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Contents

Foreword	4
Khir Tahar	4
Prof. Samir Baklouti	5
Prof. Dr.-Eng. Valentin Plenk	6
Combining Challenge-Based Learning with Design Thinking Methodology	7
Nadia Cheikhrouhou	7
Implementation of Virtual Exchange Method in the Teaching Process	14
Islem Megdiche and Mahmoud Assad.....	14
Effect Of Educational Robotics in a Project-Based Learning Environment	19
Sonia Selmi.....	19
Design of Intelligent Dairy Cow Unit using Scrum Methodology	24
Jamel SLAIMI , Radhouane ALOUI and Nour CHEBBI	24
Control of a Photovoltaic System for the Extraction of Maximum Power	27
Naoufel Zitouni, Rabiaa Gammoudi and Nejib Hamrouni	27
FabLabs for Project-Based Learning of Industrial Installations	35
Riadh BEN JEDDOU and Mnawer GASSOUMI.....	35
Using design thinking to build an automation project	41
Mondher Haggui	41
Design of an industrial dryer test bench: Control of a multivariable system	45
Alaä CHABIR	45
Cognitive neuroscience for innovative pedagogy and interdependent learning.....	48
Souhaib AMDOUNI and Jamel SLAIMI	48
Anti-contamination robot	57
Souhaib AMDOUNI, Aymen SAADI, Nabil MAGHRAOUI and Malek AOUACHRI.....	57
Student Involvement Project in the rehabilitation of the PLC Programming Laboratory	64
KHADHRAOUI Malek, MABROUKI Lotfi and GHODHBANI Salah	64
Study of a photovoltaic solar installation.....	69
Rzig Ramzi and Troudi Fathi	69
Design of a Level and Flow Control Test Bench	73
Alaä CHABIR	73

Automation Programming by Applying Project Based Pedagogy	79
BEN AMMAR IMEN and SGHAIER NARJESS	79
Prevent the outbreak of fire: Design of a connected aircraft to map risk areas	83
Imen Ben Omrane and AmenAllah Massoudi.....	83
Reactive Power Optimization and Voltage Control in an Electrical Grid by FACTS Devices.....	87
Sahbi Marrouchi1 and Mansour Baazouzi.....	87
Design of Storage Robot for Automatic Picking up and Putting the Ball	93
Rihani Rihab , Dhaoui Samir and Elouni Mohamed.....	93
Operation of the plastic extrusion training bench.....	97
SAIDI Mourad	97
Constructing a hydroponic plant nursery connected and controlled by a smartphone	100
Chaima BEK, Jamel SLAIMI and Siwar BEN SALAH	100

Foreword

Khbir Tahar

The Higher Institutes of Technological Studies “ISETs” constitute a network of higher education and applied research establishments under the supervision of the Ministry of Higher Education and Scientific Research in Tunisia.

Through ISETs, establishments offer training for various fields in engineering such as mechanical, electrical, civil, process and computer science engineering as well as in the field of management sciences and law. The diplomas awarded to the training hereby constitute of the “licence” and the “mastère”.

Furthermore, the network of ISETs has been enjoying flourishing collaborations with the German Corporation for International Collaboration (GIZ) under the umbrella of a project called “ALEJE”. ALEJE is a project aiming to strengthen the capacity of teachers in order to adapt the training offered to students to the needs of the socio economic environment hereby improving their employability and enhancing their professional skills.

Based on the principle that employability does not literally mean hiring but rather equipping future graduates with perceptible tools in terms of developed skills, solid scientific and technical means of communication. Such qualities further enable future graduates to easily integrate into the labor market and to rebuild their career in the event of job loss.

With that at hand, the ALEJE project offers real opportunities to consolidate the training of students and to improve their soft skills. The activities carried out within the framework of this project are focused on industrial automation and robotics. Furthermore, ALEJE has already offered scientific and technical equipment to six establishments. This interest confirms the correct orientation of the project as well as its futuristic and efficient vision.

In addition, a special fund has been granted by the DAAD program to ensure the dissemination of training and skills acquired for all establishments in the ISET network. This rendered it possible to organize the highly requested conferences

on industrial automation and robotics with vital players in the field of research and development.

The papers published in this proceeding have been presented in ARNT2021 and illustrate the results of research carried out in Higher Institutes of Technological Studies and other higher education institutions in Tunisia. The studied topics relate to industrial regulation, robotics, and artificial intelligence. The experimental results obtained on didactic models are analyzed and interpreted.

Furthermore, the papers included provide adequate solutions to solve real problems proposed by actors in the socio-economic environment and deal with subjects relating to agriculture, environment, and production management.

The contributions may constitute a basis for continuing applied research in the different indicated fields and for choosing optimal designs for industrial prototypes.

I would like to thank GIZ and all those in charge of the DAAD program as well as those in charge of the ALEJE project for their interest in higher education and scientific research in Tunisia and for their fruitful collaboration on which we place great value.

I also thank the whole team who participated in the monitoring of the ALEJE project and in the organization of the ARNT2021 conference.

KHIR Tahar

General Director of Technological Studies
Minister of Higher Education and Scientific Research



Prof. Samir Baklouti

The general directorate of technological studies “DGET” supports all national and international partnership programs within the network of higher institutes. Hereby, “DGET” aims to improve the, in order to improve to a better level the quality of teaching, the acquisition of skills and the exchange of experiences to tally according to the requirements of the labor market employment needs. The latter All these objectives will be transferred to our students in order to increase enhance their chances of easily swiftly integrating into a the job ,. Moreover, by better preparing students for the labor market and that our institutes (ISETs) become leaders in ensuring the employability of their graduates at national and international levels.

In this context, was born this distinguished the project called ALEJE “Appui à L’Employabilité des Jeunes Etudiants” (ALEJE) which mainly aims to support training in the field of industrial automation and robotics. The project It has been completed and, in a complementary part, it will be disseminated to all the institutes of in the network.

Finally, I would like to thank all the people involved in the conduct of this project namely GIZ, DAAD as well as, Hoof uUniversity. Additionally, I’d like to thank as well as the organizing team of this first ARNT conference, wishing this conference will last for several sessions.

Professor Samir Baklouti

Director of the Higher Institutes of technological studies



Prof. Dr.-Eng. Valentin Plenk

The project “Appui à L’Employabilité des Jeunes Etudiants (ALEJE)” organized by the GIZ and sponsored by the Bayerische Staatskanzlei gave the initial impulse for the “Automation & Robotics Network Tunisia (ARNT)”. Within the ALEJE project, the contact between German and Tunisian colleagues, teaching similar subjects and facing similar didactic and practical problems, fostered and fueled the exchange of concepts and problem-solving approaches. Furthermore, the network facilitated closer contacts and even surfaced friendships that in the end led to the creation of the “Automation & Robotics Network Tunisia (ARNT)”. The ARNT is a new project funded by the DAAD aiming at the enhancement of ALEJE with specific regard to the development of didactic approaches that focus on giving students more autonomy and self-reliance than the classical teaching methods.

ARNT envisions a Tunisian network where teaching staff from all the Tunisian ISETs exchange technical and pedagogical ideas. More importantly: Even though the initiative originated in Germany, the intra-Tunisian network will continue to exist and will carry on helping to exchange Tunisian ideas between Tunisian teachers.

The papers collected in this book represent the first round of ideas exchanged during the 1st Conference of the Automation and Robotics Network Tunisia (ARNT2021) held from October 29 to October 31 in Sousse, Tunisia.

The papers fall into four categories:

1. **Modwels:** These papers present new model constructions and the rehabilitation of old in-house installations for teaching purposes. The propositions were selected with a view to the limited financial resources of the ISETs. Consequently, the papers provide a multitude of interesting impulses for low-cost implementation of teaching high-tech subjects.

2. **Didactics:** In this category the papers expose a flurry of learning approaches applied on automation and robotic subjects. The presented didactic methods are deduced from real teaching experiences.

3. **Visions:** These contributions introduce futuristic student projects which will need more than one iteration to be realized.

4. **Study plan:** In this session, the authors demonstrate the efficiency of their innovative ideas and discuss their integration on study plans.

Prof. Dr.-Eng. Valentin Plenk

Vice President Research & Development , Hof University,
Hof, Germany

Dr.-Eng. Malek Khadhraoui

Director, ISET Kasserine, Kasserine, Tunisia



Combining Challenge-Based Learning with Design Thinking Methodology : ISET Béja-Tozeur-Kasserine Hackathon

Nadia Cheikhrouhou¹

¹Higher Institute of Technological Studies of Béja.

Environment Boulevard, 9000 Béja
nadia.cheikhrouhou@beja.r-iset.tn

Abstract.

This paper reports on the ISET Béja-Tozeur-Kasserine (BTK) Hackathon, held in the framework of « Tunisia - Bavaria: Support for the Employability of Young Students (ALEJE) ». The novelty of this initiative is twofold: one it allowed the students that come from different engineering fields, to work in teams, in a short time frame (24 hours), to solve a real-life industrial challenge by applying the Design Thinking methodology and two, it offered professors who participated as mentors an informal learning platform to experiment new pedagogical tools that could be transferred to their regular courses in different subjects. The results of post hackathon surveys showed that students improved both their technical and transversal skills, and professors improved their teaching practices. The focus of this study lies on the implementation process of the BTK hackathon, and its impact on both the participating students and professors and provides lessons learned and recommendations to implement future initiatives.

Keywords: Hackathon, Challenge-based Learning, Design Thinking, Employability Skills.

1 Introduction

Unemployment has been a significant issue in Tunisia, particularly among Higher Education graduates. Indeed, during the third trimester of 2020, 30% of Higher Education graduates were unemployed [1]. This alarming situation made employment the primary concern of the Tunisian government [2]. According to Dr. Slim Feriani, a former Tunisian Minister of Industry and SMEs, «There is a gap between the skills of our abundant la-

bor supply and the requirements of industrial firms [...] graduates need to be multitalented knowledge workers who not only have technical skills but, additionally, non-technical skills, like communication, problem-solving, decision-making, and multidisciplinary work and life skills » [3]

Therefore, Tunisian Higher Education Institutions should ensure students gain the appropriate hard and soft skills needed in the job market by redesigning the curriculums and building strong ties with the industry. Additionally, educators should rethink their pedagogical approaches and find novel ways to enhance students' employability skills. In that regard, hackathons offer an interesting framework to foster students' problem-solving competencies and provide a competitive yet collaborative environment that stimulates creativity, critical thinking, and peer learning.

The main purpose of this paper is to present the hackathon as a teaching tool that combines both challengebased learning and the design thinking methodology and investigate its impact on both students' skills and professors' pedagogical practices. This paper is structured as follows: first, the author presents the theoretical framework on the subject and the implementation process of BTK hackathon. Next, the description of the research methodology is presented. Finally, the author provides an analysis of data and recommendations to implement future initiatives.

2 Theoretical framework

Hackathons are “competition-based events where participants work in small teams over a short period to ideate, design, rapidly prototype, and test their ideas with a usercentric approach to solve a determined challenge. The word hackathon is composed of two parts: hack and marathon. The term hack refers to the creative problem-solving, designing, prototyping, and tackling of the challenge, while the word marathon indicates the intensity of the event” [4]. Hackathons originated in the IT

community but are being used more and more in different sectors [5]. The emergence of hackathons dates back to 1960 [8]. However, their extensive use in the software development field emerged in the 1990s [7]. The hacking culture stems from the open-source movement that fosters developing technological solutions within a community where everyone, irrespective of background or expertise, is encouraged to address real-life challenges [7]. Many companies nowadays host hackathons as part of their open innovation strategy [4]. Open innovation can be described as a concept where valuable ideas can come from both inside and outside the company [9]. Companies adopting the open innovation concept actively seek collaborations from the outside world, to cocreate new products or find innovative solutions to complex problems with different partners, suppliers and even customers. Universities are seen as critical external partners for companies embracing open innovation since they provide them with talented students who could additionally be hired for internships or full-time positions.

From the university's standpoint, hackathons make for excellent informal learning platforms [6]. Hackathons offer opportunities for Higher Education Institutions to build strong ties with the industrial fabric and confirm their community engagement which is one of the three core responsibilities of higher education, together with research and teaching [7]. It is increasingly necessary for the subjects of universities to be connected to the Sustainable Development Goals (SDGs) [10].

Through the process of solution development to a specific challenge, Hackathons are an effective way to accelerate the development of entrepreneurial skills [11]. By applying the design thinking methodology, hackathons foster systematic and holistic thinking [12] and T-shaped skills acquisition with both deep vertical technical expertise in a technology or set of technologies and horizontal competencies

in critical thinking and the capacity to link expertise across disciplines. Hackathons, in that regard, contribute to equipping students with the 4Cs of the 21st century skills: Critical thinking, Communication, Collaboration, and Creativity [13]. The current context characterized by the rapid shifting of the nature of employment and the unpredictability of the future urge universities to ensure that degrees align with the job market's needs. This includes the development of capacities such as lifelong learning, civic engagement, and critical thinking [14].

3 The Implementation of BTK Hackathon

3.1 Context and Pre-Hackathon Stage

BTK Hackathon was held in the framework of the «Tunisia Bavaria: Support for the Employability of Young Students (ALEJE)» project. The ALEJE project, funded by the Chancellery of Bavaria and ran from October 2019 to June 2021, aimed to support Higher Education Institutions in Tunisia to adjust their training offers to the real needs of the industry. Six institutions were targeted by this project: ISET Béja, ISSAT Mateur, ISET Kasserine, ISET Tozeur, ISET Gabès and ISET Djerba. Carried out by the Gesellschaft für Internationale Zusammenarbeit (GIZ) in cooperation with Bavarian companies and universities, this project provided faculty from the six Tunisian partner institutions with training in the fields of mechatronics, electrical engineering, and entrepreneurship.

In that context, BTK 24 Hour hackathon took place between the 25th and the 26th of March 2021. 59 students coming equally from ISET Béja, ISET Tozeur, and ISET Kasserine participated in this event - held in a hotel located in Gammarth - in collaboration with Kromberg and Schubert (K&S), a German company established in Béja and focusing on the development and production of complex wiring systems for the automotive industry [15]. K&S's role was to provide the hackathon challenge: a real life problem encountered within the company and for which an innovative solution was required. K&S also provided prizes for the winning teams.

To prepare for this event, faculty who participated as mentors, received training on how to coach students and use design thinking methodology to bring innovative solutions to complex problems. In turn, the same faculty facilitated Design Thinking workshops to familiarize the participating students with this user-centric methodology.

Among these faculty, focal points in each participating institution were nominated and were responsible for (1) promoting this event, (2) disseminating the marketing materials through different communication channels well ahead of the date of the event in order to ensure the news reached the largest number of students and (3) handling the registration and the selection of the participants. It was also crucial to get the right students for the challenge since this will impact the quality of the hackathon's outcomes. The selection criteria (number of students and specialty) were decided in concert with K&S and considered the Corona context and the compliance with the health protocol. In that regard, each institution selected the first twenty senior students who applied before the deadline and whose fields of studies are Mechatronics, Embedded Systems, and Electrical Engineering. As far as possible, the participating students were divided equally between these three specialties.

We also requested that students mention why they would like to participate in this event in the registration form. Their motivations were diverse but included some common features such as: gaining hands-on experience and broadening their knowledge, working in teams, networking, gaining new skills, being open to new opportunities, discovering what is a hackathon, enriching their résumés, winning the competition, and going through a challenging experience. One of the respondents stated: «I'm interested in the challenge, and I'm ready to test my limit under pressure; also, it could be a nice experience to meet and compete against likeminded people ».

Prototyping materials were also made available at this stage, and a day before the event, on-site preparations were organized.

3.2 The Hackathon Stage

On the day, the different stakeholders were present : the students who were selected to participate, the coaches, three representatives from K&S (human resource manager, communication manager, and operation manager), GIZ - who had been responsible for the logistical aspects of the hackathon and the coordination between the different stakeholders so far - and the facilitators. The facilitators were two trainers from Denkmodell - a German consulting company - responsible for training the participating coaches, consulting the different stakeholders to prepare the hackathon program, the evaluation criteria and the jury's composition. They were also the persons who made sure everything ran smoothly during the event and, if needed, were there to guide the coaches.

The Hackathon program was as follows: after the official welcome, teambuilding activities were organized by the facilitators to form teams and match them with coaches. Eight teams were formed with a mixture of students from the three partnering institutions and from the three specialties mentioned above to ensure interdisciplinarity. After the teambuilding activity, the challenge was announced by K&S. The challenge was about eliminating unnecessary movements during the transfer of cut wires from the cut zone to the storage zone by workers within K&S factory. Students watched a video to illustrate the problem faced by K&S's workers. After the challenge's announcement, students started applying the Design thinking methodology to come up with creative ideas to solve the problem. They started by engaging with the end users - who are K&S representatives - through interviews to have a better understanding of the problem (this was the explore phase). Then they tried to make sense of what they learned from their interviews and research by defining the problem they were going to solve (This was the understanding phase). A How Might We question was formulated by each team at the end of the understanding phase. Then came the brainstorming of potential ideas that could solve the problem, and what followed was a series of two iterations where teams started by developing a prototype

1.0, testing it with K&S representatives, getting feedback from them to develop prototype 2.0. At the end of the second iteration, each team pitched their ideas to a jury composed of subject-matter experts. The evaluation criteria were: creativity of the solution, its desirability by the company, its feasibility, its viability, teamwork and the quality of the pitch. The top teams were announced immediately after judging, followed by an awards ceremony. The prizes were Bluetooth headsets and internships within K&S.

4 Impact of the Hackathon on both Students and Professors

4.1 Research Methodology

At the end of the hackathon, it was essential to step back and reflect on the whole experience: what worked well and what needed to be improved. Therefore, the following research questions were investigated (1) What is the impact of the BTK hackathon on students' skills? and (2) what is the impact of the BTK hackathon on teachers' pedagogical practices?

The following hypotheses were formulated for the study (1) Through participating in the BTK hackathon; students gained technical, and non-technical competencies and (2) participating teachers shifted their pedagogical practices from a transmissive to a student-centered setting.

In order to address the research questions, two major data collection tools were designed, namely surveys for students and interviews for teachers. Surveys used closed and open-ended questions. In closed questions, a 5-point Likert scale was used to probe participants' degree of agreement or disagreement with different statements. Open-ended questions were mainly used to get feedback on what students liked and did not like about the hackathon and collect their suggestions on improving the next initiatives. Interviews were conducted with participating teachers to gain insights into their satisfaction with the whole experience, their suggestions for im-

provements, and how their pedagogical practices were impacted. A descriptive statistical analysis was subsequently carried out using the SPSS tool to confirm or refute the initial hypotheses and answer research questions.

4.2 Results and Recommendations

In total, 15 students out of 59 filled out the questionnaire sent to them by email. 27% were mechanical engineering students, 40% electrical engineering students, and 33% IT students. 100% of the respondents agreed that the hackathon improved their problem-solving competencies. 93.3% of the respondents agreed with the following statements: participating in the hackathon enhanced my self-confidence, working in an interdisciplinary team was an enriching experience for me, and the hackathon enlarged my network. 73.3% agreed with the following statements: I developed my critical thinking and my technical skills thanks to the hackathon. 80% of the respondents agreed that they enhanced their teamwork skills and that they could transfer the knowledge and the competencies acquired during the hackathons into other contexts. 66.7% of the respondents felt ready for the job market and that they enhanced their public speaking skills. So, the first hypothesis was confirmed: hackathons improve students' technical and transversal skills.

Students mainly liked the following aspects about this experience: meeting new people, teamwork and solidarity between team members, the hackathon's good organization, and the new knowledge acquired. One respondent stated: « To me, it was above my expectations, the challenge itself and to deliver it in a short period, with the competition against other creative partners, being surrounded by amazing teams, and being able to show what I'm good at to other people. I liked people putting faith in me same as my trust in them". This highlights trust and solidarity as important factors for effective teamwork.

The respondents were mainly dissatisfied

with the duration of the hackathon; for them, 24 hours was a short period to develop their prototypes. Others reported tiredness and conflicts between team members. One of the respondents pointed out, “I wish there will be better prizes for winners next time, and to make the challenge harder since most of the solutions to the challenge span around the same thing... Make it harder and watch them get creative.” Therefore, the duration of the hackathon, the value of the prizes, and the degree of complexity of the challenge are essential factors to be taken into consideration by the hackathon organizers because they affect the participants’ satisfaction and can cause their frustration.

Regarding the suggestions to improve future initiatives; the respondents provided the following answers: extend the duration of the hackathon, provide more trainings for the participating students before the hackathon to prepare them for this event, offer better prizes for the winning teams, have better communication between teams and their coaches and select better students. One respondent suggested: « Raise the level of competition to the next level, like minigames during the main challenge itself, that makes teams gain access to the bonus, example: if they win a challenge they can ask extra questions to the jury, or have access to better materials and tools for the prototype.” Introducing this gamification aspect within hackathons is a venue to be tested and studied.

Interviews were also conducted with the participating coaches, who were also faculty at the three partnering universities. These were face-to-face interviews either in person or virtual using the video conferencing tool MsTeams. Teachers were asked open ended questions about how they evaluate the hackathon experience and how they perceive this event’s impact on their pedagogical practices. That is why these interviews were conducted two months after the hackathon so that teachers could have enough time to experiment new didactic approaches. 6 out of 10 coaches consented to participate in this study.

The main results are: coaches mainly

appreciated the general atmosphere of the hackathon and the strong involvement of K&S representatives to answer students’ questions about the challenge and provide constructive and insightful feedback to the teams to improve their prototypes. They also appreciated the high motivation and commitment of the different teams, organizers and coaches, the excellent organization, and the quality of the final prototypes and pitch. However, teachers did not appreciate the long period between the design thinking training and the hackathon. Also, they did not like the lack of follow-up of the winning projects. Therefore, they suggested a follow-up for the winning solutions either by developing the prototypes as part of an end-of-study project or a technology transfer agreement between the university and the partnering company. As for the impact of the hackathon on faculty’s pedagogical practices, the respondents pointed out that they shifted from transmissive pedagogy to challenge-based pedagogy in their classes and reported higher motivation and commitment of their students. Teachers also reported their use of the design thinking methodology to tutor students’ end-of-study projects and teach their regular courses. So, the second hypothesis of our research was confirmed as well.

5 Conclusion

This paper aimed to investigate the impact of the BKT hackathon on both participating students and teachers who played the role of coaches. Post hackathon surveys showed that hackathons provide informal learning platforms for students who improved their technical and non-technical skills such as problem solving, critical thinking, and teamwork. Results also showed that students felt more self confident, especially when it comes to public speaking since they pitched their innovative solutions to the challenge in front of a jury composed of a subject matters experts. They also felt more ready for the job market since they tried to solve a real-life problem. In that regard, hackathons contribute to closing the gap between graduates’ skills and the job market needs.

Teachers were also positively impacted by

their participation in this event, and results showed that they transferred both challenge-based and design thinking methodologies to their regular classes. Shifting, thus, from a transmissive to a student-centered pedagogy.

It was also important to provide colleagues from other universities with a step-by-step guide on how the BTK hackathon was organized, and share lessons learned and recommendations on improving future initiatives. Organizing a hackathon entails challenges and needs a firm commitment from all the stakeholders involved. It is crucial for coaches to be transparent about their role and the type of guidance they should provide to their teams. Coaches should also continuously communicate with their teams and be careful of their specific needs, especially when conflicts arise between teammates or in case of burnout. Likewise, the partnering company must be transparent about following up with the winning team after the hackathon. Coaches suggested to further develop the winning prototype as part of an end-of-study project or in the framework of a technology transfer agreement between K&S and the partnering ISETs. Finally, the duration of the hackathon, the prizes and the level of complexity of the challenge are important factors that need to be well considered by the hackathon's organizers because they deeply impact student's motivation and satisfaction with such an event.

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Implementation of Virtual Exchange Method in the Teaching Process

Islem Megdiche¹ [0000-0002-7908-3720] and Mahmoud Assad² [0000-0002-9001-6502]

¹Higher Institute of Technological Studies of Beja

Boulevard de l'environnement B.P 340 Béja 9000,
Tunisia
islemmegdiche@beja.r-iset.tn

²Mechanical Engineering Department,
An-Najah National University,

Nablus P.O. Box 7, Palestine
m_assad@najah.edu

Abstract.

During the last two years, due to the spread of COVID 19, multiple sectors have been forced to move to virtual life, including the higher education sector. The regular offline academic exchange was difficult for most higher education institutions; therefore, the virtual exchange (VE) is the only way to maintain academic exchange. This paper represents the virtual exchange program that connects mechanical engineering students from Higher Institute of Technological Studies of Beja (ISET Beja), Tunisia, and mechanical and electrical engineering students from An-Najah National University (ANNU), Palestine, by working on a robotics-related project. This paper shows the importance of enhancing soft skills that prepare students to get engaged in the industry and marketplace. It also focuses on global/multi-cultural skills that prepare the students to integrate into an interconnected world. Results show that the students appreciate this collaboration and believe it fosters their communication and teamwork skills with the multidisciplinary team. Educators seek to expand the size of the virtual exchange program in the future by involving more students and establishing other partnerships.

Keywords: Virtual exchange, Global/multi-cultural Fluency, Robotics.

1 Introduction

Higher education institutions must adapt their teaching approaches to provide their graduates with the necessary skills to integrate into a constantly changing world. According to Campbell [1], the five skills that companies are looking for in their candidates include critical thinking and problem solving, teamwork and collaboration, professionalism and strong work ethic, oral and written communication skills, and leadership. According to the National Association of Colleges and Employers, these skills are rated 99.2%, 97.5%, 100%, 95.9%, and 68.6% essential, respectively. However, graduates tend to be proficient with only 55.8%, 77.0%, 42.5%, 41.6%, and 33.0% in each of those skills, respectively. Teaching methods must foster these skills by designing the appropriate curriculum and activities. As such, students must engage in active learning by doing internships, field trips, labs, active discussions with their peers or professors to think about real-life problems and apply their technical skills to solve specific problems. These active discussions can equally boost teamwork skills. Teamwork skills can also be developed by collaborating on a common project and promoting the exchange of ideas. Professionalism and ethics can be developed by habituating the students to be punctual, not cheat in their assignments, and submit their coursework on time. Oral and technical communication skills are a fundamental component in teaching and must be fostered throughout all subjects and activities. Students must be trained to be good listeners and conduct active conversations. Furthermore, students must be acquainted with the necessary writing skills to convey concise and straightforward messages. Acquiring this is extremely important when looking for jobs, as they must write effective resumes and motivation letters or use appropriate language in a professional environment within the company. Last but not least, leadership can result from all the skills and can be developed by teaching the students to self-evaluate their skills and establish the area of strengths and weaknesses. Those are the must-have skills that most employers are looking for in a candidate. However, as we

live in an interconnected world where many companies have subsidiaries across many regions in the world, one more skill must be added to the list, global/multicultural fluency [2]. Therefore, a candidate can behave as a global citizen by communicating and working with colleagues from different cultural backgrounds, a skill of paramount importance if a graduate decides to work in a multinational company while either based at home country or abroad. In order to promote those skills for the students, a virtual exchange program is being conducted between ISET Beja, Tunisia and An-Najah National University, Palestine. The program connects students from the Department of Mechanical engineering of ISET Beja and the Department of Mechanical and Mechatronics engineering of ANNU to work on a robotics-related project.

This paper is organized as follows: In section 2, the virtual exchange and the Stevens Initiative effort are described, and the activities that promote the virtual exchange program are highlighted. Section 3 presents the previous virtual exchange programs conducted at both partner universities. Section 4 details the current project, including the participants and the educators, their background, and the specific tasks. Section 5 presents the results of this collaboration through conducting interviews with the participants. Section 6 gives the project outcomes, and section 7 summarizes the essential findings and provides recommendations for future works.

2 Virtual Exchange and the Stevens Initiative Effort

A virtual exchange consists in connecting people using the technology across different regions for education and exchange purposes. Virtual exchange can be international by connecting people who are living in different regions of the world. The goal behind it is to help participants, who are usually young people, gain global competencies to allow them to navigate the world's challenges. Virtual exchange replaces the physical exchange that requires physical mobility, hence financial resources. Virtual exchange is an excellent opportunity to promote the

internationalization of each institution and student at home [3].

The virtual exchange has been used since at least the late 1980s when International Education and Resource Network (iEARN) conducted a program to connect high school students from the United States and the Soviet Union to bridge the divide of the Cold War. The advancement in telecommunication and technology and the easy access to the Internet have promoted Virtual exchange [4].

The Stevens Initiative is an international effort that aims to expand the area of virtual exchange between institutions, organizations, universities, and schools in the United States and the Middle East and North Africa (MENA) region. The effort was created in 2015 to pay tribute to the American Ambassador J. Christopher Stevens, who dedicated his life to build bridges between different countries by conducting open dialogues. The effort awarded 60 grants and aims to expand its reach to more than 43,000 young people by summer 2022. The Aspen Institute administers the effort.

According to [3], a virtual exchange program helps foster knowledge of the other country or culture, cross-cultural communication, collaboration, self-confidence, and better presentation skills. However, there are some related challenges. For example, scheduling exchanges between different time zones and school schedules can be cumbersome. Additionally, involving an unequal number of students from both sides might inhibit connection as the few participants from one side will have to spend extra time on the activities. Furthermore, the technology issue must be accounted for if there is a connectivity problem. Also, the language barrier is a common problem if participants lack English proficiency. These challenges were accounted for during the present work, and best practices were adopted to alleviate these issues.

3 Previous VE programs at ISET Beja and An-Najah National University

The VE approach was implemented previously at ISET Beja for the Entrepreneurship course through a collaboration with the University of Michigan from October to December 2019. During this collaboration, 35 students participated, where 25 students from University of Michigan were enrolled in the Innovator's Toolkit course, and ten students from ISET Beja were enrolled in Entrepreneurship course. Two educators supervised the group. Students work on creating a prototype for a seawater farm in the region Khniss, Tunisia. The participants were split into five groups, where each team had five students from the University of Michigan and five students from ISET Beja. Each team had students from different technical backgrounds, namely computer sciences, mechanical engineering, and psychology, to form multidisciplinary groups. Each team focuses on a specific aspect, including legal, social, cultural, engineering, and environmental aspects. This work was analysed qualitatively by conduction interviews with the participants. Participants from the University of Michigan expressed their appreciation towards this collaboration as it permitted them to learn from their peers at ISET Beja about Tunisia and the Tunisian culture.

Furthermore, they confirmed that they learned new approaches to solve problems from their peers and overcome the challenge of keeping everyone on the same page through regular communication. Participants from ISET Beja highlighted that this exchange was an opportunity to practice their English, make friends from the other side of the world and gain technical skills. The exchange was also a fruitful experience for the educators who learned to adapt their pedagogical methods to each other [5].

ANNU has adopted in-person exchange with other national and international institutions since its establishment, and it is one of its priorities to increase the global reputation and international collaborations.

Over the past five years, with the rapidly moving technology and communications tools, ANNU has adopted virtual exchange to be part of the global connections and in-

ternational collaborations. Several virtual exchange programs were implemented at ANNU. One of the most famous programs is the connect program from Soliya, which the Stevens Initiative supports. The connect program aims to connect students worldwide and mainly from MENA universities and the USA universities [6]. The students virtually have dialogues about various topics related to culture, religion, etc. Such dialogues improved and strengthened the student's 21st century skills and leadership skills. However, due to the COVID-19 pandemic, several virtual exchange programs (for students or staff) were held nationally and internationally. Most of these programs aim to improve their communication skills, create dialogues using the English language, explore a foreign culture and enrich their technical experience.

4 The Pilot Project

Seven students connected through this exchange. ANNU team has four students in their final year, where three of them belong to the electrical engineering program and one student to the mechanical engineering program. The team of ISET Beja has three students in their second year of mechanical engineering with a major in mechatronics. The exchange is taking place from November to December 2021. Students work on the design and implementation of an industrial robotic arm. The main parts of this project consist of deriving the kinematics and dynamic model, designing the robotic arm via SolidWorks software, controlling the robot, choosing the electrical components, and implementing the robot. Students from ANNU started working on this project in February 2021 as a graduation project, and the students from ISET Beja joined them to work on some parts of the project. The central part that will be the subject of the exchange is the derivation of the robot's kinematic model and checking the 3D model. The selected parts belong to the curriculum of mechanical engineering at ISET Beja.

Two educators were involved in this project to facilitate the exchange. Both educators have a similar background, Dr. Islem Megdiche from ISET Beja is an expert in Robotics and com-

putational mechanics, and Dr. Mahmoud As-sad from An-Najah National University is an expert in innovation and design of thermal-mechanical engineering systems with professional skills in computational mechanics. The facilitation was performed by conducting weekly meetings with the students to track their progress. Students were advised to speak about cultural topics and not only be limited to the technical problem they were solving. A Facebook group and email list were created to facilitate communication with students.

5 The Results of the Exchange

Interviews were conducted with the students to investigate whether they appreciated this new teaching approach. One student from ISET Beja says that he could exchange ideas with peers from ANNU through this virtual exchange. He also appreciated teamwork as this will improve the quality of the work. He also expressed that this was an excellent opportunity to enhance his English, allowing him to work in multinational companies. He also indicated that he enjoyed working with students from different cultures since this interaction allowed him to learn about their culture and country.

The student reveals that he prefers to choose his topic rather than being assigned a project and, he mentions that involving other partners from other countries will make the exchange experience richer.

A student from ANNU said that he was struggling with some parts of the project, and thanks to the knowledge of Tunisian students of the kinematic derivation, he could derive a correct model. Generally, all the students agreed that this is a fruitful experience and they expect to learn many skills from it.

6 The Project Outcome

The project is promising as it has many positive impacts on the students' attitudes and ways of thinking. Students are expected to enhance their communications skills and improve their abilities to communicate in English. Students were advised not to use Arabic and push

themselves to speak English even if they make mistakes. Additionally, this collaboration is an excellent opportunity to enhance teamwork skills with peers from different cultural backgrounds, where this is a common situation, they will encounter in their professional life. Furthermore, students will master the use of technology as the new learning environment and learn how to overcome challenges related to problems of connectivity or time differences. Also, students will enhance their technical skills and critical thinking. Educators and universities also benefit from this collaboration as they will improve their international collaborations, making them more visible in the international education community.

7 Conclusions and Future Work

This project integrates the virtual exchange approach in the teaching process by connecting ISET Beja and ANNU students to work on a robotics-related project. The goal was to investigate the behavior of the students in response to this type of collaboration. Students showed to be very motivated, and they confirmed that they want to have other collaborations in the future. Educators considered this as an incentive to set milestones for future works. These milestones consist of remote virtual labs from which students of ISET Beja will benefit from the equipment of ANNU. Additionally, the project will be extended to include other partners from other countries to have access to better facilities and foster students' skills. Furthermore, educators are looking for partners from USA universities to apply for the Stevens Initiative fund.

Acknowledgement

Authors would like to thank the volunteers' students for their engagement and the time dedicated to the project. These students are Bassem ben Hamza, Seif eddine Chaouachi and Chaima Aabdi from ISET Beja and Abd-AL-Rahman Khwaireh, Noor AL-Deen-Salah, Mutaz Alul and Harith Bani-Fadel from ANNU.

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Effect Of Educational Robotics in a Project-Based Learning Environment

Sonia Selmi¹

¹Higher Institute of Technological Studies,
KAIROUAN, TUNISIA
soniaselmiarfaoui@gmail.com

Abstract.

