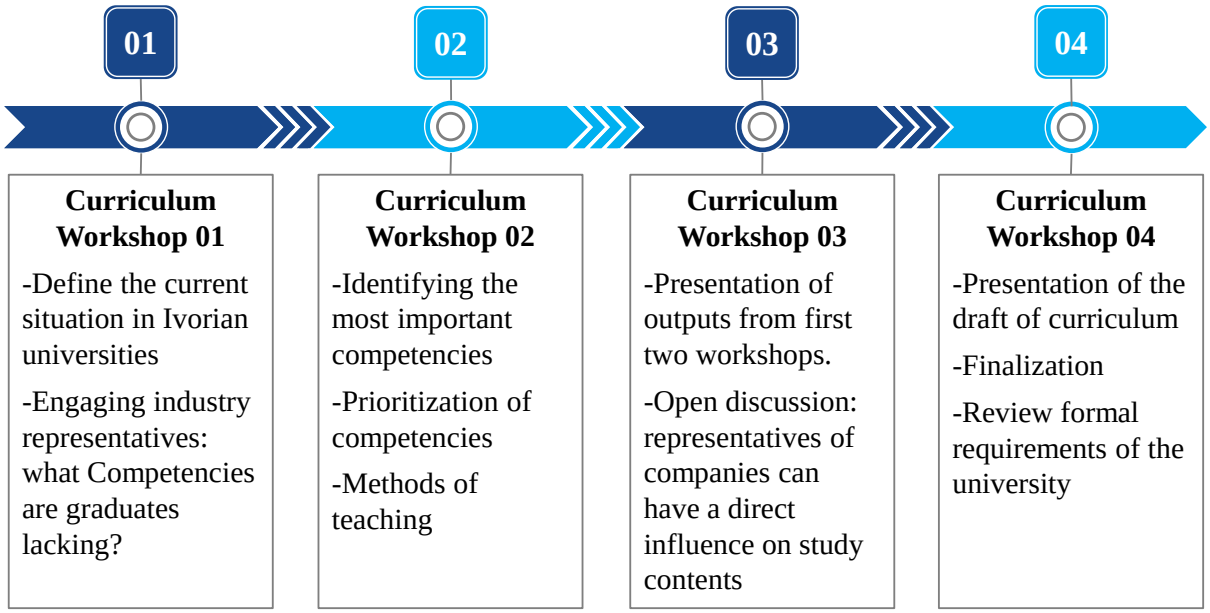

Figure 3: Work Packages of the First Workshop in Côte d'Ivoire for Curriculum Development (Chronological Order)

In order to integrate companies and their interests into the curriculum, several representatives of interested companies and ministries were invited to the workshops. They were part of the working groups, gathering ideas and concepts for the curriculum. The results from the workshops were processed in such a way that a curriculum with the most important study contents can be developed and thus, meets the requirements of the Ivorian companies.

After the official implementation of the curriculum for the dual master's program at the university, another major challenge followed with the selection of the ten best students to start the first group. By aiming an equal number of

five female and five male students for the course of study, the student group ensures gender parity. Local procedures for the recruitment of interested parties have been taken up, such as

1. Advertising banners at the universities and local hotspots
2. Publications on universities and project websites
3. Publications on various social media channels (i.e., Facebook, German embassy Facebook, LinkedIn) and private statuses (e.g. WhatsApp)
4. Word-of-mouth.

For the selection process of the best students, conducting an assessment center is a very good option for a large number of applications (385 registered, 166 completed applications). It is decided to do a first pre-selection in order to limit the number of student participants for the assessment center to 41 - a number of participants that is well suited for conducting this kind of an assessment center. For this, all applicants were invited (onsite and online for candidates abroad) to take a written test that assessed important competencies for completing the developed dual master's program (e.g., logical thinking, basic scientific knowledge, etc.). In order to conduct an assessment center, it is first necessary to determine which competencies are to be tested in which disciplines. Following this, it is still necessary to determine which tasks and instruments will be used to test these competencies in an objective way. This all can be used to create an assessment center evaluation matrix. Within the described project, the following matrix is developed (see Figure 2). Each column represents an assessment task to be done by the applicants (partly as group work), while each row represents a competency to be evaluated at different tasks. In the end, each task is used to evaluate several competencies, which are shown in detail as colored fields in blue, red, and green and their corresponding abbreviations (e.g., A1).

In detail, the first selection of applicants is divided into groups and each group has to work on the following tasks (as a group or individually):

1. Group work case study: Applicants are divided into groups and randomly distributed case studies. A presentation on the case studies is to be prepared in the assigned group.
2. Second written exam: Students have to make a written exam with questions covering (1) thermodynamics (2) engineering fundamentals, (3) mathematics, (4) energy management, (5) design/construction, (6) data analysis, (7) business administration fundamentals.