Digital technology and robotics are constantly evolving. However, making young students aware of these sciences is a significant stake. Nowadays, a decrease in interest in science and technology (S&T) among students is documented internationally. This decrease would harm on their academic success. Thus, this article aims at identifying the effects of educational robotics (ER) specifically on the interest and learning of computer science students. A total of 90 students participated in this project, and two principal measures were collected at the end of the task: a performance index resulting from the variation of problem-solving percentage before and after robotics assessed learning in S&T, and a questionnaire of Likert-scale situational interest developed for this project to get students' opinions on the adopted methodology and assess interest in S&T. The significant difference in the variance of student interest suggests that ER would generate some student interest in S&T. The main conclusion of this study is that the integration of educational robotics in a task in science and technology makes it possible to stimulate more the interest of the students than the same task mobilizing traditional material, while allowing an equivalent learning.

Keywords: Project-based Learning, Robotics, Education

1 Introduction

Computer science, as well as most scientific disciplines, suffers student's lack of motivation [1] due to traditional methods of education based on rote learning and abstraction. Consequently, it is necessary to find and develop an educational route which may be more attractive and more adapted to student needs.

In recent years robotics has gained the high attention of teachers as a valuable tool to develop cognitive and social skills for students and support learning in science, technology, informatics, and other interdisciplinary learning activities. Then as we seek to motivate learners' interest in these fields, Students explore the field of robotics as a real-world discipline in which the fundamentals learned are put to practical use [2] in a project-based environment.

In this study, the focus group was composed of technological higher school license students. Robotic-Project based learning environment was designed to support programming courses which represents for students the hardest learning unity. In project-based learning (PBL), tasks are given to students, and they created teams for group works. Students collaborated to manage their project. They tried to apply critical thinking principles by debating ideas, making predictions, asking questions, collecting, and analyzing data, making conclusions, and communicating their findings to others. This study aimed to prove how emotions and learning at work are closely related and highlighted the interest in emotional intelligence, which refers to how one can monitor feelings and direct students' thinking and actions accordingly.

1.1 Project-based Pedagogy

Project-based Pedagogy also called "learning by doing," is an active method in which learning is in action. The instructional process with project-based learning described in Fig.1, provides a valuable opportunity for the learner to apply acquired skills and knowledge to situations of concern. The tri-

al-and-error experience affirms or disconfirms the usefulness/applicability of the acquired skills and knowledge set employed.

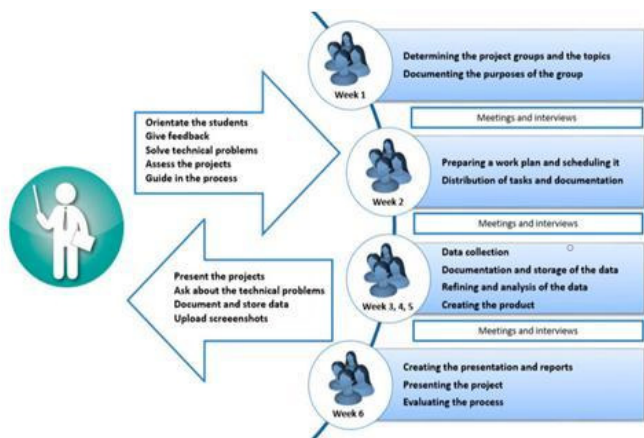


Fig. 1. The instructional process with project-based learning [4]

The first objective of this approach consists of a “formative” function that makes it possible to give meaning to the learning, to combat the lack of motivation by allowing students to engage in a meaningful activity: their project. The accomplishment of the work must consider time, economic, material, and human constraints. The search for resources and information to carry out the project, which plays the role of didactic function, brings the student to process and organize varied and sometimes new knowledge [5]. The project can also fill a social and mediation function: since the project’s pedagogy leads the student to open to others, to other institutions, to be recognized by them; it also led the group to share skills and compare opinions, as shown in Fig.2.



Fig.2. Principal student role in PBL

1.2 Educational Robotics

Educational Robotics uses programmable robot constructs to engage groups of students in playful collaborative problem-solving activities. It enables students to become familiar with and deepen their knowledge of robotics and programming, while at the same time learning other cognitive skills.

Educational robotics is included within the so-called STEM (Science, Technology, Engineering, and Mathematics) [3] education, a teaching model designed to teach science, mathematics, and technology together and one in which practice takes precedence over theory. Educational robots help develop the mental process we use to solve problems of various kinds through an orderly sequence of actions.

Educational robotics uses robotics kits, programming software, and computers as hands-on learning tools. It can create a learning environment that can enhance collaboration and communication among students, problem-solving skills, critical thinking skills [6], and creativity. During the last decade, educational robotics started its promotion by developing FABLAB (Fabrication laboratory), a platform for rapid prototyping of physical objects, “intelligent” or not. at the platform targets entrepreneurs who want to move faster from concept to prototype, designers, artists, and students wishing to experiment and enrich their practical knowledge.

2 Research Motivation

In this study, we start from some observations:

1. Traditionally, learning takes place in an abstract classroom situation. Students without the necessary abstraction skills may fail.
2. There is often concern that learners may become discouraged when programming repeatedly fails.
3. The research elaborating emotions in organizational settings has increased considerably in recent years. However, we lack a

comprehensive understanding of the role of emotions in learning at work or learning by doing.

4. The rate of a student leaving the institute without having a diploma is fairly increasing.

Then we are trying to offer an outline of a solution.

3 Methodology

The pedagogical experiment took place during the educational practice of students at the Higher Institute of Technological Studies, KAIROUAN, TUNISIA, during three school years (2018-2021). Third-year students of IT specialties attended the experiment, and it concerned a sample of 90 students (a class of 30 students per school year)

According to the nature of the PBL, students were distributed into groups of three; each group selected a team leader. Then, we conducted an exploratory study on students' activities for one semester to identify the effect of educational robotics on motivation and success rate in a project-based context. For that purpose, a questionnaire was administered to explore the impressions on the projects' organizational aspects, the students' ability to work in a team, their satisfaction of the work accomplished and their investment in the project. As shown in Fig.3, robots used are of the Elementary Speechi type.

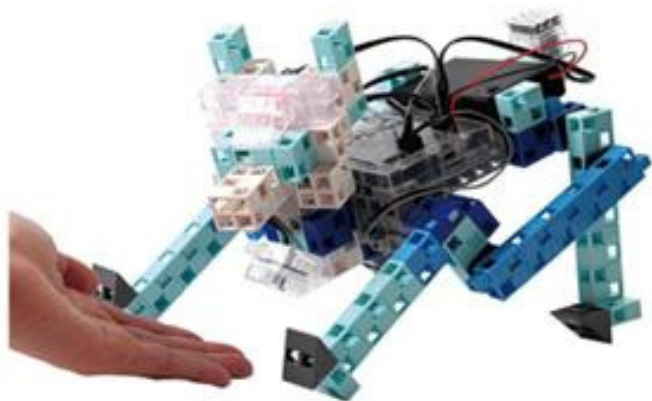


Fig.3. The Elementary Speechi robot

There are 5 Robot models to create (construction and programming): Line tracking robot, conveyor, remote control, crane car, or even the doggy Robot. The programming of the Robot is with Studuino and its programming software.

- The first phase is an observation phase of different programs.
- The second is to use icon programming.
- The third phase is programming by block.
- In the fourth phase, the student already had a clear idea of how his robots work, and he will be more motivated to start programming with the Arduino IDE.

A group of three students has a project assigned. The final mark will be an average of 3 marks: one mark per programming phase. The first two notes will be encouraging since most students will pass the first two simple phases, their emotional role will undoubtedly improve the student's self-confidence and motivate him to pass the last programming phase. The following data collection element used was a pre & post robotics team interview. I as a teacher also kept a researcher journal to record my observations at the end of each week. I made visual observations of the students working and listened to them interact with each other.

4 Findings

As shown in Fig. 4, the strategy described above helps to solve several problems.

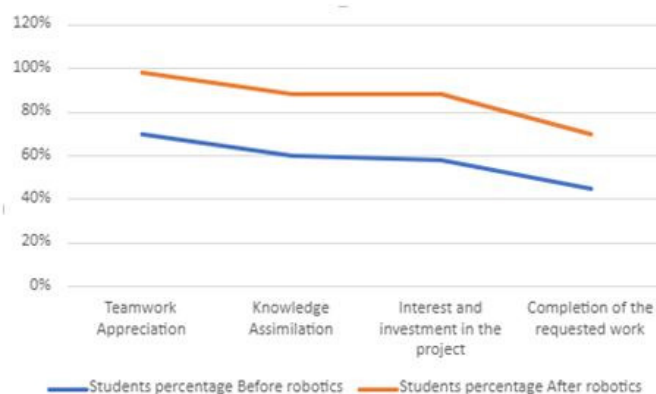


Fig. 4. Problem Solving Strategy Results

We can notice that educational robotics enhanced the motivation of students to work in group, improved their knowledge assimilation and interest in the project, which helped most of them complete the requested work. This improvement of motivation is due principally to the act of gaining self-confidence during the two primary phases. Good emotions engendered concurrently aspect which leads to better results. Indeed, The Absenteeism-Rate presented in Fig.5, is decreasing thanks to the excellent atmosphere of teamwork based on cooperation, coordination, and competitive aspect between groups.

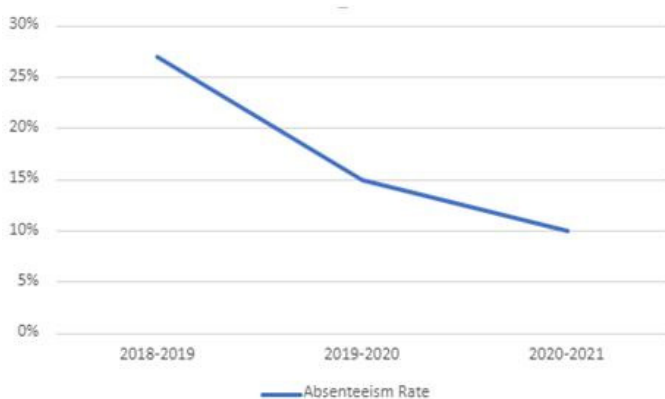


Fig. 5. Variation of Absenteeism Rate

then to 0%. This decreasing tendency correlates to the hope of finding a place in the labor market, higher self-confidence level than those who left the institute without graduating and go to the military searching for a job and are desperate to be admitted to their field of study.

The success rate-improvement shown in Fig. 6 is due to all the above factors.

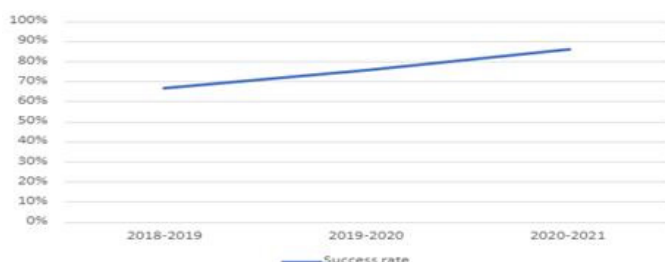


Fig. 6. Variation of success rate

A questionnaire of Likert-scale situational interest, developed for this project to assess interest in S&T, clearly shows in Fig. 7 the positive opinion towards the adopted methodology.

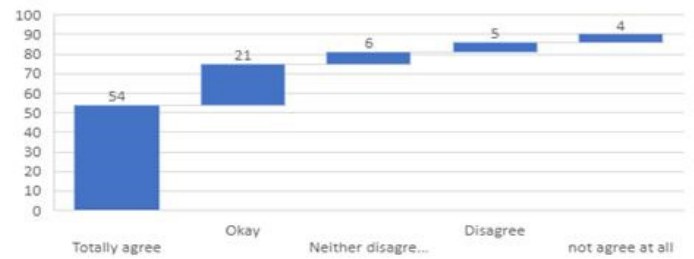


Fig. 7. Students' opinions on the adopted methodology

Discovering that errors are not final, but a source of new conclusions is a valuable lesson for the future that helps students develop several skills as introduced by Fig. 8. The group challenge approach encourages socialization and collaboration. The search for solutions and the freedom to assign new functions to these robots stimulate imagination and creativity. Achieving success in a new field improves students' self-awareness. In addition to boosting their self-esteem, success in one field stimulates them to take on new tasks in other fields. Students learn to assess their performance by seeing the results of their actions instantly, without the need for a teacher to tell them whether they have done well or poorly.



Fig. 8. Skills that student develop thanks to educational robots

Other cognitive skills that are positively influenced by educational robots are responsibility, order, and more optimal development of spatial perception and relationships between objects.

5 Conclusion

In this paper, we reported on our experience of integrating educational robotics activities into higher education with project-based environment. The goal was to identify the effects of educational robotics specifically on the interest and learning of computer science students. Our results show valuable benefits from such activities and indicate that educational robotics is a promising tool in a project-based environment. Finally, we can say that the integration of educational robotics in a task in science and technology makes it possible to stimulate more the interest of the students than the same task mobilizing traditional material, while allowing an equivalent learning.

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Design of Intelligent Dairy Cow Unit using Scrum Methodology

Jamel SLAIMI¹, Radhouane ALOUI² and Nour CHEBBI³

¹Department of mechanical engineering-Higher institute of technological studies of Béja, Environment Boulevard, 9000 Béja, Tunisia

slaimijamel@gmail.com

aloui.radhouane@gmail.com

nourbennourdj@gmail.com

Abstract.

Food waste is one of the biggest problems dairy farmers and ranchers face. There are two reasons behind this problem: cows do not have the exact nutritional needs due to the quantity and quality variation from cow to cow and the gestation cycle. The project used the Scrum methodology to meet a need expressed by a farmer in the region where an automated livestock unit allowed the dosage of the appropriate amount and type of feed for each cow. The work is executed in an innovation laboratory with dynamic specification expressed by the product owner, the farmer.

Keywords: Scrum Methodology, Sprint, Cow Farm Unit First Section

1 Problem presented by Customer

The problem, as expressed by the product owner consists in waste of food. Cows do not always present the same food need qualitatively and quantitatively as depicted in Fig. 1. This results in losses estimated at 200 – 300 TND/day corresponding to 6,000 – 9,000 TND/month and 72,000 – 108,000 TND/year. Adding to that, farmer will also lose time in the distribution of foods cows or in managing his quantity of cow foods.

Cow « A » need 3kg of food every 12 hours and could produce more than 5 liters of milk in a day.

Cow « B », a pregnant cow, need 2kg of another type of food every 12 hours and produce just 2 liters of milk in a day

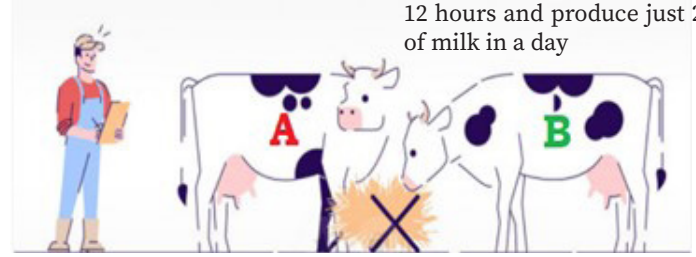


Fig. 1: Different food needs for cows

2 The Efficiency of the Scrum Methodology

The Scrum methodology allows a higher consideration of the specifications from the real customer, in our case, the farmer. Trello tool [1] was used to generate the iterations and work as a team; many sprints [2] were developed to meet the dynamic specifications of the project as shown in Fig. 2. A work schedule is prepared during work, and a working team meet with the farmer to discuss the project requirements and specifications, which are detailed in the following figure:

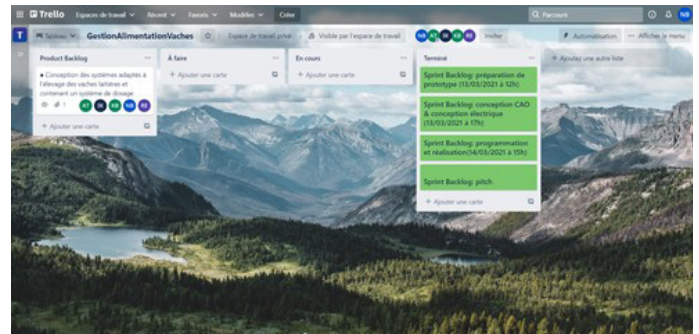


Fig.2: First sprint steps developed in Trello user interface

3 Solution

An automated distribution system is developed to feed the dairy cows. Fig.3 and Fig4. Depict the system. This system consists of two parts: the place where cows raised and the location of distribution. The system is composed of:

- Two hoppers where the food will be placed
- Distribution's channel (for each hopper) composed of distributions pipe and an aspirator
- Cow's food bins

- Cow's locations

Firstly, the system will identify the cows using RFID technology, so each cow will have her own RFID tag, the RFID reader will be placed near the cow feed bins to assure the perfect functionality and identifications for the cows. Then using the database server that we have, and that describes each cow need of food, the system will manage automatically the quantity and the quality of needed food. Then the distributions channels will deliver food for each cow and will assure the non-loss of food and the win of time.

- Interaction zone is composed of:

- Raspberry PI card
- Database server
- Board computer or a mobile phone

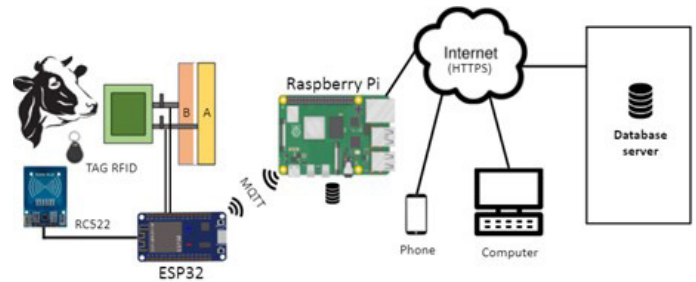


Fig. 5. Hardware of the System

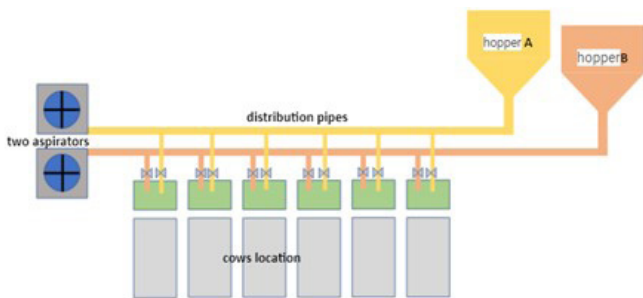


Fig.3. Layout of the distribution system

5 Interconnexions

Fig. 6 depicts the signal path from the cow to the database server. After reading the cow ID, an electrical signal is communicated to the ESP 32 card, which communicates with the RASPBERRY PI card via the LORA network [3, 4]. The RASPBERRY PI control board [5] uses WIFI for communication with the internet and optic fiber with the database server.

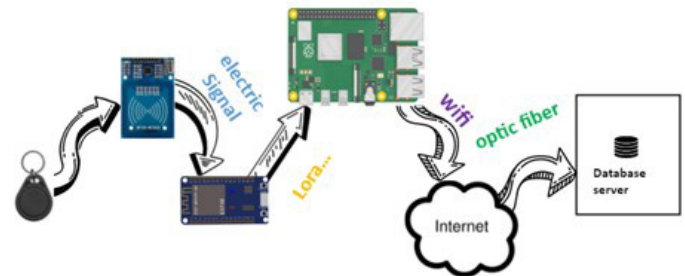


Fig. 6. Signal path

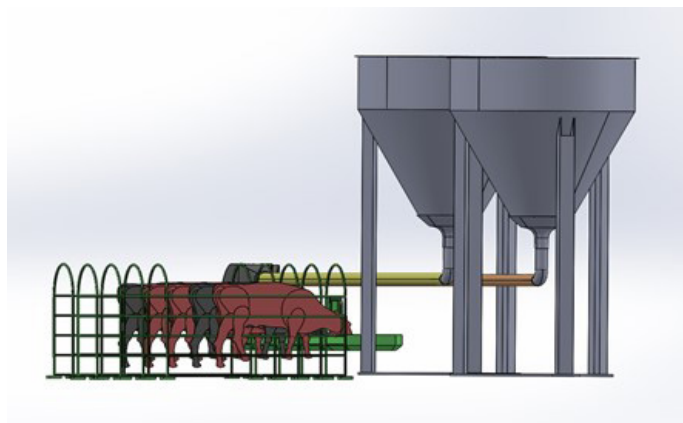


Fig.4. 3D Model of the Distribution system

4 Hardware

Fig. 5 present the hardware of the system. The breeding area is composed of:

- RFID tag attached to the cow
- RC522 RFID reader
- RC522 RFID reader
- ESP32 card
- Two dosers 'A' and 'B'
- The HMI man-machine control

6 Software

The software part consists of programming the Raspberry PI card, communicating with the ESP32 card, retrieving information from the database, determining the cow's need, and recording the data for the ESP32 card, it consists of programming the control of metering units, and the communication with the Raspberry PI card. Adding to that, internet will give all access to the farmer, so he will be able to control, manage or modify the system, as he wants using phone or computer.

7 Conclusion

Starting from a local problem we tried to find out the newest and the best solution, that why we want the system to be automatic because automating this agricultural activity is necessary because it saves time and money.

Cow's automatic breeding system is an innovation system that provides a new way of managing farmers especially managing one of the most important activities nowadays, it is also considering as an agritech innovations that helps farmer be more profitable, it helps again farmers gain their time. Therefore, this solution is sustainable. The farmer can consult the statistics of the consumed quantities to estimate the profitability and most important farmer can manage this data and statistics so he can make decision carefully as example he can know if cows' usage of food is increasing or not and which cows need more food than the others, which needs type 'A' and which need other type.

These entire data can really make a difference that is what agritech is all about it is to help farmers grow to a brighter future.

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Control of a Photovoltaic System by a PLC (CPU 1200) for the Extraction of Maximum Power

Naoufel Zitouni¹, Rabiaa Gammoudi² and Nejb Hamrouni³

[0000-0002-9001-6502]

¹Research and Technology Centre of Energy (CRTE) Centre of Energy Technoparc Borj Cedria B.P.N 95 – 2050 Hammam-Lif-Tunis-Tunisia

naoufel.zitouni@yahoo.fr

²National High School of Engineering of Tunis (ENSIT), Tunis, Unit of Research ERCO-INSAT

rabiaagammoudi@yahoo.fr

³Electronics Department ISSAT Mateur, Mateur Tunisia

hamrouni_nejb2003@yahoo.fr

Abstract.

The work presented in this project aims to contribute to the study of a solar photovoltaic system operating at its maximum power. In this sense, the PV system must include an adaptation stage associated with an MPPT algorithm. This work focuses on a validation through an experimental test, whose test bench contains a photovoltaic generator, a chopper, a resistive load, and a CPU 1200 type PLC that ensures the control.

Keywords: MPPT (Maximum Power Point Tracking), MPP (Maximum Power Point), CPU (Programmable Logic Controllers), PVG (PV Generator).

1 Introduction

Given the global energy problems caused by the depletion of conventional (fossil) sources, the use of renewable energies (eg: photovoltaic generators) presents an alternative solution. PV panels are characterized by the non-linearity of their output characteristics influenced by environmental factors causing the shift of the operating point to achieve maximum power. So, to locate this point and ensure continued optimal operation, the entire PV system must be controlled to operate at the point of maximum power continuously.

For this, an adaptation between the PV source and the load is necessary [1-4]. This adaptation is achieved by inserting a DC / DC type static converter driven by an optimal operating point tracking system. At the electronics laboratory located at ISSAT Mateur, we have a photovoltaic panel of the Solarnova PQ 40/50 type characterized by a maximum power of 50W under standard test conditions and a BOOST chopper which is designed and produced by students as part of their study project. We will use the industrial programmable logic controllers CPU 1200 to control this converter and implement the maximum power point tracking algorithms. The work proposed in this project will be based primarily establishing a test bench for the extraction of maximum photovoltaic power. This work's main objective is to implement of the "P&O" technique on the CPU 1200 PLC while analyzing the working principle of this dedicated method for optimal power extraction. There are also various devices for viewing and saving the results.

2 Learning Technique: Academic Knowledge

Part I:

Acquire academic knowledge for the management of photovoltaic energy in the student (autonomous and guided): Develop a sense of autonomy in the student

Part II:

Develop the system:

- Import new features, improve the system,
- Use new technologies.

This allows us to develop a sense of responsibility in the student, involve him in the training cycle and make it more dynamic.

It also allows the student to:

- Know the importance of photovoltaic energy,
- Study photovoltaic energy,
- Study the operation at maximum power,
- Learn PLC programming,
- Carry out experimental studies.

The student must also be able to manage a system powered by a photovoltaic source.

2.1 Importance of Photovoltaic Energy

Ask the energy problem and let the student discover the energy difficulties in the world: Given the growing global demand for energy as well as the limitation and exhaustion of the reserves of traditional sources (oil, natural gas, uranium), the most appropriate solution is to use clean energies, also known as “renewable energies,” which have the advantage of producing electricity while respecting ecological requirements.

2.2 PV energy study

To use photovoltaic energy: It is necessary to know its principle.

Modeling of PV cell

A solar cell is a diode having a p-n junction exposed to light. When the diode is sufficiently illuminated by sunlight, it generates an electric current in a load resistor. This current is due to the “Photoelectric phenomenon” [5, 6]. Figure (1) clearly shows the photovoltaic effect at the scale of a cell.

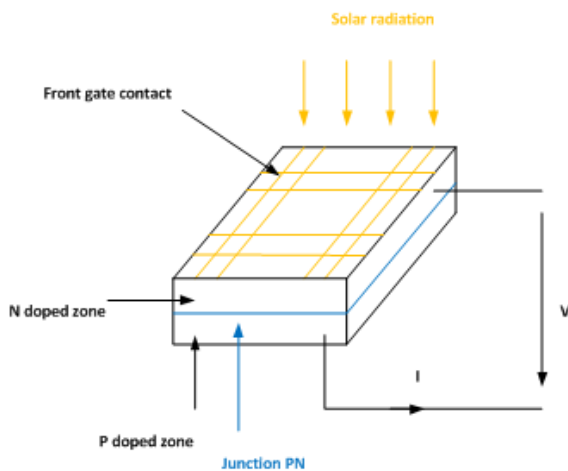


Fig. 1. Photovoltaic effect at the scale of a cell

Solar cells are manufactured using several technologies that are distinguished by their performance, degree of maturity and lifetime:

- First generation,
- Second generation,
- Third generation.

A PV cell is generally modeled by the following equivalent electrical diagram shown in Fig 2:

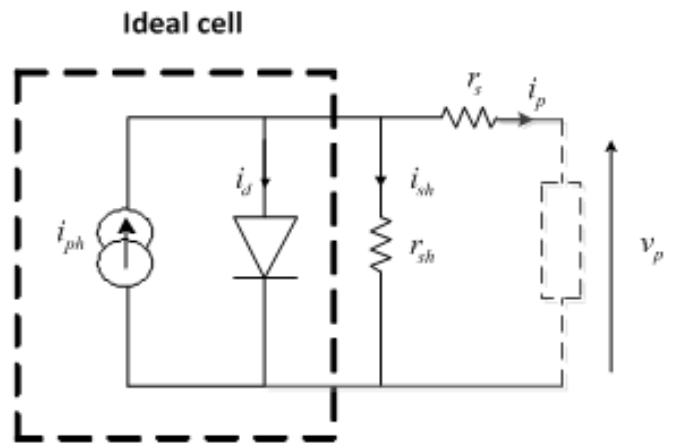


Fig. 2. Electric model of a solar cell

In the sense of this diagram, the mathematical model of a solar cell is given by equation (1):

$$i_{ph} = i_d + i_{pv} + i_{sh} = i_d + i_{pv} + \frac{V_{pv} + r_s i_{pv}}{r_{sh}}$$

Mathematical Model of a Photovoltaic Module and Generator

A photovoltaic cell produces a no-load voltage for crystalline silicon between 0.5 and 0.6V, and it remains in the range 0.6 to 0.9V for amorphous silicon. So, to increase this voltage, ns cells are connected in series constitute a photovoltaic module. Thus, a cell’s nominal power is always limited to a few watts, where it is better to market solar energy in the form of modules or panels. Another series-parallel configuration of several panels is called a photovoltaic generator. A PVG is a configuration comprising N_p rows in parallel; each row is formed of N_s panels in series [7-10]. The quantities that characterize a PVG generator are voltage and current, respectively, and are expressed by:

$$(2) \quad \begin{aligned} V_p &= n_s \cdot N_s \cdot v_p \\ I_p &= N_p \cdot i_p \end{aligned}$$

We can also write:

$$(3) \quad I_{phr} + I_{sr} \left(\exp\left(\frac{V_p + R_s I_p}{V_{Tr}}\right) - 1 \right) + \left(\frac{V_p + R_s I_p}{R_{sh}} \right)$$

The external current-voltage characteristic of a solar panel is similar to that of an elementary cell. This characteristic represents three essential areas, figure (3):

3 Study of Operation at Maximum Power: Extract the Maximum Power delivered by the Panel

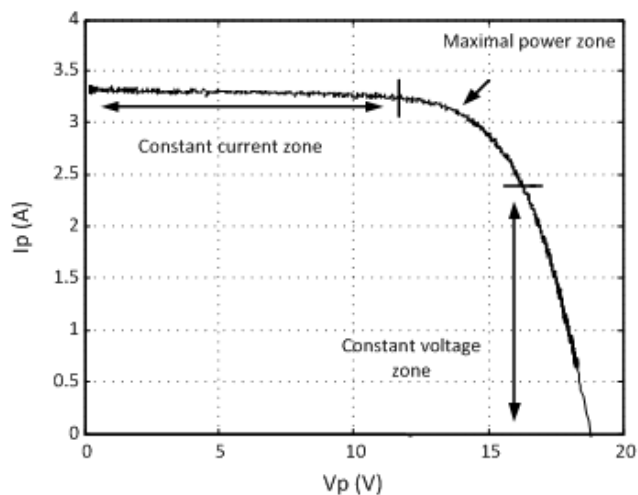


Fig. 3. Different areas of the characteristic (current-voltage)

The simplicity and low cost of the direct connection between the PV source and the load allow it to be the most used, [11].

However, the major drawback of this connection is the direct connection of the power extracted from the source to an application which is often very far from the maximum power that the photovoltaic generator can deliver, as shown in the following figure 4.

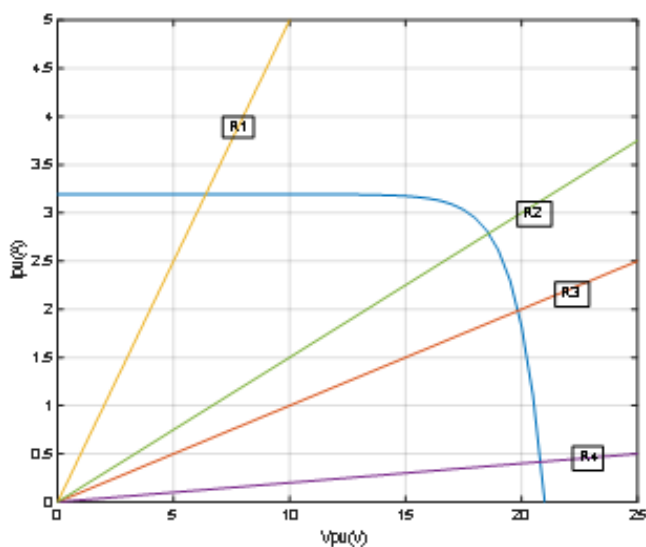


Fig. 4. Evolution of the operating point with a direct link between the source and the load

3.1 Study of a DC / DC Converter Controlled by an MPPT: How to guide the System to the MPP

Therefore, the insertion of a DC / DC type static converter is necessary [12]. This converter acts as an adapter between the source and the load.

In order to reach the maximum power point which corresponds to the optimum power generated by the PV generator, the adaptation stage must be equipped with a control stage to ensure the monitoring of the MPP by automatically acting on the duty cycle of the selected static converter.

These commands are generally found in the literature as “Maximum Power Point Tracking” (MPPT). These techniques essentially consist of returning each time the operating point of the photovoltaic generator to the MPP, regardless of sudden load variations or climatic conditions [13]. The schematic diagram of the study system is given by figure (5).

3.2 Buck DC/DC Converter

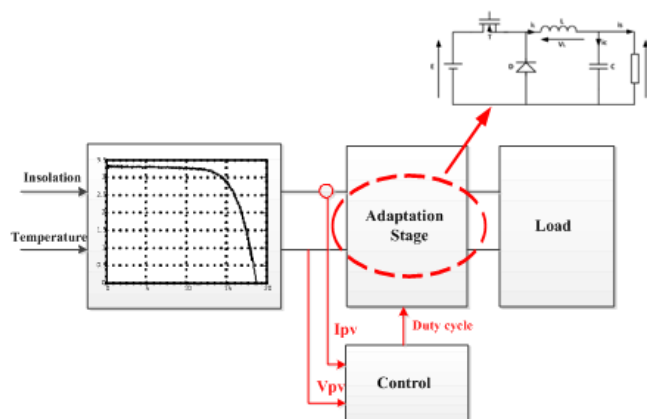


Fig. 5. Schematic diagram

The function of DC-DC converters is to provide a variable DC voltage from a fixed DC voltage. The name of BUCK chopper is linked to the fact that the average output voltage is lower than the input. It comprises a switch with controlled starting and blocking (bipolar transistor, MOS, or IGBT transistor) and a switch with automatic blocking and starting (diode).

The structure of this converter is given by figure (6):

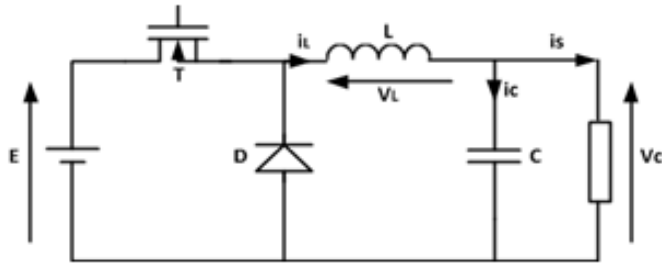


Fig. 6. General structure of BUCK converter

The value of the average voltage at the terminals of the load is given by the following relation:

$$(4) \quad (V_c)_{moy} = aE$$

3.3 MPPT controller

Description of control approaches

Several works on MPP search techniques appear in the literature [14]. These commands differ from each other generally in point of view; operating principle, precision, and speed of finding the maximum power point. These different techniques are classified into several families:

- Family of direct methods,
- Family of indirect methods,
- Families of methods with variable structures,
- Family of intelligent methods.

The method chosen in this work is the P&O technique, part of the family of direct methods (characterized by the simplicity of implementation).

Principle of the perturb and observ (P&O) command

The Perturb and Observ method (commonly referred to as P&O) is the "Hill Climbing" type. This approach is based on a periodic disturbance (incrementation or decrementation) of the voltage or current and the observation of the influence of this disturbance on the power delivered by the PVG. Based on this observation, the algorithm of this method decides what to do during the next iteration, Figure (7)

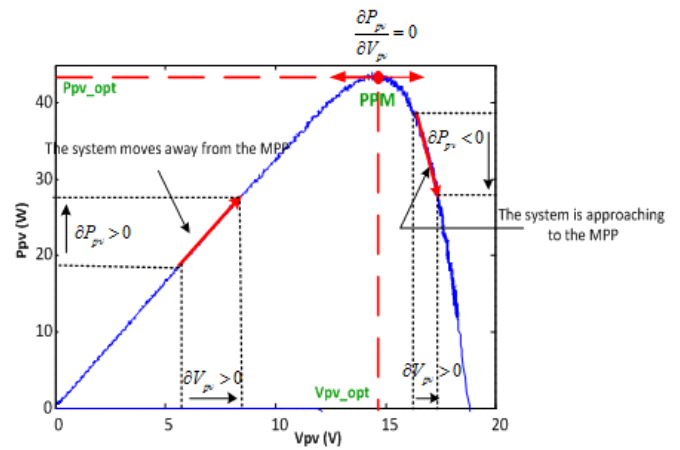


Fig. 7. Trajectory of the operating point on the characteristic (current-voltage)

We can also write:

$\frac{\partial P}{\partial V_p} < 0$: The operating point is to the right of the maximum power point; the control system moves the operating point in the same direction of the disturbance.

$\frac{\partial P}{\partial V_p} = 0$: The operating point is at the point of maximum power; the disturbance is kept the same.

$\frac{\partial P}{\partial V_p} > 0$: The operating point is to the left of the maximum power point; the operating point moves in the opposite direction to the disturbance, [15].

This method requires the use of a voltage sensor and a current sensor to calculate the power at any time. Fig. 8 gives the algorithm of the proposed method:

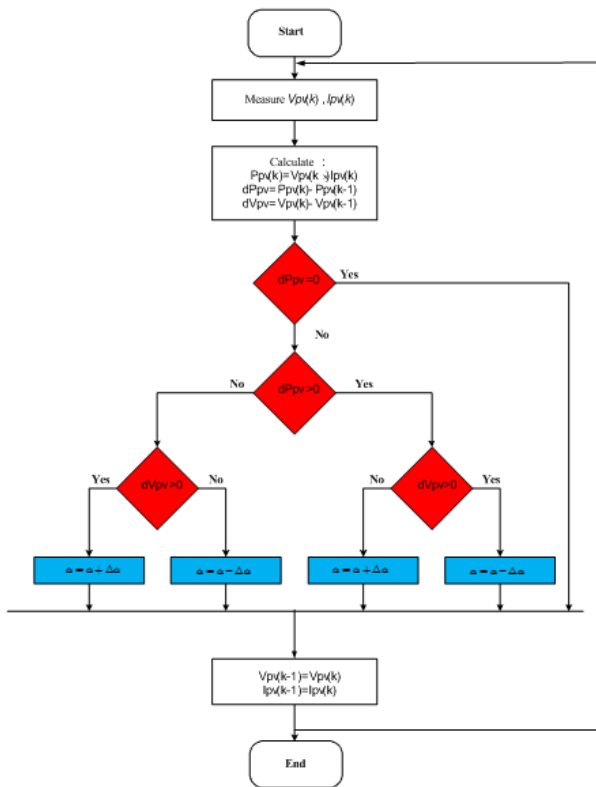


Fig. 8. Algorithm of P&O method

4 Learn PLC Programming: How is the maximum Power Extraction Algorithm implemented on the PLC

4.1 SIMATIC S7-1200 Controller

The SIMATIC S7-1200 PLC is a modular mini-controller used for a small performance. There is a comprehensive range of modules for an optimized adaptation to the automation task. The S7 controller consists of a CPU that is equipped with digital and analog signal inputs and outputs.

The student must study the sensors, then choose the appropriate sensors for measuring the current and the voltage of the PV panel.

Current Sensor:

The ACS712s sensor is a hall effect sensor whose maximum current that can withstand it is 5A.

This sensor is connected in series in an alternating (AC) or continued (DC) circuit, and it uses the magnetic field generated by the current (and therefore the hall effect) to measure the current flowing through it, figure (9).



Fig. 9. Current sensor ACS715 type

Voltage sensor:

The voltage sensor used in this work is DC0-25V type. This module is based on a resistive separation principle and it can only measure up to 25V, figure (10).



Fig. 10. Voltage sensor DC0-25V type

4.2 PLC Study and Programming

We used TIA PORTAL software to develop our ordering program, based on the “P&O” optimization approach. The inputs of this block are accurate signals (current and voltage) that are obtained from the sensors. The “PWM Generator” block mainly makes it possible to supply a PWM signal to drive the MOSFET gate.

To implement the maximum power control approach, we need to measure specific quantities; voltage and current are key elements in real-time control. The programmed system overview is given by figure (11).

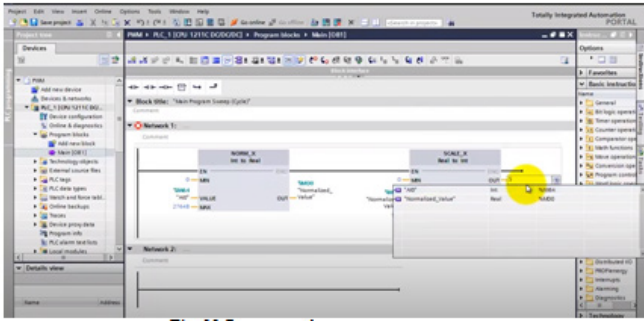


Fig. 11. Programmed system overview

5 Carrying out Experimental Studies: How to implement the Energy Management System

5.1 General structure of study system

The schematic diagram of the photovoltaic system studied in this work is composed of a PV generator equipped with an adaptation stage between the source and the load provided with a control which is ensured by an industrial programmable logic controller as shown in the figure 12.

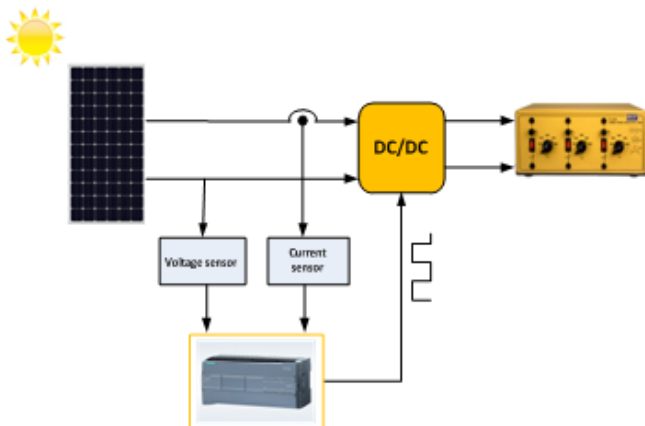


Fig. 12. Block diagram of the proposed system

6 Experimental Validation

The purpose of the manipulation:

- Master the operation of a photovoltaic system,
- Observe and verify the effectiveness of the MPPT method,
- Study a complete resistive load-photovoltaic generator system in real-time.

6.1 Test bench

The test bench that is the subject of this work is part of the equipment of the electronics laboratory of ISSAT Mateur. Figure (13) shows the experimental test bench used to implement and study the performance of the proposed MPPT technique through the CPU. This test bench consists of a PV panel characterized by a maximum power of 50W in STC, a voltage sensor and a current sensor, a buck chopper, a CPU 1200 programmable controller, and finally, a variable resistive load.



Fig. 13. Test bench, view 1

6.2 Results

The principal objective of this manipulation is to master the operation of a photovoltaic system and to observe and verify the efficiency of the MPPT method studied for a complete resistive load-photovoltaic generator system in real-time. Figure 14. shows another view of the implemented test bench.



Fig. 14. Test bench, view 2

These figures show the values of the voltages at the input and output of the chopper, respectively. These values prove very well the effectiveness of our control and the BUCK converter.

The development and improvement of the system by the students:

- Network operation,
- Remote control, supervision (on-board system),
- Use new technologies.

Work in collaboration with industry: Internships, PFE ...

7 Enabling Plan

Part I:

Teach the student: Ask the problem and wait for the student's feedback in the different stages for mastery of energy management

Part II:

Develop the system: Academic knowledge -> development of skills and monitoring of technological development.

8 Conclusion

In this work, we have developed a real solar cell model, the different manufacturing technologies, and the recording of the characteristics of a photovoltaic panel in order to show the influence of climatic parameters on their operation. We also investigated the importance of optimal operation and exposure of a maximum power point tracking method. Finally, we exploited a BUCK chopper produced as part of an end-of-study project to perform real-time tests to verify the dynamics of the PV system with the MPPT control method.

We have tried to interpret these results as a whole, but they leave us convinced that this is just the beginning and that the main thing lies in improving the studies carried out for future work.

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FabLabs for Project-Based Learning of Industrial Installations: A promising pedagogy in technological education

Riadh BEN JEDDOU¹ and Mnawer GAS-SOUMI²

^{1&2} ISET Kasserine, BP 448, Kasserine Tunisia

¹riadhbenjeddou6@gmail.com

²mnawergassoumi@gmail.com

Abstract.

The aim of this paper is to adopt the “Project-based learning” at university specifically for the practical modules. Hereby, a logistical problem arises. What space should we provide? The solution was mainly to put FabLabs at the service of “Project-based learning”.

Our experience was applied for a practical module called: “Industrial Installations”, taught to first year students of Electrical Engineering. A choice justified by the industrial aspect of the subject, which can make it easier for students to reach a feasible project. The hosting space for students is the ISET innovation lab in Kasserine. The innovation lab does not solely epitomize an open space for the student’s creativity; however, it is also part of the all-in-one well-equipped open access laboratories.

Our experiment targeted a sample of 28 students. This sample was the subject of an experimental study to evaluate approaches in question. This paper will include evident results.

Keywords: PBL, FabLab, Motivation, Pedagogy, Industrial processes, Innovation.

1 Introduction

Among the methods that can improve student motivation lies the Project-Based Learning pedagogy, representing a widely used approach in vocational and higher education in a bevy of countries (France, Germany, Quebec etc.). Project-based learning (PBL) is a teaching method in which students learn through active engaging in real and personal outstanding projects [1].

Our most important goal is the application of the PBL approach in practical university teaching with the focus on technical modules.

A host of university teachers from the ISET network had the opportunity to gain Professor Valentin PLENK’s experience from Hof University (Bavaria, Germany) within the framework of a training course which included “A project to support the employability of young students” (ALEJE). It is a teaching experience which is based on the PBL model and which, therefore, impacts the contributing teachers in the training .

Still, we have to bear in mind whether our laboratories and university workshops can possibly support such a cumbersome approach, which is demanding high volumes of material and consumables. That can call for entanglement and cooperation of various disciplines, teams and specialties. The most suitable spaces that meet the requirements of the PBL approach are the FabLabs.

Motivated by the effective contribution of PBL, we thought about enacting the approach with a group of students. Furthermore, since the PBL approach concords with the offered practical modules within the ISET network, we applied the content of the practical modules and the FabLabs’ efficiency for incubation and realization of students’ projects. Concrete results will be put forward summarizing our experience [2].

Part 2 outlines the current traditional approach and its impact on demotivated students.

In part 3 we will then give an idea about the Project-Based Learning approach and present how such approach can be fitted to the scope of our project (FabLabs for Project-Based learning of industrial installation).

Finally, in part 4, we will present the experience gained by adopting the PBL approach in FabLabs and by realizing it with the students. Results with analyzes are presented at the end of the paper.

2 Practical teaching within the ISET network

2.1 The traditional pedagogical approach

Practical education is one of the characteristics of the ISET network courses. The hourly volume devoted to practical work largely ex-

ceeds that of all other Tunisian universities. Table 1 provides a comparison between the overall weekly hours and those allocated to practical work for licenses in similar specialties and in different institutions. It is clear that practical education occupies a fairly important place within ISETs.

Table 1. Hourly load of practical modules in various Tunisian universities.

Level	Fundamental license EEA* Faculty of Sciences of Monastir	Applied license EEA ISSAT of Sousse	Applied license EI** ISET Network
Semester 1	19%	29%	42%
Semester 2	19%	25%	48%
Semester 3	18%	32%	42%
Semester 4	28%	42%	48%
Semester 5	12%	32%	50%
Total	19%	32%	44%

*EEA: Electronics, Electrical Engineering and Automation **EI: Industrial Electricity

The objectives targeted by each practical work are briefly mentioned in a subject file which is established by a sectoral commission of teachers chosen by the DGET for ISETs and by the rectorate for other university institutions. This paper epitomizes a contract to be achieved by the teacher of the subject. Teachers must formulate the specific objectives in the form of a report which will then be completed and submitted by students or a group of students at the end of each practical session.

We should also highlight that the practical work depends on two essential factors:

On the one hand it relies on the progress of the theoretical subject courses associated with the practical modules. On the other hand, practical work hinges on the level of laboratory equipment available for use. These Factors will hinder a global vision of the module and prevent the realization of a practical project. Assembling, testing and experimenting therefore remains to be laboratory work and does not look like what can be found in the industrial environment. In their best cases, practical projects are carried out on educational models for specific objectives only.

2.2 What educational approach should we adopt?

It is clear that practical education in ISETs occupies a prominent place in official curricula. This, of course, represents a major asset for graduates. However, a flurry of problems re-

duces the effectiveness of the educational approach employed. The classic approach that has always been used boasts indisputable advantages such as continuous monitoring, permanent assistance and supervision. However, it still remains to be a feeding back model with the reputation of being unmotivating for the learner.

Therefore, there is a need for teaching with higher student attendance and more discreet involvement rates and a more effective teacher attendance. The tested and highly effective PBL approach may present the best solution to the prevailing problem [3].

However, remedying the inadequacy of conventional laboratories with the help of the PBL approach, requires an unlimited accessibility in terms of time, space, interference from several work teams and managers as well as a wide variety of equipment. Knowing that several institutes have a FabLab or a form of lab that has a similar concept (Innovation lab, living lab, etc.) where sharing spaces, machines, skills and knowledge is completely free, we thought that the practical projects could be carried out in such FabLabs. A pedagogical approach based on teaching certain practical modules in FabLabs whilst adopting project-based learning can constitute a promising pedagogy in technological education.

3 Project-Based Learning (PBL)

3.1 What is Project-Based Learning?

Project-Based Learning (PBL) is a student-centered pedagogy that involves a “dynamic classroom”-approach which is based on the allegation that students acquire a deeper knowledge through active exploration of real-world challenges and problems [4]. Students learn about a subject by investigating and responding to complex question, challenges, or problems over an extended period of time [1][5]. Hence, PBL is a style of an active and inquiry-based learning. Furthermore, PBL contrasts to paper-based, rote memorization, or teacher-led instructions by posing questions, problems or scenarios instead [6][7][8].

3.2 Who chooses the project and defines it?

What we suggest is to guide students, in the most discreet way, to commit to choices that meet the needs of the program. Before choosing or drafting a problem and planning the progress of the PBL activity, we will have previously determined the objectives that will be attained. These objectives will concern knowledge (concepts, principles, rules, procedures, methodologies, ways of doing things, etc.), skills and attitudes specific to the targeted content and perhaps even more general skills developed in the program. The more the student is involved in defining and writing the project, the more he will be motivated [5][9][10].

4 Application of the approach

4.1 Framework of the experience

Students of electrical engineering, industrial maintenance, mechatronics, electromechanics or other fields have imperatively “Industrial Installations” courses. The practical teaching of this module in a traditional electrical diagram laboratory or industrial process laboratory fails to achieve the objectives targeted by the material sheets furnished by university curricula. Certainly, in handling industrial installations, one manages to start, as it should be, a three-phased asynchronous motor. However, this simple start-up procedures leave no student to place the element of driving force in a true industrial manufacturing process. After meeting and questioning Tunisian university graduates about their experience, it becomes clear that the graduates are very discontent and dissatisfied with the application of practical projects during their course of study. Further, they noted that manufacturers and potential employers criticized them for the lack of mastery of instrumentation, data acquisition elements (various sensors, conditioners, etc.), PC-PO interface elements, human interface elements, machines and the handling of effectors (conveyor, movement transfer or transformation system, etc.) at industrial plant level.

4.2 Approach

The sample chosen for the experiment is a first year Electrical Engineering class. The class is made up of 28 students, 13 girls and 15 boys, with an average age of 19. The chosen module is “Industrial Installation workshop” one of the cardinal practical modules. The experience spans the second semester of the 2020-2021 academic year from February to June. Students, divided into groups of four, were asked to define their projects within a deadline of one week. Consequently, they received a presentation of a model design made by the teacher in order to carefully prepare specifications guiding students to correct composition, defining and describing their project. After one week, a recapitulative meeting took place to separately discuss the projects and to develop the specifications in order to achieve the objectives of the material sheet. The latter took place with no fixed coaching appointments, but rather debriefing meetings left to the students’ choice.

The innovation lab of ISET Kasserine is available for the students. The space has been consolidated with material that is somewhat specific for the previously mentioned module.

4.3 Results and findings

Choice of project: The majority of students (six out of seven groups) have succeeded in providing specification notes (compare Figure 1). In total, we have kept five of whom three required some fine-tuning (they were very ambitious and/or financially demanding). The remaining other project was denied because it lacked originality and did not meet module objectives. In addition, one group did not submit specifications note. These two groups have chosen projects out of a list prepared by the teacher.

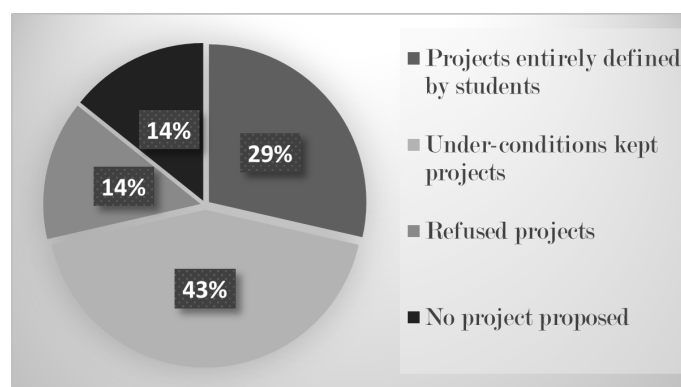


Fig. 1. Distribution of projects according specifications’ relevance.

Student autonomy: The teacher has chosen to be available twice a week for possible requests by the students. Once in his office and once in the workplace in the innovation lab. The results presented in Figure 2 show the number of meetings requested by the students and which reveal that some students were significantly more independent than others.

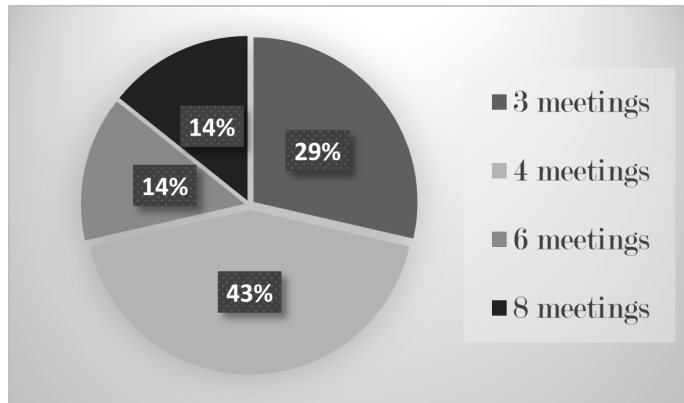


Fig. 2. Student ranking according to meetings with the teacher.

Impact of space on student work: Logistical problems prevented us from developing a system for monitoring student attendance in the innovation lab. However, according to the lab's bookings book we can conclude that students have spent a lot of time working on their projects when compared to the hourly volume of the material in the classic approach. In Addition, when questioning the satisfaction of our participating students with their work in the innovation lab, we received that 75% are very satisfied, 11% are satisfied and merely 7% each feel either indifferent or not satisfied (compare Figure 3).

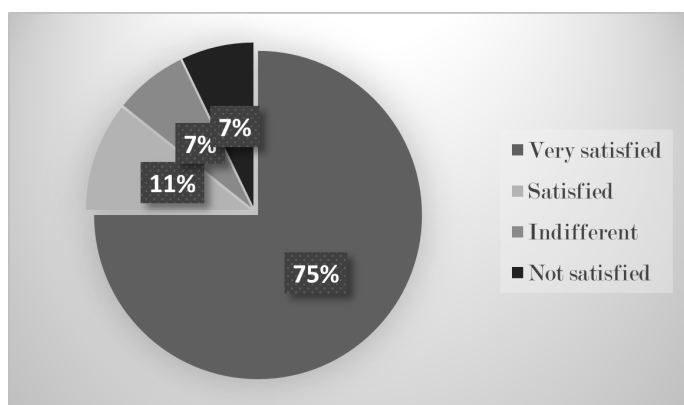


Fig. 3. Satisfaction rate with innovation lab.

Project evaluation: We opted for a formative evaluation which promotes the progression of learning, and which informs the student as well as the teacher on what has been learnt or on what needs to be improved. Four possible levels were given in the projects: 'Excellent', 'Good', 'Average' and 'Substandard'.

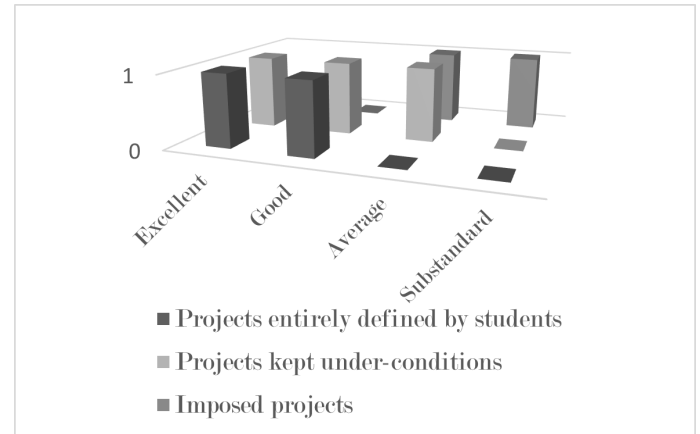


Fig. 4. Ranking of projects according to specifications note author.

Experience evaluation of "the PBL approach in the Innovation lab": To resolve, we have asked the students the following question: Under which circumstances did you feel at ease, under the classic approach and in classic labs or those of the PBL approach within the innovation lab? The results of the questionnaire revealed, that 82% of the students felt more at ease under PBL within the Fab-Lab approach than under classical or other approaches (compare Figure 5).

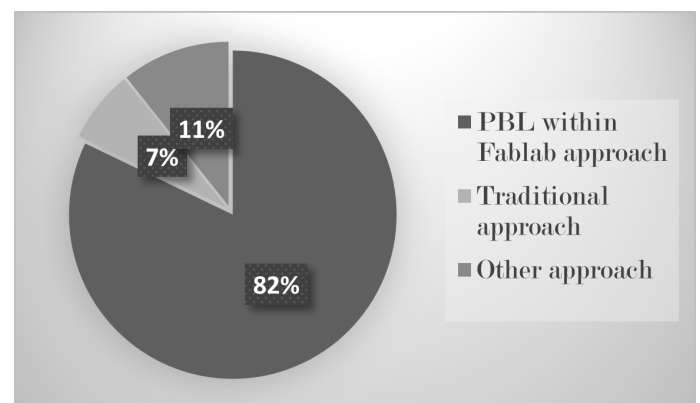


Fig. 5. Rate of students according to the choice of the pedagogical approach

4.4 Interpretation of the results

For students it is clear that the current approach is much better than the classic approach. To be more objective, we will recall the other parameters of the survey. The voluntary autonomy of most of the students was outstanding. More than 72% of students claimed meeting the teacher for only 4 times at most throughout a full semester. We have found that students can perform better if the teacher rather plays the roles of a guide, a motivator, a facilitator and a mediator, instead of a 'tutor'. In this case the students feel challenged and empowered which enables them to release their full energy.

We noticed that the more the students are at the origin of the project, the better results they achieve. Indeed, of the 72% of the students that have dealt with their own ideas, 80% of projects were good or even excellent.

The results indicate that over 85% of projects are above average, over 50% are good projects and 29% are even excellent ones. These percentages have never been reached by these students whether for the same module in the first semester or for the other practical modules of the same semester.

5 Conclusion

Our study was based on a comparison between the classical teaching method and project-based learning and more particularly the teaching of practical technical modules in FabLabs or any other similar forms of space with a project-based approach. "Industrial Installations" and "Industrial Processes" in particular are very suitable modules for this educational approach since finding a project in the industrial field that meets the objectives of the subject seems to be a fairly easy task for the students.

Freeing themselves from all obstacles of time and space and finding themselves faced with their own project and situations that they themselves have conceived, can act as a motivation for students to prove their ability to develop a project from the idea to the achievement.

The innovation lab, despite being in the process of being furnished and not yet ready, may

have been an additional source of motivation. The idea of being free in time and space is attractive especially for such young men and women.

We don't need ingenious analysis to find that the students enjoyed their time in the practical project. In addition, having had results that exceeded our expectations, students developed new skills such as: problem solving, proactive thinking, self-directed learning, critical thinking, communication, integration, group spirit and teamwork, etc.

Nonetheless, all of the benefits cannot hide the limitations of PBL. We have found that group work can lead to disadvantages such as:

- The team can trust a leader and will be dominated by his conduct or just the contrary, it can be influenced by the less motivated.
- Engagement can decrease with the difficulties a team may face.
- The PBL approach has not yet found its place in the legislative framework of Tunisian higher education.

All in all, the PBL pedagogical approach has helped students become more committed especially with their choices. It cuts away the classical feedback-based approaches which are no more useful. As the results have shown, its efficiency has become quite stunning when practiced in the FabLabs.

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Using design thinking to build an automation project

Mondher Haggi¹

¹ Department of Mechanical Engineering, Higher institute of technological studies of kasserine, Kasserine, Tunisia

Abstract.

In the field of the automation industry, the development of a specific machine or an automated project is carried on through a series of stages that allow the automation engineers to successfully accomplish their tasks. In Addition, the industry aims to improve overall quality in projects by involving upgrades in such machines. To be in phase with expectations of the industrial part, the concept of design thinking is considered in this work. the concept is an innovative method that places creativity at the center of the process. It is based on a more pragmatic view of a problem by promoting the rapid prototyping of solutions.

The aim of this work is to apply design thinking to produce relevant and effective solutions for Bottle Packaging Machines in order to fully automatize it. The project has been realized by students in cooperation with the vegetable oils industry and backed by the university. Results have shown the relevance of the concept of design thinking in a learning project. Keywords: Automation, Design thinking, Packaging machine.

1 Introduction

This study examines the importance of design thinking competencies in dynamic project environments. According to findings a lack of communication, the inability to understand objectives, and the inability to manage industry expectations are the key reasons for project failure. The diagram below (compare Fig.1) shows the principal stages (empathize, define, ideate, prototype, and test) of the design thinking tool. Design thinking is an innovative approach frequently used to solve complex problems, uncover hidden needs, and develop more desirable solutions by adopting a collaborative user-centered approach [1]. Hence, a growing number of industrial companies have involved design thinking to develop sophisticated products and

services. W. Tushar et al. [2] have introduced a design innovation (DI) approach that considers design thinking techniques as well as desirability and empathy to establish a sustainable smart energy system for buildings. V. Malele et al. [3] illustrate how design thinking could be applied to align the Science, Technology, Engineering, Agriculture, and Mathematics (STEAM) curriculum towards the expectations of the fourth Industrial Revolution. Malele et al. present a project which was executed with students engaging in designing and building automated plant watering/irrigation systems using any wireless-based solutions. M. Lynch et al [4] have conducted a study of the relationship between technology and entrepreneurial education through design thinking. In this context, they found that in order to bridge the gap between science and engineering education they will have to educate their students by upgrading their skills to innovative industry standards, Therefore, introducing design thinking accordingly has been given increasing attention both in practice and research [5].

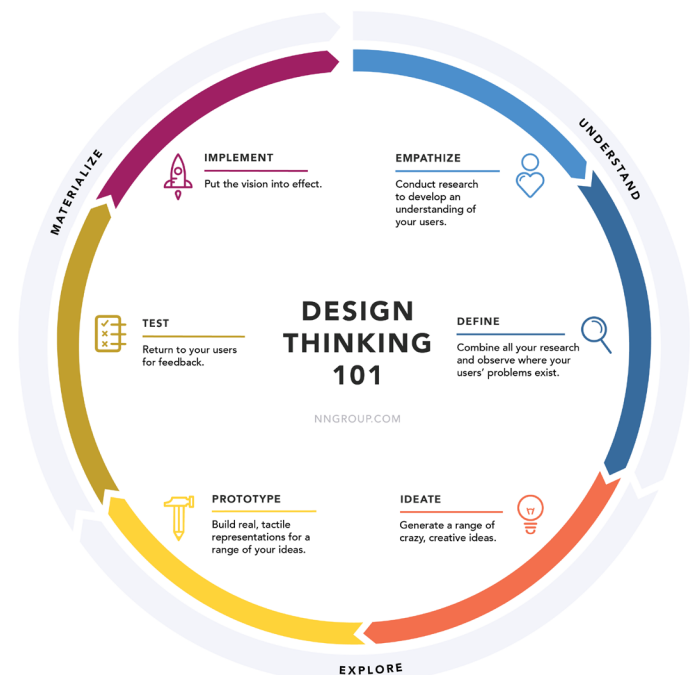


Fig. 1 Design thinking process

2 Design thinking and automation project

2.1 Architecture for Industrial Automation Systems

The emergence of the Industrial Internet of Things (IIoT), allows reconsidering many traditional notions in relation to industrial automation systems. Broadly speaking, the topologies are based on technological considerations. As shown in Fig. 2, the information and communication side of existing industrial automation control systems are traditionally divided into the shape of a “Pyramid” following the ISA-95 standard. In the ISA-95 pyramid, five layers are defined from top to bottom including enterprise resource planning (ERP), manufacturing execution systems (MES), supervisory control and data acquisition (SCADA), the controller (PLC), and field-level (sensors and actuators).

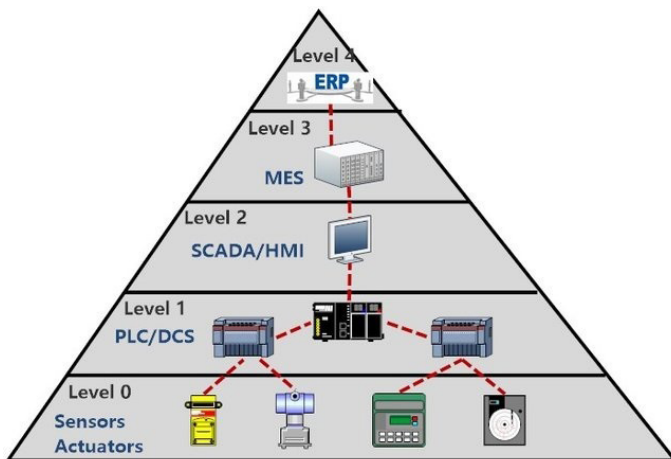


Fig. 2 ISA-95 Architecture for Industrial Automation Systems

2.2 Design thinking in Automation system

There are two ways to establish design thinking DT in an automation system. The first one includes DT from the outset and the other way focuses on upgrading an existing system or machine, which is the case in this paper. Therefore, we will now present the distinct stages of DT in relation to developing an automation system.

Empathize: You will have to know all the features that the special machine will have to integrate. For this it is of utmost importance

that you ask, ask, and ask. If you have the slightest doubt, ask the right person (Operator, technical manager, engineer...).

Define: Explore and define the parts which are concerned for upgrades. The methods used for this purpose include user activity diagram, personas, behavior-based frameworks, a hierarchy of purpose and system functional modeling.

Ideate: Generate ideas and questions to ask, to solve the design thinking problem in relation to parts of the project. There are a host of techniques used in this stage such as mind-mapping which is an ideation method that is analogous to human memory. Furthermore, we can use C-Sketch as a graphical, team-based ideation technique for creating refined solutions to design problems and opportunities. In addition, design by analogy is an efficient process of transferring solutions through different design domains.

Prototype: Realize an inexpensive scaled down sample version.

Test: Rigorously try and test the solutions.

3 Case study: Bottle Packaging Machine

3.1 Presentation of Problem

With the currently existing semi-automatic machine for bottle packaging, companies have the problem that carrying out the cashing operation manually or semi-automatically disrupted efforts to expand production and increase profits. The purpose of this study is to define a solution that makes it fully automatic by application of the design thinking concept. In the following subsections the Design Thinking methodology will be applied (compare 2.2).

3.2 Empathize

To be empathic towards the users of the existing machine, several methods were applied. First of all, the students observed the bottling machines in their “natural environment”. Then, during the working sessions they ob-

served the machines with their team in order to capture the reactions as they go. Additionally, they have conducted interviews with different members of the team about the difficulties that they face. Another interview was carried out with the manager to define what his precise needs comprise. The students then prepared a document about the situation of the machine which included technical parts, historical repairs, etc...

3.3 Define

After using a user activity diagram, the students have defined the necessary major upgrades to be:

- Automate the cashing operation.
- Scale back working time and costs by improving mechanical parts.
- Increase the feasible amount of production.
- Improve efficiency.

3.4 Ideate

At this stage, students have developed ideation through the mind mapping method (compare Fig.3). They have presented solutions in relation with mechanical parts, sensor and detection, the controlling part and the IHM part.

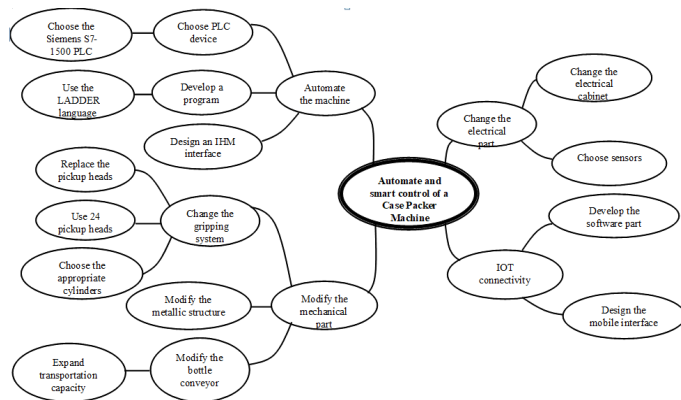


Fig. 3 Mind mapping method

3.5 Prototype

Students have realized a full 3D design of the bottle packaging machine with CAD software containing a real simulation of the process (compare Fig. 4). The controlling part of this concept was realized through Siemens S7-1500 PLC. Then they continued with designing an interface IHM with Win CC Flexible Engineering System (compare Fig.5).

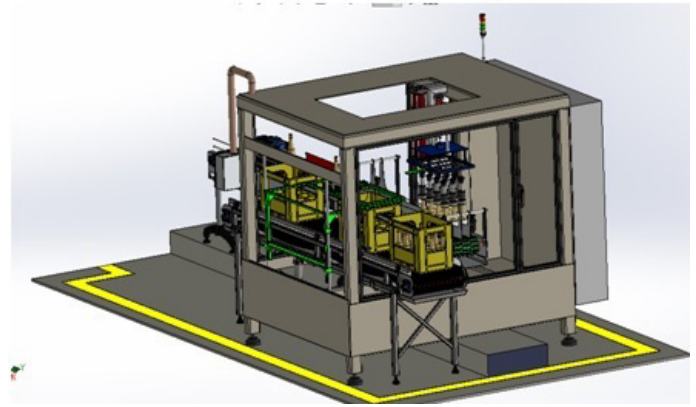


Fig.4 Bottle packaging machine

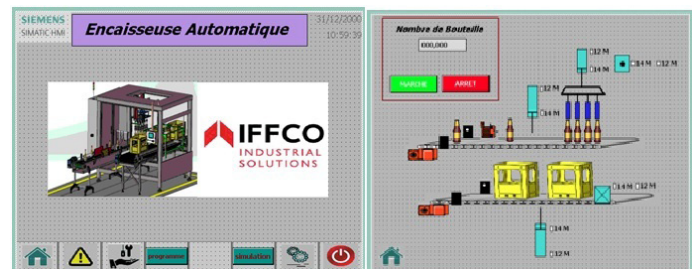


Fig.5 IHM for the packaging machine

3.6 Test

The test was successfully realized first in form of a simulation at the university and was then transmitted to the industry.