3. Individual presentation: Each student is randomly assigned a current topic in the energy industry and has to present it in a few minutes.
4. Personal interview: Each student is interviewed in a five-minute personal interview so that specific questions about the individual resumes can be asked.

Following the analysis of the results, radar charts are compiled for each individual, in order to select the final group of ten students, covering as many important competencies as possible. Figure 3 shows exemplary radar charts of applicants.

4. Results

As part of the project "Industry Integrated Dual Engineering Studies in a North-South Collaboration" (IIDES-NSC) and as one of the first steps, we organized a workshop in Côte d'Ivoire in October 2021, in order to receive inputs for the planned dual study program. The workshop was meant to involve company CEOs, students, lecturers, university administrators, government actors such as the higher education ministry, the ministry of hydraulic, the ministry of energy members. One goal of this workshop was to establish a permanent collaboration between the local industry and universities in order to consistently get feedback on the needs of industry on the skills and competencies of the graduates of the dual study program.

The curriculum has been successfully developed and implemented at the University NANGUI ABROGOUA, using the methodology described above. The model of the dual study program at the Department of Mechanical Engineering at the Hochschule Niederrhein was used as a basis and adapted to the Ivorian academic framework. The most interesting part is the simultaneous theoretical study at the university combined with practice work in local companies during the whole study program. The students will work at companies dealing with the topics of energy or water supply or adjacent fields, so that knowledge from practical work and theoretical study can mix and leads to benefits for both, academia, and industry, in Côte d'Ivoire. The basic structure of the Ivorian dual study program is shown in Figure 4.

Within the workshop for curriculum development, topics out of the three main subjects "technical studies", "economical studies" and "social studies" are covered. The additional project work deals with the applied use of newly gained knowledge in order to plan, construct, set up, and calculate the economic feasibility of solar-powered electricity and water supply system for remote areas in Côte d'Ivoire.

Within a short application period of only two weeks, 166 applications have been received from people interested in the newly developed study program. The structured approach of the pre-selection process and the following assessment center successfully identified the ten best students among the applicants.

Since the share of female students in science study programs in Côte d'Ivoire is even lower than at German universities, it is quite remarkable that more than 35 applications also came from female students. The original goal of selecting five female and five male students who, as a team, cover all the mandatory competencies, was thus achieved.

5. Discussion and Outlook

An important framework condition supporting the project can be built by interested business partners with the willingness to participate in the dual study program. These companies can draw a benefit from the project, e.g. the possibility to employ a graduate from the study program, because of the additional interdisciplinary and practice-oriented skills.

In order to allow students of the dual study program to work in local companies during the study program, it is mandatory to find suitable business partners in Côte d'Ivoire, preferably working in the field of electricity or water supply or adjacent areas (i.e. circular economy, wastewater treatment, waste management, etc.).

For this, it is mandatory to get into contact with local companies and business networks to explain and show them (their) benefits of hiring the students of the dual study program. Discussions and exchanges that have already taken place with experts of Rwanda and NGOs have shown, that the universities have to actively invite companies to information events at the universities, allow bilateral meetings or open up platforms for the specific exchange between academia and industry. Disseminators, such as Chambers of Industry and Commerce should also be taken into account as well as already known networkers in universities or industries. Further possibilities to get into contact with local industry still have to be found out and tested as soon as possible, so that the first group of students can find a hosting company during their studies.

Future projects within the curriculum (e.g., new types of prototypes) could be tested and implemented in those villages and areas to be connected to the electric grid (see the Ivorian Program 'Programme National d'Électrification Rurale'), to support the aims of the Ivorian government.

For the next group of the dual study program, a new main focus can be chosen, depending on the interest of possible industrial partners, arising economic necessity or the government development plan. Additional financial funds may be used to finance the supplies for future prototype projects.

The possibility to expand the dual study program into other topics of interest should be taken into account and be discussed internally at the University NANGUI ABROGOUA as well as with industrial and governmental partners.

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	Individual Assessment (From Questionnaire)							Group Assessment	Individual Assessment	
	Thermodynamics	Fundamentals in engineering	Mathematics	Energy management	Design / Construction	Data Analysis & Modelling	Business fundamentals	Group Exercise or Case study	Project Presentation	Interview
Analytical thinking	A1	B1	C1	D1	E1	F1	G1	GE1	PP1	
Communication				D2			G2	GE2	PP2	INT2
Cultural sensitivity								GE3		INT3
Team work								GE4		INT4
Creative thinking					E5			GE5	PP5	
Problem solving	A6	B6	C6	D6	E6	F6	G6	GE6	PP6	
Scientific / technical credibility	A7	B7	C7	D7	E7	F7	G7	GE7	PP7	INT7