4 Conclusion

All in all, this study has shown the importance of design thinking competencies in automation project environments. The successful application of our upgraded bottle packaging machine (upgrading it to be automatic and connected) reveals that adopting a user-centric and holistic approach is momentous for the innovative industry. Furthermore, it demonstrates that design thinking is applicable in pedagogy and that its use at university may diversify the teaching/ learning process.

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Design of an industrial dryer test bench: Control of a multivariable system

Alaä CHABIR¹

¹Higher Institute of Technological Studies of Gabes

alaa.chabir@yahoo.fr

Abstract.

Temperature control is still a theoretical approach in our study plan. On the other hand, the industry lacks efficient techniques to control an industrial dryer. The idea is to realize a test bench which touches the previously mentioned fields.

Keywords: Thermal behavior, Test bench, multi-control system.

Introduction

Drying is an operation that removes some of the solvent (usually water) from a body, by vaporizing the solvent. The product then passes from a “wet” state (liquid or solid) to “dry” [1]. The choice of the drying technique is important because it consumes energy to then provide the latent heat of evaporation [2]. Today, industrial hot air drying is the most common method. There are numerous methods of hot air drying, depending on the relative direction of circulation of the air and the product [3].

This article proposes a design and realization of an industrial dryer used as a thermal test bench. The system presented is a multivariable system of MISO type. Another challenge is to provide appropriate control over the system.

Thermal test bench design

The thermal test bench design is constructed of an industrial air-drying system which is used to reduce humidity. It is a didactic bench which serves to familiarize the students with the thermal field.

The thermal test bench is composed of a motor (blower) which is controlled by a variable speed drive VSD. The air flow passes through a pipeline equipped with three heating resis-

tances controlled by SSR relays. A Pt100 probe is placed at the end of the pipeline (compare Figure 1).

The resistance of Pt100 is expressed as follows:

$$R(T) = R_0(1 + \alpha T)$$

Where R_0 represents the resistance for $T=0^\circ\text{C}$ and α sensor thermal sensitivity.

The system is controlled by Siemens PLC S7 1200. A transmitter is wired to the Pt100 probe to get a voltage image [0 10V] of temperature.

The test bench presents an open-source facility where the system could be controlled by s7 1200 PLC or by a temperature controller AS-CON type KR3-HCIRRD.

This controller is already wired to Pt100. Indeed, this controller has two outputs and plays two main roles:

1. Transmitter by converting the resistance output of Pt100 to voltage image (1st output). The converted voltage is wired to the PLC analog Input.
2. Local controller by reading the actual temperature value and releasing PWM signal (2nd output). This output could be wired to the SSR Relay.

The PLC CPU is 1212 having 3 pwm outputs and two analog inputs.

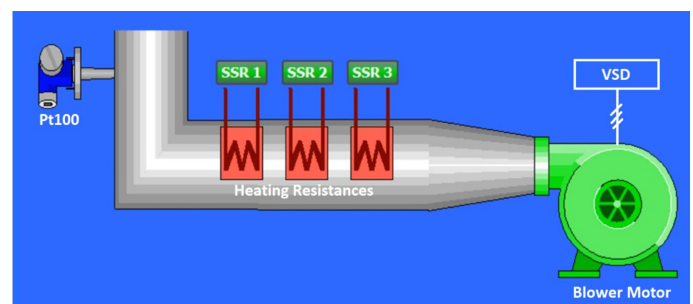


Fig.1. Test bench design.

Controller structure

Within the controller structure of the design the focus lies on temperature control which can be monitored by three types of controllers:

- **Hot controller:** Maintain a fixed motor speed Ω (constant air flow) and vary the temperature by a PWM signal to the SSRs vary the heating resistance power.
- **Cold Controller:** Maintain a fixed heating power WR and vary the air flow. Here we are dealing with a reverse effect regulation: the increase of air flow causes the decrease of temperature because the air in circulation will not have enough time passing through the resistors.
- **Mixed Controller:** of previous controllers by SSR and variable speed drive: multi-variable system with two inputs and one output (MISO).

In the following sub-sections, we will shed a closer look onto the application of temperature control under the use of no controller (open loop) and under the simultaneous application of multi-controllers.

Open loop

In the open loop, we start the system by giving the SSR relay 50% as a heating set point. Then we start the blower by giving 50% to the VSD. We observe that the system's response indicates that there is an instable zero. Indeed, the temperature slides a little before rising to the final value. Within the open loop the system remains stable.

Multi-controllers

When integrating our three types of controllers which we outlined at the beginning of this section, we get the following controller architecture (compare Figure 2):

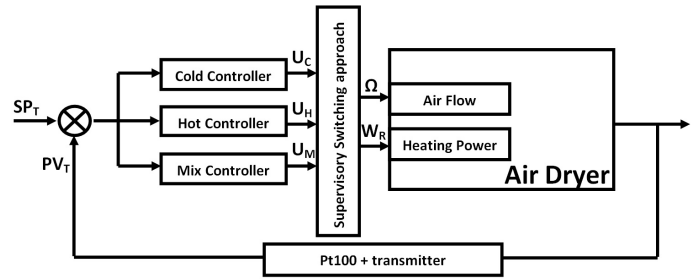


Fig.2. Controller architecture.

Within this architecture the supervisory switching approach designates the desired behavior of the system by controlling:

- Optimization of thermal consumption U_H
- Speed of convergence to a desired state U_C
- Combination between the two concepts U_M

For the Mixed U_M control two strategies can be introduced:

Switching Controls:

$$U_M = \sigma_1 \cdot U_C + \sigma_2 \cdot U_H$$

Where σ_1 and σ_2 are two Boolean variables:

$$\sigma_1 \oplus \sigma_2 = 1$$

Fusion Controls:

$$U_M = \sigma_1 \cdot U_C + \sigma_2 \cdot U_H$$

Where σ_1 and σ_2 are two real variables:

$$\sigma_1 + \sigma_2 = 1$$

Conclusion

In this paper a didactic thermal bench has been realized. The multi-controller structure is developed depending on the identification of the dynamics of the open loop and regarding a supervisory layer. The behavioral study of the system is developed by the GEMMA tool. The existing system in the laboratory of automatism illustrates the practical sessions of temperature control (compare Figure 3).

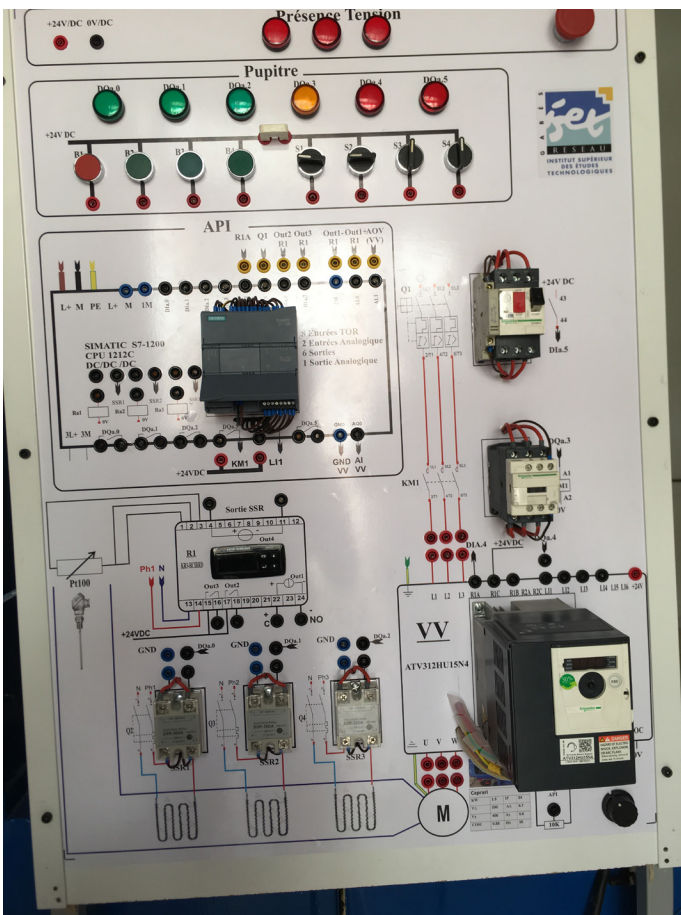


Fig.3. Real Dryer

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Cognitive neuroscience for innovative pedagogy and interdependent learning

Souhaib AMDOUNI^{1*} and Jamel SLAIMI^{2*}

¹ Higher Institute of Technological Studies of Béja. Environment Boulevard, 9000 Béja, Tunisia

¹Souhaib.amdouni@isetb.rnu.tn

²Higher Institute of Technological Studies of Béja. Environment Boulevard, 9000 Béja, Tunisia

²slaimijamel@gmail.com

Abstract.

In this paper, the authors present an innovative approach to the integration and motivation of students in technical education. An approach based on the concept of “Steven Covey’s Seven Habit” [1] to match modern teaching methods [2] as flipped classroom and learner-centered teaching and by orienting these approaches towards the effectiveness of learning addressed by cognitive neuroscience.

After an in-depth evaluation of the practical teaching at the level of the Department of Mechanical Engineering a gap was detected between the objectives and the reality of the skills acquired by the students. To make up for this gap and to ensure the correct perception of technical and technological concepts, a work team put a strategy in place to address all practical and theoretical gaps and to ensure student engagement in practice sessions and theoretical course sessions.

The goal was to simultaneously develop both technical and life skills or 21st skills defined by “World Economic Forum” [3]

Keywords: competency, initiative, motivation, Empowering, Teaching Process, competence-based approach, Cognitive neuroscience, Lifelong Learner, Learner-centered teaching.

1 Introduction

During the last decade, the field of new technologies such as mechatronics, robotics and automation, teaching access to

skills was based on the learner’s ability to use hybrid sciences. Hybrid sciences within this context are understood as combined sciences such as mechatronics, which requires mastery of the concepts of mechanics as well as computer science and electronics. To control a flexible production cell or a robot in a practical work session, the student must call upon a mental presence and technical skills as well as great social and emotional intelligence. The student requires these skills so that he can coordinate with his coworker’s team members and carry out all the tasks required and succeed in innovating or creating. Internal studies [4] at the ISET Beja have shown a lack of personal motivation, critical thinking, problem-solving skills and most importantly self-training and peer training (training among students).

Furthermore, empowering students [5] in technical fields is not a simple task but requires a lot of work and research. Professionalizing teaching and especially using the project-based approach requires the teacher to have a capacity for rapid evolution so that he can succeed his mission. Teaching in a traditional way using mock-ups and having students perform repetitive tasks only creates a routine and demotivates the group. This paper presents a learning approach using cognitive neuroscience techniques paired with the approach of soliciting targeted areas of the brain to develop intelligences demanded by this evolution (Solicit social intelligence). To create, for example, a constructive synergy between students and an interdependent and enriching communication, teachers should prepare a scenario using the teaching methods and the learning pyramid to vary the learning channels among students.

Moreover, rapid technological change requires a synchronous evolution of human intelligence, computers and the machines used. Technological change invites teachers to create intuitive learners and to solicit the sense of initiative, innovation, and creativity in them.

How can learning channels be valued in the

teaching process? How can we create and/or improve the motivation to learn and understand? How do we enhance the students' sense of innovation and creativity? What is the relationship between cognitive neuroscience and technical education? How can we exploit the interactions of learning methods and intelligences to make our students intuitive learners? How can we prepare life-long learners(LifeLong Learner 3L)?

This paper is organized as follows:

Section 2 provides a bigger picture of how people learn with a particular focus on the applied learning process.

Section 3 then presents a synthesis of the internal evaluation of ISET Beja, carried out according to the AQIUMED framework of the second field: Training.

Section 4 provides the method adopted for the modernization of the teaching of mini-robotics projects to target not only technical skills but also life skills.

Section 5 summarizes the impact and results of the new approach and finally section 6 concludes the paper.

2 Education and learning process

According to the National Research Council NSC and the Committee on Developments in the Science of Learning, the retention rate of what has been taught depends on the method of learning that used these results as well are related to the learning styles of the students. The most effective method is one that meets the needs of all learning styles and enables the active and effective participation of all students. It is therefore important to know how to improve learning methods that allow maximum retention for all students. The pyramid below (compare Figure 1) illustrates learning methods based on the retention rate for learners. [6 & 7]

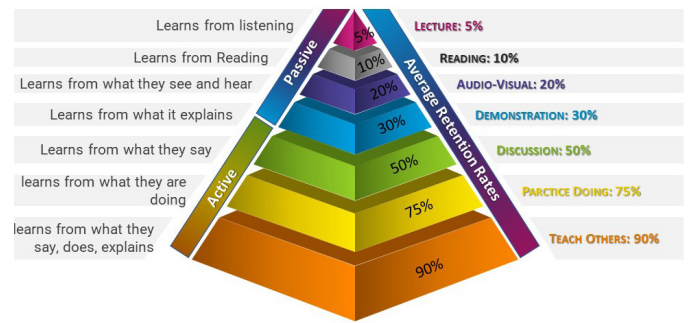


Fig. 1. The learning Pyramid, Knowledge retention rates [9]

Many authors say that retention rates, are really related to learning methods, however even methods with low rates are important and necessary in the learning process. That is the reason why it is important to renew pedagogical methods and work with active pedagogy without neglecting reading and passive methods that develop solitary, auditory, visual intelligence, sense of comparison and critical thinking. [7 & 8]

Pedagogical methods are designed to develop and improve intelligences, enabling the learner to gain knowledge. But are all the methods applicable to all types of learners? Of course not. Consequently, we must find the perfect combination to reach the maximum intelligence for most learners.

According to "How People Learn" [6], we use more cognitive space in our brain when we learn a new thing/method/process, namely the prefrontal cortex, the parietal cortex, and the cerebellum. However, once the skill is learned, only one area (called the motor-sensory cortex) will be used to perform what has been learned. This means that learning a new thing takes much more time and energy than remembering it. As a consequence, the teacher must work with the brains of the students. The research suggests that the teacher should divide the information into small pieces so that it is compatible with working memory and long-term transfer. Telling students something new is not enough to retain or understand. Teachers need to be involved in guided instruction while students are engaged in productive group work.

This does not mean that we rely solely on direct instruction and simply telling students

what they need to know. On the contrary, we need to guide students to new levels of understanding and ensure that they have a multitude of opportunities to practice and use this information so that it moves into long-term memory and can then be accessed by the working memory without the constraints of the number of elements that can be used [9 and 10]. We can conclude that:

- Research clearly shows that we learn best when one actively participates in observing, speaking, writing, listening, thinking, drawing, and doing.
- Learning is consolidated when a person sees the potential implications, applications, and benefits of what is learned.
- Learning builds on knowledge already acquired even if it is false.
- Learning is built when knowledge is presented in small pieces to be compatible with working memory. This is called the teaching scaffolding method that reduces the demand for work memory and facilitates long-term retention. [5]

3 Results of the internal assessment

As part of the continuous improvement of ISET Beja and the training, an internal audit with an assessment according to the AQI-UMED standard was established in March 2020. The students interviewed are almost equally divided between female and male (compare Fig. 2.) and originate from the three specialties taught at the ISET Beja (Mechanical Engineering, Electrical Engineering and Computer Science) and from the continuing education (compare Fig. 3.).

By including all three departments at a consistent percentage (~ 30%), we further eliminated the possibility of mistaking a specialty problem for a more generally concern of students (compare Fig. 4.).

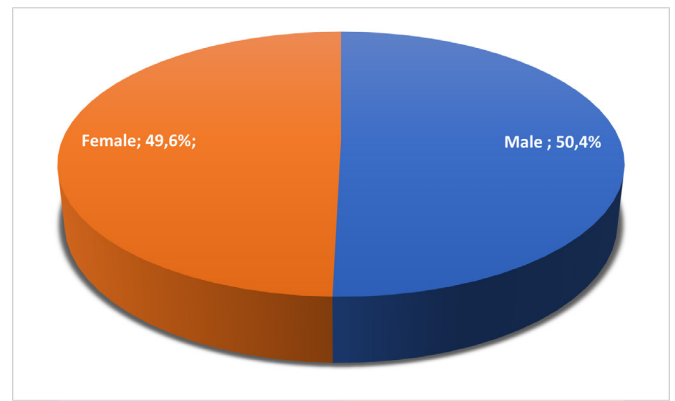


Fig. 2. Gender

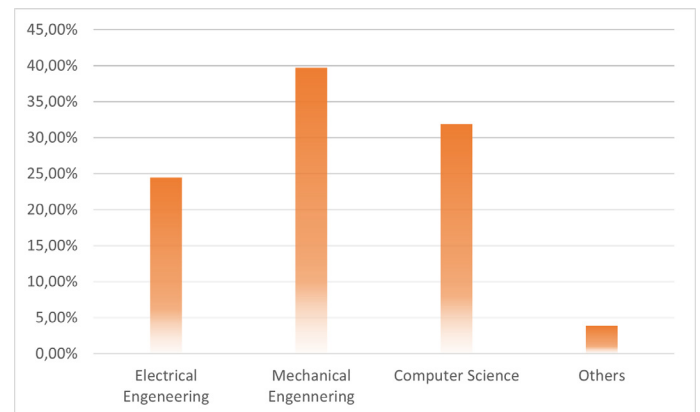


Fig. 3. Percentage of students interviewed by department

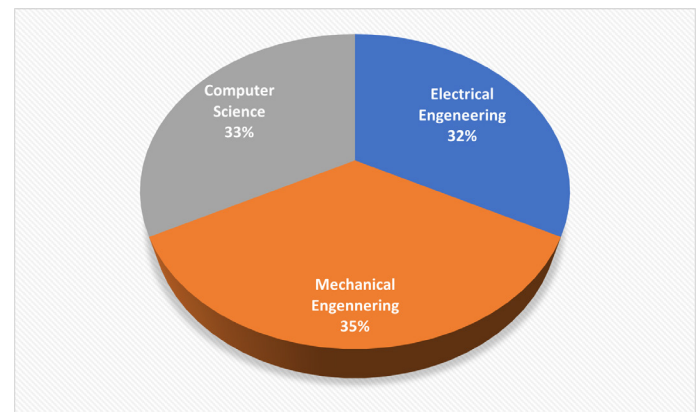


Fig. 4. Percentage of educators interviewed by department

When looking at the results of the interviewed students we find that although 37% of students are quite satisfied with their teachers' ability to explain the course, 29% of students are dissatisfied and 20% of students even submitted that they are not at all satisfied with the teaching methods used. Nevertheless, students additionally submitted that they do not find it difficult to communicate well with their teachers.

As for the competency of the teachers, 40% of the students are convinced by their teachers' expertise however, students additionally consider 51% of them to be dispassionate about the subjects taught and 41% of students think that the objectives of the course are not met.

When asking the students about the organization of the course and about their degree of accompaniment, 37% say that they are quite satisfied and 29% admit they are dissatisfied. In the face of this problem, teachers should make use of certain active teaching methods to give students the opportunity to be better directed and accompanied.

The modules and subjects taught at the level of each specialty represent a basic reference of the quality of the training perceived by the students. The latter are mixed as to their degree of satisfaction with each measurement criterion. Indeed, most students are (very or fairly satisfied) with the homogeneity and coherence between subjects and modules (58%), the hourly volume (51%) and the completion rate of modules (54%).

On the other hand, 72% of teachers interviewed confirmed that students' concerns are: (compare Fig. 4.).

- Lack of initiative and total absence with worrying laziness
- Communication issue
- Concerns about writing and clarity of ideas
- Total dependence on the teacher, always waiting for the recipes ready to carry
- Huge lack of student motivation
- No future projection
- They are not aware of the objectives of the modules or their usefulness in their training.

However, teachers and students are divided between little and no satisfaction with the other criteria and more precisely regarding the overload of modules, the materials available and the state of the rooms. This requires considering the layout of rooms in poor condition and upgrading existing equipment at the institutional level.

However, both teachers and students are dissatisfied with the content of the modules and think they are quite cumbersome hence coordi-

ination among teachers to better target the parts that need to be taught will allow for better understanding and therefore selective discernment.

Teaching at ISET Beja seems to cover all the required aspects. However, a reflection shared by the students remains to be led on the harmonious integration of other complementary training, allowing the students to enrich their training and life skills. In the same sense, the students strongly expressed their desire to consider the possibility of finding a solution for the improvement of teaching methods and working with teachers as teams. Which methods can give them the opportunity to better understand and learn? Moreover, another very important part students and teachers have confirmed, the need to direct all mid-project and practical sessions to real case studies inspired by industrial problems has to be addressed and resolved.

4 Improvement method

When referring to the bibliographic study and especially the internal evaluation of ISET Beja, we recognized that in order to meet the needs of educators and students, the institute has to improve connectivity between the three elements of the learning triangle (Knowledge, educator, learners). Hence, it is necessary that the educator work on the development of two parts, namely technical skills and life skills.

4.1 Empowering to success and self-reflection

To improve the sense of belonging and to strengthen the motivation and personal initiative of students, it is necessary to:

- Act directly on their paradigms and encourage them to reflect on themselves and to adopt their attitudes positively.
- Raise awareness to adopt a positive and active learning attitude
- Motivate students to embody the concept of empowering with the primary goal of developing the skills of tomorrow (skills for future).

To meet these objectives, a strategy, based on a concept of comparison, has been developed. Two pilot groups of mechatronics specialties will be formed in ‘Empowering for success’, following the concept developed by Saloua Saidane Rezgui.

Professor Saloua Saidane Rezgui created his approach to ameliorate the Tunisian education system and to create lifelong learners, based on his Tunisian training and his expertise as a professor of higher education in the US. The concept developed by Prof. Saloua is inspired by the approach of Steven Covey and The Landis Ray Component. Furthermore, his concept aims to create an awareness among learners and educators of the need to change their paradigms to improve the level of learning using modern and targeted teaching methods and universal values (compare Fig. 5. & Fig. 6.). The method is based on a horizontal relationship and win-win spirit. The goal is not to change students but to invite them to get to know each other and to deliberately work on themselves to renew their perceptions and paradigms about themselves, others and about life.

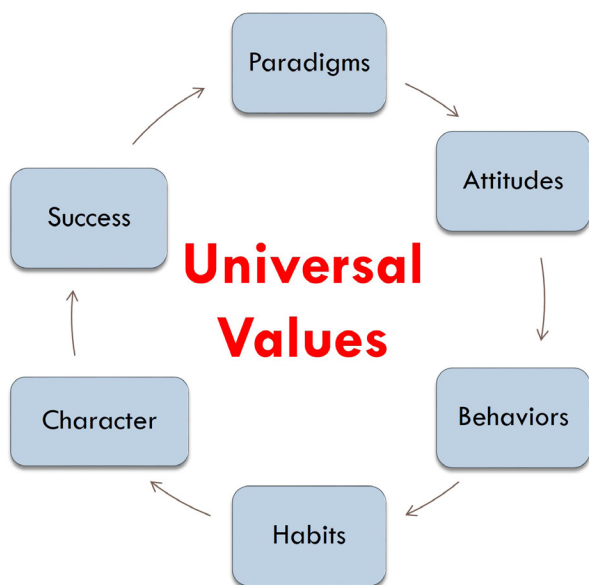


Fig. 5. Curriculum, The Student Course, Saloua’s Approach

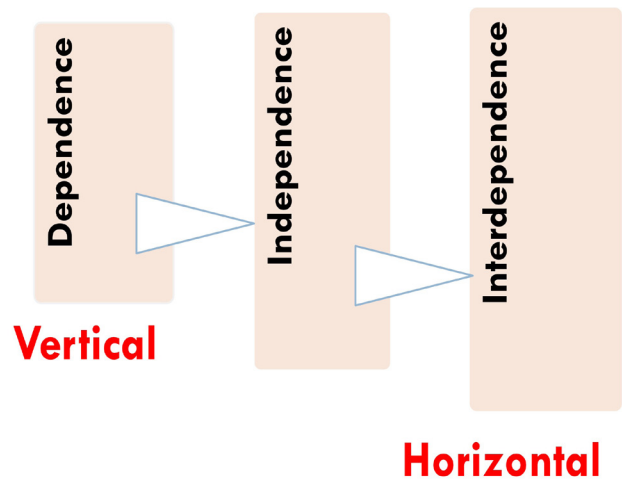


Fig. 6. Personal Growth, The Landis Ray Component

Only two groups MT2.1 and MT2.2 will be trained in empowering during the second year of mechanical engineering (compare Table 1).

In the third year of mechanical engineering (four groups MT3.1, MT3.2, CFM3.1 and MI3.1) the students have technical projects (compare Table 2) during which we will test the rate of autonomy, motivation, and initiative by using a new approach to animate the sessions of the practical work.

Table 1. Statistics of students in the second year of mechanical engineering (2020-2021)

Task	Abbreviation	Semester 1: Empowering	Male	Female	Total
Mechatronic	MT 2.1	Yes	21	07	28
	MT 2.2	Yes	09	08	17
Mechanical Design and construction	CFM 2.1	No	21	10	31
Industrial Maintenance	MI 2.1	No	12	04	16

Table 2. Statistics of students in the third year of mechanical engineering (2021-2022)

Task	Abbreviation	Semester 1: Empowering	Male	Female	Total
Mechatronic	MT 3.1	Yes	20	09	29
	MT 3.2	Yes	12	08	20
Mechanical Design and construction	CFM 3.1	No	19	10	29
Industrial Maintenance	MI 3.1	No	09	03	11

4.2 The mini-project and teaching methods

The Mini-Project 4.1 subject constitutes the constituent element of an optional teaching unit (E.C.U.E.O) for students in the third-year Mechanical Mechatronic Course classes. The project contains 42 hours of practical work at a rate of 3 hours per week. The work proposed to the students involves the design and realization of a robot.

The old method of teaching mini-projects:

This version of teaching concerns students who have not participated in the preparation for the programmed success in the second year. During the first session, the work teams are formed, and specifications are provided to the students for the following topics:

- A robot following lines
- An obstacle detector robot

The four groups then select one topic from the two proposed topics with the following project stages:

- Bibliographic research
- The needs analysis by analyzing the specifications and determining the requirements of the design and implementation
- The 3D designs
- Actuator control after signal acquisition and processing
- Writing an activity report

Furthermore, teachers avoid giving recommendations for grouping, assignment, and work planning.

The students are evaluated by three criteria, namely 3D/2D Design, Programming and Actuator Control and Report (compare Table 3).

Table 3. Statistics of students in the third year of mechanical engineering (2021)

Criteria	Score
3D/2D Design	.../07
Programming and Actuator Control	.../07
Report	.../06
Total Score	.../20

The new learner-based method

The objectives, referring to the newly set curriculum “Third year of mechatronics: Mini-project 4.1” define that the student must be able to:

- prepare specifications for a robot
- 3D Design a robot
- handle sensors signal acquisition and electronic card programming control an actuator
- write an activity report
- present the work in front of a jury

To follow the evolution of the student’s involvement in the learning process, the targeted competencies are specified to be communication, emotional intelligence and teamwork.

The idea is to stimulate the specific intelligence of each student involved in the mini-project work. To join the aim of this objectives, we must diversify the type of work planned. Hence a list is proposed to the students, containing different types of robots such as a robot driven by multifilament muscles, a pizzaiolo robot, a welding robot and a dancer robot.

• Originality and diversity of work:

The mechatronics student is invited during his training course to learn mechanical design, programming, and control. The design and realization of a robot in this mini project, therefore, requires students to leverage acquired skills by adopting a hybrid multidisciplinary approach combining the use of mechanical engineering, electrical engineering, and computer science).

• Diversity and complementarity of roles:

Based on cooperative learning, students are divided into groups. The cooperative learning method involves putting students in groups so that they work together to understand and learn. Student groups are generally composed of a maximum of two to six members. The grouping is heterogeneous in relation to the characteristics of the students and their learning styles. Group members share the different roles of learner and teacher and interdependently achieve the group learning objective. At the start of the practical work phase, students are invited to share doable tasks considering the skills of each team member. All group members play their part by leveraging their strengths whilst simultaneously learning from others. Consequently, all team members develop, improve, or perfect, all facets of their intelligence. The methods’ aim is to concurrently develop technical and social skills by promoting the cohesion and harmony of the group. Furthermore, this method teaches to respect individual opinions and to learn from others. Hence, this concept provides a methodology that allows students to evolve their intelligence, develop their critical thinking, and refine their communication skills. [5]

Practical working sessions with the new method:

The work of this mini project took place for 14 weeks, with the last two weeks reserved for the writing of the report and the presentation.

- The **first session** is dedicated to the presentation of the general theme of the mini-project and to set up the working teams for a group of 16 students.

This step can be done randomly by passing through the students and numbering from 1 to 4 and then forming the team made up of members with the same number. [5]

Furthermore, it is recommended that the teams choose the team spokesperson to present progress and reports, the student responsible for graphic design (graphic designer) in 3D (CATIA, SW, etc.) or 2D, the student responsible for taking notes and remarks as well as the student responsible for time management.

- During the **second session**, the students then discuss the content of the mini-project specifications, considering the time allocated and the bibliographical research carried out. At the end of this session, the project's Gantt-chart is prepared for each team.

- **In the third to the sixth session** the students finalize the mechanical design of the robot in 3D and the technical projection in 2D. Within this context, it is recommended to allow students to present their skills to allocate time for presentations of kinematic animations and graphic designs of the robot.

- **Within the seventh to the twelfth session:** students must choose an actuator, a sensor installed in the robot. In the following the students first program the acquisition and the processing of the sensor signal and then control the actuator.

- **As mentioned earlier, the last two weeks are reserved for the writing of the report and the presentation. Therefore, in the thirteenth session** the students discuss the contents of the activity report, taking into consideration the written notes.

- Lastly, in the fourteenth meeting, the students present their project. The presentation is supposed to last 15 minutes per group. Further, it is strongly recommended that all students contribute to the presentation.

Students are then assessed according to a host of criteria, namely the 3D/2D Design, Programming and Actuator Control of the project, the degree of teamwork & synergy within the group, the quality of their report as well as the presentation and consistent interventions from all team members (compare Table 4.).

Table 4. Statistics of students in the third year of mechanical engineering (2021-2022)

Criteria	Score
3D/2D Design	.../04
Programming and Actuator Control	.../04
Teamwork & Synergy	.../04
Report	.../04
Presentation and consistency of contributions from all team members	.../04
Total Score	.../20

The components, teamwork, synergy and harmonization of responses, invite students to consolidate their teamwork and to develop the competence of all team members without exception to achieve the previously defined goals.

Motivation and sustainability:

To motivate the teams a competitive spirit with long-term projections of the projects is defined. This long-term projection state that the first three teams will win the following price:

- Personalized follow-up and intensified supervision for the completion of the work and the realization of the robot in the innovation laboratory (Innovation LAB) during 4 weeks of internship.

- Personalized support by specialized teachers, for the realization of prototypes using conventional and CNC machining machines, shaping, construction and three-dimensional metrological control in mechanical engineering department workshops

- Additionally, the teams will be involved in the procurement process of specific components

5 Impact and results:

The assessment is conducted throughout all sessions since observing the learning groups in action allows the teacher to effectively evaluate the students' work and their understanding of the objectives set by the program. Through monitoring the students' behavior during their group work, the teacher gains the opportunity to intervene if necessary to correct mistakes as well as things misunderstood by the students. It also enables students to reflect on and to evaluate themselves and others.

Hence, this process allows for:

- face-to-face interaction and therefore the facilitation of communication.
- individual responsibility.
- appreciation of group effort through an assessment grid that highlights the interdependence in teamwork
- the development of all intelligences.
- reflection, evaluation, and continuous improvement.
- the development of the student's involvement through diverse topics and flexibility in the realization of the work by allocating time to personal initiatives of design and animation 2D/3D

Furthermore, by closely examining the working groups, this approach provides the learners with the opportunity to:

- engage in an activity that forces them to reflect on ideas and how they use them regularly assess their own level of understanding by applying new concepts to solve problems and obstacles encountered (this process is also called "metacognition" [6])
- acquire knowledge by participating or contributing; engage mentally, and often physically, in activities that lead them to gather information, reflect and solve complicated problems [10]
- experience peer training
- accept the difference of others
- develop a sense of sharing and collective success

6 Conclusion

In the scope of this paper the authors present a participatory approach for the development of knowledge of students. The first steps are to train teachers in "empowering students to suc-

cess", then adapt new methods to conduct the practical work sessions to solicit the updating of student paradigms in regard of adopting teamwork ethics and acceptance of each other. This participatory approach aims not only at the amelioration of technical skills but also at raising awareness to continually self assess, build self-confidence and self-esteem.

It is true that the official program of the participatory approach defines the technical skills that should be acquired. However, it also contains a list of future skills that students should attain., This list is set by the World Economic Forum [3] and entails the following skills:

- Analytical thinking and innovation
- Active learning and learning strategies
- Complex problem-solving
- Critical thinking and analysis
- Creativity, originality, and initiative
- Leadership and social influence
- The use, monitoring and control of technology
- Technological design and programming
- Resilience, stress tolerance and flexibility
- Reasoning, problem-solving and ideation

This paper developed a qualitative analysis, to find reliable and realistic results for the technical teaching at ISET Béja. However, it is necessary to further deepen the analyses and to conduct quantitative analyses. In addition, the students' sample should be expanded and the work on the three departments should be continued to further test the students' ability to adapt. By persistent analyses, the difference between courses and specialties in terms of responses to the methods will become visible.

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Anti-contamination robot

Souhaib AMDOUNI^{1*}, Aymen SAADI^{2*}, Nabil MAGHRAOUI³ and Malek AOUACHRI^{4*}

*Higher Institute of Technological Studies of Béja, Environment Boulevard, 9000 Béja, Tunisia

¹Souhaib.amdouni@isetb.rnu.tn

²saadiaymen1996@gmail.com

³maghraoui.nabil@yahoo.fr

⁴aouachrialak@gmail.com

Abstract.

The automatic routing technique has developed considerably in many industrial disciplines (Agriculture, pharmaceutical, aeronautics, etc.), but it was not considered in the health sector, specifically the sterilization of medical devices. However, while manual routing has its advantages, it is not a risk-free act. During their transportation after each operation, the medical devices used undergo microbiological contamination increasing the risk of transmission of an infection and with non-compliance with ergonomic standards as a result the sterilization department agents risk several dangers. The present project aims to develop an automatic machine for transporting medical devices and to improve the quality of the disinfection process whilst protecting staff. The development of this machine will ensure the quality of its delivery process and close disinfection by improving delivery time, reducing the risk of contamination, and protecting the health of medical staff. In order to complete the development of the machine, it was essential to start with examining the sterilization's conditions at the Cartagena Hospital Center. Then, a very deep functional analysis of the machine was carried out, followed by a study to choose the different elements of the final concept and eventually the machine's design.

Keywords: Robot Transporter, Sterilized Material, Contamination, Disinfection

1 Introduction

Being aware of the problems and risks caused by the manual transport of equipment, materials and tools used in the operating room of clinics and hospitals, we had the idea of developing an automatic machine to transport bins as well as surgical and medical equipment containers after each operation.

This project was implemented in the health sector and enabled us to design and automate a biomedical sterilization system. We first tried to understand the sterilization process which consists of destroying various microorganisms (bacteria, viruses, fungi, parasites ...) that are present on a material medium. Sterilization is obligatory for all medical and surgical equipment, (such as compresses, wicks, materials used for the injection of medicaments, for the installation of eye drops or at the skin incision, etc.) to be used under strict aseptic conditions.

A specialized team equipped with protective materials (gloves, bibs etc.) has the responsibility to transport the bins and containers of the surgical and medical equipment used after each operation to the laundry service to sort, wash and disinfect materials.

2 Technical and current state

2.1. The Sterilization Process

After sterilization, the probability of finding a non-sterile object is one per million, partial sterility does not exist. A device that has just been used for a patient must first be pre-disinfected at its place of use, then washed thoroughly, dried, checked, conditioned, sterilized, and then redistributed after validation. All these steps take a minimum of three and a half hours.

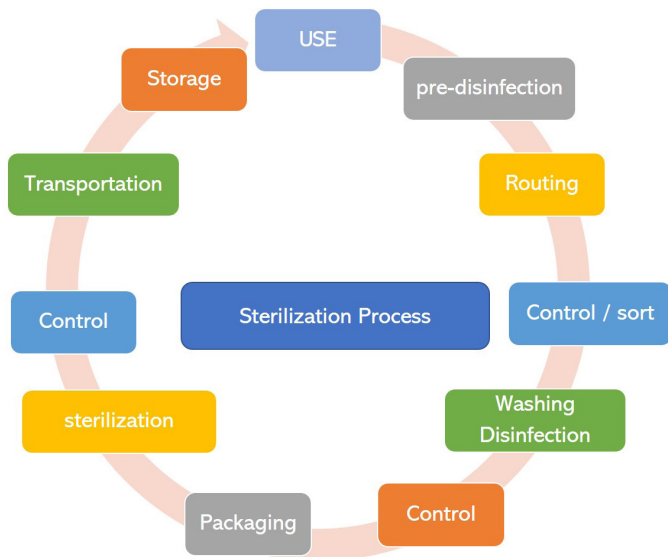


Fig. 1. Sterilization Process

In the sterilization department of the Hospital, a special team performs the following tasks:

- Making sure that containers and bins are present in the unloading desk
- A hygiene officer manually loads the equipment on a transport trolley (Overall size: 700 * 480 * 900mm, load capacity: 25kg) present in front of the counter. (compare Fig. 4.)
- Transport of loads by the agent who pushes the trolley towards its destination.
- Manually unloading the bins and containers in the laundry area for sorting and control.



Fig. 2. Trolley with load capacity 25 kg

2.2. Continuous improvement and risk assessment

Referring to the PDCA method (Deming method) [11] (compare Fig. 3.), an analysis at the Carthagène clinic shows the significance of improving the process of transporting surgical equipment from the operating room to the sterilization and hygiene services. The current process requires manual transport and includes interactions with hygienic agents, which increases the probability of direct contamination by contact.

The design of an automated solution, to address these concerns and to improve the safety of health workers, has been developed based on ISO 11737-2:2009 (Tests of sterility performed in the definition, validation, and maintenance of a sterilization process) [3,4], and on the standard of ergonomics and handling of medical equipment and materials [8, 9 and 10].

Within this concept, ergonomics aims to adapt working conditions of employees, to ensure health and comfort of the staff and to allow for high efficiency and effectiveness of work. The ergonomics aims are , therefore: a balance between constraints and resources.

3 Identification of needs and constraints

At first, by using qualitative methods, we discovered the importance of the product for the customer. Further, we then integrated this gained knowledge to establish the list of requirements which will be used to develop the basis of the trolley transport system by two rails.

The two qualitative methods used are:

- The interview with the head of served sterilization of the Cartagena Hospital Center Tunisia to describe his needs related to the machine.
- The different problems of manual routing in the different clinics in Tunisia.

All needs were scored from 1 to 5 and identified according to their importance. A score of 1 corresponds to a need that is of little relative importance to the client. In addition, the need classes are: Base (B)¹, Performance (P)² and Attractive (A)³, according to the KANO method (compare Fig. 4.). This method is intended to help understand how the consumer assesses and perceives quality.

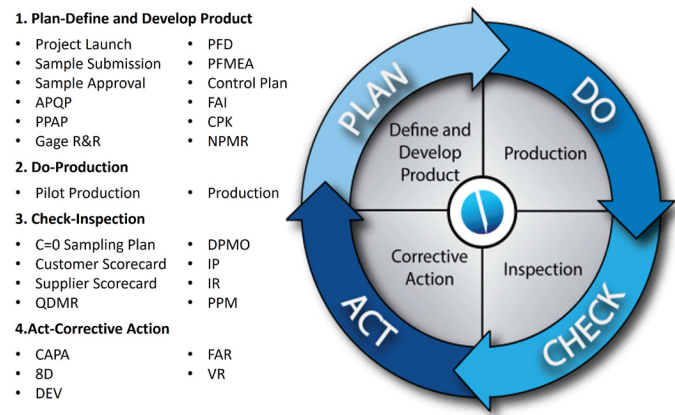


Fig. 3. PDCA, Deming Method [11]

1 The so-called basic mandatory requirements: as their name clearly implies, these are the requirements that cannot be dispensed with. Of course, customers may not notice them; however, they are essential to the operation of the product and must be present to ensure customer satisfaction.

2 The stated requirements of performance: here, the needs and expectations of customers are clearly expressed, and their satisfaction depends on the level of performance or quality of the product

3 The latent requirements called attractive: the needs are necessary here but may not be expressed. It is creativity that must above all take precedence since it will be a question of creating a differentiating element that can surprise the customer. This is called the “happy surprise”. That said, his absence should not be a source of dissatisfaction or frustration for the customer



Fig. 4. Kano Method for satisfying customer

Table 1. Needs identified by the qualitative

N°	Needs	Scoring	Kano
B1	Is safe	5	B
B2	Can be easily maintained	3	P
B3	is inexpensive	2	P
B4	Uses the room's electrical sources	5	B
B5	Ergonomic	3	A

Once the customer's needs are clearly identified (compare Table 1.), it is necessary to determine the essential functions of the machine to tally these needs. The functions of the machine were found using the NETWORK method, the conversion of needs, and the Jobs-To-Be-Done method. In this stage, the formulation of simple functions is momentous in order to keep user functions to a desirable level of complexity of concepts.

The functional approach, therefore, requires asking warranted questions about the objective or subjective expectations of future users as well as all the constraints of the environment or regulations to be respected.

To find the other functions of the product, the RESEAU method was used. RESEAU is a method for identifying, exhaustively and in a minimum time, the functions to be fulfilled by the machine. It consists of six phases, each of which makes it possible to detect part of the functions. All the functions result from the sum of the six methods:

- Intuitive search.
- Environmental review.
- Sequential Analysis of Functional Elements (SAFE).
- Examination of movements and efforts.
- Analysis of a reference product

- For this project, four methods were used: Intuitive Search, Environmental Review, SAFE and Motion and Effort Review.

4 Solution and Design

4.1. Process

In this part we will indicate, in an implicit and simple way, how the robot works and how it performs the different operations. In order to clarify necessary developments for the program, we provided the ensuing program:

- **Call for the robot's presence**

After each surgery carried out in the operating room the agent must put the equipment and tools used in a dip tank and pick up the containers. He then opens the door of the separation window to put them on a special tray that will pass on a linear guidance. The presence sensor located under the tray will issue an instruction for the presence of a tray in the window with the precise coordinates that will initiate the operation of the system and the opening of the door of the window automatically.

- **Triggering the robot's movement**

The robot then receives the instruction of presence and location of the equipment and tools to be transported. It then moves to the destination received under a precise speed and stability. The robot will then travel the computed distance with the help of a distance measurement sensor that will indicate to stop the engine when the destination is reached.

- **Loading tools on the anti-contamination robot**

A presence sensor detects the arrival of the robot, the system then automatically starts the motor of the rack and pinion system to move the electromagnet under the tray. As soon as the tray is detected in the loading position, the electromagnet snaps in to pull the tray onto handling balls which will help guide the tray onto the trolley.

- **Unloading tools on the wash station**

After placing the tray on the robot, the pinion system motor stops and the displacement

system starts to move the load to the wash station following the predefined path. When the destination is reached, the Rotary Tray Motor starts to rotate to 90°. When the Rotary Tray Motor stops the unload will activate as the load steps with the electromagnet enable reverse. As soon as the unloading is successfully completed, the trolley returns to its rest location pending another control of the wickets.

4.2. Mechanical Design

The mechanical system is divided into 5 independent subsystems mounted together:

- **Load storage system:**

consists essentially of four parts, namely separation windows with adjustable pressure (existing), linear tray guidance of containers, containers and two counter doors (manual operating room door and automatic hallway door).

- **Loading and unloading system:** composed of essentially of two parts, namely the rotating tray with handling balls (Compare Fig. 5, 6 and 7) and an electromagnet loading and unloading System (Compare Fig. 8 and 9).

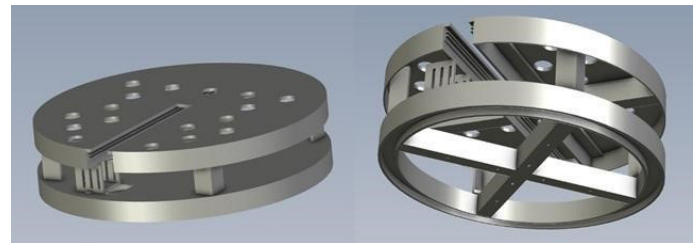


Fig. 5. Rotating table with handling balls

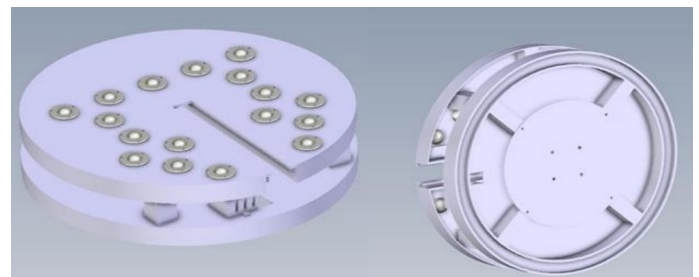


Fig. 6. Rotating tray

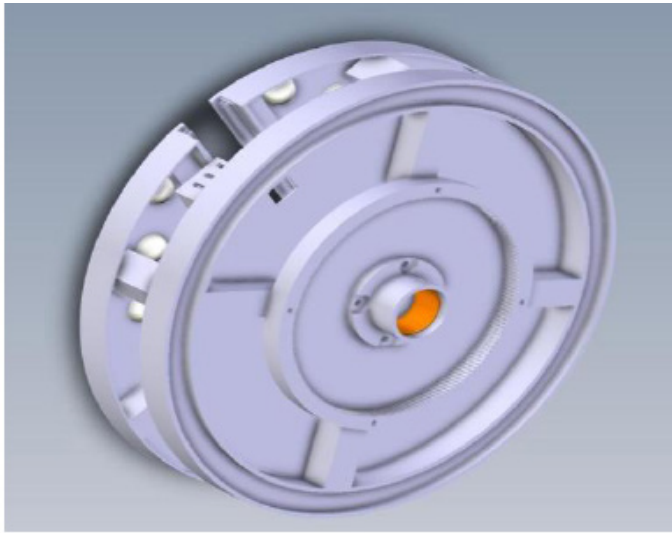


Fig. 7. The rotating system

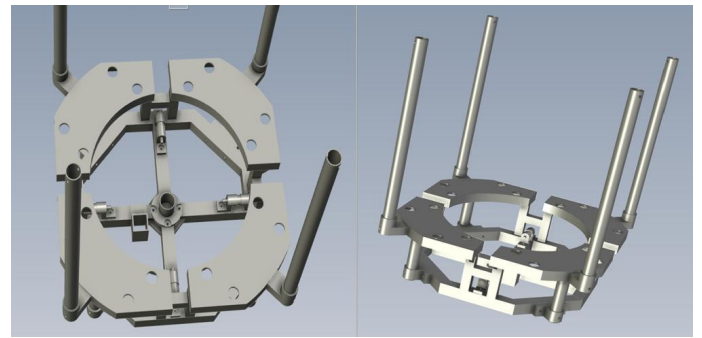


Fig. 10. Lower part of the robot chassis

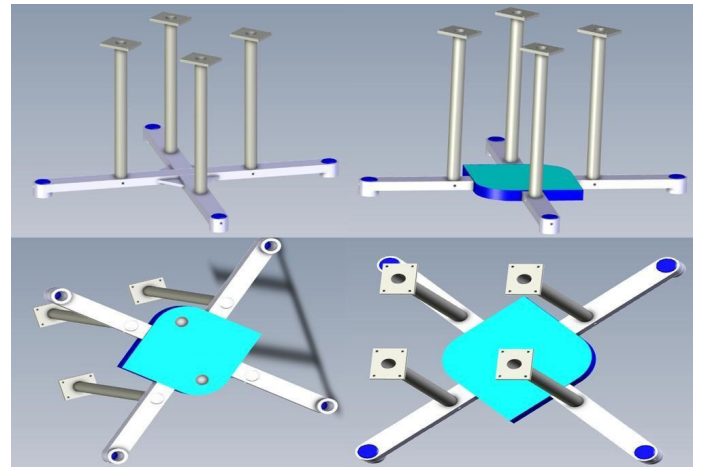


Fig. 11. The upper part of the robot

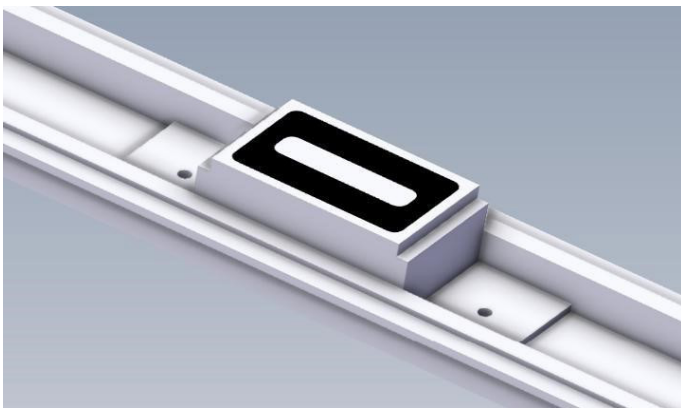


Fig. 8. Electromagnet

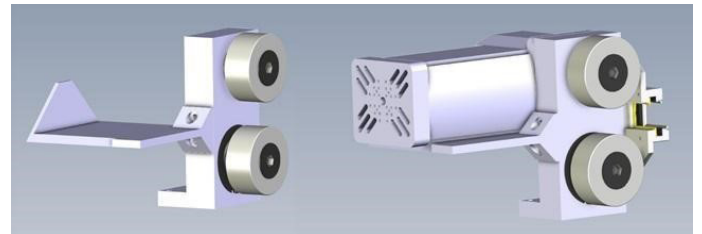


Fig. 12. Drive roller

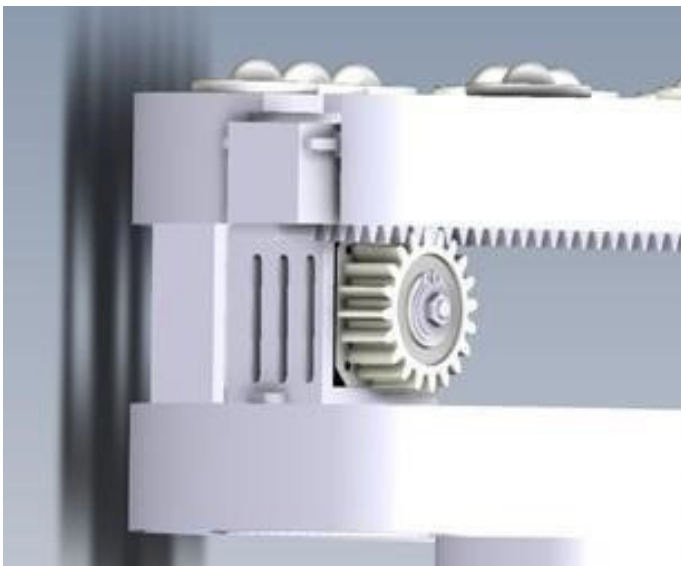


Fig. 9. Rack and pinion system assembled with motor

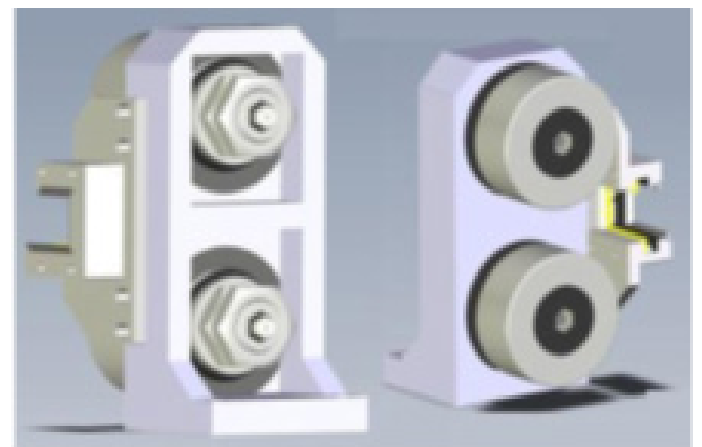


Fig. 13. Roller

• **Displacement system:** comprises fundamentally three parts, namely the main wheel of the trolley (Compare Fig. 10 and 11), the suspension roller and the guide rail (Compare Fig. 12, 13 and 14).

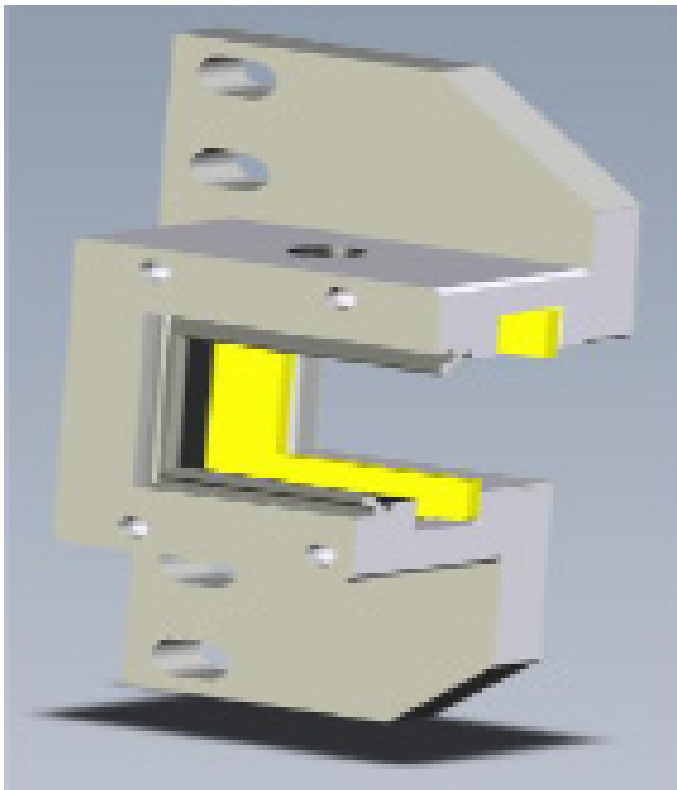


Fig. 14. Scraper

• **Intelligent communication system:**

This system is important from the user point of view, hence it is characterized by the easy-to-use touch control with a color LCD screen (compare Fig. 15). This system simplifies the work of the operator when using the machine and it allows for the graphic visualization of information. Through its self-diagnostic system, the control system constantly displays the parameters of the cycles in progress and the alarms to optimize the routing process and to customize the programs integrated into the device.

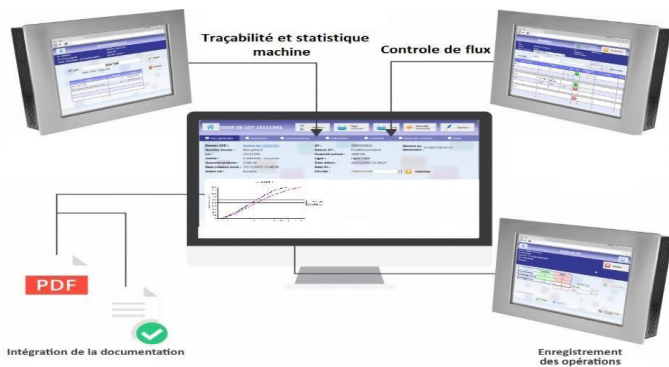


Fig. 15. Intelligent communication Systems

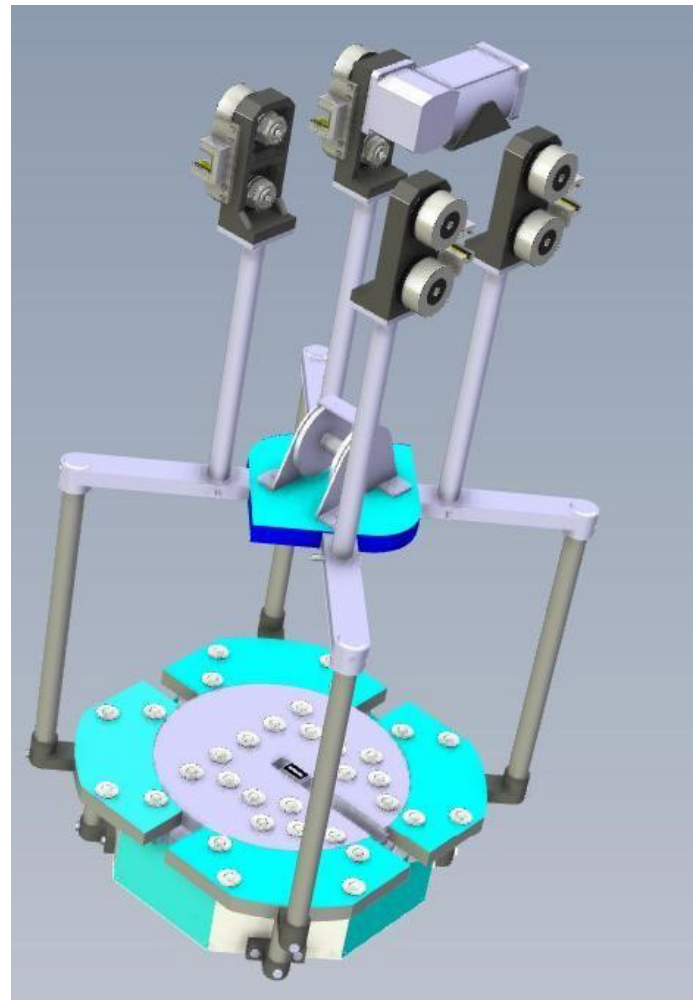


Fig. 16. The anticontamination Robot

• **Protection system (Personnel and Machine Components):**

consists of an obstacle detection system, an automatic shutdown, an emergency stop, electric and mechanical buttresses, and an emergency alert system that detects overload, rocking and malfunctions.

5 Conclusion and perspectives

The development of the anti-contamination robot (compare Fig. 16) was to reduce the risk of contamination, of non-compliance with ergonomic standards and to free the staff from tedious tasks. In order to achieve that, we went through several stages:

First, it was essential to start with a study of the state of the sterilization department of the Cartagena Polyclinic and the search for opportunities for the machine.

Secondly, we had to track the current state and determine the causes of problems to help fix errors and to satisfy the customer.

Thirdly, to discover the importance of the product for the customer and to know all the features of the machine, a functional analysis was performed and ordered in the form of a functional tree.

In the last step, after having chosen the final design of the machine, a sizing study was carried out to select all the components of the machine. Furthermore, a description of the system was carried out to understand the operation of this machine and a 3D design on Catia V5 R20 was realized.

Overall, however, the concept of the contamination robot was successfully developed and installed in the Cartagena clinic in Tunis. The solution validation phase was in close collaboration with the relevant departments. The first phase of improvement was launched with the medical staff to test, detect all the points of possible improvement.

However, the development of this robot requires further improvements that will be discussed later for automation, control and supervision. A clear idea requires technical development and realization using TIA Siemens in collaboration with specialists in mechatronics and automation. However, the improvement analysis is carried out by the PDCA approach, the tasks will be defined in terms of specifications and divided into projects to assign them to the students. The Project Leader proposed that we work in the next steps with agile scrum to manage projects simultaneously, to better manage delays and ensure the quality of the deliverables.

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Student Involvement Project in the rehabilitation of the VIPA CPU-based PLC Advanced Programming Laboratory

KHADHRAOUI Malek¹, MABROUKI Lotfi² and GHODHBANI Salah³

¹ ISET Kasserine, Kasserine, Tunisia
malek.enim@gmail.com

² ISET Kasserine, Kasserine, Tunisia
lotfimabrouki@yahoo.fr

³ ISET Kasserine, Kasserine, Tunisia
salahghmailroom@gmail.com

Abstract.

In this paper, authors propose a laboratory rehabilitation, aiming at both recovery of used and abandoned materials, along with the application of a new didactic approach based on the student contribution. The proposed project is applied to the Programmable Logic Controller (PLC) advanced programming laboratory mainly equipped by a VIPA-CPU 214 DP mounted on a Profibus network. Authors expose software and materials configurations steps, programming tools and tricks and an in-house touch panel configuration. The used didactic approach throughout the rehabilitation laboratory activities invites students to contribute in the didactic platforms' installation and the development of student teaching booklets using a project-based learning method. Rehabilitation exercises are supervised and time-tabled using a scrum method by programming several sprints to achieve predefined pedagogical and workshop goals. The developed deliverables and experiences are then shared over the ISET network with those who mainly use the same didactic platforms based on the old VIPA-CPU. The given method shows its effectiveness on student motivation and PLC programming laboratory workshops with low-cost expenses.

Keywords: Automation, Profibus, VIPA, Siemens, Didactics, Laboratory, Rehabilitation, Scrum.

1 Introduction

During the last decade, the Tunisian universities have revised their study plans in order to

fit the soft and hard skills of their students to the required competences of social and economic partners. This strategy has been kept up to boost the employability of Tunisian students by ensuring a smooth transition into the regional, national and international employment market [1].

Furthermore, a huge investment in Tunisia, powered by the world bank, is being paid to university institutions to strengthen its infrastructures and capabilities. This aims to improve the attractiveness of universities towards entrepreneurs and teaching abilities according to the national and international norms to fit the economical partners recommendations.

On the one hand, a scale of efforts has been deployed to ameliorate student's capabilities to reach the level of job creators or recruited qualified agents. On the other hand, employment statistics in Tunisia failed to reach the estimated goals. This divergence between big efforts and real goals is highly probable caused by the ignorance of the importance of the undeniable importance of the teaching approach. In fact, Tunisian students still have classical practical classes which have led to a decrease in motivation to attend classes. After getting classical and repetitive instructions from their teachers, students have lost their confidence of creation and innovation ([2] and [3]).

Moreover, a high-cost didactics materials in Tunisian university laboratories have been abandoned and not maintained due to a bevy of reasons. This loss is mainly due to the demotivation of teachers and students when using the same platform and the same instructions repetitively/year by year. If compared to real used installations, materials technologies render obsolete. This observation can be traced back to the ignorance of existent teaching models and the surging demand of new high-cost didactic tools.

Motivated by these facts and in order to enhance the creative and innovative student dynamics, authors propose to present the

rehabilitation project of the PLC advanced programming laboratory at the ISET of Kasserine. The mentioned laboratory is mainly based on a 200 series of old VIPA PLC which has been created since 1996 and a touch panel developed since 2005 by VIPA company [4]. Such PLCs are interlinked by a Profibus network in order to animate a production management system prototype already installed at a host of ISETs in Tunisia. In this paper, authors present hardware and software techniques to restore such obsolete technologies with low-cost expenses. The authors' contribution consists of managing technical tools with the support of students taught in such laboratories.

The outline of this paper is organized as follows. Section 2 gives the principals manipulations to restore the hardware configuration of the VIPA PLC and programming plan of the didactic platform. Section 3 presents the adopted didactic approach. The fourth section summarizes the advantages of the presented method and then section 5 concludes the paper.

2 Rehabilitation Plan

2.1 The Hardware Configuration of the VIPA-CPU 214 DP

The VIPA-CPU 214 hardware description: The old VIPA CPU 214 DP (compare Fig. 1) has been produced by the VIPA company since 1996. It has a modular architecture capable of building a decentralized and/or centralized automated system. This CPU is mainly used in the PLC advanced programming laboratory of the ISET network. Five 200 series VIPA CPUs are interlinked by a Profibus network with its 485-communication interfaces to control 4 modules of a production management automated system with a supervision device.

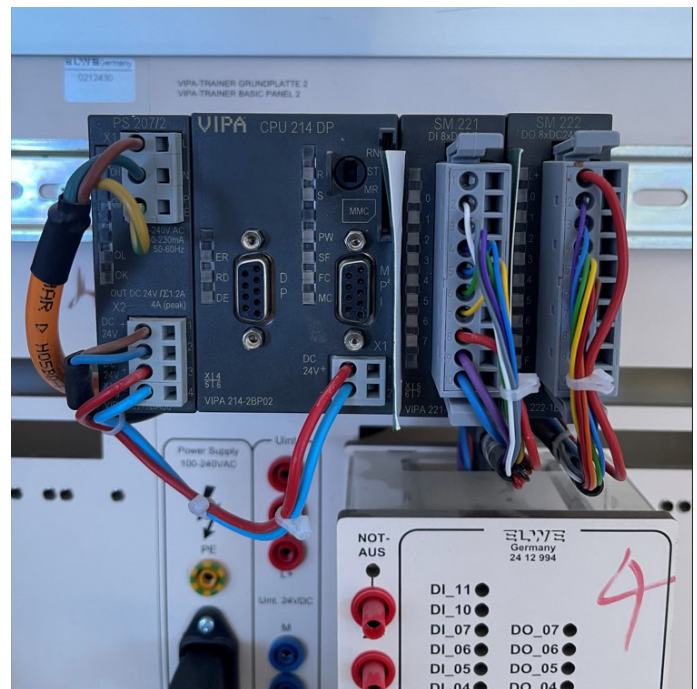


Fig. 1. VIPA CPU 214 DP

- The VIPA CPU 214 DP features [4]:
 - Work Memory [KB] : 96
 - Interface [RS485] : MPI
 - Interface [RS485] : PROFIBUS-DP slave
 - MMC card slot
 - Voltage range DC 20.4...28.8 V
 - Max modules per rack : 32

However, this CPU (VIPA CPU 214) is no longer produced and nor maintained. Hence, the company only provides a material description in a downloadable GSD file on the official VIPA site [4]. On the base of the mentioned VIPA CPU features, authors propose assimilating the existent PLC description and communication procedure to the S7 315 2DP from Siemens company.

- The S7 315 2DP features [5]:
 - Work Memory [KB] : 256
 - Interface [RS485] : MPI
 - Interface [RS485] : PROFIBUS-DP
 - MMC card slot
 - Voltage range DC 19.2...28.8 V
 - Max modules per rack : 8
 - Max rack : 4

Henceforth, teachers and students can work with Siemens' technologies norms and utilize the same software environment called Simatic manager or Totally Integrated Automation (TIA).

The software environment:

The VIPA CPU 214 DP is originally configured using winPL7 software or SPEED7 studio provided by VIPA company. Both are either paid application or non-compatible tools to actual hardware environments (New PLC technologies).

In fact, users have access to the mentioned VIPA configuration via Simatic manager from Siemens or TIA software.

In this paper, authors propose two methods to set up the considered PLC

- Method 1: Using GSD Files.
- Method 2: Virtual configuration using S7 315 2DP station.

Method 1: Initiation using GSD file:

The GSD file is, in fact, a downloadable General Station Description file from the construction site. It allows users to configure the PLC hardware using a software environment. Noting that the VIPA CPU is no longer detectable on the Simatic manager or TIA Portal environment, users still have the access to the hardware configuration by downloading the VIPA CPU 214 DP GSD file called “V133” and installing it using the GSD manager as shown in Fig. 2.

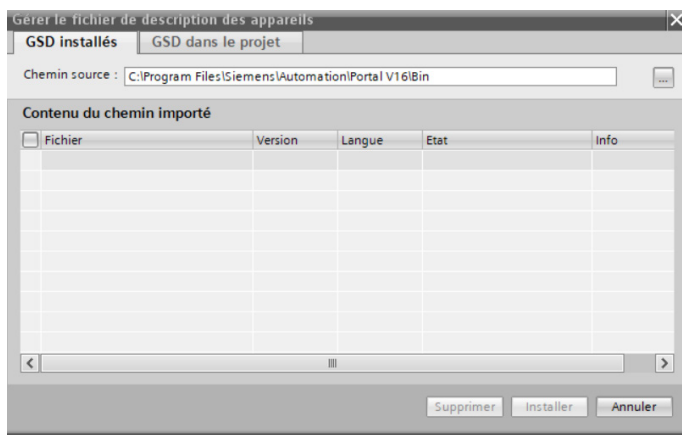


Fig. 2. GSD manager of TIA Portal

Users, then, can get the VIPA CPU description at the hardware catalog at PROFIBUS DP > Additional field devices > IO > VIPA_System_200V.

Once the VIPA CPU is added, authors propose to connect the VIPA PLC on a virtual Profibus network at address 1 with S7 315 2DP master-device as shown in Fig. 3. [6].

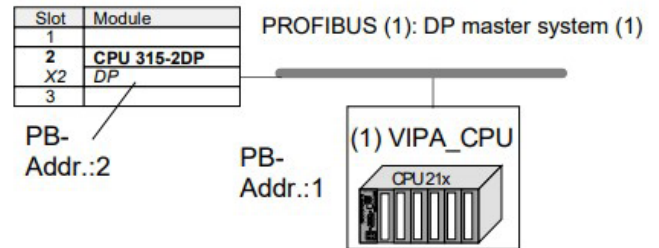


Fig. 3. Virtual Profibus network

The insertion of a program block to the VIPA CPU is primarily done via a MPI (Multi Point Interconnection) cable by a DB9 version on the cable extremities or by the MPI programming cable with USB adaptor.

Method 2: Description using the CPU 315 2DP: Authors propose to directly use the S7 315 2DP station without inserting the VIPA GSD files as a virtual station which can be recognized as a VIPA hardware description.

2.2 Input-Output Interfaces

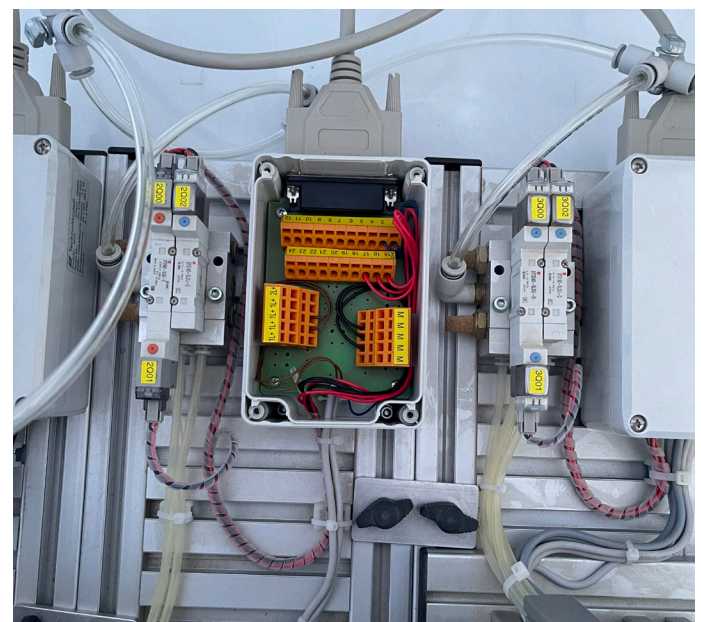


Fig. 4. Sensors and actuators interface

Before programming, teachers enable their students, according to the project-based learning method, to check the state of the sensors, actuators and actuators' controllers (compare Fig. 4) by isolating the input-output interface from the PLC, feeding all components with the suitable voltage range and by measuring all outputs.

These operations can be realized as separate instrumentation workshops.

The list of the main PLC advanced programming laboratory model is given as follows:

- Sensors:

- o Presence sensors: optical, capacitive and inductive technologies,

- o Color sensors,

- o Ultrasound sensors for measurement operations.