Figure 4: Assessment Center Evaluation Matrix

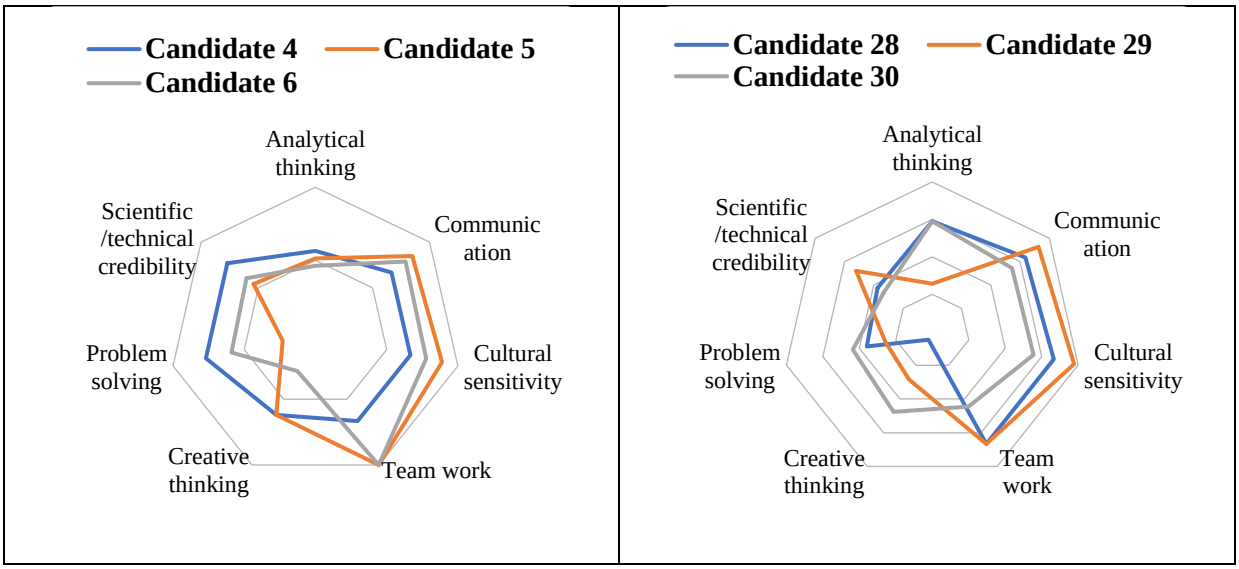

Figure 5: Exemplary Radar Charts for Candidate Competencies

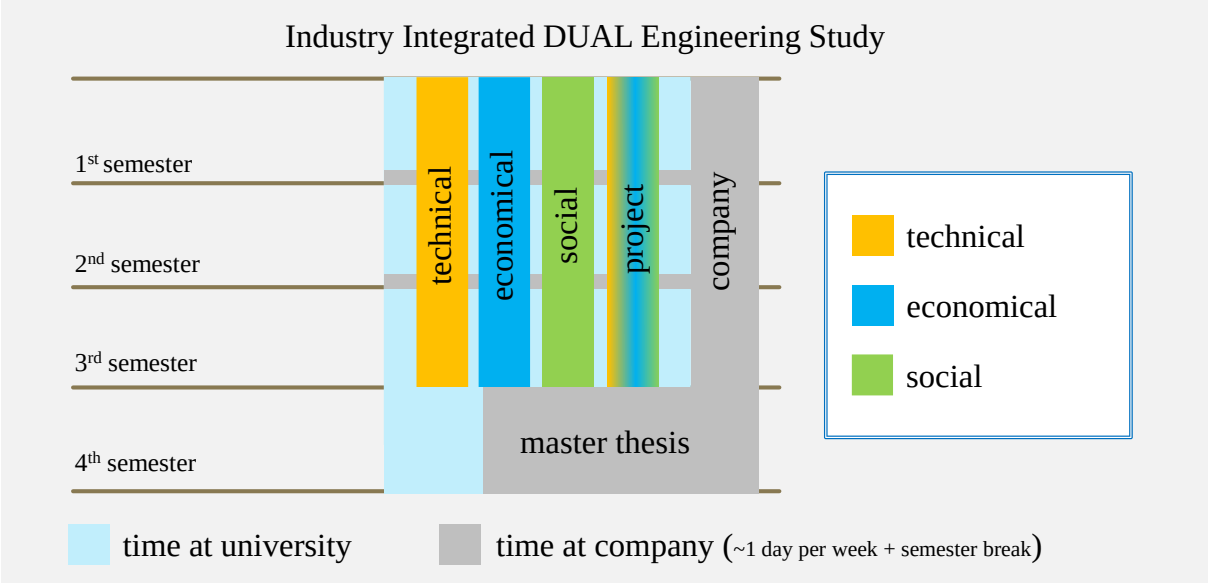

Figure 6: Basic Structure of the Dual Study Program