- Actuator's controllers:

- o Electrical and pneumatic distributors,

- o Magnetic contactors.

- Actuators:

- o DC motors,

- o Pneumatic cylinders,

2.3 Programming Environment

Hereby, and after checking all hardware setting and configuration, students can use IEC 1131-3 norm to manipulate:

- Logical bit operations for sequential and conditional instructions,
- Timers for transition and synchronization operations,
- Counters for counting production operations,
- Comparison for sorting by color operations,
- Supervision.

3 Didactic Approach

3.1 Labor Division

Considering that the VIPA CPU-based didactic model is set up by 4 automated modules for production management system, students have been divided into four teams.

- Team 1: Configuration and rehabilitation of supply module and supervision task.
- Team 2: Configuration and rehabilitation of transition module and regulation task.
- Team 3: Configuration and rehabilitation of special operations module and supervision task.

- Team 4: Configuration and automation of sorting module and supervision task.

Every team is inspired to develop a part of the main manuscript with details of his own team project.

3.2 Scrum Method Application

Students of ISET Kasserine have had the opportunities to learn about the scrum method and to practice it with Trello tools during the hackathon organized by the ALEJE program in 2021 [7]. The laboratory teachers, then, have leveraged this experience to structure the management timeline of the PLC advanced programming laboratory. Rehabilitation tasks have been programmed within several sprints and according to the considered division task approach. Programmed sprints have been updated and checked every week during teaching period (12 weeks) under the supervision of the teacher.

4 Method Evaluation

4.1 Project Cost

The ISET Kasserine has contacted a specialized company on repairing and buying academic installations which estimate the task cost according to Table.

Table 1. Technical Hardware and Software Rehabilitation by specialized company

Task	Demanded material	Cost (€)
Hardware, software and supervisor configuration	The VIPA CPU based platform	5000
Input-Output Interfaces diagnostic	The VIPA CPU based platform	0
Booklet development	Printing format	100
Training Session	The VIPA CPU based platform for 5 teachers	700
Transport Cost	The VIPA CPU based platform	200

Table 2 now shows the cost of repairing and rehabilitating of the PLC programming laboratory with the involvement of all student's promotions and all department teachers as suggested by authors

Table 2. Technical Hardware and Software Rehabilitation by student

Task	Demanded material	Cost (€)
Hardware Configuration	VIPA CPUs 214 DP, CPU Datasheet (Existent)	0
Software configuration	MPI Cable (Existent)	0
Supervisor configuration	Touch Panel (Existent)	0
Input-Output Interfaces diagnostic	Multi-Meter, Current Generator (Existent)	0
Booklet development	Printing and cloud storage (Administration)	0

Comparing Table 1. with Table 2., we can easily conclude the effectiveness of the proposed project.

4.2 Deliverables

Students have been involved in the redaction of the teaching booklets which contain practical exercises linked to a project-based learning method. After the exposed project implementation, the PLC programming laboratory is equipped with:

- An advanced PLC programming workshops booklet,
- an Instrumentation workshops booklet,
- a Manual of programming according to the IEC 1131-3 norm,
- a VIPA-CPU 214 DP datasheet,
- a S7 315 2DP datasheet.

5 Conclusion

In this paper, authors have presented the advanced PLC programming laboratory rehabilitation based on abandoned VIPA-CPU. The exposed method shows its effectiveness by the involvement of student in the rehabilitation exercises and the deliverables' development. The advantage of the presented strategy is rooted in the low-cost activities using existent materials in the mentioned laboratory of ISET Kasserine and the shared deliverable and experiences with the ISET network. The proposed method shows a great contribution in students' motivation and their implication on the laboratory workshops. The given approach can be extended to shared workshops using the floating multiuser license of the Totally Integrated Automation software.

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Study of a photovoltaic solar installation

Rzig Ramzi¹ and Troudi Fathi²

[1, 2] Higher Institute of Technological Studies of Kef

lrzigramzi10@gmail.com

²trouidi.fathi@gmail.com

Abstract.

This present paper presents an experimental study of solar photovoltaic installation and demonstrates how photovoltaic circuits can be exploited in different utilization cases [1]. Indeed, this manipulation begets the study of an electrical energy production system from solar energy (photovoltaic energy) [2]. Students were required to manually construct and connect a photovoltaic cell. To achieve a more realistic case study, two types of dissipations (24 V and 230 V) are put in place.

Keywords: photovoltaic circuit, solar energy, photovoltaic energy.

1 Introduction

Ever since the industrial revolution, energy consumption has steadily increased. Consequently, global final energy consumption has increased by 115% in 46 years (1973 to 2018) according to the International Energy Agency and the share of renewable energies has increased by 0.5 points, from 15.5% in 1990 to 16.0% in 2018 (compare Figure 1).

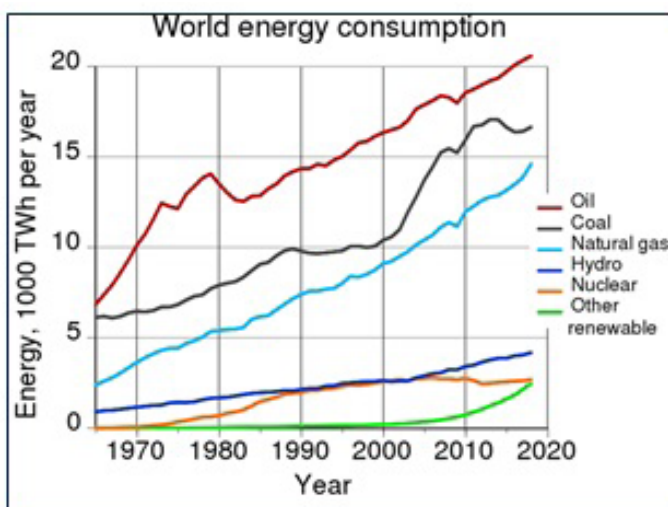


Fig. 1. Energy consumption.

The most discussed subject in the world is the protection of the environment against the greenhouse effect which is understood as the warming of the Earth's climate by the accumulation of polluting atmospheric emissions, in particular CO₂.

The model delineated in this paper allows for the use of photovoltaic energy sources, the demonstration of the different operating modes as well as occurring dissipations under 230 V voltage and 24 V voltage. The didactic photovoltaic model ensures the implementation of the following educational objectives:

Students should:

- understand the operation of industrial photovoltaic solar installations.
- start the photovoltaic system, adjust it and ensure electricity production.
- size the installation, the power produced and the efficiency of the various components.

2 Didactic model

The model (compare Fig. 2) highlights the characteristics of the photovoltaic installation, reveals the cabling constraints of the various components, and explains the different 230 V and 24 V dissipation situations and the battery discharge constraints [3].

The industrial installation is more powerful than that of the presented model, however, the wiring and installation constraints of the industrial installation match those of the model. As a result, the operating simulation aims to highlight the operating constraints of the real installation.



Fig. 2. Didactic model.

Hence, we receive the following technical sheet of the model:

Electrical Specifications

- Voltage 230 V AC
- Amperage 16 A
- Frequency 50 Hz

Main bench

- Length 1760 mm
- Width 820 mm.
- Height 1810 mm.
- Weight 150 Kg

Bench of photovoltaic panels

- Length 1280 mm
- Width 510 mm.
- Height 1540 mm.
- Weight 50 Kg

The wiring of the photovoltaic installation is explained by the following figure (Figure 3).

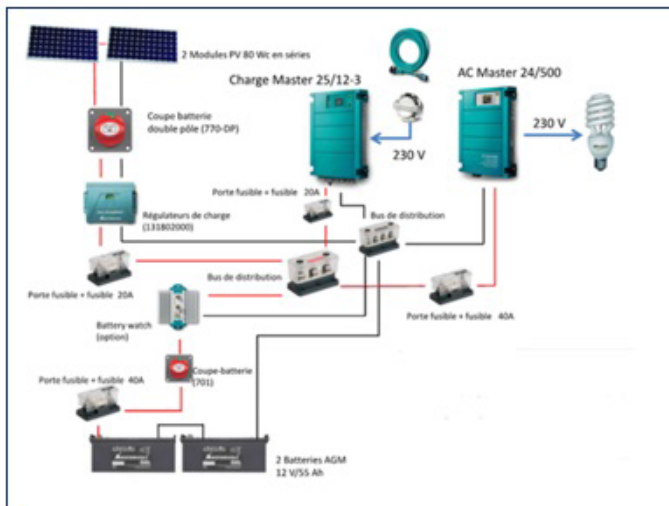


Fig. 3. Wiring of the photovoltaic installation.

The installation is made up of a photovoltaic solar panel allowing the production of electricity (Table 1), a charge regulator which enables the correct operation of the installation and a voltage converter (OND1) which renders it possible to supply two lamps and a fan with 230 Volts instead of 24 Volts. Moreover, two batteries that allow the storage of electricity either produced by the panels or coming from the STEG network are connected (compare Figure 4).

Table 1. Batteries and panels.

ITEM	NAME
3	Photovoltaic solar panel
4	Radiation probe
5	Two 12V / 55Ah AGM batteries

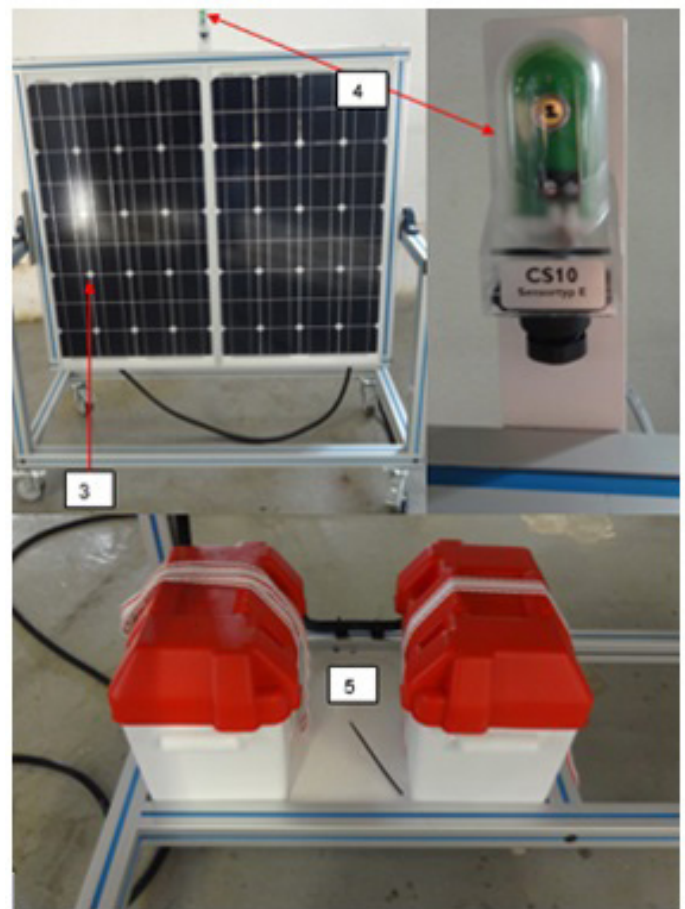


Fig. 4. Panels and batteries.

Furthermore, the model utilizes a dissipation element that allows the installation to operate realistically. Measurement elements are presented to know the power consumed or the sunshine in W / m^2 (compare Table 2, Figure 5).

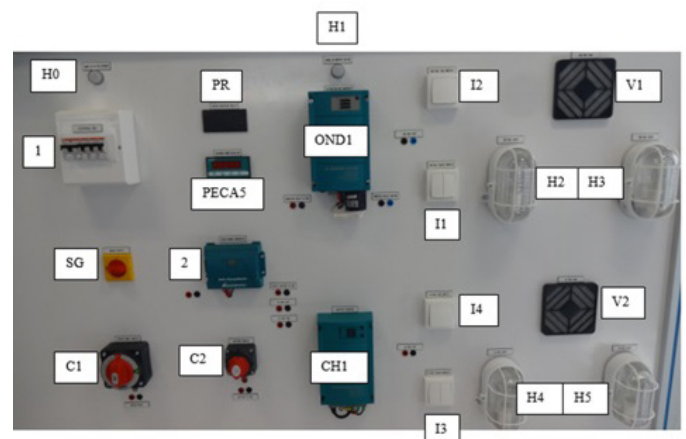


Fig. 5. Main bench.

Table 2. Main bench equipment.

ITEM	NAME
H0	Electrical box power indicator
1	Electrical box
SG	General disconnecter
C1	"ON OFF" switch for photovoltaic solar panels
PR	Sunshine value display
PECA5	230 V network analyzer
2	20 A charge regulator
C2	Battery ON OFF switch
H1	Converter start-up indicator
OND1	Inverter (24 Vdc / 230Vac voltage converter)
CH1	Battery charger
I1	Switch for 230Vac H2 and H3 lamps
I2	230Vac ventilator switch
I3	Switch for 24Vdc H4 and H5 lamps
I4	24Vac ventilator switch
V1	230Vac ventilator
H2 et H3	230Vac lamps
V2	24Vdc ventilator
H4 et H5	24Vac lamps

Also, the circuit breakers allow the mock-up to operate and the indicator light provides visual control of the start-up (compare Table 3, Figure 6):

Table 3. Circuits breakers.

ITEM	NAME
QG	General differential circuit breaker
Q1	Battery charger differential circuit breaker
Q2	240 Vac mains differential circuit breaker
Q3	Differential circuit breaker of the network analyzer and the solar power display (W / m^2)
H0	Two 12V / 55Ah AGM batteries



Fig. 6. Electrical part (Circuit breakers).

3 Mock-up of the Practical model

While reviewing the results of the model we realized that there are two possible configurations for the photovoltaic solar system:

- The production of electricity by the panels is greater than the need for the lamps and fans on and in this case the battery is charged.
- The electricity production of the panels is not sufficient and in this case the battery will supply the shortage and will therefore discharge.

Furthermore, we identified that in order to prepare the installation of our model you need to take the following steps:

1. Place the bench of photovoltaic solar panels (3) in the sun (tilt it more or less depending on the sun and the work required, be careful that there is no object hiding part of the panel).
2. Block Connect the Harting socket of the photovoltaic solar panel bench to the general bench.
3. Connect the socket to the STEG network.
4. Put all the circuit breakers (QG, Q1, Q2, Q3) back to the "ON" position.
5. Turn the general disconnect switch (SG) to "ON".
6. The H0 power indicator should light up.
7. Switch on the voltage converter and the battery charger if necessary.
8. The inverter power-on indicator (H1) (voltage converter) should light up.
9. To connect the photovoltaic solar panels to the batteries, we must rotate the switches C1 and C2 to the "ON" position.

When looking at the results of our experiment (compare Tables 4 to 7) and using our intensity measurements, we can see the following conclusions:

Charging the batteries: 100% of the energy produced is sent to the battery (compare Table 4).

Table 4. Charging the batteries.

Measuring point	Value	Unit
Battery voltage	13.10	VDC
Battery current	3.5	ADC
Panel voltage	13.23	VDC
Panel current	3.5	ADC

230 V dissipation: 100% of the energy produced is sent into the use, but since the production is not sufficient, a small part of the energy is produced by the battery. The battery drains slowly (compare Table 5).

Table 5. 230 V dissipation.

Measuring point	Value	Unit
Battery voltage	12	VDC
Battery current	-0.63	ADC
Panel voltage	12	VDC
Panel current	3.5	ADC
Inverter input voltage	11.9	VDC
Inverter input current	4.3	ADC
Inverter output voltage	200	VAC
Inverter output current	0.15	AAC

24 V dissipation: The energy produced is divided between use and charge of the battery (compare Table 6).

Table 6. 24 V dissipation.

Measuring point	Value	Unit
Battery voltage	12.5	VDC
Battery current	0.34	ADC
Panel voltage	12.45	VDC
Panel current	3.5	ADC
Dissipation voltage 24VDC	12.45	VDC
Dissipation current 24VDC	3.1	ADC

230 V and 24 V dissipations: 100% of the energy produced is sent to the use, but since the production is not sufficient, a large part of the energy is produced by the battery. The battery drains quickly (compare Table 7).

Table 7. 24 V dissipation.

Measuring point	Value	Unit
Battery voltage	11.7	VDC
Battery current	-3.34	ADC
Panel voltage	11.7	VDC
Panel current	3.5	ADC
Dissipation voltage 24VDC	11.6	VDC
Dissipation current 24VDC	6.85	ADC

4 Conclusion

This study is a small application for the use of photovoltaic solar panels on an industrial scale and can be integrated into automation and industrial instrumentation (UEF340). In addition, the photovoltaic installation can be repeated annually given the simplicity of the model's operation. Moreover, this approach allows the downsizing of a photovoltaic energy system. Hereby, it enables students to make the connection between theoretical and practical installation of such a system and simultaneously demonstrates the work of two types of dissipations (24 V and 230 V) to get closer to the real case.

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Design of a Level and Flow Control Test Bench: Monitoring and DP Networking through a project-based approach

Alaä CHABIR

Higher Institute of Technological Studies of Gabes

alaa.chabir@yahoo.fr

Abstract.

Pumping system remains one of the classics in the industry. Such a system has its own standards and its own challenges. To correctly control this system a student must not only handle the dynamics of the process variables such as pressure and flow but also observe the pump variables (torque and speed). This paper aims to design and realize a test bench that touches on the above-mentioned areas in addition of adequate teaching methods.

Keywords: Cascade loop, DP networking, Teaching Method.

1. State of The Art

The management of water storage systems is vital in many fields, such as agriculture, industrial, and food manufacturing plants [1]. An important aspect to consider is the water level in the storage tank used in the irrigation or manufacturing system. The most crucial aspect will be controlling the water level to meet the consumer's needs [2]. To this end, many automatic control studies have been conducted; the most accepted water level controller is the classic PID controller, which is widely used in laboratories and industry [3]. Indeed, the model design and realization, will constitute a polyvalent platform that can be exploited in two ways: one, within a teaching framework that implements several practical works in a laboratory; or secondly, within a scientific research framework that allows experimental tests for the validation of the theoretical results of a simulation.

First of all, we will describe the designed control model. Then we will mention the installation procedure, as well as the procedure for commissioning the pumping station. The teaching method will be presented lastly.

2. Test Bench Design

The idea was initially to design a system to expand the automation laboratory. Another concern is building a system where a student would see the combination of several subjects (PID control, Monitoring, PLC programming and Instrumentation). By visiting the scrapyard of the institute, we were able to retrieve a pump, a flowmeter, a multilayer pipe, and plexiglass necessary for the manufacture of water storage tanks. Using the available materials, we decided to build a water control test bench between two tanks. Then I convinced the administration to buy the remaining equipment (transmitters, PLC, HMI, and VSD) by saying this 5000 Euro investment would be recovered by providing training sessions for industrial teams on the same bench. In fact, the test bench is fully operational and the amount was recovered after two training sessions for oil and gas company.

The designed scheme consists of two tanks, 4 level detectors, a pressure transmitter PT, a radar level transmitter LIT, a flow transmitter FIT, three-phase pump, two manual valves HV1 and HV2, and a solenoid drain valve. The designed process shown in Fig.1 allows the control of water level in the upper tank to reach a desired set-point.

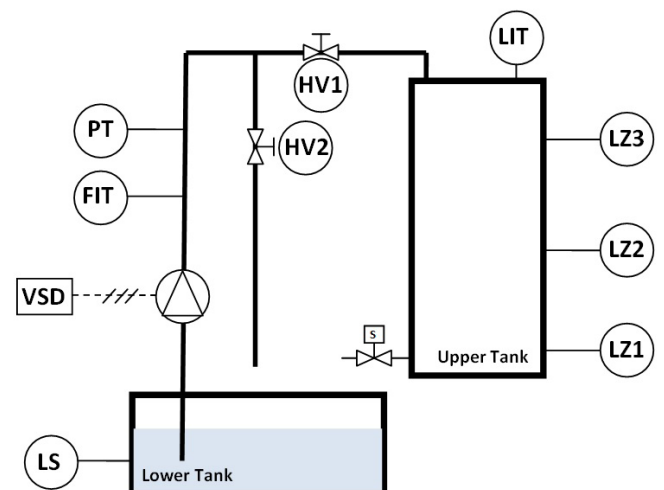


Fig.1. P&ID scheme of designed test bench

The water in the upper tank is transported by a centrifugal pump, three-phased with speed variation using a variable speed Drive VSD. The level is also measured with an analog radar placed on top of the tank. The water flow is measured by a flow meter.

Many scenarios are made by opening/closing the valves HV1 and HV2 to create a greater pedagogical experience:

- Flow Control loop by closing HV1 and opening HV2
- Level Control loop by closing HV2 and opening HV1
- Cascade Control loop by closing HV2 and opening HV1

2.1 Sensing Devices

The following sensors are used to get proper control for the described bench:

Ultrasonic Radar LIT: The NUS-4 is a compact ultrasonic level transmitter with ultrasonic sensor and embedded electronics. It has been designed for a non-contact level or volume measurement in tanks, containers, open or closed tanks, or flow measurement in open channels.

The sensor emits an ultrasonic pulse train and receives the echo in return. The microprocessor electronics processes the received echo signal after reflection on the liquid surface and calculates the transit time between the sensor and the liquid surface. A standard analog output signal is available for data transfer, and a possible alarm relay output.

This sensor has been mounted on top of the upper tank and been calibrated as follow:

- Upper Range Value: 100 cm (20 mA)
- Lower Range Value: 0 cm (0 mA)
- Height of the tank: 150 cm.

Flow Transmitter FIT: The flowmeter is an instrument designed to measure the volumetric flow of fluids, either gases or liquids or to measure the mass flow. In this design, we used the IFC0-80 KROHNE electromagnetic flow sensor [0 - 2 l/s] chosen after empirical testing on the pump operating at full power (max flow =1.3 l/s).

2.2 Pump Control

Speed variation by frequency variation, reducing or increasing the frequency of the supply voltage of a motor implies a change in the speed of the rotating field and therefore in the speed. When the static component of the manometric height is raised, the flow rate does not vary proportionally with speed. A small change in speed can produce a significant change in flow. The exploited pump has a power of 1.2 kw. An ABB ACS355 VSD controls this pump.

2.3 Safety Devises

A pressure transmitter PT has been placed in series with the pump to anticipate closing the two valves during the entire working system to ensure the system's safety. A capacitive proximity sensor LS has been placed at the bottom of the lower tank to protect the pump from cavitation.

2.4 System Control

The used automation system is the SIMATIC S7-300, a modular controller consisting of a power supply, a CPU, and an input or output module. The CPU 314C-2 PN/DP is the compact CPU for systems with a decentralized structure. This compact CPU with its extended 192 kB RAM is ideal for medium-sized applications, with 4 pulse outputs (2.5 kHz), 4 counting and measuring channels with 24 V (60 kHz) incremental encoders, 24 logic inputs, and 16 logic outputs, as well as 5 analog inputs and 2 analog outputs. The PROFIBUS DP master/slave interfaces and the PROFINET I/O controller enable the connection of decentralized peripheral units via PROFIBUS and PROFINET.

2.5 Monitoring

For system monitoring, the Siemens touch screen KTP700 was chosen, which provides several functions that are part of the basic configuration:

- It provides a fully graphical visualization of processes and process states.
- Control the test bench through a customizable user interface with its menus as PID

parameters menu or changing the control approaches menu shown in Fig.2.

- It provides signals of events as pressure alarms or LS alarms.
- Its storages measured values and messages in a process database represented in a curve to evaluate the control performance.
- It manages users and their access rights.

3 Controller Architecture

In this installation, the control algorithm has to bring a physical quantity PV to the desired value SP under the action of a command OP, also called regulation setpoint SP with a measurement process value PV.

The control algorithm is the PID of Siemens PLC called Cont_C found in SFB41.

3.1 Open Loop Tests

Indeed, we have two open loops to identify: the first is the level loop, and the second is the flow loop. We remind that the input parameter in each open loop is the pump velocity expressed in %.

The level open loop is an unstable delayed system having an integral component. This result is deduced after fixing the pump velocity at 50% and observing the evolution of level variation. The level during this test follows a ramp, and after linearization, the transfer function $HL(p)$ is written as follows:

$$(1) \quad HL(p) = \frac{a \cdot e^{\alpha p}}{p}$$

On the other hand, the open flow loop is a first-order system presenting a slight delay. This result is deduced after fixing the pump velocity at 50% and observing the evolution of flow variation. After linearization, the transfer function $HF(p)$ is written as follows:

$$(2) \quad HF(p) = \frac{k \cdot e^{\beta p}}{1 + \tau p}$$

3.2 Simple Loop Flaw

The CONT_C command is used to control technical processes with continuous input and output variables in SIMATIC S7 automation systems. By setting the parameters of this block, the user can activate or deactivate partial functions of the PID controller to adapt it to the set system. In addition to the setpoint and measurement branch functions, the instruction implements an operational PID controller with a continuous output for the manipulated variable and the possibility of manually changing the setpoint. The Sampling time is fixed at 100ms when putting the controllers into OB35 Cyclic Interrupt Organization Block.

Unfortunately, the level PID controller lacks precision. Indeed, we need an anticipating algorithm that calculates the proper flow in pipe to reach the desired level SP.

3.3 Cascade Loop

The cascade loop design shown in Fig. 2 has to respect some standard:

- An inner loop with high dynamic
- An external loop with lower dynamic

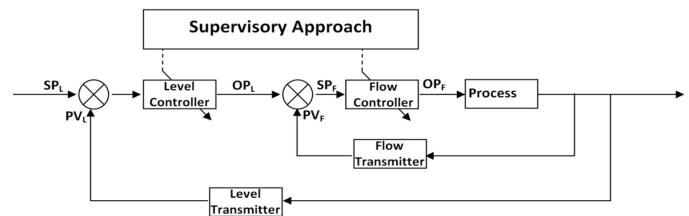


Fig.3. Level and flow realized test bench

The flow loop has faster dynamic regarding the level loop.

Firstly, as shown in Fig. 3, we close the HV1 valve and open HV2; then, we activate only the Flow PID from the HMI menu. After tuning the correct parameters, we pass to the external level loop.

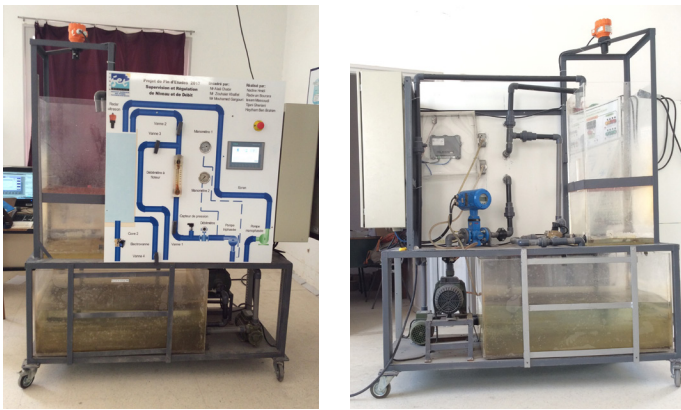


Fig.3. Level and flow realized test bench

4 VSD-PLC Networking

The concept also extends to the networking of the ABB VSD with the Siemens PLC to exploit the drive's internal variables (speed, torque, current, energy...). In order to get a consistent control algorithm [4], considering all the data around the system.

4.1 Topology

Profibus (Process Field BUS) is a field bus invented by SIMENS and has gradually become a communication standard in the industrial world. The PROFIBUS-DP is used for the control of sensors, actuators, or PLCs by a central control. The topology used in our system is Bus. It has some advantages:

- Easy to add or remove a node.
- Failure of a node: no impact on the network.
- Simple and reliable system.

For a FieldBUS, a termination resistor equivalent to the cable impedance is required to polarize the line in the absence of a signal. In general, these are built into the connector and can be activated by a switch.

Then we opt for Master-Slave means of access.

- The PLC Master is the entity that allows access to the medium.
- The VSD Slave is the entity that accesses the medium after requesting the master.

The ABB drive can communicate via a network coupler module or the integrated protocol with an external control system. It can communicate on the following Field Bus systems:

- PROFIBUS-DP (network coupler module FPBA-01).

- CANopen (network coupler module FCAN-01).
- DeviceNet (network coupler module FDNA-01).

In our case, we used the FPBA-01 network coupler module, and the network coupler module is connected to terminal X3, as shown in Fig. 4:

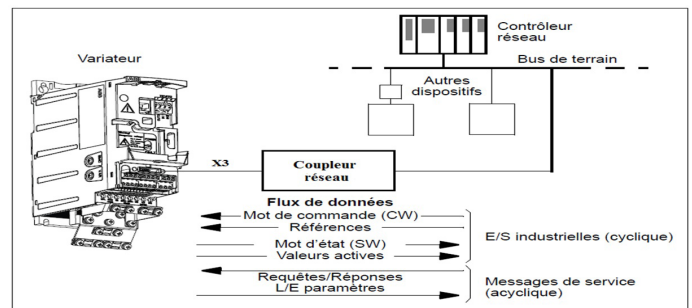


Fig.4. Connecting the network adapter

4.2 Data Exchange

We connect the drive to the plc, but, the drive is still unknown regarding the Siemens standard. The ABB standard is quite different from the Siemens one. A GSD file must be installed, and some configuration must be made as giving addresses, fixing the ProfiDrive profile or PPO...

The PPO type selection depends on the number of variables read from or written to the VSD. Each PPO type has a w pkw area and a PZD area.

The terms PZD (German initials for "Process Data") and PKW (German initials for "Parameter Values") are used in the description of the ProfiDrive profile.

- PZD is an area of the Profibus telegram used to exchange data between the drive and the controller cyclically: control word, status word, speed setpoint, torque, etc...

- PKW is a separate area designed to read and write of single parameters on the drive; it is operated cyclically.

The PPO-05 contains 10 PZD: 2 PZD are fixed for CW/SW and REF/ACT and 8 PZD can be used to read or write the selected variables.

In the "Networking" view, as shown in Fig. 5, we have:

- The network architecture with their Field BUS type and addressing
- Display of PPO type.

- PZD1: displays the status word.
- PZD2: displays the actual speed.
- PZD3: displays the current.
- PZD4: displays the frequency.
- PZD5: displays the power.
- PZD6: display: displays the motor torque.

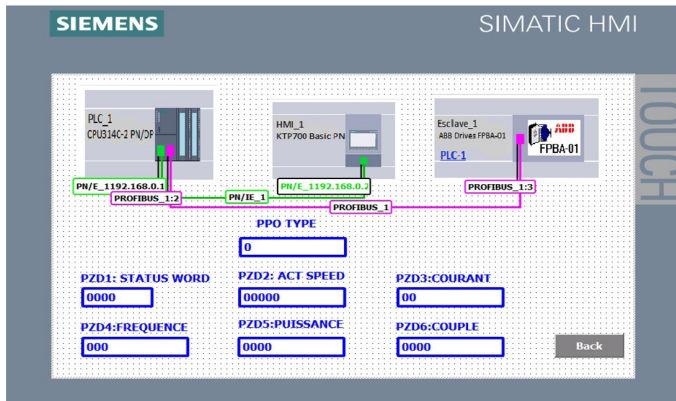


Fig.5. HMI Networking view

The HMI views are designed in order of increasing complexity as follows:

- Instrument view: the student sees the variation of pressure, level and flow as well as the scaling operation.
- Open loop view: the student can manually control the pump velocity in order to identify the internal system model and see the impact of the velocity on the flow and level.
- Simple regulation view: the student can set the PID parameters to control the level or the flow while visualizing the curves.
- Cascade control view: it is about setting the parameters of the two controllers in cascade.
- Profibus network view: allows you to visualize the exchanged data between the PLC and the drive as shown in Fig. 3.

5 Project Based Approach

Project-based learning is a teaching method in which students acquire knowledge and skills by working over an extended period to investigate and respond to an authentic, engaging, and complex question, problem, or challenge [5].

In our study case, the controller design remains the main project. Students are invited to implement the controller on Siemens PLC and design some monitor menus. These tasks

are made during 15h of mini-project practical sessions.

In an institutional program, the central goal of project-based teaching method, can be expressed in a set of objectives:

- Knowledge, i.e., the appropriation of scientific knowledge up to a predetermined level. As for us, the identification of open-loop functions or the scale/unscale of analog process values.
- Skills, i.e., a certain number of general and transversal know-how: arguing, expressing oneself orally and in writing, searching, managing and synthesizing information, estimating and checking, working in a team, etc.
- Attitudes and judgment, a concern for developing critical thinking for choices and decisions in the face of problems. As HMI design or control adjustments...

Table 1. Project based approach tasks.

Task	Challenge	Programming Skill
Analog Input	Convert the analog PLC inputs (pressure, flow and level) to real values	hardware configuration, Scale
Analog Input	Convert the calculated analog output (VSD Setpoint) to 4-20mA control	Unscale
System Identification	Fix the VSD setpoint and observe the scaled inputs	Move, data logging
PID Parameter	Performance base approach to calculate adequate parameters	OB35, Cont_C
PID Implementation	Use the cyclic Siemens blocks and configure the PID block	
HMI Menu Design	When getting the right parameters, a hmi is needed to facilitate the operator task	Wincc, view design
Data logging	Process values logging for curve representation and alarm reporting	Alarm, Curve logging

The student started the first session with a lack of motivation due to the overload of information and preliminary tasks as the transmitter's calibration phase.

Motivation is increased in the manual control and model identification phases where the student gets a close look at the cause/effect concept and consequently returns to the Control theory basics. All students manage to do the level control but half of them is able to do the cascade control with variable performances.

6 Conclusion

In this paper, a didactic bench has been made. The controller structure was developed after the identification of the dynamics of the open-loop. The behavioral study of the system was developed by the GEMMA tool, and networking has enhanced the control mentioned above.

The existing system in the laboratory of automatism illustrates the practical sessions by a project approach based on the students' terminal level.

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Automation Programming by Applying Project Based Pedagogy: Automation of a Modular Production System

BEN AMMAR IMEN¹ and

SGHAIER NARJESS²

¹ The Higher Institute of Technological Study of KELIBIA, Oued EL Khatef City, 8090 KELIBIA,
benammarimen81@yahoo.fr

² The Higher Institute of Technological Study of KELIBIA, Oued EL Khatef City, 8090 KELIBIA
sghaier_narjess@yahoo.fr

Abstract

Programming of an automation is presented by way of the modular production system comprising four didactics stations and the project-based Pedagogy. The idea of applying the project-based learning method in automation allowed me to introduce the notion of teamwork with students. The project-based Pedagogy helped to direct them towards concrete goals, to encourage learning specific knowledge in the field of automation (using and handling technical equipment documents, setting up GRAFCET, mastering PLC programming languages: LADDER language, SFC, etc., identification of inputs / outputs of pre-wired systems ...) and project management knowledge (deciding, planning, coordinating...).

Keywords: Programming of an automation, Project-Based Pedagogy, Teamwork, LADDER DIAGRAM, SFC and GRAFCET.

1 Introduction

The FESTO didactic learning system for automation and technology is designed to meet several different training and vocational requirements. The system and stations of the modular production system (MPS) facilitate industry oriented vocational and further training, in which the hardware consists of didactically suitable industrial components.

The modular production system presented in Fig.1 is a didactic system available in the automation laboratory located in the mechani-

cal engineering department of ISET in KELIBIA and has four stations:

- Distribution station,
- Control station,
- Handling station,
- Sorting station.



Fig. 1. The modular production system (MPS)

The modular production system provides an appropriate system for practice-oriented tuition of the following key qualifications:

- Social competence,
- Technical competence,
- Methodological competence

In addition, training utilizing project-based pedagogy can be provided to foster teamwork, team-spirit, willingness to cooperate and to improve organizational skills.

2 Technical Description of the Distribution Station

2.1 Design

The mission of the distribution station presented in Fig.2 is to separate workpieces from a magazine and transfer workpieces through a rotary drive a suction cup.

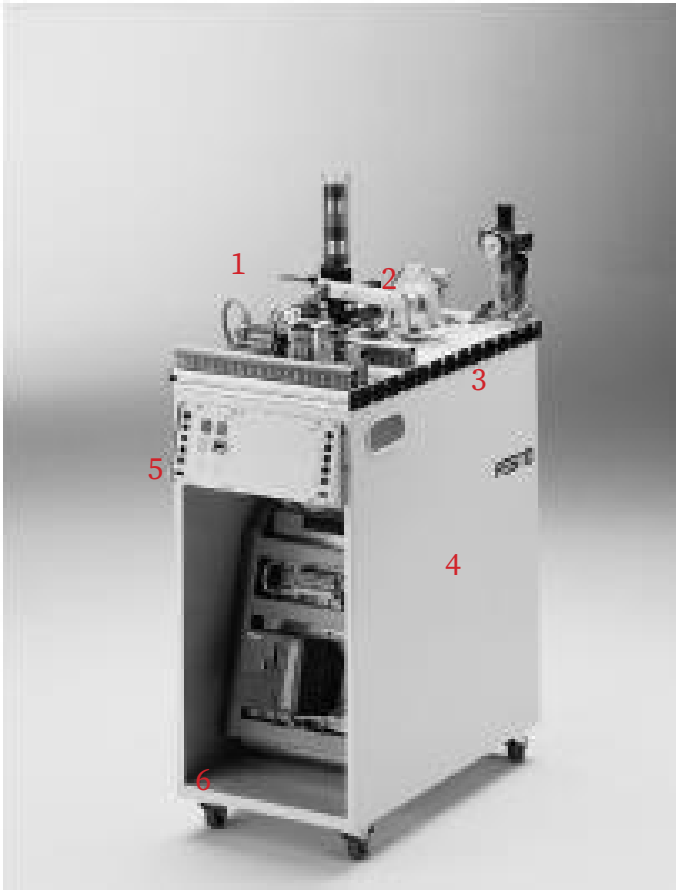


Fig. 2. Distribution station

The distribution station consists of the following:

- 1: Stack magazine module,
- 2: Transfer module,
- 3: Profile plate,
- 4: Trolley,
- 5: Control panel,
- 6: PLC board equipped with a SIEMENS S7-300 / CPU 313C-2DP PLC.

2.2 Function

The distributing station separates workpieces from the stack magazine module. The magazine barrel of the stacking magazine holds up to eight workpieces. The filling level of the stacking magazine is monitored by using a through-beam sensor. A simple acting cylinder pushes out the workpieces individually.

The transfer module grips the separated workpieces using a suction cup. A vacuum switch checks whether a workpiece will be picked up.

The arm of the transfer unit, which is driven by rotary drive, conveys the workpiece to the transfer point of the next station,

2.3 Sequence Description

- Start Prerequisites: Magazine filled with workpieces.
- Initial Position: ejecting cylinder extended, rotary drive is in position “magazine” and vacuum is off.
- Sequence:

- The rotary drive swivels to the position “next station”, if workpieces are identified in the magazine and the START button is pressed.
- The ejection cylinder retracts and pushes a workpiece out the magazine.
- The rotary drive swivels to the position “magazine”.
- The vacuum is switched on. When the workpiece is securely held, a vacuum switch switches.
- The ejection cylinder advances and releases the workpiece.
- The rotary drive swivels to the position “next station”.
- The vacuum is switched off.
- The rotary drive swivels to the position “magazine.”

3 Organization of LEARNING: Applying a Project-Based Pedagogy

We adopted the project-based learning method for training in Industrial Automation.

- Target audience: students in the second level Mechanical Engineering Specializing in Industrial Maintenance. The students in Fig.3 are part of the Industrial Maintenance MI21-2021 class.



Fig. 3. Classroom Industrial Maintenance MI21-2021

- Students are divided into four teams.
- Each team consists of a maximum of four to five students.

The automation project for the four MPS stations spread over ten weeks.

- Each team chooses the station that will be the object of its automation project by drawing lots.
- During the workshop session each team will be invited to:
 - Expose the progress of his project.
 - Discuss the difficulties encountered and the solutions adopted to overcome them.

3.1 The Steps of the Automation Project

Each team will carry out its automation project by following the steps below:

- STEP1: Identify and locate the different components of each station ==> the equipment of the operating part, the control part and the relation part.
 - STEP2: Consult the manufacturer's document relating to the PLC mounted in the PLC table of the station in question and master its implementation.
 - STEP3: Identify the addresses (symbolic and absolute) of the inputs / outputs of the station in question and draw up the symbol table.
- The four first sessions of the workshops are reserved for executing the three previous stages by carrying out guided practical work. During these sessions, I play the role of trainer to supervise and guide the teams to acquire targeted knowledge in automation.
- STEP4: Familiarize yourself with the programming environment of the SIEMENS PLC S7-300: STEP7 or TIA PORTAL.
 - STEP5: Choose the programming language to use in the project: LADDER DIAGRAM or S7-GRAPH.
 - STEP6: Describe the operation of the model using the GRAFCET according to the functional description of the station.
 - STEP7: Make the hardware configuration via the programming environment.

Program, compile, load the program into the API and test.

The four stages that follow are divided into five workshop sessions where each team carries

out their project on their own. During these workshops' sessions, I play the role of a motivator and facilitator only.

The last workshop is reserved to evaluate the automated operation of the four stations of the MPS module carried out by the teams.

3.2 The Advantages of the method: Project-Based Learning

This method is new because it makes it possible to place experience at the center of learning and makes it possible to develop a sense of autonomy in the student and his ability to conduct research, learn and master new concepts adapted to the student. Technological evolution nowadays in the field of automation. This approach allows students to develop technical capacities, the ability to perform as a team and to manage their project.

The project-based learning method allows to:

- Develop learner motivation,
- Develop learner autonomy,
- Become the actors and the authors of their projects,
- Acquire a responsibility allowing students to eventually complete the activities in which they participated.

3.3 Roles of the Teacher during the Project

The teacher can perform the activities shown in Fig.4 while preparing the project.

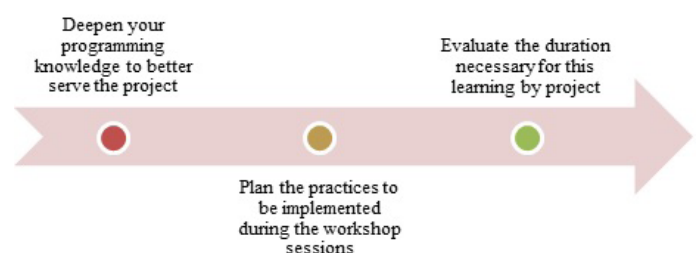


Fig. 4. The teacher's preparations for the project

During the project, the teacher plays different roles shown in Fig.5:



Fig. 5. The different roles of the teacher

- Coach,
- Animator,
- Motivator,
- Evaluator

4 Conclusion

The project-based learning method is a critical tool that not only helps the students to deepen their understanding of automation but also enables the learner to:

- Define and distribute roles to team members,
- Make decisions,
- Create a group dynamic,
- Work in collaborative mode,
- Share technical information,
- Overcome the encountered problems and programming difficulties,
- Evaluate and celebrate the work accomplished.

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Prevent the outbreak of fire: Design of a connected aircraft to map risk areas

First Author¹ Imen Ben Omrane and Second Author¹ AmenAllah Massoudi

1 Higher institute of technological studies of Djerba

imenbo7@yahoo.fr
amenallah633@gmail.com

Abstract.

Campfires, the abandonment of different types of waste, mainly glass, are the main causes of forest fires in Tunisia. Indeed, the glass condenses the light in a single point which causes heat that can reach several hundred degrees Celsius. Our project is an aircraft that will fly over areas of the forest to detect these heat sources and warn forest rangers. As a first step in this mega project, we started by designing a prototype airplane which is eco-friendly as it is powered by solar energy and it works with the Internet of Things system. It will be equipped mainly with two infrared and ultraviolet cameras to detect areas with a concentration of glass that is likely to capture the spark. The intercepted images will be sent by GPRS communication to the control station for possible interventions.

Keywords: Forest fire prevention, Cartography, Airplane, Internet of Things, GPRS, 5G, thermal camera, ultraviolet ray camera

1 Introduction

1.1 A general context

Forest fires are a natural disaster and a problem that has become a burden on the planet, adding to the pollution caused by the second generation of the industry. This environmental disaster has negative causes on the ecosystem regardless of the intensity of its fire.

According to several studies made by the General Directorate of Forests (DGF) under the Tunisian Ministry of Agriculture, the main causes of fires in Tunisia are due to drought, campfires, neglect but also to waste, especially glass, which condenses light into a single

point, causing heat up to several hundred degrees Celsius. So, if we can detect these causes in advance, we could prevent devastating fires. This is the role of our aircraft: PREVENTION. It will fly over an area predefined by the rangers to detect if there are places with high heat, compared to a threshold, which is likely to be a fire start.

1.2 A presentation of the project

Our project is to design and build a light aircraft, designed with the dynamics of a bird, which is based on the “Internet of Things” system.

This plane is a geophysical device that flies on solar energy. It has solar panels along its wings which allow it to obtain enough energy to fly for long hours and operate the devices on board it.

Its primary purpose being to detect elements likely to cause fires, it will carry two high-sensitivity cameras: a thermal camera to detect dry areas and an ultraviolet ray camera to detect the most reflective objects. These two cameras are activated together to draw a map through which it is possible to detect places contaminated by materials with high light intensity and which cause 45% of burns. A third SingleSensor will identify hidden materials by analyzing sent and received radio waves. By analyzing these three data, dangerous places can be identified using artificial intelligence algorithms.

As for the duration of flight, the greater the heat and the luminosity of the sun, the longer the flight and therefore the area of exploration is wide, because the energy consumed is the concentration of light photons above the wing.

The GPRS 5G protocol controls this aircraft.

2 Preliminary study

Considering the multitude of aircraft types and the use of drones in this type of investigation, we did some research to determine what type of aircraft we will use.

Let us start with drones. The payload and range of drones are limited because the propellers must constantly rotate to counter the force of gravity and stay in flight. This gener-

ates an expenditure of energy which influences the autonomy of the device.

On the other hand, planes use their wings to generate lift and promote flight, so they are not energy consumers compared to drones.

A medium-sized drone will stay in the air for around 10 to 15 minutes. In contrast, an average electric airplane flies about 20 to 60 minutes in “normal” use.

Airplanes are preferred for cartography and long-range flights.

Faced with the diversity of aircraft types, we opted for a glider. The different reasons for our choice are:

To stay in the air as long as possible, the glider is the best choice.

For the flight to last long, the wing has to be large, which is where gliders are great.

They should be as light as possible.

With the propeller mounted at the front, the cameras are mounted on the underside of the fuselage.

3 Conception

3.1 Aerodynamics: aircraft design

To design our aircraft, we need aerodynamics. As the airfoil moves through the air mass, it generates two aerodynamic forces: lift and drag as shown on figure 1.

The lift, perpendicular to the displacement, compensates part of the the glider’s weight, preventing it from falling vertically.

The drag, parallel and opposite to the displacement.

Lift + Drag = Aerodynamic Resultant. This result is perfectly opposite to the weight and have the same value. Therefore, the glider is in equilibrium (constant trajectory, constant speed) and can hover.

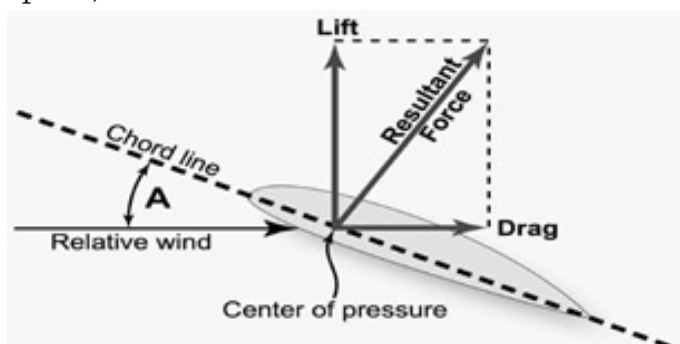


Fig. 1. Resultant Force

Equation of the lift force is:

$$R_z = \frac{1}{2} \rho V^2 S C_z \quad (1)$$

where :

V : the velocity of aircraft expressed in m/s.

ρ : air density, affected by altitude.

S : the wing area of an aircraft measured in square metres.

C_z : the coefficient of lift, depending on the angle of attack.

3.2 Solidwork design

We started by designing the glider wing first (Fig.2). The hallmark of the glider is that it has a long wing.

Based on the aerodynamic equations, particularly on the lift, we calculated the wing area, which is 38400mm².

We have considered: temperature of 25 degrees, the density of the air is 1.292 g.l-1 , relative wind speed = 30km/ h and $C_z = 0.5$

This surface makes it possible to:

-create a good lifting force.

-contain the solar panels necessary to power the various electronic components. (Fig2)

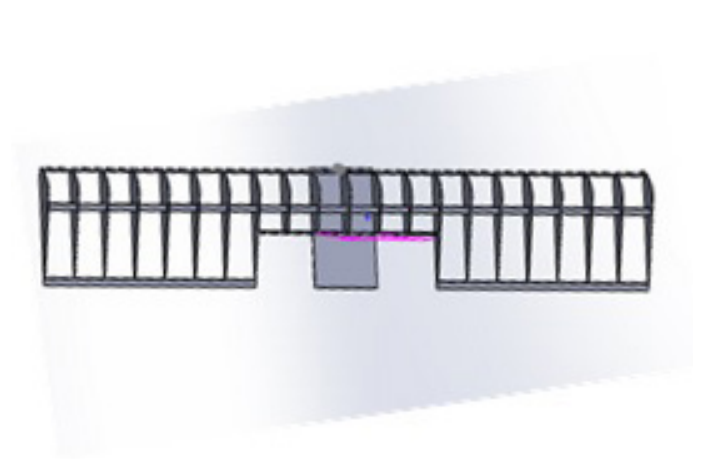


Fig. 2. Wing SolidWorks design

Body Design

-The weight applied along the z axis = 982N

-The applied drag along the x axis = 400N

-the propeller force follows x = 1045 N

-Portance along the z axis = 4000N (Fig.3):

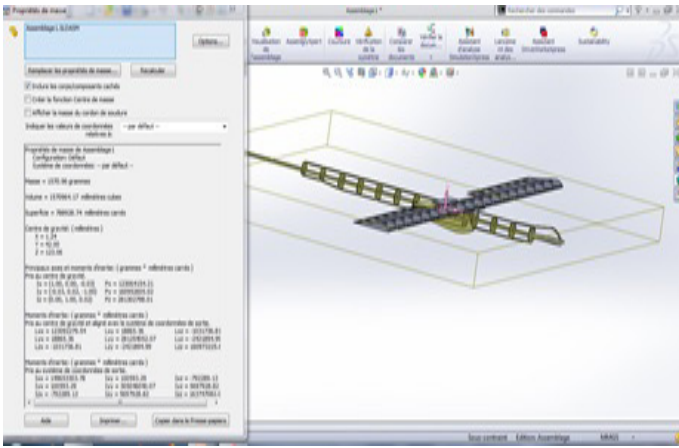


Fig. 3. Plane SolidWorks design

4 Power supply

To power the various equipment, onboard our glider, we have chosen photovoltaics as the energy source.

The solar panels will power 2 3S Lipo batteries, which need 120 Watt. So, we will install 40 5-Watt solar cells on the wings of our glider.

Since solar energy is not stable and to ensure continuity of current, we used the charge controller that will be wired according to the diagrams in Fig.4 shown below.

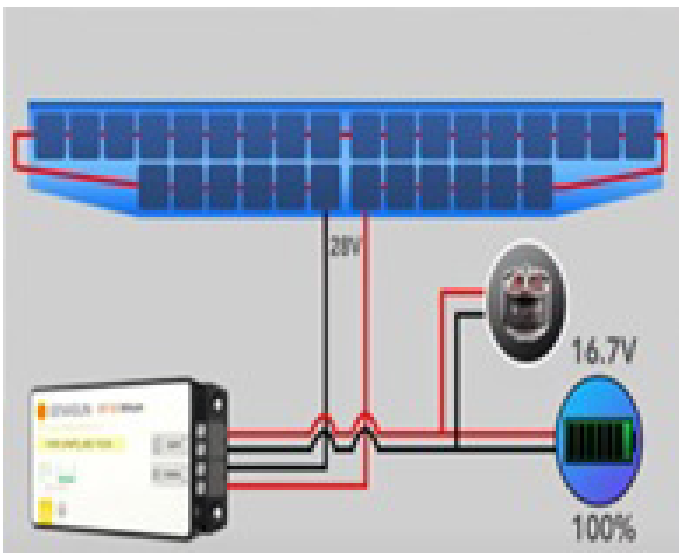


Fig. 4. Charge controller wiring

The charge controller, according to this arrangement, is placed parallel to the battery. The goal is that it can charge the battery, and at the same time, power the engine in case the torque increases, especially when taking off because it needs a lot more power.

5 IoT Solution

Once our plane is designed, we will equip it to become connected and controlled. Our main goal is to send us a map of the surface overflown to detect and prevent fire from starting using a standard IoT architecture, as shown in Fig.5 below.

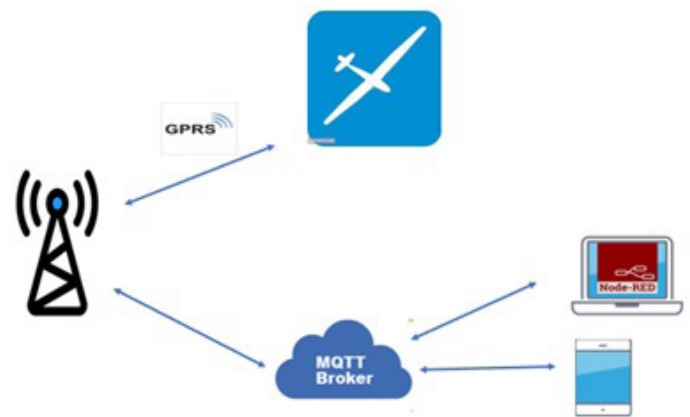


Fig. 5. IoT architecture

Moreover, we are going to embed the following material on it.

5.1 Cameras

Two infrared and ultraviolet cameras will be installed in our glider on a mobile bearing which will be designed later and placed under the glider fuselage. These two cameras will photograph the forest. The data is sent to the control center to analyze and delimit the danger zones.

5.2 Accelerometer

The ADXL355 3-Axis Accelerometer (Fig.6) will be placed at the aircraft's center of gravity (Fig.7) to maintain its balance and infer the condition of the aircraft in the air.

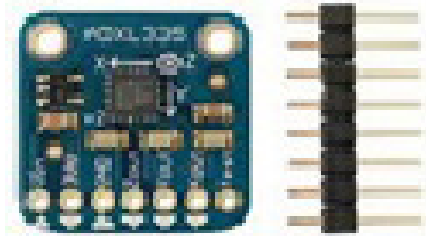


Fig. 6. ADXL355 3-Axis Accelerometer

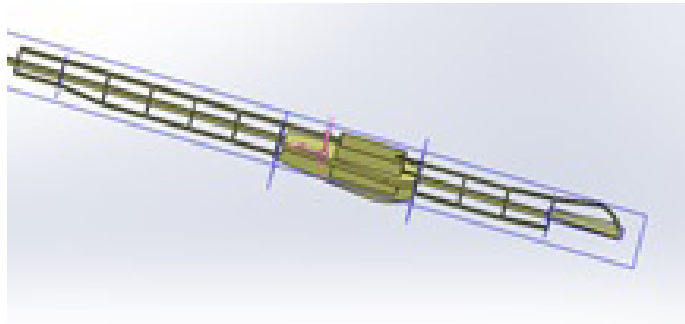


Fig. 7. Wing's location of the accelerometer

5.3 GPRS GSM module

The sim800l GPRS GSM module shown in Fig.8 connects to the Internet over long distances. It allows mobile positioning, and it obtains the position through the mobile network.



Fig. 8. Sim8001 GPRS GSM module

6 Conclusion

In this article, we present our project, which is still in the research and development phase. We have presented the different parts studied so far. The glider is in progress. The motorization and its supply by photovoltaic energy via the charge controller are in the test phase.

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Reactive Power Optimization and Voltage Control in an Electrical Grid by FACTS Devices

Sahbi Marrouchi^{1,2} and

Mansour Baazouzi^{1,3}

Department of Electrical Engineering,

¹ Higher Institute of Technological Studies of Kef, ISET KEF

² Lattice Laboratory, ENSIT

³ Laboratory of Computer Science for Industrial Systems, University of Carthage, INSAT,

¹ sahbimarrouchi@yahoo.fr

² baazouzi.mansour@gmail.com

Abstract.

During the fault appearance phase, the static compensators restore the levels of the affected voltages to a stable state using a controlled exchange of a quantity of active and/or reactive power which depends on the margins of variation of the state variables considered, between these converters and the busses to which they are connected. Such an exchange of power (UPFC-network) can only be ensured based on control algorithms, voltage, and current loops. So, in order to have an optimized power compensation likely to restore the network to a stable state, we proposed the control strategy of the compensator implemented in a network. In this paper, we present a strategy based on optimizing active and reactive power by the UPFC controlled by two fuzzy regulators. The strategy was implemented on an IEEE-14 bus test network, and the results were promising.

1 Introduction

The FACTS devices presented above make it possible to act only on one of the three parameters determining the power transmitted in a line (voltage, impedance, and angle). Combining the two types of devices (shunt and series), makes it possible to obtain hybrid devices capable of simultaneously controlling the variables mentioned above. The

best known compensator in this category is the UPFC (Unified Power Flow Controller). Indeed, the UPFC allows both active power control and line voltage control. In addition, it can perform the functions of other FACTS devices [1,2], namely voltage adjustment, reactive power compensation, stability improvement, and attenuation of power oscillations.

In this context, our paper is articulated, which consists of the development of new control laws of the UPFC to compensate for the reactive power in the electrical networks. Our choice fell on the UPFC compensation system given its skills and performance compared to other compensation means. The UPFC is inserted between two busses, one to receive and the other to send voltage (fig.1); it is made up of two voltage converters linked together through a DC bus placed in high voltage transmission lines in well-defined locations. The UPFC is one of the static compensators ensuring the reestablishment of the equilibrium level of the voltage at each bus in the presence of one fault and particularly during the voltage drop and this by means of a better compensation in reactive and active energies specifically requested in disturbed mode. To achieve this, it is necessary to integrate the UPFC between two busses connecting the most vulnerable line in order to compensate for the need for active and reactive power.

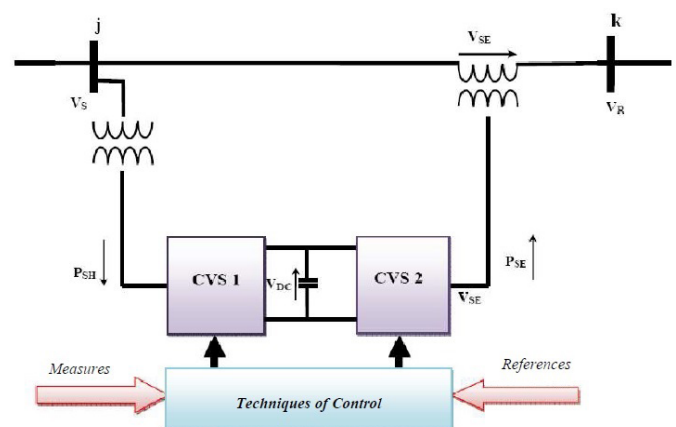


Fig. 1. Block Diagram of UPFC [3].

In order to find suitable control laws, it is necessary to have suitable study models. With adequate control in disturbed conditions and taking into account the instantaneous specifics of the state variables of the network studied, these power systems provide optimized power compensation capable of returning the network to a stable state. Thus, better identification of the margins of variation of the state quantities of the studied system (network-FACTS) in an instable regime, will establish a well-founded control strategy capable of effectively contributing to the establishment of a stable state of the studied network.

To this end, we have consulted certain works. Shahraki [4] presented a mathematical model of a UPFC connected to an electrical network whose innovation was the separation of the parallel part of the UPFC into two subparts: a part considered as a controllable susceptance to control the reactive and active powers indirectly and another part considered as a current generator responsible for controlling the active power entering and leaving the UPFC. Although the methods of identification used of the parameters allowed the minimization of calculation and the restitution of the point of equilibrium, in other words, they ensured the stability of the power system; they did not take into account the level of the voltage at the terminals of the UPFC, which has exceeded its nominal value for a short time. S. Tara Kalyani and G. Tulasiram Das [5] developed a UPFC model that adopted the automatic voltage control mode. This is done by monitoring the level of the DC bus voltage and the voltage level where the UPFC is interconnected. These control loops were made through simulations in the PSCAD environment.

The mentioned strategies have shortcomings in the event of the appearance of a fault qualified as severe. This inspires us to develop a new robust strategy that considers the guarantee of stability and continuity of service even in the event of a fault.

2 Mathematical Model

During the appearance of a fault, the static compensators intervene to restore the voltage levels to a stable state using a controlled exchange of a quantity of reactive and/or active power expressed as a function of the variation's margins of the state variables between the converters and the buses to which they are connected (figure 2).

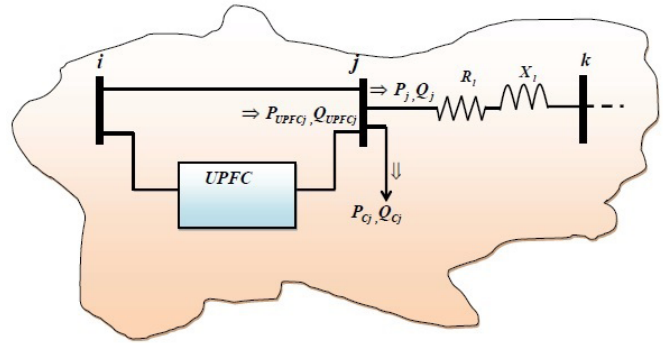


Fig.2. Block diagram of a studied compensator

The voltage drops between any two busses j and k interconnected via a transmission line characterized by resistance R_l and X_l reactance can be expressed according to the following equation:

$$(1) \quad \Delta V_{jk} = V_j - V_k = R_l \cdot I_k \cdot \cos \alpha + X_l \cdot I_k \cdot \sin \alpha$$

Based on the equation of the voltage drop between two busses i and j expressed by the following relation:

$$(2) \quad \Delta V_j = \frac{R_L}{V_j} \cdot P_j + \frac{X_L}{V_j} \cdot Q_j$$

With:

$$(3) \quad \begin{cases} P_j = Y_L \cdot V_j^2 \cdot \cos(\theta_L) - Y_L \cdot V_j \cdot V_k \cdot \cos(\alpha_j - \alpha_k - \theta_L) \\ Q_j = -Y_L \cdot V_j^2 \cdot \sin(\theta_L) - Y_L \cdot V_j \cdot V_k \cdot \sin(\alpha_j - \alpha_k - \theta_L) \end{cases}$$

This reveals that any fault-causing variations in the voltages result in a call for the desired active and reactive power. Under these conditions, the UPFC (Unified Power Flow Control) compensator contributes to the compensation of these powers to restore the voltage levels.

In disturbed mode [6], the powers injected by the UPFC are affected by oscillations at a double frequency than the network under study. This is because the active and reactive powers have fluctuating components. In the context of identifying the fluctuating components affecting these powers injected into the network and based on Fortescue's theory [7], we can express the apparent power injected into a bus j as follows:

$$(4) \bar{S}_j = \left[V_{jd}^+ + j.V_{jq}^+ \right] \cdot \begin{pmatrix} (RY_{jk}^{sh} - j.IY_{jk}^{sh}) \cdot (V_{jd}^+ - j.V_{jq}^+) \\ + (RY_{jk}^L - j.IY_{jk}^L) \cdot (V_{jd}^+ - j.V_{jq}^+) \end{pmatrix}$$

By developing the previous equation, we draw those of the active and reactive powers injected into a bus j :

$$(5) \begin{cases} P_j = P_{j0} + P_{j2f} \\ Q_j = Q_{j0} + Q_{j2f} \end{cases}$$

These expressions are the basis of our control strategy for the UPFC compensator to fictitiously isolate the UPFC from the impact of simulated faults. The UPFC compensator consists of two converters CR_i and CR_j interconnected through a DC voltage level bus V_{busc} . It is assumed that this compensator is inserted to keep the voltage level \bar{V}_n at a constant value at a network bus n following the occurrence of a fault. In fact, in the presence of a fault qualified as serious and in the absence of any defense strategy, the voltage reaches a critical level $V_* = V_n - \Delta V_n$ unacceptable by the standards and consequently the network can be in a situation of collapse.

This amount of reactive power injected by the compensator is the image of a need expressed by the voltage drop at a perfectly localized point. This formulation of the problem can be extended to cases where the level of the voltage at the bus considered undergoes a mode of evolution characterized by oscillations resulting from the appearance of a certain disturbance of a random nature. It follows then that the term ΔV_n , during the phase of appearance of a fault, is expressed as follows:

$$(6) \Delta V_n = \sqrt{V_{d-p}^{+2} + V_{q-p}^{+2}} - \sqrt{[V_{d-p}^+ + V_{d-n}^+]^2 + [V_{q-p}^+ + V_{q-n}^+]^2}$$

The presence of the components of the negative sequence of the voltage, V_{d-n}^+ and V_{q-n}^+ , attributes to the voltage \bar{V}_n a character fluctuating with a double pulsation of that of the studied network ($2.f$). Consequently, the reactive power Q_n that the compensator must restore at the connection point summarily reproduces the same pattern:

$$(7) Q_n = \frac{V_n}{X_l} \cdot \left[\sqrt{V_{d-p}^{+2} + V_{q-p}^{+2}} - \sqrt{[V_{d-p}^+ + V_{d-n}^+]^2 + [V_{q-p}^+ + V_{q-n}^+]^2} \right]$$

This power can be expressed as the sum of a constant term Q_{n0} on which is superimposed a term oscillating at twice the frequency Q_{n2f} . Either then:

$$(8) Q_n = Q_{n0} + Q_{n2f}$$

The term Q_n expressed should constitute a dynamic reference for the control laws of the UPFC. To establish control algorithms considering the fluctuating quantities at double the network frequency, we have proposed new control techniques taking into account possible fluctuations in the levels of active and reactive power in all the busses of the network in question.

Our preventive strategy is based on optimizing the quantity of active and reactive power requested by the network in the event of possible disturbances.

The evaluation of the active and reactive power (P_{UPFC} , Q_{UPFC}) that the UPFC must inject, was established with a perfect knowledge of the new modes of evolution of the reactive powers Q_k ; $k = \{1, \dots, N_{noeuds}\}$ injected into any bus of the network, during the disturbed phase, Fig.3.

$$(9) \begin{cases} Q_{UPFC} = F_Q \left(\sum_{k=1}^{N_{noeuds}} \Delta Q_k \right) \\ P_{UPFC} = F_P \left(\Delta P_k \right) \end{cases}$$

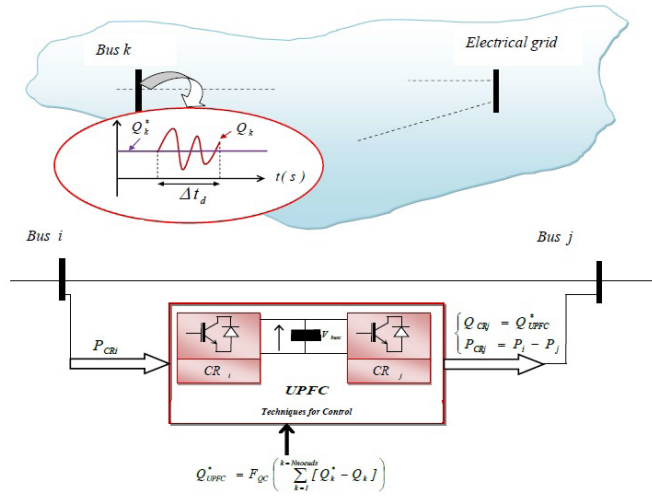


Fig.3: Compensation procedure following the fault appearance

The term ΔQ_k represents the instantaneous variation of the reactive power injected into any bus k with respect to a reference value counted before the appearance of the fault. We then write:

$$(10) \begin{cases} \Delta Q_k = Q_k^* - Q_k \\ \Delta P_{UPFC} = P_{CRi} - P_{CRj} \end{cases}$$

The strategy is based on estimating an amount of reactive power Q_{UPFC}^* by comparing the amounts of reactive power injected before and during a fault through a fuzzy controller. These quantities will be given as references for the UPFC to synthesize them and inject them into the busses concerned.

Indeed, we evaluate the sum of the reactive powers injected at the various busses

which we compare with the sum of the reactive powers injected at the same busses

counted before appearance of the fault. Therefore, we had the idea to implement a fuzzy regulator in the benchmark reactive power

evaluation algorithms. This is due to the dynamic adaptation of this type of regulator to follow the amplitudes of the variables to be controlled. This compensator has been integrated into the IEEE 14 Bus Test network. The method adopted to determine the control vectors is the re-

sponsible center of gravity method searching for the desired optimum on the swept area [8].

$$(11) \begin{cases} u_1^* = \frac{\int_0^1 u_1 \cdot \mu(u_1) \cdot du_1}{\int_0^1 \mu(u_1) \cdot du_1} = Q_{UPFC}^* \\ u_2^* = \frac{\int_0^1 u_2 \cdot \mu(u_2) \cdot du_2}{\int_0^1 \mu(u_2) \cdot du_2} = P_{UPFC}^* \end{cases}$$

3 Proposed Strategy

In order to have an optimized power compensation likely to restore the network to a stable state, we present the control strategy of the compensator implemented in a network, as shown in figure 4:

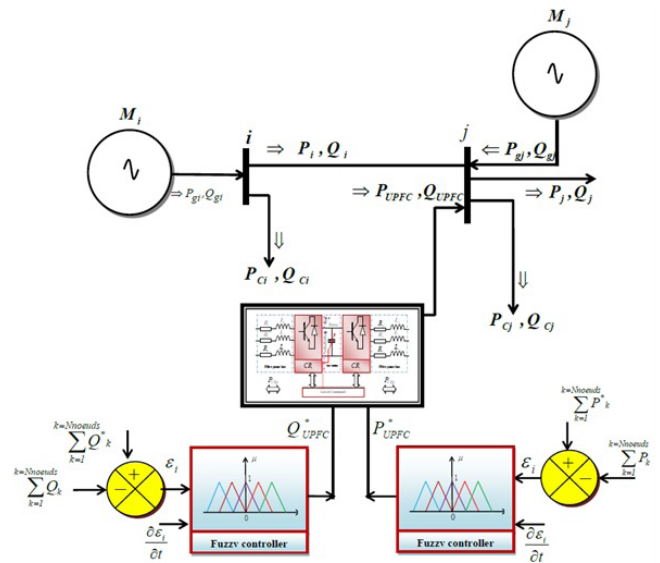


Fig. 4. UPFC control strategy.

Indeed, we evaluated for each fuzzy regulator the sum of the active or reactive powers injected to the different busses ($\sum_{k=2}^{k=N} P_k, \sum_{k=2}^{k=N} Q_k$) and we compared it instantly with respect to their reference values counted before the appearance of the fault.

The use of the fuzzy regulator in the algorithms for evaluating the active and reactive powers of reference (P_{UPFC}^*) and (Q_{UPFC}^*). This is due to the dynamic adaptation of this type of regulator to follow the amplitudes of the

variables to be controlled.

The analysis of the dynamic behavior of the electrical network is based on adequate modeling considering any electrodynamic states affecting the network.

We have defined the functions in active power $F_P(V_i, \alpha_i)$ and in reactive power $F_Q(V_i, \alpha_i)$ at any bus of the network as follows:

$$(12) \begin{cases} F_P(V_i, \alpha_i) = P_i - P_{spec-i} \\ F_Q(V_i, \alpha_i) = Q_i - Q_{spec-i} \\ F_P(V_j, \alpha_j) = P_j - P_{spec-j} \\ F_Q(V_j, \alpha_j) = Q_j - Q_{spec-j} \end{cases}$$

where, P_{spec-j} , P_{spec-i} and Q_{spec-j} , Q_{spec-i} are the specific powers evaluated as follows:

$$(13) \begin{cases} P_{spec-i} = P_g - P_{UPFC} - P_C \\ P_{spec-j} = P_g + P_{UPFC} - P_C \\ Q_{spec-i} = Q_g - Q_{UPFC} - Q_C \\ Q_{spec-j} = Q_g + Q_{UPFC} - Q_C \end{cases}$$

With:

P_{C_i} , P_{g_i} and P_i denote respectively the powers consumed, generated and injected at the bus i .

P_{C_j} , P_{g_j} and P_j denote respectively the powers consumed, generated and injected at the bus j .

4 Simulation and Results

This UPFC control strategy has been applied to the 14-bus IEEE test network with 5 synchronous machines [9]. For the control of this type of compensator, we have assigned different loads, connected to the network studied, values imposing a nominal operating regime

on the five machines such as $(\sum_{i=1}^{i=5} P_g = \sum_{l=1}^{l=4} P_C)$.

Based on Figure 5, the simulation of a fault materialized by the opening of line 4-5 from the instant 62 sec until the instant 63 sec, the UPFC being disconnected, showed the notable degradation of the voltage levels.

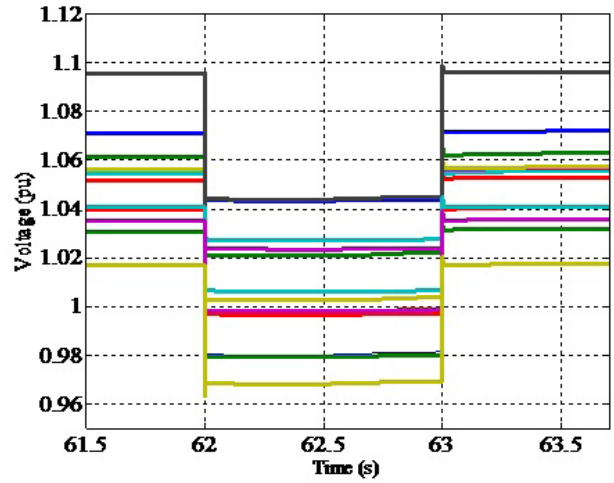


Fig 5. Voltage at the different busses

In the presence of the UPFC and for the same fault, we noticed that the voltage levels established a new state of equilibrium, proving the contribution of the UPFC to the stability of the electricity network.

Referring to figure 6, we noticed that the quantity of active power produced by machine 4, in the absence of the UPFC, is greater than in its presence, which shows that the UPFC contributes to the production of energy active in the event of a fault.

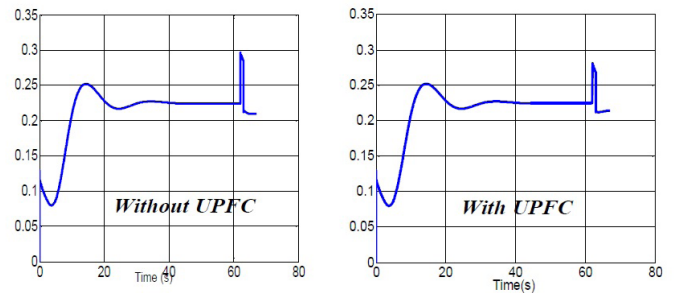


Fig 6. The quantities of active power supplied by machine 4 (25MVA) - without and with UPFC

On the other hand, based on figure 7, we noted a decrease in the amount of reactive power produced by machine 4 when integrating the UPFC, at the time of fault occurrence. Indeed, the amount of reactive power contributed by the machine to node 4 without UPFC is of the order of 0.07 pu while in the presence of the UPFC the amount has a value of 0.04 pu which justifies the entry into service of the UPFC in order to supply the rate of reagent necessary for the restoration of the levels of the voltages.

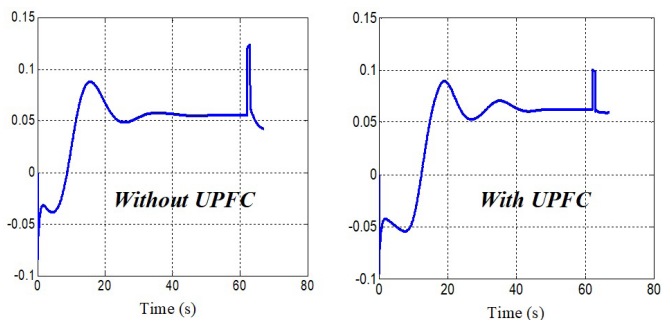


Fig 7. Reactive powers supplied by machine 4 (25MVA) - without and with UPFC

5 Conclusion

Our strategy is based on implementing a UPFC type compensator to ensure perfect optimization of the quantity of the reagent to be injected to stabilize the voltage of the network studied and subsequently guarantee synchronous control of the two converters of the 'UPFC in unbalanced mode. A single fuzzy regulator estimated the quantity of the reagent in order to ensure better profitability of the strategy. The simulation results obtained justify a marked improvement in the network voltage profile when it is affected by severe faults.

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Design of Storage Robot for Automatic Picking up and Putting the Ball Based on Fischertechnik Model

Rihani Rihab¹, Dhaoui Samir² and Elouni Mohamed³

Département Génie électrique, ISET Béja
rihab.rihani87@gmail.com,
dhaoui.samir71@gmail.com,
mohamed.elouni@isetb.rnu.tn

Abstract

A programming course implementation, which only involves virtual aspects of programming, can be an issue for beginners. The missing correlation of virtual objects in code and real objects in the physical world makes the learning process more difficult. The Fischertechnik model provides a better carrier for educational innovation and experimental innovation as an innovative teaching system. Based on the Fischertechnik model, we designed the storage robot to pick up the ball and to put it properly in the pre-selected place. The practice has proved that the teaching robot we designed has good promotion and application prospects in teaching.

Keywords: Fischertechnik combination model, storage robot, PLC control system.

1 Introduction

In recent years, robotics education has been developed significantly; it allows an individual to learn faster and keep up with the fast growth rate of innovation. Here also motivation is the key for exploring and creating new ideas so that through robotics learning, the user has an authentic experience and can see the result immediately, instead of just a virtual learning experience. It has been proven that this way of learning makes technology and programming more fun. As a result, it generates interest among students and attracts a major section of young minds, who are willing to go further and learn more things by themselves [1].

For that, we designed and developed a teaching robot system- a storage robot based on

Fischer's creative combination of model platform and the application of the PLC. This scenario-based approach creates a link between the Lego robots and software engineering concepts. It combines the learning of mechatronic and computer science concepts by providing a "two hands-on learning activity" through the use of a robot. The robot is made up of multiple sensors and motor and is using PLC control from the hardware and software of control respectively [2].

2 The Fischertechnik Model

Fischertechnik's creative combination model is a teaching aid characterized by its simplicity, stability, systemization, and flexibility. It is a family of structural parts and an innovation system composed of mechanical components, electrical components, sensors, pneumatic components, computer controller, and software [3]. The model design uses a modular project that can be unlimited expanded and repeatedly disassembled. Its products are systematic and varied, and it can realistically perform the mechanical components and scientific principles; It can also program control to understand the electromechanical integration process comprehensively. It can demonstrate a production process to provide a preliminary analog and demonstration for the study and design of industrial automation machines. Moreover, the application of this model can be malleable. Firstly, in structure, the user can assemble any mechanism by choosing the construction bricks, which can reflect the various types of projects. Secondly, in software, the application of this model is extensive, and it can be controlled with a computer, and even in a computer, the user can control it by using different software [4].

3 Overall design

Working Principle. Our storage robot is used in storage racks where the goods are stored and retrieved automatically. The user can assemble the storage robot model and wire the electrical elements described in the assembly instructions. The storage system also includes a receiving station where the goods are delivered or retrieved.

The robot motion form and workspace. An overview of the various axes on our model are given in the Table 1. shown below:Table 1. The robot motion.

Action	Axis	Motor	Limit switch	Pulse sensor/ encoder
Move rack feeder	X	M1	I1	C1
Load fork up/ down	Z	M2	I3	C3
Load fork forward/ back		M3	I2 - Fork at rear I4 - Fork at front	

The Motor direction of rotation

you need to regulate the motor speed by PWM, you have to set IN1 and IN2, to confirm the direction of rotation motor, then generate PWM pulses for the activated terminals. The motor is in the free stop state when the signal from the activated terminal is 0. When the activated signal is 1, if IN1 and IN2 are 00 or 11, the motor is in the brake state and the engine stops running. If IN1 is 0 and IN2 is 1, motor A rotates clockwise of a watch. If IN1 is 1 and IN2 is 0, the motor rotates counterclockwise [5].

Robot transmission program. Pressing the "AUTO / MANU" pushbutton to choose the mode of operation, then pressing the "START" push button starts the M2 motor. The fork moves forward until the limit switch I4 is pressed to enter the barrel; then the stacker lifts the fork at a well-defined distance, then the fork moves back to the limit switch I2, then the stacker moves to the right with the distance calculated on the X-axis.

Note: this distance is calculated with the encoder integrated into the motor-encoder by a program used in the calculator block.

The stacker raises the fork to the specified distance on the Z-axis, then the fork moves forward until sensor I4 is detected, then the stacker descends to place the barrel in its position, the fork moves back and the stacker goes down to the sensor I3 as well as the carriage returns to the initial state up to the position sensor I1.

Fischertechnik components assembled into a robot is shown in Fig.1

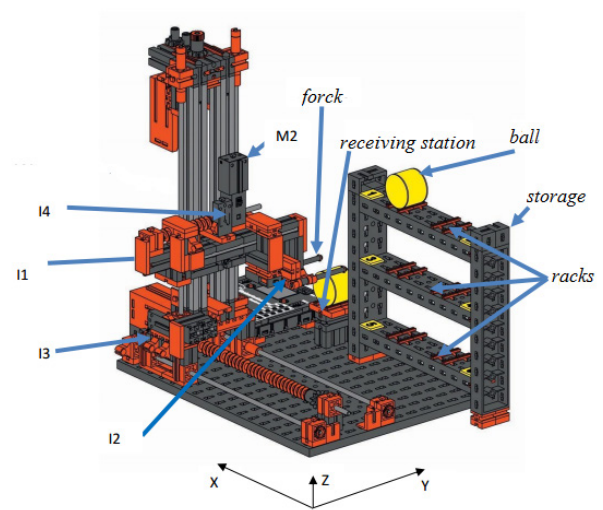


Fig.1 The whole structure of the robot

DC motor has been widely applied in the robot-driven.

We also used motor controller modules L298N; each card can control two motors so we can control the speed and the direction of the motors.

Control system program. The robot produced by Fischertechnik components can use a dedicated intelligent interface board to control and be compatible with other controllers. In Industrial areas, the use of the PLC logic control is extensive; the Fischer robot is the origin of simulated industrial automation machines, so using PLC as the control core is very reasonable [6]. The control system includes the searching path: when the ball is on the receiving station. After finding the ball, it begins to move to put the ball in the pre-selected place on the racks, then returns to the original way according to the record of the travel counter. When back to the origin point, the counter will be reset to 0 waiting for the next time to store the ball. The flow chart is shown in Figure 2.

During the practical work sessions, students are led to identify the inputs and outputs of the system and to understand the functioning of the model. As a task, they can modify the system by adding a floor and do the necessary modifications to the program or they can use the system in reverse road; instead of having a storage system they can create a destocking system.

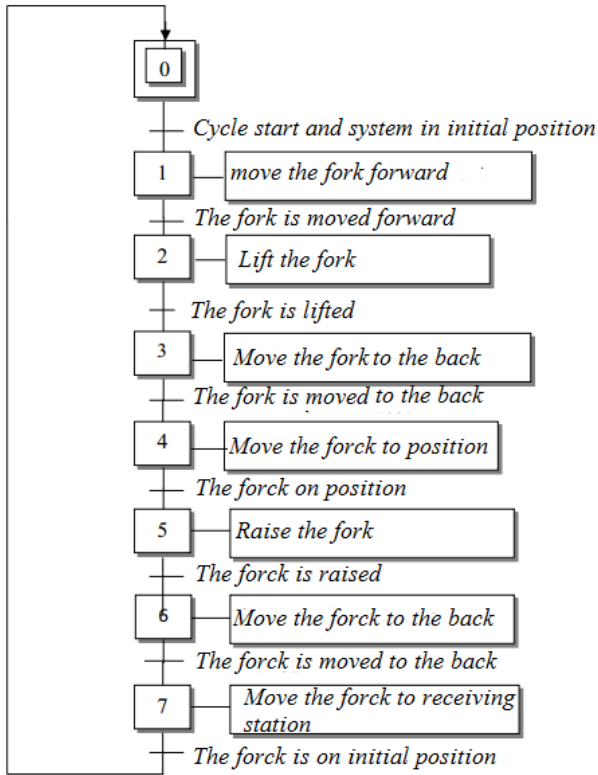


Fig.2 The grafcet

The overall structure. The hall storage robot with the power and the control card is shown in Fig.3

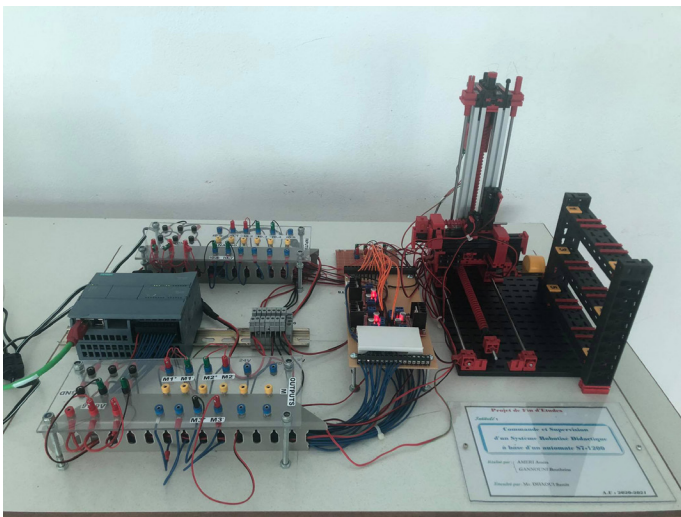


Fig.3 The storage robot

The controller boards. There are three push-buttons used for interaction with the user. A “START” button to start the robot. A “pause” button to change the output state to the STOP state when the outputs are unlocked. If the outputs are locked, the user cannot change the state, and the “reset” button causes the immediate initialization of the entire system

and return. The controller also contains six buttons numbered from one to six used to choose where the ball will be placed. In addition, the controller can also display the speed of each motor. The controller board is shown in fig.4

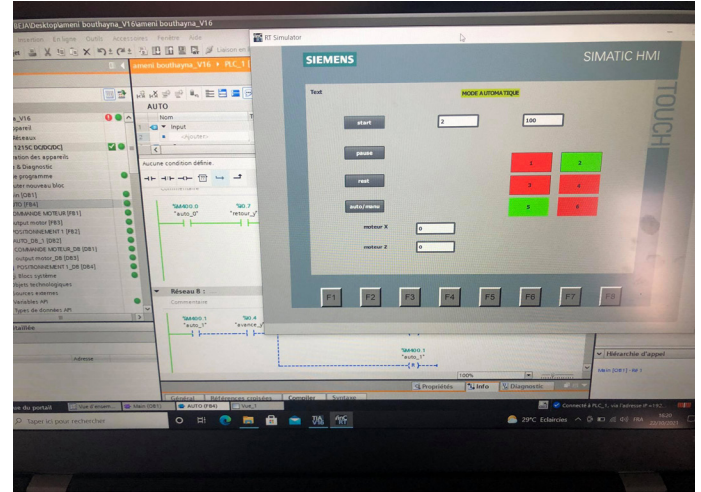


Fig.4 The controller board

4 Testing and evaluation of the storage robot

The robotics kit composed of Fischertechnik construction bricks, an assembly of all-purpose electronics components and the board controller was tested during the project graduation. We made two robots; the storage robots and the gripping robot shown in fig 5.

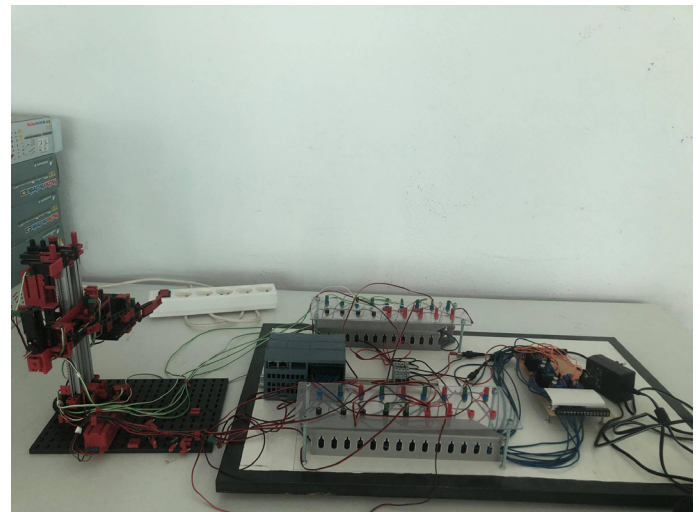


Fig.5 The gripping robot

In the second part of this project, a robotics workshop will be divided into our automation lab using the storage robot and the gripping robot. Students working in groups designed, performed, documented, and finally, understood the production process because the usage of these two robots allowed students' hands on the actual, physical objects to link them to the virtual objects.

5 Conclusion

A teaching robot based on Fischer's creative combination model platform was designed. The teaching robot can help students visually analyze the robot's overall mechanical structure and control system structure. It can also help students understand the laws of robot kinematics comprehensively to master the manipulation of the robot proficiently. The robot has high promotion and application prospects in the teaching field.

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Operation of the plastic extrusion training bench

SAIDI Mourad¹

¹ Higher Institute of Technological Studies of Kasserine,
University Campus Kasserine, TUNISIA

Abstract.

In the plastics industry, plastic products are usually made by extrusion. With a material in granular form, a process is followed using a programmable logic controller S7-1200 (PLC). Plastic extrusion is a thermo-mechanical industrial process. It allows, in fact, to transform the raw material to pipes, alimentary bags, alimentary film, etc. This transformation is carried out under pressure with a conditioning in temperature and flow of the material proportional with the speed of rotation of the screw. The main objective of this didactic bench is that the student should be able to master the programming techniques using the programmable logic controller (PLC) and to use the new technologies to facilitate their integration in the industrial application.

Keywords: Didactic bench, Plastic Extruder, Programmable Logic Controller (PLC) S7-1200, Pedagogical Project Method.

1 Introduction

Faced with the global challenges of environmental protection, the idea of recycling has become more relevant in the political and economic sphere. The recovery of recycled and reprocessed plastic waste began in the 1990s. Ever since, the demand for recycled materials has steadily increased, driven by environmental concerns to reuse plastic waste and to give manufacturers the opportunity to produce high-performance materials.

Due to the high levels of production of plastics, one of the major challenges constitutes the management of this waste. [1], [2], [3].

For this reason, as part of a final-year project, we proposed to design and build a plastic extrusion didactic bench (compare Figure 1. (a)). Extrusion is a technology in full development in the food industry. It is essentially a system for the continuous manufacture of a tremendous quantity of food products.

Furthermore, it plays a vital part in the manufacture and processing of plastics. Extrusion, therefore, can be understood as the fragmentation process that is applied to solid waste, especially plastic waste [4], [5], [6].

This article presents the extrusion process as well as the different parts of the plastic extruder where students learn the technique by engaging with them. By engaging in this complex and concrete project, the students develop and apply skills and gain knowledge. Moreover, a programmable logic controller (compare Figure 1. (b)) is used to control, monitor, and regulate the different parameters in the machine, namely the speed of rotation of the screw, the temperature of the barrel, the flow of the granulated plastic material and the speed of the fan.

In addition, the application of the pedagogical method of project prompts students to learn the industrially required skills related to the process of plastic extrusion.

2 Presentation of the Plastic Extruder

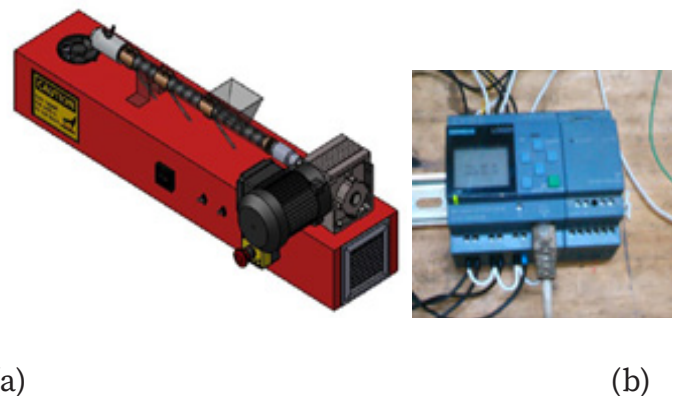


Fig.1. Plastic extrusion didactic bench (a), Programmable Logic Controller (b)

The extruder (compare Figure 2) comprises a cylindrical sleeve (5) which is embedded by a coupling (2) combined with the screw (3). It is heated by means of heating collars (6) inside which a screw (3) rotates and is fed through a dosing device by a pellet feed hopper (4). The screw (3) is characterized by its length (L) and its diameters (D and d). The screw (3) continuously mixes, compresses and transports the fluidized and homogeneous material to the Spinneret (8) which is embedded with the sleeve by the fixing screw (7).

Finally, the film is cooled by a fan (9), at the exit of the Spinneret (8), and the extruder is followed by a programmable logic controller (PLC) which adjusts the material.

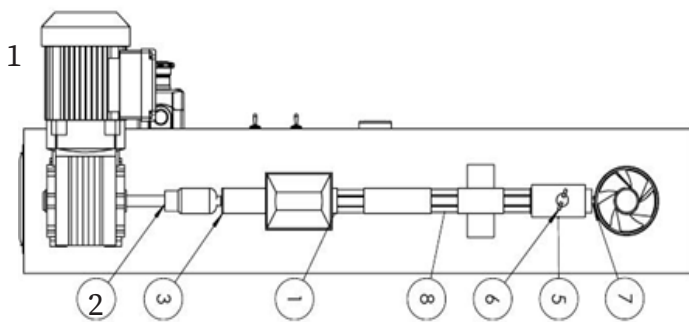


Fig.2. Component of the Plastic Extrusion Didactic Bench

Legend:

- Gear motor (1)
- Coupling (2)
- Worm screw (3)
- Hopper (4)
- Sheath (5)
- Heating collars (6)
- Fixing screw (7)
- Spinneret (8)
- Fan (9)
- PLC S7-1200 (10)

3 Application of the pedagogical approach

Teachers use methods and approaches to create an educational environment and to specify the nature of the activity in which the student and teacher will participate during the course or practical work [7], [8].

Project-based learning refers to a pedagogi-

cal approach, strategy or method. The project can be individual or collective. This teaching approach refers to an active pedagogical practice that allows to foster learning through the realization of a concrete production. The project allows learners to identify and formulate their own problems and to develop know-how. Project-based learning is a learner-centered model. Learners have the opportunity to work more independently and to build their knowledge when they are placed in a problem-solving situation [9].

For this reason, we used the pedagogical method of the project to realize the didactic bench of plastic extrusion where the students learned the skills related to the process of plastic extrusion and were taught to master the new techniques of programming on the PLC.

4 Conclusion

From this project, the expected results for the students are:

- Understand the plastic extrusion process
- Design and build the different components of the system
- Master advanced PLC programming techniques using the S7-1200 PLC where they control the temperature of the barrel, the rotation speed of the Archimedes screw and the flow of plastic material.

Therefore, project-based learning fits perfectly with the use of programming and automation technology in the school. Our technology project entitled Plastic Extrusion Trainer is interdisciplinary, collaborative, research-based, self-directed, motivating, and meets all the needs and learning styles of the students.

In effect, this didactic bench is a way to develop the students' learning experience while achieving specific pedagogical objectives to facilitate their integration into industrial life. In addition, they use a correct method for the project approach and its management.

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Constructing a hydroponic plant nursery connected and controlled by a smartphone

Chaima BEK¹, Jamel SLAIMI² and Siwar BEN SALAH³

^{1,2,3} Department of mechanical engineering-
Higher institute of technological studies of
Béja, Environment Boulevard, 9000 Béja, Tu-
nisia

¹bekchayma37@gmail.com

²slaimijamel@gmail.com

³siwar1723@gmail.com

Abstract.

This paper outlines the benefits, the application, the mechanical design and the electronic control of a hydroponic plant nursery connected and controlled by a smartphone. The hydroponic plant nursery is a revolution for conventional agriculture. It creates a self-regulated microclimate adapted to plant growth, optimizes growing conditions and automates the growing process.

Keywords: hydroponic plant nursery, remote control, mechanical design, hydroponic, mobile application.

1 Introduction

This paper is based on a project called “The smart Green House” which aims to automate hydroponic plant nurseries, it creates a self-regulated microclimate adapted to plant growth through the use of sensors, actuators and monitoring [1] and control systems by connecting it to a smartphone. The smartphone then will be used to control and monitor the hydroponic plant nursery, these make it possible to optimize the growing conditions and to automate the growing process. What renders this project appealing is the fact that it is a recent and rapidly developing technology. Smart agriculture has a host of undeniable advantages such as ensuring steady growth of plants, minimizing their time of growth and ensuring a good quality. Moreover, smart agriculture increases the yield of production, simplifies the order process and most importantly the technology keeps all farmland running and safe.

Furthermore, this hydroponic plant nursery provides the advantage of eliciting the right planting system for the consumer. Within this context, the smart nursery chooses between two previously configured planting methods, namely automatic watering using a pump and wiper tank or a self-watering using the hydroponic method.

Since we now delved into the advantages and remedies this project presents, the following paragraphs will outline the application, mechanical design and electronic control of the hydroponic plant nursery project.

2 Application of Hydroponics Planting using the Seeding Tray

The hydroponic system we used is based on the water that is positioned in a drawer located directly under the plant’s soil [2] as shown in Figure 1. In the next step, the seeding tray will be directly exposed to the water and the plants, consequently, will soak up as much water as it needs according to the osmosis law. The use of this method allows us to avoid the waste of water, limit the consumption of potting soil and by its depth promote the rooting of seedlings.

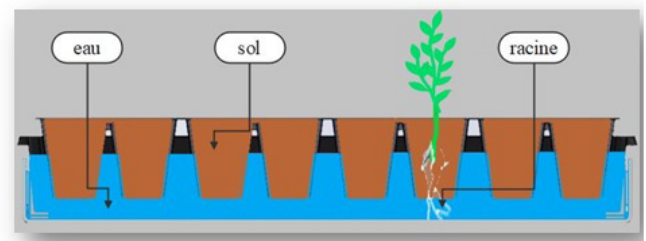


Fig. 1. Design of the hydroponic system using the seeding tray

3 Mechanical Design

Design is the creative phase of a project. Hence, the primary purpose of the design should enable the creation of a system or process that meets a need within specific constraints.

This nursery, therefore, consists of three main parts as depicted in Figure 2 and Table 1. At first, we used Medium Density Fiberboard (MDF) cover to ensure the nursery’s stability and the embedding of electronic components. For the second part, plexiglass was used to allow visualization inside the nursery. At last,

there is a sliding recessed drawer that fits inside the bottom-half of the nursery and is used as a water tank to support the seeding tray. The drawer provides a slide connection to the base and the lid.

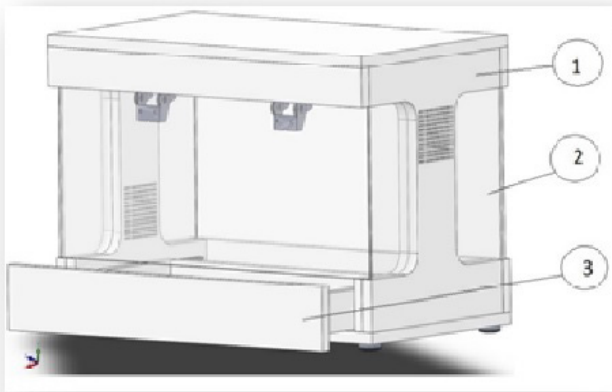


Fig. 2. Prototype for the design of the smart nursery

Table 1. Type of materials used for the distinctive parts of the smart nursery

Number	Name	Materials
1	Lid	Wood MDF
2	Roof	Plexiglass
3	Drawer	Wood MDF

Each agricultural nursery must be equipped with a system that will control the climatic parameters. Therefore, this system must control the temperature and the humidity of the air as well as the humidity of the soil. These parameters actually constitute the cardinal variables to control plant survival and growth.

However not only humidity and temperature of the soil play a vital part for our smart nursery. To provide sufficient electronic control we had to assure the following:

- The system must control the temperature and humidity of the greenhouse.
- The temperature and humidity of the greenhouse can be edited by the user.
- The soil moisture can be edited by the user.
- The system must control an electric heater so that the temperature does not fall below a maximum decided value.
- The system must trigger a watering system to maintain a fixed moisture content.
- The system must commence an engine for ventilation as soon as the maximum temperature is reached.
- Light is user-controlled

The user can choose to use the hydroponic system or the simple irrigation system. The agriculture control system is controlled by an ESP32 card in conjunction with a DHT22 sensors, a soil moisture sensor and actuators [4] which are the LED lamps, fans, water pump, and relays (compare Figure 3). The nursery is then connected and controlled with a smartphone from a mobile application.

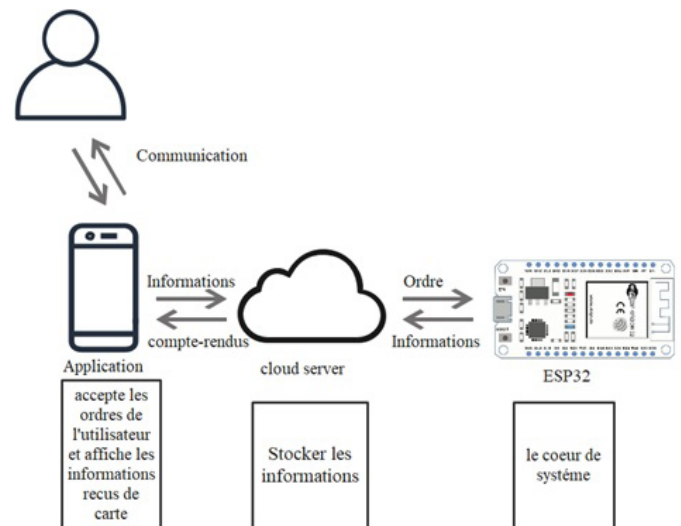


Fig. 3. Operating diagram

In the smartphone application we then enabled our users to choose adequate intervals for temperature and humidity of the nursery to allow a good plant growth as shown in Figure 4. The user can enter the desired temperature and humidity interval and save them.

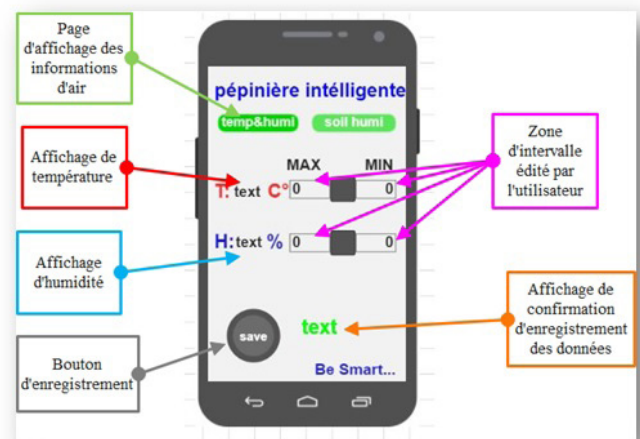


Fig. 4. Settings for the desired temperature and humidity interval

In order to create the perfect growing environment for the distinct plants we had to empower the user to distinctively adjust the soil moisture for each sensor. Therefore, we implemented a feature which allows the user to enter the desired moisture intervals and save them (compare Figure 5).

In addition, if the user uses the hydroponics method for planting, it is not necessary to use this interface and the soil moisture sensor since this part will be automatically adopted.

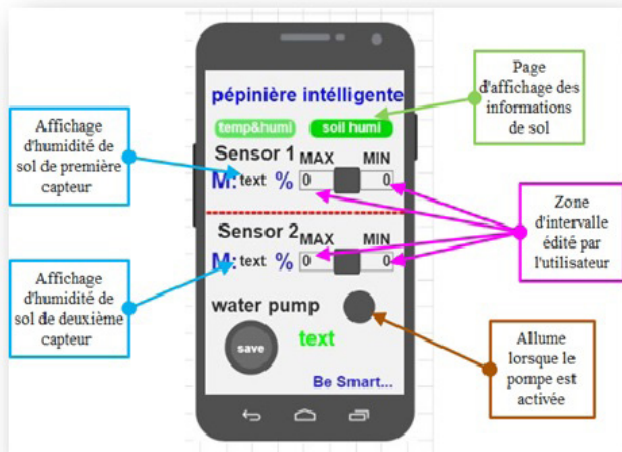


Fig. 5. Settings for the humidity control of the plans for the distinct sensors

The need for light [3] is vital for most plants since at the origin of the photosynthetic process, light energy allows plants to feed and develop [5]. Hence the mobile application empowers users to open and close the LEDs and do the necessary tests as shown in Figure 6.

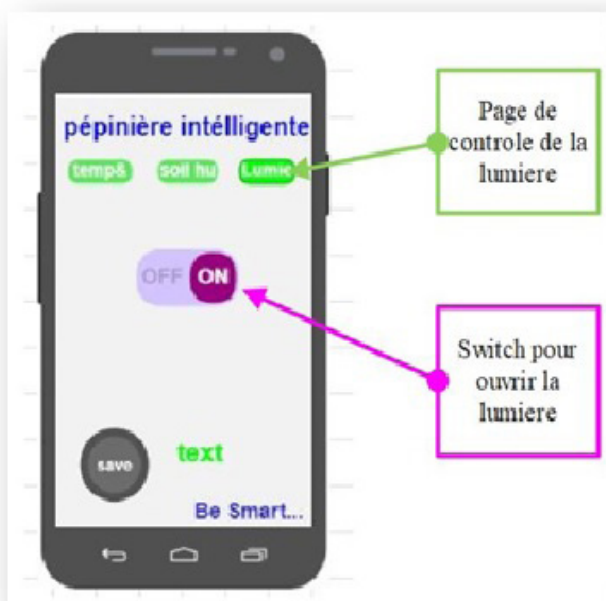


Fig. 6. Light control within the mobile application

5 Conclusion

In the future, more than one sensor can be used to control humidity and temperature in the nursery. A cloud server allows you to bring the information from the card to the smartphone. This will make it possible to monitor its greenhouses at a distance and a great assurance of the sealing using very precise methods. Optionally, this system can be equipped with an audible alarm that tells us if the temperature and humidity are not within the operating range. And do not forget that this system offers two planting methods according to the choice of the user.

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